STAMFORD HOSPITAL
The Regional Center for Health
affiliate Columbia University College of Physicians and Surgeons
member New York-Presbyterian Healthcare System
A Planetree Hospital

RECEIVED
APR 13 2015
Office of
HEALTHCARE ACCESS

April 9, 2015

Lisa Davis, MBA, BSN, RN
Deputy Commissioner
State of Connecticut
Department of Public Health
Office of Health Care Access Division
410 Capital Avenue
MS#13HCA
P.O. Box 340308
Hartford, CT 06134

Re: Certificate of Need Application to Acquire and Operate a
320-Slice CT Scanner at The Stamford Hospital in Stamford, CT.

Dear Deputy Commissioner Davis,

Enclosed is the original Certificate of Need Application for the acquisition and operation of a 320-Slice CT Scanner at The Stamford Hospital in Stamford, CT. Also, enclosed are four copies of the application and a CD of the scanned application and documents in MS format.

Please do not hesitate to contact me at 203-276-7510 or our outside counsel, Stephen Cowherd, at 203-259-7900 if you have any questions regarding this application.

I look forward to working with you during the review process.

Sincerely,

David L. Smith
Senior Vice President, Strategy
Chief Strategy and Market Development Officer

Cc: Stephen M. Cowherd, Esq. (w/ encl.)

Instructions:

1. **Please check each box below, as appropriate; and**
2. **The completed checklist *must* be submitted as the first page of the CON application.**

☑ **Attached is the CON application filing fee in the form of a certified, cashier or business check made out to the "Treasurer State of Connecticut" in the amount of $500.**

For OHCA Use Only:

Docket No.: 15-31990-CON **Check No.:** 383562
OHCA Verified by: KR **Date:** 4-13-15

☑ **Attached is evidence demonstrating that public notice has been published in a suitable newspaper that relates to the location of the proposal, 3 days in a row, at least 20 days prior to the submission of the CON application to OHCA. (*OHCA requests that the Applicant fax a courtesy copy to OHCA (860) 418-7053, at the time of the publication)***

☑ **Attached is a paginated hard copy of the CON application including a completed affidavit, signed and notarized by the appropriate individuals.**

☑ **Attached are completed Financial Attachments I and II.**

☑ **Submission includes one (1) original and four (4) hard copies with each set placed in 3-ring binders.**

Note: A CON application may be filed with OHCA electronically through email, if the total number of pages submitted is 50 pages or less. In this case, the CON Application must be emailed to ohca@ct.gov.

Important: For CON applications(less than 50 pages) filed electronically through email, the singed affidavit and the check in the amount of $500 must be delivered to OHCA in hardcopy.

☑ **The following have been submitted on a CD**

1. **A scanned copy of each submission in its entirety, including all attachments in Adobe (.pdf) format.**
2. **An electronic copy of the documents in MS Word and MS Excel as appropriate.**

VENDOR NAME: TREASURER STATE OF CONN.

VENDOR NUMBER: 02301

DATE	CHECK NO
03/13/15	383562

'OICE DATE	INVOICE / CREDIT MEMO	DESCRIPTION	INVOICE AMOUNT	DISCOUNT	NET PAID
⌣_,04/15	CON APPLICATI		500.00	0.00	500.00
					*****$500.00

THE FACE OF THIS DOCUMENT HAS A MULTI-COLORED BACKGROUND ON WHITE PAPER

Stamford Hospital
30 Shelburne Rd.
P.O. Box 9317
Stamford, Connecticut 06904-9317

Wells Fargo Bank, N.A.
Hartford, CT

51-110
211

CHECK NO.
383562

DATE 03/13/15

PAY FIVE HUNDRED 00/100

CHECK AMOUNT
*****$500.00

TO THE ORDER OF
REASURER STATE OF CONN.
DEPT OF PUBLIC HEALTH/HEALTH SYS
PO BOX 1080
HARTFORD, CT 06143

*** VOID AFTER 90 DAYS ***

Kathleen Silard

Authorized Signature

RUB RED IMAGE FADES WITH HEAT

SECURITY FEATURES INCLUDED. DETAILS ON BACK.

⑈383562⑈ ⑆021101108⑆ 2000012045093⑈

THE ADVOCATE CLASSIFIED

SOUTHERN CT JOBS

203-330-6553
classified@scni.com
Hours: 8:30 a.m.–5:30 p.m., M-F
Major Credit Cards Accepted

PUBLIC NOTICES

CITY OF STAMFORD
ZONING BOARD OF APPEALS
LEGAL NOTICE

Notice is hereby given that the following Certificate of Decision has been filed in the office of the Town and City Clerk of the City of Stamford:

GRANTED - (With Conditions) Application #006-15 of Child Care Learning Centers, Inc., for a variance of Article IV, Section 12.D.20 (Child Care Use Requirements) of the Zoning Regulations in order to permit 53 onsite parking spaces in lieu of the 103 parking spaces required. Said property is located on the west side of Lockwood Avenue at the intersections of Frank and William Streets in an R-5 zone and is known as 83 Lockwood Avenue.

The above mentioned Certificate of Decision may be seen and examined in the office of the Zoning Board of Appeals, Stamford Government Center Building, 888 Washington Boulevard, Stamford.

Dated at the City of Stamford, Connecticut this 29th day of January 2015.

Attest: Mary Judge
Board Administrator

CITY OF STAMFORD
ZONING BOARD OF APPEALS
LEGAL NOTICE

Notice is hereby given that the following Certificate of Decision has been filed in the office of the Town and City Clerk of the City of Stamford:

GRANTED - Application #004-15 of William Jarvis et al for a variance of Table III, Appendix B (Side Yard Setback Requirements) of the Zoning Regulations in order to allow for the existing fire place, generator and AC units allowing the accessory structures over the side yard setback to remain. The proposed would be 2.0 feet side yard setback for the existing fire place in lieu of the 10.0 feet minimum allowed; 5.0 feet side yard setback for the existing generator in lieu of the 10.0 feet minimum allow and 7.5 feet side yard setback for the existing AC units in lieu of the 10.0 feet allowed. Said property is located on the north side of Ocean Drive West at the intersection of Woolsey Road in an R-10 zone and is known as 21 Ocean Drive West aka 0 Woolsey Road. This application is exempt from Coastal Area Management, Exemption number 10E.

The above mentioned Certificate of Decision may be seen and examined in the office of the Zoning Board of Appeals, Stamford Government Center Building, 888 Washington Boulevard, Stamford.

Dated at the City of Stamford, Connecticut this 29th day of January 2015.

Attest: Mary Judge
Board Administrator

CITY OF STAMFORD
ZONING BOARD OF APPEALS
LEGAL NOTICE

Notice is hereby given that the following Certificate of Decision has been filed in the office of the Town and City Clerk of the City of Stamford:

GRANTED - Application #002-15 of Melanie Healey for a variance of Table III, Appendix B (Side Yard Setback and Total Side Yards Setback Requirements) of the Zoning Regulations in order to construct an addition to the existing dwelling. The proposed would be 3.5 feet from the side yard property line in lieu of the 6.0 feet required; 5.8 feet from the side yard property line in lieu of the 6.0 feet required and 9.3 feet total side yards setback in lieu of the 12.0 feet required. Said property is located on the east side of Selby Place in an R-7-1/2 zone and is known as 14 Selby Place.

The above mentioned Certificate of Decision may be seen and examined in the office of the Zoning Board of Appeals, Stamford Government Center Building, 888 Washington Boulevard, Stamford.

Dated at the City of Stamford, Connecticut this 29th day of January 2015.

Attest: Mary Judge
Board Administrator

PROBATE NOTICES

NOTICE TO CREDITORS

ESTATE OF Crefile Benoit

The Hon. Gerald M. Fox, III, Judge of the Court of Probate, District of Stamford Probate District, by decree dated January 16, 2015, ordered that all claims must be presented to the fiduciary at the address below. Failure to promptly present any such claim may result in the loss of rights to recover on such claim.

Nelly V. Slocum, Clerk

The fiduciary is:

Michele A. Benoit
c/o Jeffrey L. Meyer, Esq.,
Jeffrey L. Meyers,
706 Bedford Street,
Stamford, CT 06901-1101

PUBLIC NOTICES

LEGAL NOTICE
PLANNING BOARD
OF THE CITY OF STAMFORD

Notice is hereby given that the **STAMFORD PLANNING BOARD** at its meeting held on Tuesday, January 20, 2015, **APPROVED** the following subdivision application:

Subdivision Application #4017 of Brundage Associates, LLC. For subdivision of property located at 88 Mulberry Street, (Lot No. 45); and 98 Mulberry Street (Lot No. 46B & 46C) for the re-subdivision of property into four (4) parcels; located on the southwest corner of Mulberry Street (south side) and Brundage Street (west side).

ATTEST: CLAIRE FISHMAN
SECRETARY
STAMFORD PLANNING BOARD

Dated at the City of Stamford this 29th day of January 2015

PUBLIC NOTICE

The Stamford Hospital is filing an application for a Certificate of Need under section 19a-638(a)(9) of the Connecticut General Statutes for the acquisition and operation of a Multi-Slice CT Scanner to be located on the main hospital campus located at 30 Shelburne Road, Stamford, CT. The estimated capital expenditure for the project is $1,385,148.

CITY OF STAMFORD
ZONING BOARD OF APPEALS
LEGAL NOTICE

The Zoning Board of Appeals of the City of Stamford will hold a public hearing and meeting on Wednesday, **February 11, 2015**, at 7 PM in the Cafeteria located on the 4th floor of the Stamford Government Center Building, 888 Washington Boulevard, Stamford at which time and place the following application will be considered:

Application **#010-15 of Sharen Holdings, Inc.** for a variance of Table IV, Appendix B (Special Regulations, Requirements) of the Zoning Regulations in order to allow a subdivision of property. The proposed would have a 1.7 FAR on proposed Lot Y in lieu of the 1.0 maximum permitted in the MG Zone. Said property is located on the south side of Selleck and the west side of Betts Avenue in a MG zone and is known as 222 Selleck Street.

At the above mentioned time and place a public hearing will be held and all interested parties are invited to attend. After the public hearing, there may be a meeting to discuss and possibly decide the application and any other business pending before the Board.

Dated at the City of Stamford, Connecticut this 29th day of January 2015.

Attest: Mary Judge
Board Administrator

CITY OF STAMFORD
ZONING BOARD OF APPEALS
LEGAL NOTICE

The Zoning Board of Appeals of the City of Stamford will hold a public hearing and meeting on Wednesday, **February 11, 2015**, at 7 PM in the Cafeteria located on the 4th floor of the Stamford Government Center Building, 888 Washington Boulevard, Stamford at which time and place the following application will be considered:

Application **#001-15 of Henry & Mary Beth Boyton** for a variance of Table III, Appendix B (Rear Yard Setback Requirements) of the Zoning Regulations in order to construct an addition to the existing dwelling. The proposed would be 22.0 feet from the rear yard property line in lieu of the 30.0 feet required. Said property is located on the east side of Sundance Road in an R-10 zone and is known as 305 Sundance Road.

At the above mentioned time and place a public hearing will be held and all interested parties are invited to attend. After the public hearing, there may be a meeting to discuss and possibly decide the application and any other business pending before the Board.

Dated at the City of Stamford, Connecticut this 29th day of January 2015.

Attest: Mary Judge
Board Administrator

PROBATE NOTICES

NOTICE TO CREDITORS

ESTATE OF K. Louise Carlson, deceased, AKA Kathryn Louise Carlson, AKA Kathryn Louise Johnson, AKA Louise Carlson

The Hon. Gerald M. Fox, III, Judge of the Court of Probate, District of Stamford Probate District, by decree dated January 13, 2015, ordered that all claims must be presented to the fiduciary at the address below. Failure to promptly present any such claim may result in the loss of rights to recover on such claim.

Nelly V. Slocum, Clerk

The fiduciary is:

Christopher C. Carlson
c/o Steven E. Ayres, Esq.,
Mead, Bromley & Bishop,
41 Bank Street,
Stamford, CT 06901

Nicoline B. Sawabini
c/o Steven E. Ayres, Esq.,
Mead, Bromley & Bishop,
41 Bank Street,
Stamford, CT 06901

Have an opinion that you want to share?
Send a Letter to the Editor
9 Riverbend Drive South Building 9A
Stamford, CT 06097

CITY OF STAMFORD
ZONING BOARD OF APPEALS
LEGAL NOTICE

The Zoning Board of Appeals of the City of Stamford will hold a public hearing and meeting on Wednesday, **February 11, 2015**, at 7 PM in the Cafeteria located on the 4th floor of the Stamford Government Center Building, 888 Washington Boulevard, Stamford at which time and place the following application will be considered:

Application **008-15 of Volodymyr & Bozhena Hubyak** for a variance of Table III, Appendix B (Side Yard Setback and Total Side Yards Setback Requirements) of the Zoning Regulations in order the construct an addition to the existing dwelling. The proposed would be 6.6 feet for the side yard property line in lieu of the 10.0 feet required and 17.9 feet total side yards setback in lieu of the 20.0 feet required. Said property is located on the west side of Woodbury Avenue in an R-10 zone and is known as 34 Woodbury Avenue.

At the above mentioned time and place a public hearing will be held and all interested parties are invited to attend. After the public hearing, there may be a meeting to discuss and possibly decide the application and any other business pending before the Board.

Dated at the City of Stamford, Connecticut this 29th day of January 2015.

Attest: Mary Judge
Board Administrator

PROBATE NOTICES

NOTICE TO CREDITORS

ESTATE OF Thomas A. Pia, Sr.

The Hon. Gerald M. Fox, III, Judge of the Court of Probate, District of Stamford Probate District, by decree dated January 13, 2015, ordered that all claims must be presented to the fiduciary at the address below. Failure to promptly present any such claim may result in the loss of rights to recover on such claim.

Nelly V. Slocum, Clerk

The fiduciary is:

Gerald C. Pia, Sr.
c/o Neil P. Phillips, Esq.,
Lennon Murphy Caulfield & Phillips, LLC., Tide Mill Landing,
2425 Post Rd, Ste.302,
Southport, CT 06890

NOTICE TO CREDITORS

ESTATE OF
Russell E. Kemp, Jr.,
AKA Russell Kemp, Jr., AKA
Russell Kemp

The Hon. Gerald M. Fox, III, Judge of the Court of Probate, District of Stamford Probate District, by decree dated January 13, 2015, ordered that all claims must be presented to the fiduciary at the address below. Failure to promptly present any such claim may result in the loss of rights to recover on such claim.

Nelly V. Slocum, Clerk

The fiduciary is:

Maria D. Kemp
c/o Jevera Kaye Hennessey, Esq.,
Kaye & Hennessey,
71 Lewis Street,
P.O. Box 788,
Greenwich, CT 06836

NOTICE TO CREDITORS

ESTATE OF Richard F. Morse

The Hon. Daniel F. Caruso, Judge of the Court of Probate, District of Stamford Probate District, by decree dated January 22, 2015, ordered that all claims must be presented to the fiduciary at the address below. Failure to promptly present any such claim may result in the loss of rights to recover on such claim.

Nelly V. Slocum, Clerk

The fiduciary is:

William R. Morse
c/o Daniel M. McCabe, Esq.,
Daniel M. McCabe, LLC,
1200 Summer Street, Suite 201C,
Stamford, CT 06905

PUBLIC NOTICES

CITY OF STAMFORD
ZONING BOARD OF APPEALS
LEGAL NOTICE

Notice is hereby given that the following Certificate of Decision has been filed in the office of the Town and City Clerk of the City of Stamford:

GRANTED - (With Conditions) Application #005-15 of Michael Grunberg for a variance of Table III, Appendix B, (Minimum Lot Area, Lot Frontage and Circle Diameter Requirements) of the Zoning Regulations for Parcels A & B. Proposed Parcel B would have a lot area of 27,461 square feet in lieu of the minimum 2 acres required; 64.1 feet of frontage requested in lieu of the 200 feet minimum required and 124 feet circle diameter requested in lieu of the 200 feet diameter minimum allowed. Proposed Parcel A would have 0 feet frontage in lieu of the 200 feet required. Said property is located on Juniper Hill Road at the intersection of Guinea Road in an RA-2 zone and is known as 1 Juniper Hill Road aka 3 Juniper Hill Road.

The above mentioned Certificate of Decision may be seen and examined in the office of the Zoning Board of Appeals, Stamford Government Center Building, 888 Washington Boulevard, Stamford.

Dated at the City of Stamford, Connecticut this 29th day of January 2015.

Attest: Mary Judge
Board Administrator

CITY OF STAMFORD
ZONING BOARD OF APPEALS
LEGAL NOTICE

Notice is hereby given that the following Certificate of Decision has been filed in the office of the Town and City Clerk of the City of Stamford:

GRANTED- Application #063-14 of Michael Agate for a variance of Table III, Appendix B, (Area Building Coverage, Front Yard Setback, Front Street Centerline Setback, Side Yard Setback, Total Side Yards Setback and Rear Yard Setback Requirements) of the Zoning Regulations in order to construct an addition to the existing dwelling. The proposed would have an area coverage of 14.6% in lieu of the 10.0% allowed; a front yard setback of 15.8 feet in lieu of the 50.0 feet required; a front street center line setback of 55.8 feet in lieu of the 85.0 feet required; a side yard setback of 18.2 feet in lieu of the 35.0 feet required; a side yard setback of 29.5 in lieu of the 35.0 feet required; total side yards setback of 47.7 feet in lieu of the 70.0 feet required and a rear yard setback of 67.9 feet in lieu of the 70.0 feet required. Said property is located on the east side of High Ridge Road in a RA-2 zone and is known as 2979 High Ridge Road.

The above mentioned Certificate of Decision may be seen and examined in the office of the Zoning Board of Appeals, Stamford Government Center Building, 888 Washington Boulevard, Stamford.

Dated at the City of Stamford, Connecticut this 29th day of January 2015.

Attest: Mary Judge
Board Administrator

CITY OF STAMFORD
ZONING BOARD OF APPEALS
LEGAL NOTICE

The Zoning Board of Appeals of the City of Stamford will hold a public hearing and meeting on Wednesday, **February 11, 2015**, at 7 PM in the Cafeteria located on the 4th floor of the Stamford Government Center Building, 888 Washington Boulevard, Stamford at which time and place the following application will be considered:

Application **#007-15 of Michele Battinelli** for a variance of Table III, Appendix B (Front Yard Setback and Front Street Center Line Requirements) of the Zoning Regulations in order to construct an addition to the existing dwelling. The proposed would be 17.5 feet from the front yard property line in lieu of the 40.0 feet required and 37.5 feet from the front street center line in lieu of the 65.0 feet required. Said property is located on the west side of Kenilworth Drive West at the intersection of Soundview Avenue in an R-10 zone and is known as 3 Kenilworth Drive West. **This application is exempt from Coastal Area Management Approval, Exemption Number 10B.**

At the above mentioned time and place a public hearing will be held and all interested parties are invited to attend. After the public hearing, there may be a meeting to discuss and possibly decide the application and any other business pending before the Board.

Dated at the City of Stamford, Connecticut this 29th day of January 2015.

Attest: Mary Judge
Board Administrator

PROBATE NOTICES

NOTICE TO CREDITORS

ESTATE OF Nancy H. Teeters

The Hon. Gerald M. Fox, III, Judge of the Court of Probate, District of Stamford Probate District, by decree dated January 22, 2015, ordered that all claims must be presented to the fiduciary at the address below. Failure to promptly present any such claim may result in the loss of rights to recover on such claim.

Nelly V. Slocum, Clerk

The fiduciary is:

Ralph N. Teeters
c/o Robert A. DeVellis, Esq.,
Blair & Potts,
Four Stamford Plaza,
107 Elm Street, P.O. Box 1214,
Stamford, CT 06904-1214

John D. Teeters
c/o Robert A. DeVellis, Esq.,
Blair & Potts,
Four Stamford Plaza,
107 Elm Street, P.O. Box 1214,
Stamford, CT 06904-1214

PUBLIC NOTICES

CITY OF STAMFORD
ZONING BOARD OF APPEALS
LEGAL NOTICE

The Zoning Board of Appeals of the City of Stamford will hold a public hearing and meeting on Wednesday, **February 11, 2015**, at 7 PM in the Cafeteria located on the 4th floor of the Stamford Government Center Building, 888 Washington Boulevard, Stamford at which time and place the following application will be considered:

Application #009-15 of **Thomas Grady/Jennifer Irwin** for a variance of Table III, Appendix B (Front Yard Setback and Street Center Line Setback Requirements) of the Zoning Regulations in order to construct an addition to the existing dwelling. The proposed would be 25.1 feet from the front yard property line in lieu of the 30.0 feet required and 50.1 feet from the front street centerline in lieu of the 55.0 feet required. Said property is located on the east side of Knapp Street at the inter-section of Lawton Avenue in an R-7-1/2 zone and is known as 138 Knapp Street.

At the above mentioned time and place a public hearing will be held and all interested parties are invited to attend. After the public hearing, there may be a meeting to discuss and possibly decide the application and any other business pending before the Board.

Dated at the City of Stamford, Connecticut this 29th day of January 2015.

Attest: Mary Judge
Board Administrator

CITY OF STAMFORD
ZONING BOARD OF APPEALS
LEGAL NOTICE

The Zoning Board of Appeals of the City of Stamford will hold a public hearing and meeting on Wednesday, **February 11, 2015**, at 7 PM in the Cafeteria located on the 4th floor of the Stamford Government Center Building, 888 Washington Boulevard, Stamford at which time and place the following application will be considered:

Application **#003-15 of Alexander and Maureen Blum** for a variance of Article III, Section 6A (Accessory Buildings Requirements) of the Zoning Regulations in order to allow for a tennis court and a fence 12 feet high that will surround a tennis court and will be located in the front yard. Said property is locate d on the south side of Farms Road in an RA-3 zone and is known as 115 Farms Road.

At the above mentioned time and place a public hearing will be held and all interested parties are invited to attend. After the public hearing, there may be a meeting to discuss and possibly decide the application and any other business pending before the Board.

Dated at the City of Stamford, Connecticut this 29th day of January 2015.

Attest: Mary Judge
Board Administrator

CITY OF STAMFORD
ZONING BOARD OF APPEALS
LEGAL NOTICE

Notice is hereby given that the following Certificate of Decision has been filed in the office of the Town and City Clerk of the City of Stamford:

DENIED - Application #062-14 of Wilson Velez for a variance of Article IV, Special Regulations, Section 12-B-1, Requirements) of the Zoning Regulations in order to allow for the addition of a second unit to the building and add four (4) parking spaces. To allow a parking space to be 2.4 feet from the dwelling in lieu of the 5.0 feet minimum allowed and to be 0.5 feet from the property line in lieu of the 3.0 feet minimum allowed. Said property is located on the east side of Lawn Avenue in an R-6 zone and is known as 157 Lawn Avenue.

The above mentioned Certificate of Decision may be seen and examined in the office of the Zoning Board of Appeals, Stamford Government Center Building, 888 Washington Boulevard, Stamford.

Dated at the City of Stamford, Connecticut this 29th day of January 2015.

Attest: Mary Judge
Board Administrator

PROBATE NOTICES

NOTICE TO CREDITORS

ESTATE OF Irving Stanislaus Fellner

The Hon. Gerald M. Fox, III, Judge of the Court of Probate, District of Stamford Probate District, by decree dated January 22, 2015, ordered that all claims must be presented to the fiduciary at the address below. Failure to promptly present any such claim may result in the loss of rights to recover on such claim.

Nelly V. Slocum, Clerk

The fiduciary is:

Mr. William S. Fellner
c/o Al P. Trebing, Esq.,
Al P. Trebing & Associates,
161 Cherry Street,
New Canaan, CT 06840

NOTICE TO CREDITORS

ESTATE OF
Rose M. Sienkiewicz

The Hon. Daniel F. Caruso, Acting Judge of the Court of Probate, District of Stamford Probate District, by decree dated January 13, 2015, ordered that all claims must be presented to the fiduciary at the address below. Failure to promptly present any such claim may result in the loss of rights to recover on such claim.

Nelly V. Slocum, Clerk

The fiduciary is:

Geri Fortunato,
65 Glenbrook Road,
Apartment 7D,
Stamford, CT 06902

PROBATE NOTICES

NOTICE TO CREDITORS

ESTATE OF Vincent S. Giovinco

The Hon. Gerald M. Fox, III, Judge of the Court of Probate, District of Stamford Probate District, by decree dated January 16, 2015, ordered that all claims must be presented to the fiduciary at the address below. Failure to promptly present any such claim may result in the loss of rights to recover on such claim.

Nelly V. Slocum, Clerk

The fiduciary is:

Patricia E. Giovinco
c/o William W. Ward, Esq.,
Ackerly & Ward,
1318 Bedford Street,
Stamford, CT 06905

NOTICE TO CREDITORS

ESTATE OF
Willie Jasper Tyson, Jr.

The Hon. Gerald M. Fox, III, Judge, of the Court of Probate, District of Stamford Probate District, by decree dated January 16, 2015, ordered that all claims must be presented to the fiduciary at the address below. Failure to promptly present any such claim may result in the loss of rights to recover on such claim.

Nelly V. Slocum, Clerk

The fiduciary is:

Marvedia Y. Tyson,
24 Adams Avenue, #4,
Stamford, CT 06902-3732

GENERAL HELP WANTED

CNC PROGRAMMER & EXPERIENCED MILL WORKER needed for high end mill work shop in Norwalk. Must be able to read blueprints. Email resume to gsoucy@cranewoodworking.com

DRIVERS Unique opportunity for people out of work! PSL required. Contact Anthony @ **Greenwich Taxi** for more info. 203-360-2351

E1 or E2 ELECTRICIANS
TO JOIN OUR TEAM!
We offer a Company Vehicle, Top Pay, Health Benefits & 401k
Paid Holidays & Vacations!
FULL TIME • Call 203-748-5690

ELECTRICIAN, E-2 - Full Time Permanent opportunity with large Stamford based Co. Must be committed, self-motivated, self-disciplined, 5 plus yrs' experience. Bnft's Inc. Medical/Dental/ 401k. Call 203-327-5907. Or email resume to: **info@camsanino.com**

LANDSCAPE FOREPERSON Supervise crews on various size high end landscape projects. Position requires good communication skills & knowledge of plant ID & Installation, must have valid clean driver's lic. Bilingual speaking a plus. 2-3 yrs experience. Email: cecl@cecibros.com

LANDSCAPE HORTICULTURIST wanted for large landscape contractor firm in Greenwich. Must have 3 yrs minimum exp. with knowledge of pruning, planting of annual flowers & property maintenance skills. Must have valid driver's lic. Email: cecl@cecibros.com

SITUATIONS WANTED

ATTENTION
The advertisers in this classification are providing a service

CAREGIVER for your loved one Local RN available part time, extensive homecare experience. Contact Ginny at 203-257-7018

LOOK

CHRISTIAN Lady looking for work, 3-4 days per week as a housekeeper. Excellent references. Please leave message, 475-282-9265.

CONGENIAL MAN AVAILABLE to be your live in housekeeper, driver & handyman in exchange for room only, no pay. Call 1-203-371-1113

PRIVATE CHEF live-in with 20 years experience, excellent ref., Gustavo 914-565-4875/ gusta@outlook.ie

LOOK

WELL EDUCATED Christian Gentleman looking for position as house man for classy family. Speaks 4 langs, exc refs & exp 646-296-1352

LOST AND FOUND

LOST: Red Glass Jewelry in Navy Blue case, on 12/31/14 at Stop n' Shop, Glenville. Reward. Call 201-953-0451

STAMFORD ANIMAL CONTROL
203-977-4437
FOUND:
IMP #15-192 Stray Dog on Tresser Blvd. male, intact, pitbull, black & white, approx 6 mos. old
FOUND:
IMP #15-193 Stray Dog on Henry St. male, intact, Huskie mix, grey/white/black, approx 1 1/2 yr old

MERCHANDISE FOR SALE

ANTIQUE SPICE JARS (2) By Victoria Checo-Slovakia, Asking $50 Call-203-981-5913

ANTIQUE SIDE DROP TABLE- One Of A Kind, Maple Wood, Serial #, $500 call 203-981-5913

ANTIQUE STAINED GLASS Wall Lamp White Color, Asking $250.00 Call 203-981-5913

ANTIQUE TEA CUP & SAUCER SETS 3, All In Good Condition! Asking $100. 203-981-5913

ANTIQUE TEA CUP & SAUCER SETS 3, All In Good Cond. Asking-$100 203-981-5913

ANTIQUE STAINED GLASS Wall Lamp White Color, Asking $250.00 Call 203-981-5913

Antique Spice Jars By Victoria Checo-Slovakia, (2) Asking $50 Call-203-981-5913

Antique Side Drop Table- One Of A Kind, Maple Wood, Serial #,$500 call 203-981-5913

ARMOIR, ITALIAN, Beige lacquer, like new, $225, 203-253-5716

ARMOIR, SCANDANAVIAN, excellent cond., $225, 203-253-5716

NFL

SUPER BOWL XLIX: PATRIOTS VS. SEAHAWKS, SUN., 6:30 (NBC)

Elise Amendola/Associated Press — Elaine Thompson/Associated Press

Patriots cornerback Darrelle Revis, left, and Seahawks cornerback Richard Sherman are two of the premier players at their position.

Hot corners get covered

By John McClain
HOUSTON CHRONICLE

CHANDLER, Ariz. — The two best cornerbacks in the NFL will be on opposite sidelines in Super Bowl XLIX.

Seattle's Richard Sherman and New England's Darrelle Revis are elite shutdown corners who have played vital roles in helping their teams pull within one victory of winning the league championship.

"They're real good, and they both have their unique style of play," Patriots coach Bill Belichick said. "Good ball skills and concentration. Good ability to defend the primary routes and with good reactive quickness and length and size to handle the routes they're not as heavy on."

Seahawks receiver Doug Baldwin goes against Sherman in practice, and he's studied a lot of film featuring Revis.

"They have different techniques," Baldwin said. "Revis is probably one of the most patient defensive backs I've watched on tape. He's very cerebral. His technique is vastly different from what I've seen from other guys. It presents a challenge.

"Sherman might not be the most patient, but he has length to him, and his competitiveness is unparalleled. Obviously, they're both very good at what they do."

The premier cornerbacks took different routes to get to their current destinations.

Sherman (6-foot-3, 195) grew up in Los Angeles, played at Stanford and lasted until the fifth round of the 2011 draft. Revis (5-11, 198) grew up in eastern Pennsylvania, played at Pitt and was drafted in the first round by the Jets in 2007. New England is his third team. When he left Seattle for Phoenix, Baldwin packed for Revis Island.

"I'm going to bring my sunblock, my shades and my hat," he said. "I'm going to Revis island and see what I can do, and I'll let you know after the game."

Sherman, the largest starting cornerback in the league, is a big talker who never shies away from a camera. He's an impressive self-promoter who backs up what he says with his performance on the field.

"He's got a great mind," Seattle coach Pete Carroll said. "He's got creativity, and he's an extremely savvy player. He can take in all of the elements and the indicators that come up -- from a lineman's stances to quarterback reads to style of play and incorporate that into his decision making. He's an extraordinary decision maker during games.

"His ability to analyze and break down things that are happening are really phenomenal, and that's why he's so unique."

New England quarterback Tom Brady played against Revis two times a season when the corner played for the Jets. They've been teammates for one season.

"He's been a huge asset to our team," Brady said. "He's a great player, a great leader. He set a great example for all the guys about how to practice and how to play.

"He's a great competitor, hates when you complete passes on him. It's been great to see him covering the other teams' best receivers."

Sherman, who stays on the same side of the field, is a noted trash talker who hasn't been afraid to tell Brady what he thinks.

"It's just part of whatever motivates guys," Brady said. "Ultimately, it comes down to how well you play. What I've learned over the years, a lot of guys talk. What you need to do is go out there and play, back it up.

"They've been able to back it up, so that's why it works for them. Hopefully, we can do our talking on the field."

Sherman demonstrated is mental and physical toughness in the victory over Green Bay in the NFC Championship Game. He suffered an injured elbow but refused to leave the game and basically finished with one arm.

"He's a great player (who) makes plays all the time," Revis said.

Asked what impresses him the most about Sherman, Revis said, "Just the ability to shut down your side, whatever side you're on.

"He plays left corner, and he's great at what he does. He's a playmaker, and that's what he does for his team."

Someone asked Revis if he could learn anything from watching film of Sherman, and he said no. Sherman wasn't offended.

"That's fine (because) I don't watch tape of him," Sherman said. "We watch offenses, and he plays defense, so I don't really find myself watching tapes of him."

Sherman and Revis are getting a lot of attention at the Super Bowl because they're recognized as the best at their position, but there's no rivalry between them.

"I think it says something to the level of play we're playing at, and also how fantastic of a season we both must be having if we're bringing that much attention to the game," Sherman said. "It's appreciated.

"Obviously, as elite corners, there's a certain respect level and admiration because you understand what it takes to play this position at a high level and how fragile the praise is.

"You give up one pass for 10 yards, and they say the world's over. You get two interceptions in a game, and they say that's what you're supposed to do. That's just what comes with the territory."

Super Bowl notebook

LYNCH SPEAKS ... SORT OF: Marshawn Lynch changed the script and fired back at his critics.

After two days of giving only scripted answers, the Seahawks' star running back gave his most extensive comments of Super Bowl week, mostly telling reporters why he won't talk to them.

"I don't know what story y'all trying to get out of me. I don't know what image y'all trying to portray of me," Lynch said Thursday. "But it don't matter what y'all think, what y'all say about me because when I go home at night, the same people that I look in the face — my family that I love, that's all that really matter to me. So y'all can go make up whatever y'all want to make up because I don't say enough for y'all to go and put anything out on me."

As he has all week, Lynch stayed five minutes before leaving.

BRADY BETTER: Tom Brady expects his cold to be gone in time for the game.

The Patriots quarterback still sounded congested when he said Thursday, "I expect to be 100 percent on Sunday. I'll be ready to go."

He showed signs of the cold Wednesday after appearing healthy during Super Bowl Media Day Tuesday.

He participated fully in practice on Wednesday and said he felt a lot better Thursday.

REFEREE CLEARED: NFL officiating chief **Dean Blandino** said the inspection of the footballs by referee **Walt Anderson** before the AFC championship game was handled properly.

Blandino said that each team will get 54 footballs Sunday — many are given to charity after brief game usage — and all of them will be taken into custody by the NFL today after the Seahawks and Patriots have prepared them.

The footballs will be inspected by referee **Bill Vinovich** three hours before the game, and Blandino said there will be "added security because of the environment we are in for this game."

— WIRE REPORTS

NFL notebook

LIONS: The team, feeling burned by a non-interference call in a playoff loss to Dallas, already have proposed expanding the use of instant replay for coaches' challenges.

Dean Blandino, the NFL's officiating director, said the competition committee will look into adding to what calls are reviewable, as it does each year.

That committee, which makes recommendations to the 32 owners on rules changes, also will re-examine the "process of the catch" rule that cost the Cowboys' **Dez Bryant** in a postseason loss to Green Bay.

JETS: The team hired **Rex Hogan** as the senior director of college scouting.

Hogan spent the last 12 years in the Bears' scouting department, working as a national scout the last three seasons after serving as a college scout for nine years.

Hogan replaces **Terry Bradway**, who was fired by new general manager **Mike Maccagnan** two weeks ago.

— ASSOCIATED PRESS

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PUBLIC NOTICES

LEGAL NOTICE

REQUEST FOR PROPOSALS

CONNECTICUT DEPARTMENT OF TRANSPORTATION
BUREAU OF PUBLIC TRANSPORTATION

The State of Connecticut, Department of Transportation (Department), Bureau of Public Transportation invites qualified vendors to submit proposals for the following:

RFP# 92-MOW14-001
Facility Management Services at the Component Change Out Building Complex

The Department seeks Proposals from qualified facility management firms to provide comprehensive facility operation and maintenance, 24 hours, 7 days/week, 365 days/year, for the Component Change Out Building Complex in New Haven, Connecticut.

If selected, the vendor must be registered with the Secretary of the State to do business in the State of Connecticut. Please note that a Small Business Enterprise (SBE) sub-contractor goal of Five percent (5%) will be required on this project. The SBE firm(s) must be certified by the State of Connecticut, Department of Administrative Services.

A mandatory pre-bid conference is scheduled for Wednesday, February 11, 2015, 11.00 a.m. at 4 Brewery Street (enter on Long Wharf Street), New Haven, for all prospective proposers. Hard hats, safety vests, and proper footwear are required for all attendees. An entry waiver will be required as well. Please note no ADA accommodations are available at this time.

TO OBTAIN THE RFP PACKAGE, CONTACT:

Mrs. Marlene Cordero
Department of Transportation
Office of Rail
50 Union Avenue,
4th Floor West
New Haven, Connecticut 06519
Tel: 203-497-3371
Marlene.Cordero@ct.gov

DEADLINE FOR SUBMITTAL OF PROPOSALS IS.
Before 2:00 P.M. Thursday, March 19, 2015

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PUBLIC NOTICE

The Stamford Hospital is filing an application for a Certificate of Need under section 19a-638(a)(9) of the Connecticut General Statutes for the acquisition and operation of a Multi-Slice CT Scanner to be located on the main hospital campus located at 30 Shelburne Road, Stamford, CT. The estimated capital expenditure for the project is $1,366,146.

Stamford Public Schools

HEADING: REQUEST FOR PROPOSAL

DATE OF AD: 1-30-15

RFP #: 14-11

TITLE: KITCHEN APPLIANCE REPAIR SERVICE FOR STAMFORD PUBLIC SCHOOLS

Sealed bids will be received and opened at the office of the Purchasing Agent, Stamford Government Center, 888 Washington Boulevard, Stamford, Connecticut. Specifications, instructions and bid forms may be obtained at the Purchasing Department of the Stamford Public Schools at the above address. This bid is subject to Board of Education Policy #3300. The Board of Education reserves the right to reject any and/or all bids.

The Board of Education is an Equal Opportunity Contractor

Specifications may be viewed and/or downloaded at the Stamford Public Schools Website.

www.stamfordpublicschools.org/district/finance/pages/bids-and-rfps

RFP 14-11

DUE DATE: 3-3-15 11:00 A.M.

LEGAL NOTICE
FORECLOSURE AUCTION SALE

Docket No.: FST-CV13-6020385-S
Case Name.
PHH Mortgage Corporation v. Carde, Ricardo et al.

Property Address:
256 Washington Boulevard, Unit 2, Stamford, CT 06902

Property Type. Residential

Date of Sale: February 7, 2015 at 12:00 noon

Committee Name.
Mark A. Sank, Esq.

Committee Phone Number:
203-967-1190

See Foreclosure Sales at www.jud.ct.gov for more detailed information.

LEGAL NOTICE
FORECLOSURE AUCTION SALE

Docket No. FSTCV126016074S
Property Address:
73 Cutler Road,
Greenwich, CT 06831
Property Type: Residential
Date of Sale: February 7, 2015
Committee Name.
Gary R. Khachian
Committee Phone Number.
(203) 899-8914

See Foreclosure Sales at www.jud.ct.gov for more detailed information

FORECLOSURE NOTICE

LEGAL NOTICE
FORCLOSURE AUCTION SALE

Docket No. FST-CV-14-6022647-S
Case Name: M&T Bank vs. Francene Costello Et Al
Property Address.
77 Wascusse Lane,
Stamford, CT 06902
Property Type: Residential
Date of Sale: February 7, 2015
Committee Name. Descera Daigle
Committee Phone Number:
203-899-8906

See Foreclosure Sales at www.jud.ct.gov for more detailed information.

LEGAL NOTICE
FORECLOSURE AUCTION SALE

Docket No. FST CV 13 6019746 S
Case Name
JPMorgan Chase Bank N.A. v. Puengpet Sirisuth, et al
Property Address:
610 Old Stamford Road
New Canaan, CT 06840
Property Type. Residential
Date of Sale: Saturday, February 7.
2015 at 12:00 Noon
Committee Name: Susan Rothenberg
Committee Phone Number.
(203) 967-4749

See Foreclosure Sales at www.jud.ct.gov
For more detailed information

LEGAL NOTICE
FORECLOSURE AUCTION SALE

Docket No..
FST-CV-13--6016612 S
Case Name:CITIBANK, N.A. vs. JIN SOO PARK A/K/A PARK, JIN S. ET AL

Property Address.
131 WEED ST.,
NEW CANAAN, CT 06840

Property Type:
RESIDENTIAL 1-FAMILY HOUSE

Date of Sale. JANUARY 31, 2015

Committee Name:
CHARLES L. SIDDONS

Committee Phone Number
203-653-2772

See Foreclosure Sales at www.jud.ct.gov for more detailed information

FORECLOSURE NOTICE

LEGAL NOTICE FORECLOSURE AUCTION SALE

DOCKET #: FST-CV-12-6012501-S

CASE NAME: DEUTSCHE BANK TRUST COMPANY AMERICAS AS TRUSTEE v. DIEGO CEPEDA, ET AL

PROPERTY ADDRESS.
15 FIELD STREET, STAMFORD CT 06906

PROPERTY TYPE. Residential

DATE OF SALE.
February 07, 2015 at 12 Noon

COMMITTEE NAME: M.L. BLOOMENTHAL, BLOOMENTHAL & TROW, LLC

COMMITTEE
PHONE: 203-316-5444

SEE FORECLOSURE SALES AT www.jud.ct.gov for more detailed information.

LEGAL NOTICE
FORECLOSURE AUCTION SALE

Docket No: FST-CV-14-6022126-S

Case Name. Wells Fargo Bank, N.A. vs. Vincent Perrone Co-Executor of the Estate of George E. Perrone Et Al

Property Address:
2435 Bedford St., Unit 21V, a/k/a Bldg 21, Unit 22,
Stamford, CT 06905

Property type: Condominium

Date of Sale. January 31, 2015, on premises 12.00 noon

Committee
Medico and Associates., LLC

Committee Phone Number.
(203) 661-8151

See foreclosure sales at www.jud.ct.gov for more detailed information.

LEGAL NOTICE
FORECLOSURE AUCTION SALE

Docket No FST-CV-14-6023296-S

Case Name. Federal National Mortgage Association vs. Restrepo, Humberto Et. Al.

Property Address.
180 Turn of River Rd, Unit 14B
Stamford, CT 06905.

Property Type. Residential Condominium Unit

Date of Sale. February 7, 2015 at 12:00 Noon
Inspection. February 7 2015 at 10.00 AM.

Committee Name.
ALBERT J. BARR, Committee

Committee Phone Number
(203) 356-1595

See Foreclosure Sales at www.jud.ct.gov for more detailed information.

LEGAL NOTICE
FORECLOSURE AUCTION SALE

Docket No. FST CV 136018174

Case Name. Retained Realty, Inc. v. Michael S. Smith Executor of the Estate of Alice M. O'Neill AKA Alice O'Neill et al

Property Address:
141 Grove Street, Unit M,
Stamford, CT

Property Type: Condominium
Date of Sale:
February 7, 2015, 12:00 noon

Committee Name:
Marianne J. Charles, Esq.

Committee Phone Number:
(203) 861-6800

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NFL

SUPER BOWL XLIX: PATRIOTS VS. SEAHAWKS, SUN., 6:30 (NBC)

David J. Phillip/Associated Press

Seahawks coach Pete Carroll, left, and Patriots coach Bill Belichick pose with the Vince Lombardi trophy, given to the Super Bowl champion, Friday in Glendale, Ariz.

SEAHAWKS

Belichick praises Carroll

By John McClain
HOUSTON CHRONICLE

CHANDLER, Ariz. — If Seattle defeats New England in Super Bowl XLIX on Sunday, Pete Carroll will become the first coach in football history to win two Super Bowls and two national championships at the collegiate level.

Last year, when the Seahawks won their first Vince Lombardi Trophy, Carroll joined Jimmy Johnson and Barry Switzer as the only coaches to win a national title in college and a Super Bowl.

And yet Carroll — at 63 the NFL's second-oldest coach to the Giants' Tom Coughlin (68) — is never mentioned as one of the greatest coaches of all time and may never be, unlike his New England counterpart, Bill Belichick.

If the Patriots beat the Seahawks, Belichick will win his fourth Super Bowl, tying Chuck Noll for the most in history.

After he arrived at Super Bowl XLIX, Belichick sounded like president of the Pete Carroll fan club.

"There's no way I could, in a brief amount of time, express the amount of admiration and respect that I have for that organization, in particular Pete Carroll," Belichick. "I think that Pete's one of the great coaches in my time.

"We kind of came up together in the same vintage and have similar experiences as coordinators and head coaches at various places along the way.

"I never worked with Pete (but), of course, I followed him into New England, and what he's done at USC and now in his five years with Seattle is beyond impressive."

Seattle is Carroll's third head-coaching job. He was fired after one season as the Jets' head coach in 1994.

He resurfaced in 1997, replacing Bill Parcells at New England. The Patriots made the playoffs the first season, and Carroll was fired by owner Robert Kraft two years later.

Carroll got another head-coaching job in 2001 at USC and led the Trojans to two national championships before bolting for Seattle in 2010. Because of NCAA violations under Carroll, the Trojans were forced to vacate one national title.

"I tried to study him closely and learn from many of the things that he and his organization have done," Belichick said. "I've watched them build that organization very carefully. ...

"They have an outstanding organization. They're very well-coached. They have a lot of great players. They're very disciplined. They're tough. They play very consistently. They're a great fourth-quarter team. To say in short, they do everything well most all of the time."

Perhaps Belichick was trying to kill Carroll with kindness.

When the Patriots win, Belichick and quarterback Tom Brady get most of the credit. When the Seahawks win, it's more about players and strategy, seldom about Carroll doing a great job.

And yet Carroll's imprint is all over Seattle having a chance to be the first team to win back-to-back Super Bowls for the first time since the Patriots 10 years ago in Super Bowl XXIX.

"Always compete," cornerback Richard Sherman said about Carroll's signature line. "That's kind of what we talk about, always competing at the highest level and preparing the right way.

"Also, just enjoying the game. Enjoying the game for what it's worth, and we're just so grateful."

PATRIOTS

Brady Belichick's biggest fan

By John McClain
HOUSTON CHRONICLE

CHANDLER, Ariz. — Bill Belichick's place as one of the greatest coaches in NFL history is secure.

Deflategate and Spygate may tarnish Belichick's legacy in the eyes of many who follow the NFL, but there's no denying that he belongs on that Mount Rushmore of head coaches.

When New England plays Seattle on Sunday, the 62-year-old Belichick will make his sixth Super Bowl appearance as a head coach, tying Don Shula for the league record.

Super Bowl XLIX will be Belichick's ninth appearance as a head coach or assistant coach, two more than Dan Reeves.

Belichick's 21 playoff victories are the most in history. His 12 division titles are the most since 1970.

If the Patriots beat the Seahawks, Belichick and quarterback Tom Brady will win their fourth Super Bowl together and break a two-game losing streak, both against the Giants.

Nobody knows the secret to Belichick's success more than Brady. They've been together since Brady was a sixth-round pick in 2000.

After going 5-11 in Belichick's first season in 2000, the Patriots haven't experienced a losing season since. In his 20 years as a head coach, the last 15 with New England, he's got a record of 211-109.

"He's very consistent with how he deals with us," Brady said. "He has high expectations for our team. He has high expectations in the spring camps, and they travel all the way through the season up to this point.

"He's always coaching. He wants us to be at our very best. It doesn't stop. The meeting rooms are important. The walkthroughs are important. The pressure is always on with him, so that ultimately gets the best out of all of us.

"This team has really risen to the occasion. Whatever challenges he's presented, the guys have always thought never back down to him, always fought through him, and it's part of the reason we're here. Whether it's one win or one loss, you try to make improvements, and you've got to play your best at the end."

Brady, who meets with Belichick once a week to go over the game plan and the opposing defense, made an interesting observation about his coach.

"I don't think there is much that's changed from his personality or his coaching style," Brady said.

Defensive tackle Vince Wilfork disagrees. Wilfork, an 11-year veteran, and Brady are the only players on the team who played in Super Bowl XXIX, the Patriots' last victory after the 2004 season.

"I've seen the difference in Bill in the 11 years I've been here, and I tell him he's getting soft," Wilfork said. "Over the years, he got a soft heart. He's more understanding now.

"When you get so used to having a certain quality of players and it changes, I think it's hard for you to adapt to change. I think he had to try to find the identity in what works for that team. He's done a great job over the years of doing that.

"At the end of the day, though, he's still Bill. He coaches the same way. He demands everything the same way. But I think he's got a little soft heart now."

Despite Deflategate hovering over him — a subject Belichick wisely has refused to address this week — he's seemed calm and confident as usual. He also has shown a sense of humor.

Belichick was asked about he and Pete Carroll presenting the first Super Bowl matchup of Croatian head coaches.

"The last big Croatian matchup I had was with coach (Nick) Saban when he was with the Dolphins, and that was within the division," he said. "We kind of had the battle of Croatia.

"(I'm) very proud of my dad's family tradition and history with Croatians.

(I) had the opportunity to visit the beautiful country a couple of times, and I'm proud of that heritage."

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PUBLIC NOTICES

NOTICE OF ANNUAL MEETING OF DISTRICT VOTERS OF THE HARBOR POINT INFRASTRUCTURE IMPROVEMENT DISTRICT

Notice from the President of the Harbor Point Infrastructure Improvement District:

The Annual Meeting of the voters of the Harbor Point Infrastructre Improvement District (the "District") will be held at 2200 Atlantic Street, Suite 600, Stamford, CT 06902, on Wednesday, February 18, 2015, at 5:00 p.m. to transact the following business.

1. Call to Order.
2. To elect the directors and officers of the Harbor Point Infrastructure Improvement District for 2015-2016
3. Adjournment

The voter eligibility requirements for such Annual Meeting are described in Special Act No. 07-6 of the Connecticut General Assembly, as amended. Copies of the Special Act, as amended, are available for inspection at the offices of the District located at 2200 Atlantic Street, Suite 600, Stamford, CT 06902.

Respectfully Submitted,
Paul Kuehner, President

PUBLIC NOTICE

The Stamford Hospital is filing an application for a Certificate of Need under section 19a-638(a)(9) of the Connecticut General Statutes for the acquisition and operation of a Multi-Slice CT Scanner to be located on the main hospital campus located at 30 Shelburne Road, Stamford, CT. The estimated capital expenditure for the project is $1,366,146.

NOTICE OF PUBLIC SALE:

The following self-storage Cube contents containing household and other goods will be sold for cash by CubeSmart 82 Fair St, Norwalk CT 06851 to satisfy a lien on 02/10/2015 at approx. 1:00PM at www.storagetreasures.com

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I LOVE LUCY Collectors Edition VHS. 15 VHS, each has 3 episodes. $40 for all. 203-661-4462

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IPhone 6 Clearview case & tech Armour-Brand New In Pkg. $25.00 Call 203-981-5913

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The ADVOCATE

TOUCHPOINT INTEGRATED COMMUNICATIONS
16 THORNDAL CIRCLE
DARIEN CT 06820

THE ADVOCATE
9 Riverbend Drive South
Building 9A
P.O. Box 4910
Stamford, CT 06907-0910
Telephone: 203-330-6208
Fax: 203-384-1158
Legal.notices@scni.com

PUBLIC NOTICE

The Stamford Hospital is filing an application for a Certificate of Need under section 19a-638(a)(9) of the Connecticut General Statutes for the acquisition and operation of a Multi-Slice CT Scanner to be located on the main hospital campus located at 30 Shelburne Road, Stamford, CT. The estimated capital expenditure for the project is $1,366,146.

THE ADVOCATE
CERTIFICATE OF PUBLICATION

I, Sa'Ran Hussey
Being duly sworn, depose and say that I am a Representative in the employ of SOUTHERN CONNECTICUT NEWSPAPERS, INC., Publisher of *The Advocate* and *Greenwich Time*, that a LEGAL NOTICE as stated below was published in THE ADVOCATE.

Subscribed and sworn to before me on this 10th Day of March, A.D. 2015.

Pamela E. Caluori
Pamela Caluori/Notary Public

My commission expires on January 2018

PO Number

Publication

Stamford Advocate

Ad Number	Ad Caption
0002053844-01	PUBLIC NOTICE The Stamfor

Publication Schedule

1/29/2015, 1/30/2015, 1/31/2015

AFFIDAVIT

Applicant: The Stamford Hospital

Project Title: Acquisition and Operation of a 320 Slice CT Scanner at The Stamford Hospital, 30 Shelburne Road, Stamford, Connecticut.

I, Brian G. Grissler (Individual's Name), President (Position Title – CEO or CFO)

of The Stamford Hospital (Hospital or Facility Name) being duly sworn, depose and state that

The Stamford Hospital's (Hospital or Facility Name) information submitted in this Certificate of Need Application is accurate and correct to the best of my knowledge.

Signature

Date 4/7/15

Subscribed and sworn to before me on April 7, 2015

Notary Public/Commissioner of Superior Court

LYNNE MACGREGOR
NOTARY PUBLIC
MY COMMISSION EXPIRES JULY 31, 2015

My commission expires:

State of Connecticut
Office of Health Care Access
Certificate of Need Application

Instructions: Please complete all sections of the Certificate of Need ("CON") application. If any section or question is not relevant to your project, a response of "Not Applicable" may be deemed an acceptable answer. If there is more than one applicant, identify the name and all contact information for each applicant. OHCA will assign a Docket Number to the CON application once the application is received by OHCA.

Docket Number:	
Applicant:	The Stamford Hospital
Contact Person:	David L. Smith
Contact Person's Title:	Senior Vice President, Strategy Chief Strategy and Market Development Officer
Contact Person's Address:	30 Shelburne Road Stamford, CT 06907
Contact Person's Phone Number:	203-276-7510
Contact Person's Fax Number:	203-276-5529
Contact Person's Email Address:	DSmith@stamhealth.org
Project Town:	Stamford
Project Name:	Acquisition and Operation of a 320-Slice CT Scanner at The Stamford Hospital, 30 Shelburne Road, Stamford, CT.
Statute Reference:	C.G.S. Section 19a-638 (a) (8)
Estimated Total Capital Expenditure:	$1,366,146

1. Project Description: Acquisition of Equipment

a. Please provide a narrative detailing the proposal.

The Stamford Hospital ("**Stamford Hospital**") is a 305-bed acute care hospital located at 30 Shelburne Road in Stamford, Connecticut. Stamford Hospital proposes to acquire and operate a new 320-slice Computed Tomography scanner ("**CT**") to be located in the new Emergency Department ("**ED**") at Stamford Hospital scheduled to open in the summer of 2016. Locating a CT directly within the new ED comports with the goals of national trauma and emergency care protocols that focus on improving patient flow throughout the treatment area, decreasing patient wait times, and enhancing overall quality of care.

On February 9, 2010, Stamford Hospital received approval from the Office of Health Care Access ("**OHCA**") to proceed with its Master Facility Plan ("**MFP**") under OHCA Docket Number: 08-31284-CON. In addition to approving the construction of a new central utility plant, the MFP CON approved the construction of one public concourse, one service corridor and one utility tunnel to connect the new main hospital building (the **"Specialty Building"**) with the existing main campus buildings. The new Specialty Building will, among other things, house the modernized ED, a replacement surgical suite with 12 operating rooms, a Heart and Vascular Institute with four invasive labs and a five-floor bed tower that will contain 180 replacement beds.[1]

In its February 9, 2010 CON ruling, however, OHCA denied one piece of Stamford Hospital's original application for the MFP. This aspect of the MFP would have allowed the Hospital to acquire and operate a new CT within the prospective ED – concluding that "it would be prudent for the Applicant to revisit the necessity of adding a third CT scanner closer to the opening of the Hospital's new Emergency Department." With construction of the Specialty Building now well underway with a projected completion/occupancy date of summer/fall 2016, Stamford Hospital is now in a position to submit this CON application for the new CT.

Currently, patients who present to the existing ED that require a CT scan are transported to Stamford Hospital's Radiology Department and the procedures are completed on one of the two 64-slice CT scanners in operation in the main building of Stamford Hospital. Stamford Hospital's Bennett Cancer Center (the "**Bennett Cancer Center**") operates a third CT simulator solely dedicated to treatment planning for its cancer patients.

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[1] The CON issued under Docket No. 08-312284-CON approved the MFP except for the capital expenditures that were connected with intervals two and three of what was expected to be a phased, 15-year construction project. Accordingly, Condition #4 to OHCA's Order to the MFP CON Final Decision that was added at Stamford Hospital's request under Docket No. 10-312284-RCN provided that Applicant would "request such approvals as necessary to comply with the requirements of any Certificate of Need modification process that is in effect at the time unless there is a change in Certificate of Need law that would render such approvals unnecessary." Those approvals became unnecessary when Public Act No. 10-179 amended the CON laws to no longer require approval for capital expenditure amounts. In addition on March 28, 2012, Stamford Hospital's Board voted to construct the entire MFP project at once, thereby dispensing with the earlier plan to undertake a phased construction of the Specialty Building.

Stamford Health also possesses two offsite CT scanners; one at its Tully Health Center and the other at its Darien Imaging Center. None of the existing CTs will be readily accessible to address patient needs in the new ED.

Within the existing hospital, the distance from the current ED to the CTs in the Radiology Department is 250 feet. The Radiology Department and the existing ED are also on the same level of Stamford Hospital. Currently, the time to travel from the ED to the Radiology Department with a transporter pushing a single patient is approximately 3 to 5 minutes depending on the transporter and the patient. A patient that may have ancillary equipment such as IV poles, ventilator equipment and additional accompanying staff could require an additional 1 to 2 minutes to transport over this short distance.

The ED that is being constructed in the Specialty Building will be much farther from the existing Radiology Department. To travel from the new ED to the Radiology Department will require patients to be transported down to the basement level by elevator, then through a 363-foot long tunnel, and then back up a separate elevator to get to the Radiology Department. While there will be a trauma elevator designated in the new hospital building, the elevators in the existing hospital will also be utilized by the Facilities, Materials, Environmental Services, Food Services and Transportation departments which will further make wait for an elevator highly variable. Consequently, the time to transport patients to Radiology from the new ED could easily take in excess of 10 minutes. By placing a CT scanner in the ED, the Hospital will eliminate the need for this transport and reduce delays in care for its most critical patients – particularly those patients suffering from stroke or trauma.

b. Provide letters that have been received in support of the proposal.

Please see *Exhibit A* for letters received in support of the proposal.

c. Provide the Manufacturer, Model, Number of slices/tesla strength of the proposed scanner (as appropriate to each piece of equipment).

The proposed scanner is a Toshiba Aquilion ONE 320 Series CT System. It has a strength of 320 slices.

d. List each of the Applicant's sites and the imaging modalities and other services currently offered by location.

Please refer to the table below

Modalities	Stamford Hospital	Tully Health Center	Darien Imaging Center	Chelsea Piers	Mill River (Office of The Heart Physicians)	Tully Urgent Care
Diagnostic Radiology	X	X	X	X		X

Modalities	Stamford Hospital	Tully Health Center	Darien Imaging Center	Chelsea Piers	Mill River (Office of The Heart Physicians)	Tully Urgent Care
CT Scan	X	X	X			
MRI	X	X	X			
PET		X (mobile)				
Ultrasound	X	X	X			
Mammography	X	X	X			
Nuclear Medicine	X	X			X	
Interventional Radiology	X					
Bone Density		X	X			
Lab	X	X				X
Inpatient	X					
Outpatient	X	X	X	X	X	
Emergency / Urgent Care	X	X				X
Cardiac Stress Testing	X	X			X	

2. Clear Public Need

a. Explain why there is a clear public need for the proposed equipment. Provide evidence that demonstrates this need.

Stamford Hospital is designated by the Connecticut Department of Public Health, and the Joint Commission as a Primary Stroke Center, and has been designated by the American College of Surgeons as a Level II Trauma Center since 1993. A dedicated CT for the new ED will prevent the time-wasting and potentially dangerous transfer of critically ill patients to the Radiology Department. The added CT within the new ED will also ensure efficient workflow and will prevent delays and inconvenience to non-emergency patients who have scans scheduled in the Radiology Department. Further, the 320-slice CT scanner will provide high-resolution images in less time, which will allow for faster and better diagnoses with less radiation.

Based on the principle of the "golden hour in shock," primary diagnostic procedures for trauma patients must be highly effective and focused. The primary clinical and radiological survey should be completed within thirty minutes after admission of the patient in the emergency room.[2] A delay in proper surgical care is a major cause for

[2] Hessmann, M.H., Hofmann, A., Kreitner, K.F., Lott, C. and Rommens, P.M., *The Benefit of Multislice CT in the Emergency Room Management of Polytraumatized Patients*. Acta Chirurgica Belgica, 106, 500-507 (2006).

preventable deaths in trauma care, and the earliest possible identification of potential lethal injuries is mandatory.[3]

Advances in imaging have led to computed tomography scanning playing a central diagnostic role for trauma patients. CT is fast, accurate and cost effective in providing clinically useful information in a single examination.[4] CT contributes significantly to reduce the time requirements for initial diagnostic evaluation due to an increased speed of image acquisition. Such whole-body CT scanning can rapidly reveal all relevant injuries resulting in an immediate treatment plan. CT is currently the diagnostic of choice for traumatic brain injury patients as it allows the exact assessment of the entire brain and the skull, as well as for thoracic, abdominal and spinal injuries.[5]

Numerous medical studies have shown that CT scanning in the emergency department significantly quickens the pace of treatment and cuts mortality rates. In one study, the time to move patients with major trauma from the resuscitation area to definitive treatment was 47 minutes for patients getting a multi-slice CT scan versus 82 minutes using conventional protocols.[6] Another study found that by integrating a CT into the trauma room the time required for CT examination was reduced from 87 to 38 minutes and the mortality rate decreased from almost 15% to 8.6%.[7] A third study found that multi-slice protocol patients had significantly shorter ER, ER-OR and ER-ICU times. The study concluded that immediate CT scans for patients with blunt major trauma leads to more accurate and faster diagnosis, and reduction in ER, ER-OR and ER-ICU times. The study also observed reduction in ventilation, ICU and hospital days and in organ failure rates.[8]

Time is especially of the essence for stroke patients who present to the ED. The overriding objective of emergency evaluation of the stroke patient is to determine whether the cause of the stroke is an ischemic infarction (ICH) or a nonvascular lesion. The most commonly obtained study remains an immediate unenhanced (noncontrast) head CT scan. The American Heart Association and American Stroke Association state that essential best practice is to initiate a CT scan within 25 minutes of arrival and to

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[3] Wurmb TE, Quaisser C, Balling H, Kredel M, Muellenbach R, Kenn W, Roewer N, Brederlau J. *Whole-Body Multislice Computed Tomography (MSCT) Improves Trauma Care In Patients Requiring Surgery After Multiple Trauma*, Emerg Med J. 2011; 28:300–304. doi: 10.1136/emj.2009.082164.

[4] Lee KL, Graham CA, Lam JM, Yeung JH, Ahuja AT, Rainer TH, *Impact on Trauma Patient Management of Installing a Computed Tomography Scanner in the Emergency Department.* Injury. 2009; 8:873–875. doi: 10.1016/j.injury.2008.12.001.

[5] Wurmb TE, Kenn W., *The Role of Early Multislice Computed Tomography in Major Trauma.* Trauma 2012; 14(4):301–12.

[6] Wurmb TE, Frühwald P, Hopfner W, Keil T, Kredel M, Brederlau J, et al., *Whole-Body Multislice Computed Tomography as the First Line Diagnostic Tool in Patients with Multiple Injuries: The Focus on Time.*, J Trauma. 2009; 66:658–665

[7] Hilbert P, zur Nieden K, Hofmann GO, Hoeller I, Koch R, Stuttmann R., *New Aspects In The Emergency Room Management of Critically Injured Patients: A Multi-Slice CT-Oriented Care Algorithm.* Injury. 2007;17:552–558. doi: 10.1016/j.injury.2006.12.023.

[8] Weninger P, Mauritz W, Fridrich P, Spitaler R, Figl M, Kern B, Hertz H., *Emergency Room Management of Patients With Blunt Major Trauma: Evaluation of The Multislice Computed Tomography Protocol Exemplified by an Urban Trauma Center*, J Trauma. 2007; 62:584–591. doi: 10.1097/01.ta.0000221797.46249.ee.

complete interpretation of the scan within 45 minutes of arrival to exclude intracranial hemorrhage prior to administration of intravenous recombinant tissue plasminogen activator.[9]

As noted in Response 1A above, the MFP includes the relocation of Stamford Hospital's ED into the new Specialty Building. With the proposed CT in the new ED, the transport time for ED patients will be negligible. In the absence of the proposed CT in the ED, ED patients would be required to travel to the current Radiology Department to use one of Stamford Hospital's existing CT scanners. The Hospital projects that this journey would take at least 8 to 10 minutes, and would further be hindered by the need to use two different elevators (one of which would not be dedicated to trauma) to transport patients through the service concourse at the basement level. Emergency patients with multiple traumas are notably difficult to transport.[10] The installation of the proposed CT in the new ED is necessary to ensure that Stamford Hospital's emergency patients are quickly diagnosed and receive a satisfactory standard of care upon the relocation of the ED.

Stamford Hospital's designation as a Level II Trauma Center requires continued verification from the American College of Surgeons (ACS). During the Hospital's last re-verification review from the ACS, the only comment for needs for improvement was to have the CT scanner located closer to the ED. The ACS was satisfied with the Hospital's response that there will be a dedicated CT scanner in the new hospital; however - if the Hospital did not have a CT scanner in the new ED, it would likely receive a citation from the ACS and lose its designation as a Level II Trauma Center.

Placing a dedicated CT scanner within Stamford Hospital's new ED is further supported by existing and projected scan volumes. The existing CTs in the Radiology Department performed 31,353 and 31,553 scans in the 2012 and 2013 fiscal years, respectively. In the most recently completed 2014 fiscal year, the Radiology Department completed 30,270 CT scans. Stamford Hospital's ED receives approximately 50,000 visits each year, and ED patients account for nearly half of all CT scan volumes at the Hospital – or 15,000 scans/year. The current draft OHCA regulations recommend a capacity of 10,000 for a hospital-based CT. Stamford Hospital projects that total CT scan volume will slowly tick up from roughly 30,000 to 32,000 scans from fiscal years 2016 to 2019. Stamford Hospital's current volume of scans fully supports the need for a third CT. Even based on the current OHCA Facilities Plan recommended capacity of 12,000/scanner, the volume for Stamford Hospital's two existing CTs is significantly over that threshold.

Currently, as noted in the endorsement letter of Michael H. King, MD, Interim Chairman of Stamford Hospital's Department of Radiology, numerous outpatient patients are forced

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[9] Summers D, Leonard A, Wentworth D, et al., *American Heart Association Council On Cardiovascular Nursing and the Stroke Council: Comprehensive Overview of Nursing And Interdisciplinary Care of the Acute Ischemic Stroke Patient: A Scientific Statement from the American Heart Association.* Stroke. 2009; 40:2911–2944.
American Association of Neuroscience Nurses. Guide to the Care of the Hospitalized Patient with Ischemic Stroke. 2nd ed. Glenview (IL): American Association of Neuroscience Nurses; 2008.

[10] Gralla J, Spycher F, Pignolet C, Ozdoba C, Vock P, Hoppe H., *Evaluation of a 16-MDCT Scanner in an Emergency Department: Initial Clinical Experience and Workflow Analysis.* AJR. 2005;185:232–238.

to reschedule scans due to emergency patients who require scans. The additional CT will alleviate many of those conflicts. The additional CT will also provide Stamford Hospital more assurance that it will be able to provide timely services in the event that a CT is offline due to malfunction or maintenance.

It should be noted that the CT simulator located in the Bennett Cancer Center installed in 2014 is paired with Stamford Hospital's linear accelerator and is dedicated solely to radiation therapy treatment planning. Scans performed on that machine were not included in the totals above. The CT in the Bennett Cancer Center is specially equipped with localization and planning software that enables the radiation therapy team to accurately set up and mark the patient for treatment. The scanner is not utilized as a diagnostic CT scanner. Although it has been online for less than a year, the CT simulator is expected to perform approximately 200 to 250 scans/year. By being located in the Bennett Cancer Center, Stamford Hospital's radiation oncologists and other members of the treatment team are able to be onsite, conduct real-time analysis of the scans, and perform additional scans immediately to determine if adjustment is required. This on-site capability at the Bennett Cancer Center increases quality of care and convenience for a fragile patient population. Such on-site CTs have increasingly become part of the standard of care for cancer centers, such as Bennett. Because of its limited use, the CT simulator is not accredited by one of the CMS-approved national accreditation bodies for the provision of diagnostic CT images (in the case of the two Radiology based units – they are accredited by the American College of Radiology). Moreover, even if the CT in the Bennett Cancer Center was accredited and its functionality not dedicated to cancer treatment planning, its location would not be conducive to treating patients presenting in the new ED.

The particular 320-slice model proposed by Stamford Hospital is state of the art technology that provides clear images and significantly reduces the radiation to which the patient is exposed. In one study, the effective radiation dose from a scan conducted on a 320-slice CT was reduced by 91% compared to a 64-slice machine.[11] Another study found a 33-46% reduction in radiation dose without any noticeable effect on image quality.[12] A third study, found a similar 34% reduction in radiation dose for the vast majority of patients and a significant improvement in image quality.[13]

b. Provide the utilization of existing health care facilities and health care services in the Applicant's service area.

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[11] Einstein AJ, Elliston CD, Arai AE, Chen MY, Mather R, Pearson GD, et al., *Radiation Dose from Single-Heartbeat Coronary CT Angiography Performed with a 320-Detector Row Volume Scanner.* Radiology. 2010; 254:698–706.

[12] Khosa F, Khan A, Nasir K, Shuaib W, Budoff M, Blankstein R, Clouse M., *Influence of Image Acquisition on Radiation Dose and Image Quality: Full versus Narrow Phase Window Acquisition Using 320 MDCT,* ScientificWorldJournal. 2013; 2013: 731590.

[13] Khan A, Khosa F, Nasir K, Yassin A, Clouse ME, *Comparison of Radiation Dose and Image Quality: 320-MDCT Versus 64-MDCT Coronary Angiography.* AJR Am J Roentgenol. 2011;197:163–8.

Provider Name Street Address Town, Zip Code	Description of Services	Hours/Days of Operation	Utilization
Advanced Radiology Consultants 1315 Washington Blvd. Stamford, CT 06902	Toshiba Aquilion 8 Slice CT Scanner	Monday – Friday 8:30 am – 5:00 pm	CY2013: 1168
Greenwich Hospital 5 Perryridge Road Greenwich, CT 06830	General Electric 64 Slice CT Scanner	Monday – Sunday 24 Hours / 365 days	CY2013: 7602
Greenwich Hospital 5 Perryridge Road Greenwich, CT 06830	General Electric VCT 32 Slice Scanner (in ED)	Monday – Sunday 24 Hours / 365 days	CY2013: 11403
Greenwich Hospital 2015 West Main St. Stamford, CT 06902	General Electric Lightspeed 8 Slice CT Scanner	Monday – Friday 7:15 am – 5:00 pm	CY2013: 621
Greenwich Radiological Group, PC 49 Lake Avenue Greenwich, CT 06830	Toshiba Aquilion 32 Slice CT Scanner	Monday – Friday 8:30 am – 5:30 pm	CY2013: 1695
Norwalk Hospital 34 Maple St Norwalk, CT 06850	General Electric Lightspeed 16 Slice CT Scanner	Monday – Sunday 24 Hours / 365 days	CY2013: 9351
Norwalk Radiology and Mammography Center 148 East Avenue Norwalk, CT 06851	General Electric Lightspeed 16 Slice CT Scanner	Monday-Friday: 7:15am-4:30pm Saturday: 7:30am-11:45am	CY2013: 6752
Norwalk Radiology and Mammography Center 148 East Avenue Norwalk, CT 06851	General Electric Goldseal VCT 64 Slice CT Scanner	Monday-Friday: 7:15am-4:30pm Saturday: 7:30am-11:45am	*Included in number above*

c. Complete Table 1 for each piece of equipment of the type proposed currently operated by the Applicant at each of the Applicant's sites.

Table 1: Existing Equipment Operated by the Applicant

Provider Name Street Address Town, Zip Code	Description of Service *	Hours/Days of Operation **	Utilization ***
Stamford Hospital 30 Shelburne Road, Stamford, CT 06902	Toshiba Aquilion 64 Slice CT Scanner	Monday – Sunday 24 Hours / 365 days	FY2014: 30,270
Stamford Hospital 30 Shelburne Road, Stamford, CT 06902	Toshiba Aquilion 64 Slice CT Scanner	Monday – Sunday 24 Hours / 365 days	*Included in number above*
Stamford Hospital 30 Shelburne Road, Stamford, CT 06902	Toshiba 16 Slice CT Simulator	Monday – Friday 8:00 am – 4:00 pm	8 months (May 2014 – December 2014):

			232
Darien Imaging Center 6 Thorndal Circle, Darien, CT 06820	General Electric 8 Slice CT Scanner	Monday – Friday 8 am – 4 pm	FY2014: 1531
Tully Health Center 32 Strawberry Hill Court, Stamford, CT 06905	Toshiba Aquilion 16 Slice CT Scanner	Monday – Friday 8 am – 4 pm	FY2014: 5021

* Include equipment strength (e.g. slices, tesla strength), whether the unit is open or closed (for MRI)
** Days of the week unit is operational, and start and end time for each day; and
*** Number of scans/exams performed on each unit for the most recent 12-month period (identify period).

d. Provide the following regarding the proposal's location:

i. **The rationale for locating the proposed equipment at the proposed site;**

The proposed CT will be located within the new ED at Stamford Hospital in space that was originally contemplated for the CT in the overall plans for the MFP. The proposed CT will be used primarily for ED patients and will support the projected volume increases expected in the ED as CT services are increasingly relied upon as the standard of care for the ED population.

ii. **The population to be served, including specific evidence such as incidence, prevalence, or other demographic data that demonstrates need;**

The proposed CT is expected to serve patients who present at the ED from Stamford Hospital's Primary and Secondary Service Areas which include the following towns:

Primary Service Area: Stamford, Darien, Rowayton

Secondary Service Area: Norwalk, Greenwich, Riverside, Old Greenwich, Cos Cob, Georgetown, New Canaan, Westport, Wilton, Weston

Stamford Hospital currently receives approximately 50,000 visits to its ED each year. Of those visits, approximately 30% result in CT scans or 15,000 scans/year.

iii. **How and where the proposed patient population is currently being served;**

The proposed patient population is currently being served by Stamford Hospital and accommodated within the hospital's existing Radiology Department.

iv. **All existing providers (name, address) of the proposed service in the towns listed above and in nearby towns;**

The providers of CT services in the proposed service area and towns, in addition to Stamford Hospital, are the following:

Advanced Radiology Consultants
1315 Washington Blvd.
Stamford, CT 06902

Greenwich Hospital
5 Perryridge Road
Greenwich, CT 06830

Norwalk Hospital
34 Maple St
Norwalk, CT 06850

Norwalk Radiology and Mammography Center
148 East Avenue
Norwalk, CT 06851

v. **The effect of the proposal on existing providers; and**

The proposal is not anticipated to have any effect on the CT services offered by or the volume of the existing providers listed above. The proposed additional CT is intended to be dedicated for use by ED patients who present at Stamford Hospital and should not impact volumes of CT services currently provided at other provider sites.

vi. **If the proposal involves a new site of service, identify the service area towns and the basis for their selection.**

Not applicable.

e. Explain why the proposal will not result in an unnecessary duplication of existing or approved health care services.

The proposal will not result in an unnecessary duplication of existing or approved health care services, because although it will be the third diagnostic CT at Stamford Hospital, it is needed to allow for timely CT services for the Hospital's ED – with particular emphasis on stroke and trauma patients.

In addition, Stamford Hospital's two existing scanners for diagnostic use are operating at over 151% capacity based on the current draft OHCA regulations that recommend a capacity of 10,000 for a hospital-based CT scanner.

3. Actual and Projected Volume

a. Complete the following tables for the past three fiscal years ("FY"), current fiscal year ("CFY"), and first three projected FYs of the proposal, for each of

the Applicant's existing and proposed pieces of equipment (of the type proposed, at the proposed location only). In Table 2a, report the units of service by piece of equipment, and in Table 2b, report the units of service by type of exam (e.g. if specializing in orthopedic, neurosurgery, or if there are scans that can be performed on the proposed scanner that the Applicant is unable to perform on its existing scanners).

Table 2a: Historical, Current, and Projected Volume, by Equipment Unit

		Actual Volume			CFY Volume	Projected Volume		
		(Last 3 Completed FYs)**				(First 3 Full Operational FYs)		
		FY 2012	FY 2013	FY 2014	FY 2015 – YTD FEB	FY 2017	FY 2018	FY 2019
CT - Scanner 1 - 64 Slice CT and CT -Scanner 2 - 64 Slice CT (Radiology Dept.)*	Inpatient	9,853	9,414	9,099	3,905	9,399	9,399	9,399
	Outpatient	7,686	6,731	6,111	2,701	6,485	6,615	6,747
	ED***	13,814	15,408	15,060	6,478	n/a	n/a	n/a
CT - Scanner 3 – 320 slice (Emergency Dept.)	ED	n/a	n/a	n/a	n/a	15,467	15,467	15,467
Total		**31,353**	**31,553**	**30,270**	**13,084**	**31,351**	**31,481**	**31,613**

* Note - Volume between the two scanners in Radiology Department cannot be broken out by unit

** Stamford Hospital's Fiscal Year is October 1 - September 30

*** These are scans performed on ED patients on the 64-slice CTs in the Radiology Dept.

Table 2b: Historical, Current, and Projected Volume, by Type of Scan/Exam

	Actual Volume			CFY Volume *	Projected Volume		
	(Last 3 Completed FYs)**				(First 3 Full Operational FYs)**		
	FY 2012	FY 2013	FY 2014	FY 2015 – YTD FEB	FY 2017	FY 2018	FY 2019
CT - Head	8,156	8,016	7,916	3,325	8,199	8,233	8,267
CT - Abdomen	436	410	414	180	429	431	432
CT - Chest	3,936	4,146	4,166	1,881	4,315	4,333	4,351
CT - Pelvis	240	217	219	104	227	228	229
CT - Cervical	2,216	2,216	2,191	1,157	2,269	2,279	2,288
CT - Abdomen and Pelvis	14,808	14,944	13,836	5,824	14,330	14,389	14,450
CT - Other	1,561	1,604	1,528	613	1,583	1,589	1,596
Total	**31,353**	**31,553**	**30,270**	**13,084**	**31,351**	**31,481**	**31,613**

b. Provide a breakdown, by town, of the volumes provided in Table 2a for the most recently completed full FY.

Volume by Patient Origin (PSA and SSA towns)	FY14
Stamford	22,390
Darien	1,391
Rowayton	19
Norwalk	1,119
Greenwich	1,275
New Canaan	561
Wilton	129
Westport	108
Weston	28
OTHER	3,250
Total	**30,270**

c. Describe existing referral patterns in the area to be served by the proposal.

The vast majority of Emergency Department patients are brought by emergency medical personnel or come directly to the Stamford Hospital ED, and are not referred through physician referral.

d. Explain how the existing referral patterns will be affected by the proposal.

Given that patients are generally not referred to the ED, it is not expected that the existing referral patterns will be affected by the proposal.

e. Explain any increases and/or decreases in volume seen in the tables above.

Inpatient Admissions are projected to increase by 3.3% in Year 1 of operation of the new Specialty Building – and the same increase has been applied to incremental Inpatient CT scans which would be performed on one of the two units based in the Radiology Department. Incremental inpatient admission projections are driven by the attractiveness of the new facility to patients and physicians, the addition of new surgical specialists to Stamford Health's employed physician network, and incremental visits to the ED which result in an inpatient admission. In an effort to be conservative, inpatient admissions are projected to flatten out after year 1.

Outpatient growth is projected at 2% annually – consistent with projections from Sg2 - an external market analytics vendor Stamford Hospital uses for such projections. This growth is to be further supported by the construction of the new Medical Office Building (Integrated Care Pavilion) on Stamford Hospital's campus which will bring additional specialists to the hospital campus who will be able to order outpatient CT scans and refer their patients to the Radiology Department.

Emergency Department volumes are projected to grow from 50,476 in FY16 to 51,200 in years FY17 and beyond; these projections are in accordance with the projections which were filed and reviewed when the Master Facility Plan was approved by OHCA previously. As a result of growing ED visits, CT scans for ED patients were projected using the hospital's prior experience which demonstrates a ratio of 30.2% of CT Scans to ED volumes.

f. Provide a detailed explanation of all assumptions used in the derivation/ calculation of the projected volume by scanner and scan type.

Please see response 3(e) above.

g. Provide a copy of any articles, studies, or reports that support the need to acquire the proposed scanner, along with a brief explanation regarding the relevance of the selected articles.

Please see *Exhibit B* for numerous articles that support the need to acquire the CT to be located in the new ED at Stamford Hospital. Most of these articles have been cited in the Response to 2(a).

4. Quality Measures

a. Submit a list of all key professional, administrative, clinical, and direct service personnel related to the proposal. Attach a copy of their Curriculum Vitae.

Please see *Exhibit C*.

b. Explain how the proposal contributes to the quality of health care delivery in the region.

The ED at Stamford Hospital serves an important public need in stabilizing and diagnosing patients with emergency medical conditions, such as poly-trauma and stroke patients. Stamford Hospital is designated by the Connecticut Department of Public Health, and the Joint Commission as a Primary Stroke Center, and has been designated by the American College of Surgeons as a Level II Trauma Center since 1993. The proposed CT for the new ED will prevent the time-wasting and potentially dangerous transfer of critically ill patients to the Radiology Department. The added CT within the new ED will also ensure efficient workflow and will prevent delays and inconvenience to non-emergency patients who have scans scheduled in the Radiology Department. Further, the 320-slice CT scanner will provide high-resolution images in less time, which will allow for faster and better diagnoses with less radiation.

5. Organizational and Financial Information

a. Identify the Applicant's ownership type(s) (e.g. Corporation, PC, LLC, etc.).

Connecticut non-stock corporation.

b. Does the Applicant have non-profit status?
☒ Yes (Provide documentation) ☐ No

Please see *Exhibit D* for documentation.

c. Provide a copy of the State of Connecticut, Department of Public Health license(s) currently held by the Applicant and indicate any additional licensure categories being sought in relation to the proposal.

Please see *Exhibit E* for a copy of the Hospital's license.

d. Financial Statements

i. **<u>If the Applicant is a Connecticut hospital:</u> Pursuant to Section 19a-644, C.G.S., each hospital licensed by the Department of Public Health is required to file with OHCA copies of the hospital's audited financial statements. If the hospital has filed its most recently completed fiscal year audited financial statements, the hospital may reference that filing for this proposal.**

Stamford Hospital's most recent audited financial statements (FY 2013) are on file with OHCA.

ii. **<u>If the Applicant is not a Connecticut hospital (other health care facilities):</u> Audited financial statements for the most recently completed fiscal year. If audited financial statements do not exist, in lieu of audited financial statements, provide other financial documentation (e.g. unaudited balance sheet, statement of operations, tax return, or other set of books.)**

e. Submit a final version of all capital expenditures/costs as follows:

5.e. -- Table 3: Proposed Capital Expenditures/Costs

Medical Equipment Purchase	
Imaging Equipment Purchase	**$1,366,146**
Non-Medical Equipment Purchase	
Land/Building Purchase *	
Construction/Renovation **	n/a (included in cost of MFP project)
Other Non-Construction (Specify)	
Total Capital Expenditure (TCE)	**$ 1,366,146**
Medical Equipment Lease (Fair Market Value) ***	
Imaging Equipment Lease (Fair Market Value) ***	
Non-Medical Equipment Lease (Fair Market Value) ***	
Fair Market Value of Space ***	
Total Capital Cost (TCC)	**$ 1,366,146**
Total Project Cost (TCE + TCC)	**$ 1,366,146**
Capitalized Financing Costs (Informational Purpose Only)	
Total Capital Expenditure with Cap. Fin. Costs	**$ 1,366,146**

f. List all funding or financing sources for the proposal and the dollar amount of each. Provide applicable details such as interest rate; term; monthly payment; pledges and funds received to date; letter of interest or approval from a lending institution.

The purchase will be funded from cash from operations.

g. Demonstrate how this proposal will affect the financial strength of the state's health care system.

Pursuant to its obligations under EMTALA and its nonprofit mission, Stamford Hospital accepts all patients that present to its ED. The proposed CT in the hospital's new ED will provide services to all patient populations, including Medicaid, Medicare, commercially insured and uninsured patients.

6. Patient Population Mix: Current and Projected

a. Provide the current and projected patient population mix (based on the number of patients, not based on revenue) with the CON proposal for the proposed program.

Table 4: Patient Population Mix

	2014	2015	2016	2017	2018	2019
Medicare	27%	27%	27%	27%	27%	27%
Medicaid	16%	16%	16%	16%	16%	16%
Champus and Tricare	0%	0%	0%	0%	0%	0%
Total Government	43%	43%	43%	43%	43%	43%
Commercial insurers	51%	51%	51%	51%	51%	51%
Uninsured	5%	5%	5%	5%	5%	5%
Workers Compensation	1%	1%	1%	1%	1%	1%
Total Non-Government	57%	57%	57%	57%	57%	57%
Total Payer Mix	100%	100%	100%	100%	100%	100%

b. Provide the basis for/assumptions used to project the patient population mix.

The Patient Population mix is based on Stamford Hospital's current payor mix for all Inpatient, Outpatient and Emergency Department encounters. At this time, Stamford Hospital does not anticipate any trends that would materially change the patient population mix over time.

7. Financial Attachments I & II

a. Provide a summary of revenue, expense, and volume statistics, without the CON project, incremental to the CON project, and with the CON project. Complete Financial Attachment I. (Note that the actual results for the fiscal year reported in the first column must agree with the Applicant's audited financial statements.) The projections must include the first three <u>full</u> fiscal years of the project.

Please see attached *Exhibit F.*

b. Provide a three year projection of incremental revenue, expense, and volume statistics attributable to the proposal by payer. Complete Financial

Attachment II. The projections must include the first three full fiscal years of the project.

Please see attached *Exhibit G.*

c. Provide the assumptions utilized in developing both Financial Attachments I and II (e.g., full-time equivalents, volume statistics, other expenses, revenue and expense % increases, project commencement of operation date, etc.).

Given that CT scans for patients seen in the Emergency Department and on the inpatient units are typically reimbursed as part of the overall case-rate, Financial Attachments I and II have been prepared taking into account only the incremental impact of the additional outpatient scan volume projected in Table 2a above. Key assumptions included in the financial model include an overall annual increase to expenses of 2.7%, increases in commercial revenue of 3.0% and, increases in revenue attributable to government payers of 1.0%. Depreciation expenses have been calculated for the cost of the CT unit, depreciated over a useful life of seven (7) years. Additionally, the cost of the new service contract of approximately $135,000 annually has been included in "other expenses." Incremental FTE growth- tied to volumes and productivity – are estimated to grow by 0.41 in Year 1, to 0.74 by year 3.

d. Provide documentation or the basis to support the proposed rates for each of the FYs as reported in Financial Attachment II. Provide a copy of the rate schedule for the proposed service(s).

Please see Stamford Hospital's chargemaster as filed with OHCA.

e. Provide the minimum number of units required to show an incremental gain from operations for each fiscal year.

280, 272 and 265 scans in FY 17, 18 and 19 respectively.

f. Explain any projected incremental losses from operations contained in the financial projections that result from the implementation and operation of the CON proposal.

There are no projected incremental losses from the proposal.

g. **Describe how this proposal is cost effective.**

By locating a CT in the new ED, the Hospital will improve the efficiency of its operations. ED patients will be diagnosed and treated more quickly. Additionally, the Hospital will require fewer transportation resources, because the treatment process will have one less step. Instead of patients being transported from the ED to Radiology to an inpatient bed, ICU or an OR, patients will be able to go straight from the ED to the inpatient bed, ICU or an OR.

Further, as noted in the Financial Attachments, based on the additional incremental volume resulting from the additional CT, the Hospital projects an incremental increase in its income of between $112,000 to $464,000 in the period FY 2017-2019.

A

STAMFORD EMERGENCY MEDICAL SERVICES, INC.

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684 Long Ridge Road
Stamford, CT 06902
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FAX (203) 322-0658

March 31, 2015

State of Connecticut
Department of Public Health
Office of Health Care Access Division
410 Capital Avenue
Hartford, CT 06134

RE: Certificate of Need Application to Acquire and Operate a 320 Slice CT Scanner at The Stamford Hospital in Stamford, CT

To whom it may concern:

I am writing in support of Stamford Hospital's CON application to add a third diagnostic CT scanner to its new facility scheduled to open in late summer 2016. The CT scanner will be located in and dedicated for use by the hospital's new Emergency Department (ED).

In 2014, Stamford Emergency Medical Services Inc. (SEMS) transported over 10,000 patients to the Stamford Hospital Emergency Department via ambulance– representing approximately 20% of the hospital's Emergency Department volume. CT scans are an essential tool in the rapid evaluation and diagnosis of emergency, trauma and stroke patients. The addition of a dedicated CT scanner in the new ED will ensure patients requiring a CT scan are able to receive it in an expedited manner and will be complementary to SEMS's commitment to continuously strive to maximize efficiency and effectiveness through constant improvement of services.

If you have any questions regarding this request, I would be happy to speak further.

Respectfully submitted,

Patricia Squires

Patricia Squires, R.N., J.D.
Executive Director, Stamford Emergency Medical Services, Inc.

STAMFORD HOSPITAL
The Regional Center for Health
[illegible] Columbia University College of Physicians and Surgeons
[illegible] New York-Presbyterian Healthcare System
A Planetree Hospital

March 30, 2015

State of Connecticut
Department of Public Health
Office of Health Care Access Division
410 Capital Avenue
Hartford, CT 06134

RE: Certificate of Need Application to Acquire and Operate a 320 Slice CT Scanner at The Stamford Hospital in Stamford, CT

To whom it may concern:

I am writing in support of Stamford Hospital's CON application to add a third diagnostic CT scanner to its new facility scheduled to open in late summer 2016. The CT scanner will be located in and dedicated for use by the Hospital's new Emergency Department (ED) which receives nearly 50,000 visits annually. Given the hospital's designation as a Level II Trauma Center - over 9,000 of the hospital's annual ED visits are for the treatment of some form of traumatic event, and over 1,000 patients are seen by the hospital's Trauma Service Team each year.

CT is the diagnostic modality of choice for trauma patients as CT scans allow for the exact assessment of the entire brain and the skull, as well as for thoracic, abdominal and spinal injuries. The dedicated CT in the ED will allow for immediate access to CT services, and prevent the inefficient, and potentially unsafe, transfer of patients requiring a CT scan to the Radiology Department. Studies have shown that CT scanning in the ED quickens the pace of treatment and cuts mortality rates by allowing for more accurate and faster diagnosis, and a reduction in the time it takes to then transfer the patient for treatment in the Operating Room or Intensive Care Unit.

Stamford Hospital's designation as a Level II Trauma Center requires continued verification from the American College of Surgeons (ACS). During the hospital's last re-verification review from the ACS, the only comment for needs for improvement was to have the CT scanner located closer to the ED. The ACS was satisfied with the hospital's response that there will be a dedicated CT scanner in the new hospital; however - if we did not have a CT scanner in the ED, we would receive a citation from the ACS and we would lose our designation as a Level II Trauma Center.

If you have any questions regarding this request, I would be happy to speak further.

Respectfully submitted,

Michael D. Stone M.D.
Chairman of Surgery

STAMFORD HOSPITAL
The Regional Center for Health
affiliate: Columbia University College of Physicians and Surgeons
member: New York-Presbyterian Healthcare System
A Planetree Hospital

March 24, 2015

State of Connecticut
Department of Public Health
Office of Health Care Access Division
410 Capital Avenue
Hartford, CT 06134

RE: Certificate of Need Application to Acquire and Operate a 320 Slice CT Scanner at The Stamford Hospital in Stamford, CT

To whom it may concern:

I am writing in support of Stamford Hospital's CON application to add a third diagnostic CT scanner to its new facility scheduled to open in late summer 2016. The CT scanner will be located in and dedicated for use by the Hospital's new Emergency Department (ED). Stamford Hospital maintains designation as a Primary Stroke Center from the Connecticut Department of Public Health, and the Joint Commission. In fiscal year 2014, the hospital treated nearly 300 patients who had suffered a stroke.

Time to evaluation and treatment is critically important for stroke patients who present to the ED – and the most commonly obtained study for stroke patients is an immediate non-contrast head CT scan. The American Heart Association and the American Stroke Association have established that best practice is to initiate a CT scan within 25 minutes of arrival, and to complete interpretation of the scan within 45 minutes of arrival to exclude intracranial hemorrhage prior to administration of intravenous recombinant tissue plasminogen activator.

The placement of a dedicated CT scanner in the new ED will enable the hospital to expedite care for this critical patient population by eliminating the time required to transport patients to the hospital's radiology department; without the new CT scanner - this transport time would otherwise be *increased* as a result of the new ED's further distance from the hospital's radiology department.

If you have any questions regarding this request, I would be happy to speak further.

Respectfully submitted,

Louise Resor, MD
Director of Neurology &
Medical Director, Stroke Program

STAMFORD HOSPITAL
The Regional Center for Health

Affiliate Columbia University-College of Physicians & Surgeons
Member New York-Presbyterian Healthcare System
A Planetree Hospital

30 Shelburne Road
PO Box 9317
Stamford CT 06904-9317
203.276.1000

www.stamhealth.org

March 24, 2015

State of Connecticut
Department of Public Health
Office of Health Care Access Division
410 Capital Avenue
Hartford, CT 06134

RE: Certificate of Need Application to Acquire and Operate a 320 Slice CT Scanner at The Stamford Hospital in Stamford, CT

To whom it may concern:

I am writing in support of Stamford Hospital's CON application to add a third diagnostic CT scanner to its new facility scheduled to open in late summer 2016. The CT scanner will be located in and dedicated for use by the Hospital's new Emergency Department (ED). The need for reliable, 24/7 access to CT services is critical for the operation of the Emergency Department.

As a Level II Trauma Center, and a designated Primary Stroke Center - Stamford Hospital operates a busy Emergency Department – receiving nearly 50,000 visits annually. Currently – the hospital's radiology department provides CT services to ED patients, as well as inpatients and outpatients utilizing two (2) diagnostic CT scanners located in the radiology suite. While every effort is made to schedule CT services for inpatients and outpatients in a manner that will allow for ongoing, expedited access to CT services for Emergency Department patients – there are instances where inpatients and outpatients are required to be rescheduled, and even, at times, be pulled off of one of the two scanners to accommodate an emergency department patient. This is not only disruptive to the operational efficiency and throughput of the department, but can also have a significantly negative impact on the patient's experience and satisfaction with their care.

The placement of a dedicated CT scanner in the new ED will enable the hospital to expedite care for ED patients, while mitigating disruptions to the care of inpatients and outpatients who will continue to be accommodated in the hospital's radiology suite.

If you have any questions regarding this request, I would be happy to speak further.

Respectfully submitted,

Michael H. King, MD
Interim Chairman, Department of Radiology

STAMFORD HOSPITAL
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Discover More

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Member NewYork-Presbyterian Healthcare System
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30 Shelburne Road
P.O. Box 9317
Stamford CT 06904-9317
203.276.1000

www.stamhealth.org

March 30, 2015

State of Connecticut
Department of Public Health
Office of Health Care Access Division
410 Capital Avenue
Hartford, CT 06134

RE: Certificate of Need Application to Acquire and Operate a 320 Slice CT Scanner at The Stamford Hospital in Stamford, CT

To whom it may concern:

I am writing in support of Stamford Hospital's CON application to add a third diagnostic CT scanner to its new facility scheduled to open in late summer 2016. The CT scanner will be located in and dedicated for use by the hospital's new Emergency Department (ED). In addition to being a full service acute care facility, Stamford Hospital is designated as a Level II Trauma Center by the American College of Surgeons, and maintains designation as a Primary Stroke Center from the Connecticut Department of Public Health and the Joint Commission.

CT scans are an essential tool in the rapid evaluation and diagnosis of emergency, trauma and stroke patients. Currently, Stamford Hospital receives approximately 50,000 visits to its ED annually, and ED patients required over 15,000 CT scans in the hospital's most recent fiscal year. The addition of a dedicated CT scanner in the new ED will ensure patients requiring a CT scan are able to receive it in an expedited manner. Meanwhile, the elimination of the need for patients to be transported to the hospital's radiology department will reduce the time it takes to complete a diagnosis and begin treatment. Numerous studies have shown that CT scanning directly in the emergency department significantly expedites the pace of treatment and reduces mortality rates.

If you have any questions regarding this request, I would be happy to speak further.

Respectfully submitted,

Jayson Podber, MD, FACEP
Chair & Director, Emergency Department

B

Acta chir belg, 2006, **106**, 500-507

The Benefit of Multislice CT in the Emergency Room Management of Polytraumatized Patients

M. H. Hessmann, A. Hofmann*, K.-F. Kreitner**, C. Lott***, P. M. Rommens**

Departments of. Trauma Surgery*, Radiology**, and Anaesthesiology***, Johannes Gutenberg University, Mainz, Germany.

Key words. Polytrauma ; computed tomography ; algorithm ; emergency room ; medical decision making.

Abstract. The early treatment of polytraumatized patients needs an effective and standardized approach. Reducing time requirements for the primary diagnostic evaluation is a major concern in the early phase of polytrauma management. Multislice-CT (MSCT) is a quick and reliable method for the initial diagnostic evaluation. Computed tomography provides more detailed and more consistent information than conventional radiography. It has the great advantage of allowing rapid examination of the head, vertebral column, chest, abdomen and pelvis during one single examination. The CT-suite needs to be adequately equipped for resuscitation and reanimation, which is done parallel to the radiological investigations.

Since polytrauma management is based on a multidisciplinary approach characterized by a coordinated interaction between trauma surgeons, anaesthesiologists and radiologists, members of all involved disciplines need adequate teaching. Guidelines and algorithms contribute to optimize the early management.

Introduction

The succesful management of polytraumatized patients remains – even today – a challenging problem. As a result of the substantial progress in the prehospital trauma care, a differentiated surgical and anaesthesiological approach and an optimized intensive care therapy, lethality in polytrauma decreased by 50% in the last 25 years (1). However, trauma os still the leading cause of death in younger people in the industrialized world. The socio-economic impact of trauma and its sequellae are tremendeous.

The management of severely injured patients is characterized by specific problems. Many patients are confused, unconscious, or even anaesthetized. Information concerning the patient's history is limited or even not existing. Life-threatening injuries or combinations of injuries are not obviously recognized, especially not in blunt trauma (2). Moreover, these injuries may be masked by other lesions, that look impressive at first sight but in fact are of minor importance, such as bleeding scalp wounds. On the other hand, misinterpretation of clinical signs adversely affects the diagnostic, therapeutic strategy and endangers patient life. The examiners suspicion therefore must rely on the trauma mechanism and the initial management should consequently focus on potential life-threatening injuries.

Multidisciplinary teamwork is a main characteristic of polytrauma management. Trauma surgeon, anaesthetist and radiologist continuously strive to improve their management strategies. Considering the specific difficulties in early trauma care, guidelines and polytrauma algorithms are highly effective tools in the early management. These tools have been shown to decrease the lethality in trauma significantly (1, 3). Bishop & Shoemaker (4) showed that mortality in a large series of trauma patients was 55 per cent when a major deviation from an exisiting decision tree occurred but only 5 per cent in cases without major deviations from the algorithm. The authors concluded that the survival of trauma patients was improved by following the specific management criteria outlined by an algorithm.

Based upon the principle of the "golden hour in shock", primary diagnostic procedures must be highly effective, focused and restricted to essential questions (5). The primary clinical and radiological survey should be completed within thirty minutes after admission of the patient in the emergency room (6). Improving the efficacy of initial diagnosis and treatment is one of the main priorities addressed by trauma algorithms.

Since early diagnosis should target on possible life-threatening complications like severe bleeding, screening radiographs of the thorax and the pelvis as well as an ultrasound examination of the abdomen and retroperitoneum in the past were essential radiological investigations in polytraumatized patients. A lateral view of the cervical spine including C7 was recommended additionally in order to exclude a fracture and/or instability of the cervical column. Clinical practice has shown that the

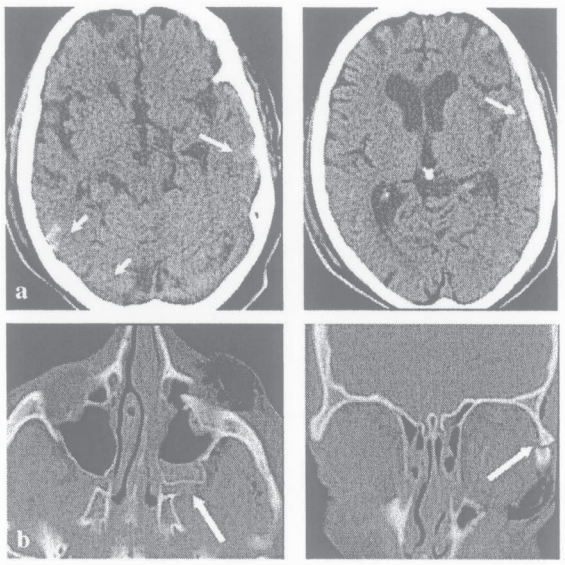

Fig. 1
a. Bilateral intracranial, subarachnoideal bleeding foci with coup and contre-coup lesions ; b. Fracture of the left orbita in the sagital and coronal view.

results of these investigations have a direct impact on the further diagnostic and therapeutic strategy.

Conventional computer tomography (CT) investigations to assess brain, thoracic, abdominal visceral and pelvic ring lesions were in the past restricted to patients that were haemodynamically stable. CT therefore was mostly assigned to the secondary survey. The procedure was time consuming and required the transfer of the intubated and ventilated patient from the emergency room to the CT suite. A further disadvantage of CT-investigations was that manipulation of the patient for diagnostic or therapeutic purposes during the time period required for data acquisition was not possible.

Multislice-CT in severely injured patients

Although emergency room algorithms focusing on conventional radiographic imaging were effective in early trauma management, it has been shown that the time needed for the initial diagnostic evaluation even in large and experience trauma centers with established polytrauma protocols was still considerable. According to the data of the German Study Group on Polytrauma, radiographs of the thorax and pelvis were taken 8-24 minutes after admission and CT-scans of the brain necessitated a mean time of 34 ± 16 minutes after arrival of the patient in the emergency room (7). HÄUSER *et al.* (8) calculated that the mean time requirements for the initial resuscitation and conventional diagnostic evaluation in the emergency room were 49 min. When a CT was performed additionally, the time required for the initial management increased up to 79 min. Another 20 min were required for diagnostic purposes after the CT-scan.

Today, there is evidence that spiral computed tomography, and particularly multislice CT (MSCT) contributes significantly to reduce the time requirements for initial diagnostic evaluation (9-11). MSCT leads to a relevant reduction of the scanning time due to an increased speed of image acquisition. Larger volumes can be examined with a high resolution and there is the ability to obtain multiplanar reconstructions and immediate

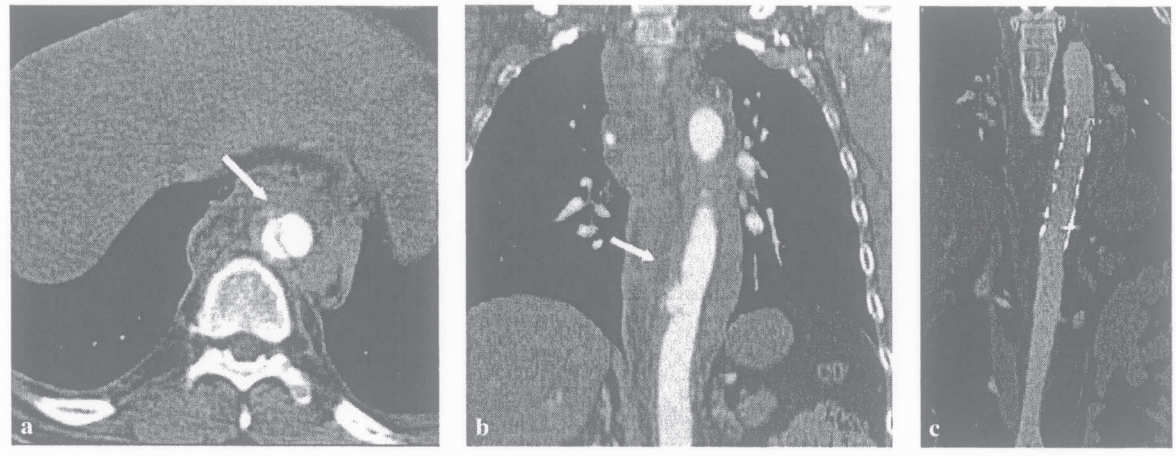

Fig. 2
a. Traumatic dissection of the descending thoracic aorta ; b. Coronal reconstruction shows the extravasation of contrast material ; c. Situation after endovascular stent insertion.

Table 1

Standardized protocol for MS-CT imaging in polytrauma patients using a 4 slice-CT scanner

Cerebral and cervical MSCT	**Lateral topogram : length 512 mm**
Cerebral CT	
Scanning volumina	Base to top of the skull
Collimation, slice thickness, increment	4 × 1-2,5 mm / 2-4 mm / 1-4 mm
Reconstruction algorithm	Soft tissues/bone
Cervical MSCT	
Scanning volumina	C1 – C7
Collimation, slice thickness, increment	4 × 1,25 mm / 2 mm / 2 mm
Reconstruction algorithm	Bone
MSCT Thorax and abdomen	**a.p. topogram : length 1024 mm**
Scanning volumina	Lung apex to ischium/greater trochanter
Timing : bolus tracking in the aorta descendens	
Alternative : delay 35 sec after beginning of the infusion of contrast medium	
Collimation, slice thickness, increment	4 × 2,5 mm / 3 mm / 2-3 mm
Reconstruction algorithm	Soft tissues/lung/bone
Secondary reconstructions	
Sagital and/or coronal reconstruction	Vertebral column
Coronal reconstructions, 3D	Skeletal face, pelvic ring/Acetabulum

on- and off-line interpretation of the images at separate workstations. These important aspects contribute to the introduction of the MSCT in the primary survey of polytrauma victims. Preliminary studies indicate that total body MSCT-scan images are available twenty minutes after admission of the patient. Time requirements for planning, scanning and infusion of the contrast material were calculated with six minutes (12). Other studies reported similar time requirements and indicate that CT can save 50% of the time previously required for diagnosis (10, 13). However, a limitation of those studies is that they do not describe prospective trials comparing one approach with another.

Successful integration of MSCT in the early polytrauma management however needs clear definition of its indications and contraindications. Resuscitation should be performed parallel with the CT investigations and this requires an adequate infrastructure and equipment in the CT-suite (see below). A senior radiologist as well as a technologist, familiar with the techniques and protocols of MSCT in polytrauma (Table 1), must be available 24 hours a day. The CT-suite must be accessible at every time of the day and night and delay because of interference with routinely scheduled patients must be avoided. This requires that the radiologist is informed early of the imminent arrival of a polytrauma patient in order to give him and his team the ability to get prepared (14).

MSCT and the detection of specific organ lesions

Craniocerebral injuries

Seventy percent of all fatalities within 24 hours after trauma are attributable to severe brain damage (15). Even before MSCT was introduced in polytrauma diagnostics, there was consensus that computed tomography due to its high sensitivity and specificity in detecting intracranial lesions is the technique of choice for the assessment of injuries of the cerebrum, the skull and the skeletal face. There is no need for conventional radiographs of the skull in the early trauma management. It is accepted that CT is indicated in all trauma patients that are unconscious, that have focal neurological dysfunction or that are suspicious for craniocerebral trauma (cervical spine lesions, history of a high energy trauma). MSCT of the brain and the osseous structures of the cranium therefore is intregrated in the standardized survey protocol for CT study in polytrauma patients (Table 1). From the prognostic point of view, it is important to document the initial situation for further follow-up studies.

Thoracic injuries

Conventional X-rays (CR) of the thorax have proven their efficacy in detecting potential life-threatening injuries in trauma patients. The investigation is cheap, non-invasive and it can be repeated at any time and

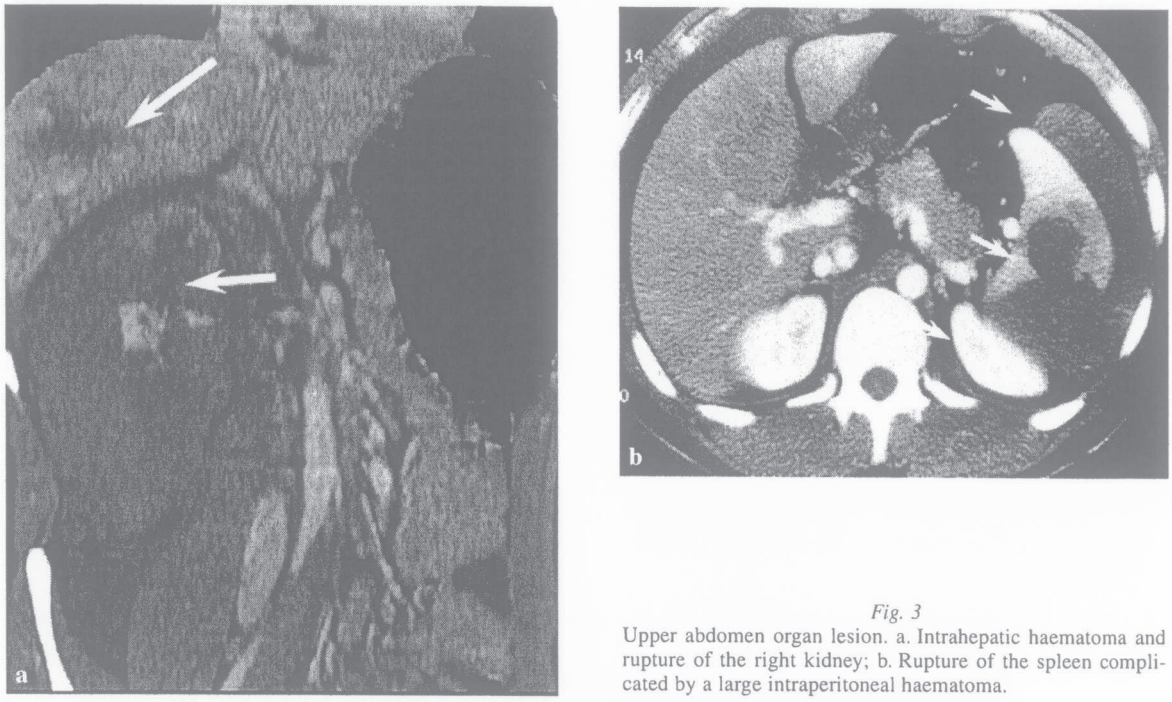

Fig. 3
Upper abdomen organ lesion. a. Intrahepatic haematoma and rupture of the right kidney; b. Rupture of the spleen complicated by a large intraperitoneal haematoma.

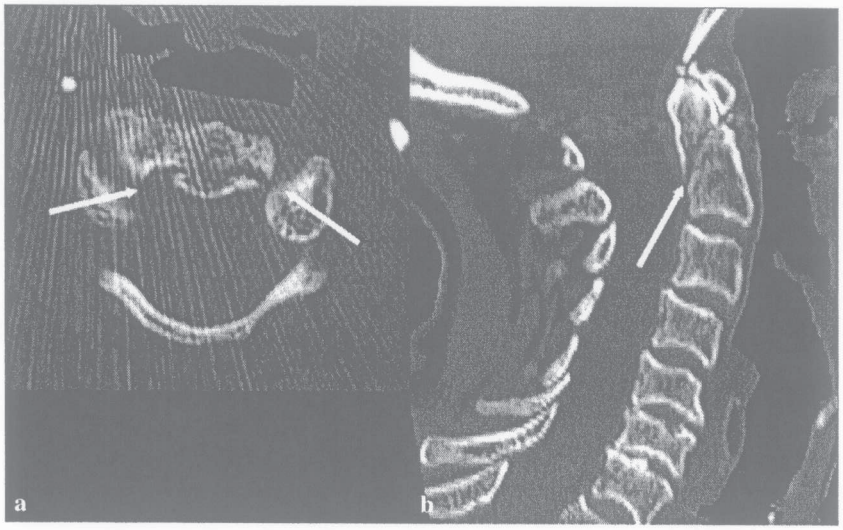

Fig. 4
a. Fracture of the second cervical vertebra ; b. Fracture morphology (Anderson type II lesion) can more appropriately be assessed on lateral reconstructions.

place. Physicians of all disciplines are familiar with its interpretation. However, conventional radiographs are less reliable for the detection of vascular lesions, small pneumothoraxes, pulmonary contusions and lacerations and also identification of diaphragm lesions is problematic. Mediastinal enlargements are difficult to differentiate according to the multiple possible origins (16). With a 90% sensitivity but a 25% specificity, CR is an adequate screening tool for mediastinal bleeding but contributes little for the objectivation of the definitive

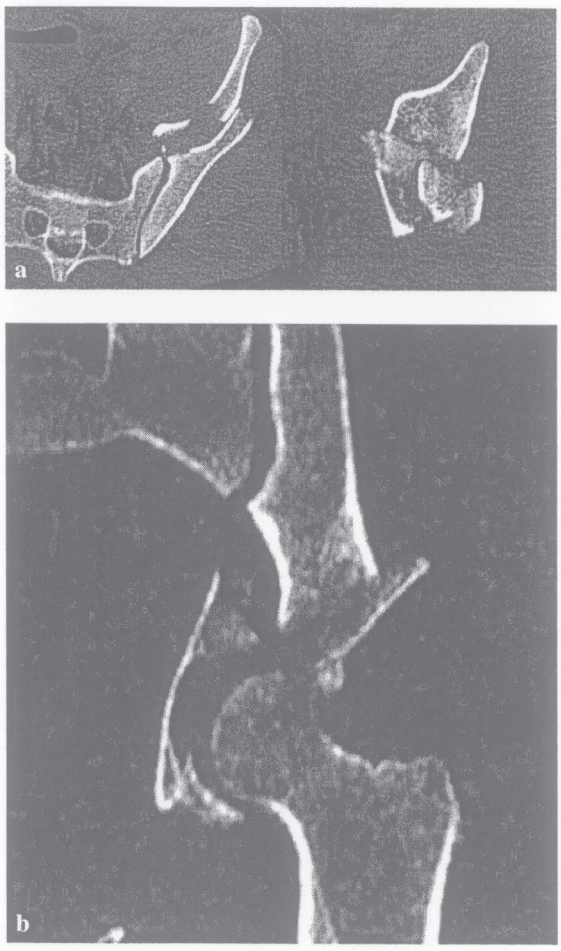

Fig. 5
a. Fracture of the left acetabulum ; b. Coronal reconstructions demonstrate the extent of the both column injury.

diagnosis (16-17). Contrast enhanced MSCT is a reliable method for detecting vascular lesions, especially traumatic dissections of the thoracic aorta.

TRUPKA *et al.* (18) demonstrated that computed tomography revealed major complications that had been missed on CR in 65% of cases. In 41% of cases, the additional CT findings did affect the treatment strategy. SIEGMANN *et al.* (18) replaced CR of the thorax by MSCT for the primary radiological survey of polytrauma patients : 159 pathological findings were detected in 120 patients. Fourty-five findings (28%) were relevant for further treatment. Correlating the CT findings to intraoperative observations, clinical parameters and follow-up diagnostic imaging revealed that there were no false-positive or false-negative findings in this study.

Abdominal lesions

Due to its very high sensitivity for detecting free intraabdominal fluid, ultrasound is widely accepted as an effective initial triage tool in patients with suspected blunt abdominal trauma. Ultrasound has almost completely replaced peritoneal lavage as a screening method for intraperitoneal haemorrhage. However, even in experienced hands, ultrasound is not sufficiently reliable to rule out organ injuries (19). The retroperitoneal space is accessible with difficulty only and free intraperitoneal air is difficult to detect.

Computed tomography has been shown to be a reliable method in diagnosing intraabdominal injuries (20, 21). Sensitivity and specificity of MSCT are reported with 95,1% and 99,9% respectively (22). Comparing ultrasound and CT in patients with abdominal trauma showed that computed tomography revealed additional relevant information in 43% of cases (23). WILLMANN *et al.* reported that 16/22 patients with active bleeding on MSCT images underwent immediate surgical or angiographic intervention (24). Other authors, however, pointed out that the additional information, gained by the CT examination had not always a clinical relevance for what concerned the further management (conservative vs. operative) (22). Also, the value of CT based injury-grading systems for predicting the outcome of conservative treatment remains unproven (19, 25). CT revealed 70% of additional findings in the series of KRETSCHMER *et al.* (26), but this information affected the treatment strategy in only 30% of cases. Nevertheless, MSCT is a very effective diagnostic screening method for demonstrating intraabdominal and retroperitoneal injuries in polytraumatized patients. Whereas CT is still preceded by ultrasound examination in some hospitals (18), we feel that computed tomography might be the first radiological investigation for abdominal trauma in patients that are not in a critical haemodynamic situation (see below).

Vertebral column and pelvic ring fractures

MSCT progressively replaces CR for the diagnosis of fractures and instabilities of the cervical and the thoracolumbar vertebral column (9, 27). WINTERMARK *et al.* (16) suggested that the sensitivity of MSCT in detecting injuries to the vertebral column is 2.5 times that of conventional radiology. In this study, MSCT detected 50% additional spine fractures that were overlooked on plain films. Also at our institution, computed tomography became the first diagnostic investigation for the spine in polytraumatized patients. Transverse scans with adequate windowing, completed by sagittal and coronal reconstructions have a sensitivity for unstable fractures of nearly 100% (16). Therefore, no conventional radiographs of the vertebral column are taken in patients, in which a spine injury is excluded on CT. This aspect also

contributes to reduce time needs for diagnostics in polytrauma. If on the other hand an unstable fracture is diagnosed, plain films focused on the fractured vertebrae are obtained in order to facilitate further treatment and follow-up.

CT is also very effective in diagnosing pelvic ring and acetabular fractures. As for the vertebral column, no CR is required in patients in which an osteoligamentar injury is excluded by CT. If a lesion became apparent, plain films will help the trauma surgeon to completely understand the lesion, which is a prerequisite for adequate treatment planning. CT scans however are indispensable since they provide more detailed information about fractures of the sacrum or disruptions of the sacroiliac joint as well as about intrapelvic organ lesions. In acetabular fractures, CT scans and 3D-reconstructions add important information about the specific injury pattern and this information is necessary in order to identify e.g. intraarticular fragments, marginal impaction and lesions of the femoral head (28).

Integration of the multisclice-CT in the early polytrauma management in Mainz

The concept of incorporating MSCT imaging in the primary survey of polytraumatized patients has been discussed in Mainz at an early stage and was realized about three years ago (29-30). The integration of CT based diagnosis in the polytrauma protocol required reorganization of the exisiting management pathways. Since the CT was not integrated in the emergency room, the local infrastructure of the CT suite had to be adapted according to the new needs ; equipment for monitoring and management of the airways and the cardiocirculatory system had to be installed ; tubes and monitor cables had to be available in adequate lengths in order to enable large volume scanning at once without disconnection.

The decision whether or not the patient is an adequate candidate for primary CT diagnosis is taken by the trauma surgeon and the anaestesiologist upon admission in the emergency room. Based upon the haemodynamic situation of the trauma victim and the information provided by the emergency physician, it is decided whether a spiral CT scan is possible and whether this examination is necessary and indicated. *The indication for MSCT is based upon the mechanism of injury, the haemodynamic situation of the patient and the suspected injury pattern.* This decision is taken before the patient is transferred on the emergency room table in order to reduce transportation times. The indication should also consider that MSCT involves a substantially higher irradiation dose to the patient than conventional radiology (16, 31). *It is stressed that the CT scan does not replace nor delay a direct clinical examination.*

In case the patient is in decompensated deep shock (moribund), CT scanning (including transport to the CT-suite and positioning on the CT table) is estimated to be too time-consuming, initial resuscitation and diagnostic evaluation will take place in the emergency room. Conventional radiological investigations, including an a. p. overview of the thorax and the pelvic ring, a lateral view of the cervical vertebral column including C7 and an ultrasound examination of the abdomen, are performed parallel to the cardiorespiratory resuscitation and the primary clinical survey. Decisions concerning the further management depend upon the ability to stabilize the cardiopulmonary functions and the findings of the clinical and radiological investigations. In most cases, the patient will be taken to the operating theatre for damage control surgery.

In case the polytrauma patient's general condition is less critical, he is transferred directly under continuous monitoring from the emergency room to the CT-room and a multislice CT scan is performed as the primary radiological investigation. Since resuscitation takes place in the CT-suite, haemodynamic instability is not a contraindication for MSCT (11). CT investigations are performed according to a standardized screening survey (Table 1) and include study of the head, thorax, abdomen and pelvis.

Clinical evaluation and stabilization of the haemodynamic and cardiopulmonary parameters are performed parallel with the apparative investigations. While the patient is positioned correctly on the CT-table, consciousness, respiratory function and circulation are evaluated and a primary clinical survey of the injury pattern is performed according to the ATLS principles. Measures performed during the preclinical phase are checked ; the patient is intubated and ventilated if required and new broad intravenous accesses are placed on the non-injured upper extremity or in central veins. Blood samples are taken and compatible blood products are ordered.

The findings of the CT scan are assessed immediately on separate workstations by the radiologist in the presence of the trauma surgeon (16, 32). A preliminary written protocol is provided to the trauma team. As MSCT generates a huge volume of images, film printing of all the available data is debatable. However, unless an adequate infrastructure for intraoperative soft-copy interpretation is available in the operating theatre, a hard-copy of scans documenting lesions with therapeutic relevance is required in order to allow the surgeon to plan his surgical interventions and to give him the opportunity to correlate the clinical findings with the radiological images intraoperatively.

Once the CT examination is completed, the further strategy will depend upon the haemodynamic situation of the patient and the specific findings of the CT scan.

Some lesions are amenable to immediate surgical treatment with the patient still on the CT-table, e.g. the insertion of a thoracic drain for the management of a pneumo- and/or haematothorax.

It is decided whether the patient is transferred directly to the operating theatre or the intensive care department (ICU) or whether further diagnostic procedures are scheduled, e.g. conventional radiological imaging of extremity fractures or angiography. Whereas some fractures of the upper or lower extremities may already become apparent on the topogram of the CT scan, further diagnosis of those injuries in most cases still relies on conventional radiographs.

While the patient is transferred from the CT-room, a secondary and more detailed survey of the CT findings will be performed by the radiologist and multiplanary reconstructions are being processed. Since this is more time-consuming, relevant secondary CT findings will be reported by telephone to the trauma team that is involved in the further management either in the OR or on the ICU.

The patient remains on the vacuum matrass from his arrival at the emergency room until he is transferred to the operating table or the ICU bed. This guarantees that the trauma victim remains adequately immobilized during the different phases of transportation inside the hospital. In our experience, the vacuum matrass does not interfere with the CT examination and does not affect the quality of the CT-images.

There is evidence that polytraumatized patients do benefit from the integration of MSCT imaging in the primary survey. Analysis of our preliminary available data revealed that the patients remain in the CT-suite for a mean time of 27 minutes (range : 15-45 min) (29). The large variations in time were mainly attributable to the different time requirements for initial resuscitation and treatment. These data are in accordance with literature. Wintermark *et al.* (16) described that the complete realization of a total body MSCT averaged 40 min : 45% of this time was required for transportation, 35% for CT data acquisition and 20% for data management. The rather long period of 14 min, required for data acquisition was explained by frequent interruptions for monitoring and resuscitation purposes.

Conclusions

Meanwhile MSCT is established in the management of severely injured patients. Its technical characteristics enable an effective diagnosis and a focused therapy of potentially life-threatening injuries at an early stage of the emergency room treatment. Computed tomography is more complete and also more consistent than conventional radiology and it has the great advantage of allowing rapid examination of the head, vertebral column, chest, abdomen and pelvis during one single radiological examination.

Therefore, early incorporation of the MSCT in trauma protocols could be beneficial for polytrauma patients.

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Whole-body multislice computed tomography (MSCT) improves trauma care in patients requiring surgery after multiple trauma

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ABSTRACT

Objectives Whole-body multislice helical CT becomes increasingly important as a diagnostic tool in patients with multiple injuries. Time gain in multiple-trauma patients who require emergency surgery might improve outcome. The authors hypothesised that whole-body multislice computed tomography (MSCT) (MSCT trauma protocol) as the initial diagnostic tool reduces the interval to start emergency surgery (tOR) if compared to conventional radiography, combined with abdominal ultrasound and organ-focused CT (conventional trauma protocol). The second goal of the study was to investigate whether the diagnostic approach chosen has an impact on outcome.

Methods The authors' level 1 trauma centre uses whole-body MSCT for initial radiological diagnostic work-up for patients with suspected multiple trauma. Before the introduction of MSCT in 2004, a conventional approach was used. Group I: data of trauma patients treated with conventional trauma protocol from 2001 to 2003. Group II: data from trauma patients treated with whole-body MSCT trauma protocol from 2004 to 2006.

Results tOR in group I (n=155) was 120 (90–150) min (median and IQR) and 105 (85–133) min (median and IQR) in group II (n=163), respectively ($p<0.05$). Patients of group II had significantly more serious injuries. No difference in outcome data was found. 14 patients died in both groups within the first 30 days; five of these died within the first 24 h.

Conclusion A whole-body MSCT-based diagnostic approach to multiple trauma shortens the time interval to start emergency surgery in patients with multiple injuries. Mortality remained unchanged in both groups. Patients of group II were more seriously injured; an improvement of outcome might be assumed.

Many patients with multiple trauma need emergency surgery as soon as possible after the physical and radiological diagnostic work-up. A gain in time with those patients might improve outcome. In order to provide appropriate surgical care for them, a rapid and complete diagnostic work-up is mandatory.[1 2]

Over the last years, CT has gained importance in the early diagnostic phase of trauma care.[3–6] The development of multislice helical CT especially has led to substantial refinement in the diagnostic work-up.[7 8] For many institutions, multislice computed tomography (MSCT) has become an essential part of the trauma diagnostic work-up.[5 6 9–11] In spite of many reports about time gain and diagnostic superiority whenever whole-body MSCT is used, it remains the subject of ongoing discussions as to whether whole-body MSCT or conventional radiography combined with ultrasound should be used as the primary diagnostic tool.[5 8 12 13] A faster diagnostic work-up might be one possible advantage of whole-body MSCT.[2 4 11] The more rapid diagnostic work-up might result in an earlier transfer to the operating theatre if emergency surgery is necessary, and this might be associated with an improved outcome. The trauma protocol at our level 1 trauma centre was changed from conventional diagnostic adjuncts to a whole-body MSCT-based algorithm in 2004.[10 14] We have now retrospectively analysed the clinical course of those patients who underwent emergency surgery immediately after finishing trauma resuscitation and diagnostics in the emergency room (ER).

We hypothesised that whole-body MSCT (MSCT trauma protocol) as the initial diagnostic tool reduces the interval to start emergency surgery when compared to conventional radiography combined with abdominal ultrasound and organ-focused CT (conventional trauma protocol). The second goal of the study was to investigate whether the diagnostic approach chosen has an impact on outcome.

METHODS

Protocol design

This investigation is a retrospective data analysis based on a chart review. Approval was obtained by the institutional review board.

Two abstractors were trained in the use of the medical charts, the hospital's clinical information system and the Picture Archiving and Communication System. The abstractors, after checking the trauma registration, identified all patients who were treated by the trauma team in the resuscitation area. Patients' data were made anonymous and subsequently entered into a standardised abstraction form. The variables of interest were the time to emergency surgery (tOR), demographics, the Injury Severity Score (ISS) and outcome variables (mortality, ventilator days and length of intensive care unit (ICU) stay). These variables are objective numbers, which are routinely registered in the chart of any trauma patient who is treated in the trauma resuscitation room.

Setting

Since 2004, our level 1 trauma centre has used whole-body MSCT for initial and sole radiological diagnostic work-up of patients with suspected multiple trauma.[10 11 15] The CT scanner is located

directly in the trauma resuscitation room. Before the introduction of MSCT in our trauma algorithm, conventional radiography in combination with abdominal ultrasound and organ-focused CT were the diagnostic measures used in the early treatment phase of multiple trauma care.

The two different algorithms are described as follows.

MSCT trauma protocol

The diagnostic part of our polytrauma algorithm is based on whole-body MSCT as the first-line diagnostic tool for trauma patients who are suspected to be major trauma victims according to a triage rule (table 1).[14 16] Trauma patients who fail to meet the triage criteria are suspected to be minor trauma victims and are treated according to the focused plain-film-based concept.

A multislice CT with a 16-row scanner ('Sliding Gantry'-Somatom Sensation 16; Siemens AG Medical Solutions, Forchheim, Germany) is located directly in the resuscitation area of the trauma suite. Any life-saving procedures including airway management, emergency laparotomy or thoracotomy can be performed on the carbon CT-examining and intervention table.[10] Before starting the MSCT, the history is taken from the prehospital respective emergency team, a physical exam is performed according to priority-based standard of care, and life-threatening conditions are treated immediately according to ATLS® and the department's Standard Operating Procedures. Focused assessment with sonography for trauma (FAST) is performed only on haemodynamically unstable patients.

The CT scan starts when life-threatening problems have been resolved. Some devices like respirator tubing, central venous lines etc. can be left unchanged in their positions, while the mobile "sliding CT gantry" moves from the head to the toe of the patient.

The whole-body MSCT is performed according to a predefined standardised protocol (table 2). After the scans have been completed, the algorithm continues with a physical reassessment of the patient and necessary emergency interventions. In the meantime, the acquired CT scan data are processed and evaluated by a staff radiologist. The patient's condition and the findings of the CT scan define the further treatment plan. The patient is transferred either to the operating room (OR) or to an ICU.

Conventional trauma protocol

Formally, the emergency room was equipped with an *x* ray unit and a mobile ultrasound system. With the arrival of the patient, the trauma team started with priority-orientated resuscitation. After life-threatening problems had been resolved, the diagnostic work-up was started with plain films of the chest, the pelvis and the cervical spine and FAST. Additional plain-films were made depending on further suspected injuries. Reassessment of the patient was carried out, and necessary emergency interventions were performed before the patient was transferred to the radiology department for organ-focused CT if required.

The diagnostic period finished with the end of the CT examination. CT scans were processed and evaluated by a staff radiologist. The patient's condition and the findings on the CT scan defined the further treatment plan.

The specialities and the degree of training of the trauma team members (attending, resident etc) were the same in both groups. In Germany, we do not have emergency physicians. Life-saving procedures like airway management, respiratory therapy and fluid management are performed by anaesthesiologists. In our institution, leadership of the trauma team is an interdisciplinary approach. Leadership of the trauma team is taken over by a 'leading group' which consists of the staff anaesthesiologist, the staff surgeon and the staff radiologist.

Acquisition of laboratory results is assumed to be similar in both groups as samples were taken early in the resuscitation phase and brought to the laboratory by emergency courier.

Due to clinical priorities, a physical exam was conducted in both groups (airway, breathing, circulation, neuro exam), similar to the primary survey of the ATLS®-concept.

The trauma team in both groups consists of

- Two anaesthesiologists (attending and resident)
- Two surgeons (attending and resident)
- One trauma surgeon (attending)
- One radiologist (attending)
- One to two anaesthesia nurses, one to two surgical nurses and two radiology technicians

Neurosurgery, heart and thoracic surgery, urology, paediatric surgery, maxillofacial surgery and otorhinolaryngology specialist consultants are available within 15 min 24 h/24 h.

Selection of participants

Two groups of patients were analysed retrospectively.

Inclusion criteria and groups

Group I: patients with multiple trauma who required emergency surgery and who were diagnosed with the conventional trauma protocol from 2001 to 2003.

Group II: patients with suspected multiple trauma who required emergency surgery and who were initially diagnosed with the MSCT trauma protocol from 2004 to 2006.

Exclusion criteria: patients who required immediate emergency laparotomy or thoracotomy directly in the resuscitation area without getting a complete diagnostic work-up were excluded from the analysis.

Emergency surgery was classified as any kind of surgery that had to be performed immediately after finishing the resuscitation period and the diagnostic work-up.

Table 1 Triage scheme for whole-body multislice computed tomography (MSCT) indication

Category I, Mechanism of trauma	Category II, Clinical apparent injuries	Category III, Vital signs
Falls >5 m	Open chest	Intubated patient with
Patient trapped in the car	Open abdominal wound flail chest	an initial GCS <9 on scene
Roll over head-on collision	Major pelvic injury	Blood pressure <80 mmHg
Ejection from car	Two or more proximal	Respiratory rate <10 or >29
Death in same passenger compartment	long-bone fractures	Pulse oximetry <90%
High-speed crash	Amputation proximal	
Crash against a truck	to wrist or ankle	
Pedestrian run over		
Explosion, buried person		

If one parameter is positive, serious injuries in one or more organ systems are suspected and MSCT is initiated.
GCS, Glasgow coma scale

Table 2 Predefined scan-protocol of the whole-body multislice CT

	Series 1 (head and cervical spine)	Series 2 thorax and abdomen (early)	Series 3 thorax and abdomen (late)
Total contrast media			150 ml
Contrast media flow	No	3 ml/s	3 ml/s
Contrast media	No	Yes	Yes
Collimation	16×0.75	16×0.75	16×0.75
Slice thickness	2 (spine)–5 mm	3 (spine)–5 mm	5 mm

Methods and measurement

tOR was analysed in both groups and was defined as the time interval from patient's arrival in the emergency room until the start of emergency surgery. It includes all life-saving procedures and all diagnostic procedures. Also included are the first online image interpretations by the radiologist, the announcement of the definitive diagnosis and the treatment plan, transfer to the operating theatre, positioning and the complete preparation for surgery. To assess whether there are any differences related to the severity of injury, patients were divided into three different subgroups according to their ISS. An ISS from 0 to 15 was considered as minor injury, from 16 to 24 as moderate injury and from 25 to 75 as severe injury.[17–20]

Outcome variables (mortality, ventilator days and length of ICU stay) were determined for both groups.

Trauma mechanism and the different surgical procedures were recorded.

Data collection and processing

A chart review was performed. Data collection included demographics, the ISS, outcome variables and the duration of tOR.

Primary data analysis

Normal distribution of data could not be demonstrated with the Kolmogorov–Smirnov test. Therefore, data are shown as median with inter-quartile range (IQR: 25–75% percentile). A non-parametric test (Mann–Whitney rank sum test) was used. A p value of less than 0.05 was considered significant.

RESULTS

In the first period (2001–2003), a total of 731 trauma patients were screened. One hundred and fifty-five of them had surgery immediately after finishing ER course (group I).

In the second period (2004–2006), 788 major trauma patients were treated in the resuscitation area of the Trauma ER. One hundred and sixty-three of them had immediate surgery and were thus included for analysis (group II).

A total of 15 patients were excluded from the analysis due to surgery immediately after arrival in the emergency room.

All patients were treated by the trauma team in the resuscitation area. All patients in group I were treated according to the conventional trauma protocol; all patients in group II were treated according to the MSCT trauma protocol.

In group I, there were 36 women (23%) and 119 men (77%), with an average age of 38 (range: 2–82). In group II, there were 41 women (25%) and 122 men (75%), with an average age of 38 (range: 3–87). The ISS in group I was 24 (13–34) (median and IQR), while the ISS in group II was 27 (17–41) (median and IQR) (p=0.001), respectively.

Overall tOR was 120 (90–150) min (median and IQR) in group I and 105 (85–133) min (median and IQR) in group II, respectively. This was a significant (p<0.05) reduction in time needed to start emergency surgery.

In the first 30 days, 14 patients died in both groups (9% group I; 8.5% group II), five of these in the first 24 h in both groups (3.2% group I; 3% group II).

There were five ICU days (1–14) (median and IQR) in group I and eight (2–19) (median and IQR) in group II (p=0.157). There were three ventilator days (1–12) (median and IQR) in group I and five (1–15) (median and IQR) in group II (p=0.107).

The results of the three subgroups (ISS 0–15; 15–24 and 25–75) are shown in table 3.

Trauma mechanism and the different emergency surgical procedures are shown in table 4. All limb fractures were open and/or dislocated fractures, and the indication for immediate surgery was therefore set by the trauma surgeon. Abbreviated Injury Scale for the fractures was greater than 3. All patients who had surgery on the spine had clinical signs of complete or incomplete paraplegia. Radiological findings showed instable vertebral fractures.

DISCUSSION

There is growing evidence for the advantages of whole-body MSCT-based trauma algorithms.[2 11 21] The presented study focuses on multiple trauma patients who require emergency surgery immediately after finishing the diagnostic work-up and resuscitation. It might be assumed that those patients benefit the most from time gain in the early phase of trauma care.

The results of study show that emergency surgery of patients with major trauma was initiated significantly quicker in group II, demonstrating a more rapid decision process when using whole-body MSCT as a primary diagnostic tool for patients with suspected multiple trauma. In our study, the effectiveness of MSCT was related to the severity of injury. So the time gain for group II was markedly high in the subgroup of the most serious injured patients (ISS 25–75; table 3). This highlights the effect of improved diagnostic work-up, particularly in the case of seriously injured patients. Earlier investigations have demonstrated that such a time gain is associated with a prompter

Table 3 Data for tOR are shown in minutes with median and IQR

ISS 0–15	Group I (n=44)	Group II (n=21)	p Value
tOR	115 (95–140)	100 (95–125)	0.866
ISS	10 (9–12)	12 (10–13)	0.021*
Mortality (24 h)	None	None	
Mortality (30d)	None	None	
ICU days	1 (0–2)	0 (0–2)	0.142
Ventilator days	1 (0–1)	0 (0–1)	0.470
ISS 16–24	**Group I (n=34)**	**Group II (n=48)**	**p Value**
tOR	125 (100–155)	110 (84–136)	0.209
ISS	21 (17–22)	22 (17–22)	0.921
Mortality (24 h)	None	None	
Mortality (30d)	1	None	
ICU days	4 (2–9)	3 (2–8)	0.379
Ventilator days	2 (1–6)	1 (1–3)	0.471
ISS 25–75	**Group I (n=77)**	**Group II (n=94)**	**p Value**
tOR	130 (90–160)	105 (85–129)	0.022*
ISS	34 (29–48)	41 (29–48)	0.0512
Mortality (24 h)	5	5	
Mortality (30d)	8	9	
ICU days	10 (5–22)	14 (7–23)	0.341
Ventilator days	7 (2–20)	12 (5–21)	0.178

ISS, ICU days and ventilator days are shown as median and IQR.
*Significant.
ISS, Injury Severity Score; tOR, time to operation; ICU, intensive care unit.

Table 4 Surgical procedures and mechanisms of trauma

	Group I (n=155)	Group II (n=163)
Surgical procedures		
Craniectomy	14	18
Laparotomy	21	26
Upper limb	22	18
Lower limb	71	61
Thoracotomy	5	6
Spine	6	14
Pelvis	16	20
Mechanism of trauma		
Car accident	65	62
Motorbike	24	31
Pedestrian	8	4
Fall >3 m	17	20
Others	41	46

decision for further treatment and an earlier transfer from the emergency room.[2 11]

A delay in proper surgical care is a major cause for preventable deaths in trauma care, and the earliest possible identification of potential lethal injuries is mandatory for optimal trauma care.[1 22–24] Therefore, rapid detection and treatment of injuries, which are well known to cause fatal outcome, are mandatory.[22–24]

To our knowledge, there are no randomised and prospective trials comparing whole-body MSCT-based trauma concepts with conventional protocols. Nevertheless, there are a considerable number of studies published, which demonstrate that a whole-body MSCT-based algorithm is a time-saving diagnostic approach to patients with multiple trauma. Weninger *et al*[2] compared a MSCT-based trauma algorithm with a conventional approach. They found a significant reduction in the time from patient's arrival in the emergency room to the start of emergency surgery. Their findings are comparable to our results as emergency surgery was started after 103 min in their MSCT cohort.[2]

Hilbert *et al*[9] recently reported a significant reduction in treatment time in the emergency room when using a MSCT-based trauma algorithm.

Rieger *et al*[4] found a 40% reduction in diagnostic work-up time when using MSCT without carrying out prior plain-film radiography.

An impact of the diagnostic work-up on outcome has not been demonstrated in randomised and prospective trials yet. Other authors demonstrated the positive correlation between mortality and saved time.[1] This was not the case in our analysis. The reason for the unchanged mortality might be due to a type II error, that is a larger sample size might be necessary to demonstrate a possible difference in mortality. Nevertheless, as the patients of group II had a significantly higher ISS and we did not observe a difference in mortality, we assume that there is an impact on outcome related to the diagnostic strategy. Recently, Huber-Wagner *et al*[25] found an increased probability of survival in polytrauma patients when using whole-body MSCT for initial diagnostic work-up. Weninger *et al* demonstrated a significant reduction in the number of ventilator days and ICU stay. Mortality was unchanged in their collective.[2]

Although we have not demonstrated reduced mortality, we gained very useful information from our data. In an earlier study, we compared the two different trauma algorithms. The evaluation stopped when the ER treatment was finished. Differences in treatment times were much more impressive.[11] In the presented study, we were looking at the further course of those selected patients going directly to the OR. As compared to the earlier study, we found that we actually lost time after leaving the ER. A possible interpretation is that we gave away the advantage of the rapid diagnostics on the way to start surgery. Further analyses should focus on to the improvement of this phase, and this might be important information for all those trauma centres trying to optimise their early trauma management.

The risk:benefit analysis is an important point while using MSCT as initial diagnostic tool. In our protocol, the indication for MSCT is based on a triage rule which is shown in table 1 .In a recent study, we found overtriage (ISS <16 retrospectively and initial use of whole-body MSCT) in 30% of our patients.[14] In the group of overtriaged patients, there were 9 out of 26 (34%) who had relevant findings in the whole-body MSCT. Eight of them had pulmonary contusions, and one had vertebral fractures. The triage criterion, which triggered whole-body MSCT for those patients, was the mechanism of trauma in all cases. From this data, we concluded that the whole-body scan was of value for these patients since injuries were detected, which probably would have been missed by a conventional approach.

Since we found similar mortality in both groups, a very important question remains to be answered in the future: How can we identify those patients who really will benefit from the early use of whole-body MSCT? What is best for the individual patient with regard to potential hazard of a higher radiation dose and the risk of missing pertinent injuries, which might contribute to fatal outcome? To answer this question, further research is required to elucidate the most relevant and independent predictive factors for the need of a whole-body MSCT in early trauma care.

A limitation of our study is that it was carried out based on chart review, since such techniques are prone to bias because of missing, conflicting or ambiguous data and the subjective nature of some data elements. In order to mitigate some of those disadvantages, strict methodological criteria were used for data collection as described in the Methods section.

CONCLUSION

Whole-body MSCT shortens the time interval to start emergency surgery for multiple trauma patients. As mortality remained unchanged in both groups, while patients of group II were significantly more seriously injured, an improvement of outcome might be assumed. Although there is growing evidence that whole-body MSCT improves outcome, prospective, randomised and controlled trials will be necessary to evaluate further whether MSCT-based diagnostic approach is superior to conventional approach with plain-film radiography, especially with regard to outcome.

Competing interests None.

Ethics approval This study was conducted with the approval of the local ethics committee.

Provenance and peer review Not commissioned; externally peer reviewed.

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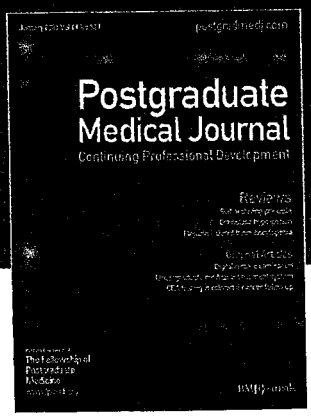

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Impact on trauma patient management of installing a computed tomography scanner in the emergency department

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ABSTRACT

Background: Computed tomography (CT) plays a central diagnostic role for trauma patients. A 16-slice multi-detector CT scanner was installed in the emergency department (ED) of Prince of Wales Hospital in December 2004. The aims of this study were to evaluate the impact of the CT scanner within the ED on trauma management and to compare the utilisation patterns of trauma CT before and after the introduction of EDCT.

Methods: Analysis of prospectively collected trauma registry data. All consecutive trauma cases admitted through the ED that underwent CT between June 2004 and June 2005 (6 months before and after EDCT installation) were included. A positive CT was defined as the identification (by a specialist radiologist) of a significant finding which was consistent with injury.

Results: There were 226 and 202 trauma patients in the 6 months before and after EDCT installation, respectively. 111 (49.1%) patients underwent CT scanning before EDCT compared with 110 (54.5%) afterwards. 72 (65%) patients had CT scans performed before admission to definitive care compared with 99 (90%) after EDCT installed ($p < 0.0001$, χ^2 test). Mean time from arrival to first CT was shorter after EDCT (102 min vs. 197 min, $p = 0.011$). Mean trauma room length of stay increased after EDCT was implemented (106 min vs. 80 min; $p < 0.001$). Median time to urgent operation (<6 h) was less with EDCT (134 min before vs. 112 min after). No changes in median time to neurosurgical operation (138 min before vs. 148 min after); mean length of stay (12.8 days before vs. 12.5 days after); or mortality (8 patients before vs. 7 patients after). There were 203 scans (1.8/patient) done before EDCT compared with 226 scans (2.5/patient) after. There was no difference in the number of scans done by body region or the proportion of positive scans (32% before vs. 30% after). Logistic regression confirmed that after adjusting for injury severity and admission physiology, time to first CT was shorter ($p = 0.0307$) but ED length of stay was increased ($p < 0.0001$).

Conclusion: After the installation of EDCT, more trauma patients had CT scanning before definitive care, and scans were done sooner, with no significant increase in the number of unnecessary scans.

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Introduction

Trauma remains a leading cause of morbidity and is the sixth leading cause of death in Hong Kong.[7] Management of the trauma patient is multifactorial,[2] but the concept of rapid accurate diagnosis and timely appropriate treatment are central to quality trauma care.[3,5]

Advances in imaging have led to computed tomography (CT) scanning playing a central diagnostic role for trauma patients. CT is fast, accurate and cost effective in providing clinically useful information in a single examination. A recent study showed that integration of high resolution CT scanning into the early diagnostic protocol markedly reduces the length of stay in the trauma room and facilitates rapid therapeutic intervention.[6]

In order to provide improved accessibility to CT for the trauma patients, a 16-slice multi-detector computed tomography (MDCT) was installed in the emergency department (ED) of Prince of Wales Hospital (PWH) of Hong Kong in December 2004. The CT room is less than 15 m from the doors of the trauma resuscitation rooms within the ED. The ED CT scanner is available for the investigation

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Table 1
Comparison of outcomes before and after the installation of EDCT.

Variable	Before installation of EDCT, $n = 226$	After installation of EDCT, $n = 202$	p
Number of trauma patients having CT scan	111 (49.1%)	110 (54.5%)	0.29
Number of patients with CT done prior to admission	72 (65%)	99 (90%)	<0.001
Median ISS of scanned patients	11	10	0.38
Median RTS of scanned patients	7.841	7.841	0.82
Mean time to first CT scan	197 min	102 min	0.011
Mean trauma room length of stay	80 min	106 min	<0.001
Median time to urgent operation	134 min	112 min	0.53
Median time to neurosurgical operation	138 min	148 min	0.86
Mean hospital length of stay	12.8 days	12.5 days	0.91
Number of scans by body region	203 scans (1.8 regions/patient)	226 scans (2.1 regions/patient)	0.11
Positive scans	42.3%	37.3%	0.44
Mortality	8	7	1.0

of the suspected major trauma patient 24 h per day. The scanner is for ED use for the majority of the working week (70%) and outwith office hours, whereas for 30% of the working week it is primarily used for oncology work. However, even within these sessions, a suspected major trauma case will take priority over elective scanning.

The objectives of this study were to evaluate the impact of the CT scanner within the ED on trauma patient management and to compare the utilisation patterns of trauma CT before and after the installation of the EDCT.

Methods

This is a retrospective study using high quality data collected prospectively for an administrative trauma registry in the ED at this hospital. Data for the trauma registry is collected prospectively by a specialist trauma nurse coordinator who maintains a specific computerised trauma database.[12] This database is used for monthly trauma audit and feedback to the hospital. The Prince of Wales Hospital (PWH) is a regional trauma centre and university teaching hospital located in Shatin, in the eastern New Territories of Hong Kong.

All consecutive trauma patients admitted through the ED and who underwent CT between June 2004 and June 2005 (6 months before and after EDCT installation) were identified and included. The CT scanner for the hospital is based in the main radiology department, around 100 m from the ED through a public corridor. The EDCT is a new supplementary CT scanner which is less than 15 m from the ED trauma resuscitation rooms. Trauma patients with suspected severe injuries or physiological derangement are admitted to the trauma rooms direct from the ambulance bay or triage area, and they undergo resuscitation according to standard trauma resuscitation guidelines. CT is then performed if necessary and the patient either goes directly to the operating room, intensive care unit (ICU) or general ward, or goes back to the trauma room until a decision has been made on the next phase of care.

At the time of the study, there were no specific formal guidelines on CT for trauma. Exceptions to this included routine head CT for patients who were not GCS 15 at the time of assessment and CT cervical spine studies for patients whose necks could not be cleared after conventional radiography or who were having a head CT performed as well.

The number of trauma patients having CT scans, number of patients with CT done prior to admission, mean time to first CT, median time to urgent surgical operation, median time to neurosurgical operation, mean trauma room length of stay, mean hospital LOS, number of scans by body region, the number of positive scans and mortality were compared between the two groups. A positive CT was defined as the identification (by a specialist radiologist) of a significant finding which was consistent with injury.

Statistical analysis was undertaken using the Statistical Package for Social Science (SPSS, v15.0, Chicago, IL). The independent samples t-test was performed on normally distributed continuous data. For skewed data, medians were compared using the Mann–Whitney U-test. Categorical variables were compared using the χ^2 test. Statistical significance was set at $p < 0.05$. Multiple logistic regression analysis was used to adjust for intervariable interaction with EDCT as the dependent variable and injury severity score and physiology on ED admission (as measured by the revised trauma score) as independent variables.

Results

Of a total of 428 trauma cases, 226 and 202 were included before and after the installation of EDCT, respectively. 111 (49.1%) patients underwent CT scanning before EDCT was introduced compared with 110 (54.5%) afterwards. There were no statistically significant differences in age, injury severity scores or revised trauma scores between the two groups. Table 1 shows the comparison of outcomes both before and after the installation of EDCT. The proportion of trauma patients requiring early CT (i.e. performed prior to hospital admission from the ED) was significantly higher in the pre-installation than post-installation group (90% vs. 65%, $p < 0.001$, χ^2 test) although the total numbers of patients eventually having CT before and after the installation of EDCT were not significantly different. The mean time to the first CT was significantly shorter after the installation of EDCT (102 min vs. 197 min, $p = 0.011$, t-test). However, the mean trauma room length of stay (LOS) was significantly longer before compared with after the use of EDCT (106 min vs. 80 min, $p < 0.001$, t-test).

Logistic regression confirmed that after adjusting for injury severity and ED admission physiology, time to first CT was shorter (OR 0.997; 95%confidence interval 0.994–1.000; $p = 0.0307$) but ED length of stay was increased (OR 1.025; 95% confidence interval 1.013–1.037; $p < 0.0001$).

However, there were no significant increases in the number of scans by body region and there was no evidence of any significant decrease in positive scans after the installation of EDCT. Both the median time to urgent operation (all specialties) and urgent neurosurgical operation were not statistically or clinically different after the introduction of EDCT. Furthermore, mortality and the mean hospital LOS were not significantly different between the two groups.

Discussion

The CT scanner was developed in 1972 by Hounsfield and refined further by Ledley in 1973.[8,11] CT has had a major impact on

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many areas of medical care, especially trauma management. Clinical examination of trauma patients can be of limited use, particularly in the immediate period following injury when consciousness may be impaired. Immediate and accurate interpretation of the CT scan remains critical for surgical and clinical management decision making. In our hospital, radiologists report trauma scans immediately during working hours and formally report all trauma scans within 24 h. Trauma team members interpret films at other times with few clinically significant missed findings noted.

Advances in CT scanning, with the change from single slice CT to multiple detector CT, have led to improved patient management and improved diagnostic results.[9] While imaging can never replace clinical examination as a foundation of trauma care, it is clear that the management of head trauma in particular has been revolutionised by CT scanning. In major trauma, patients are increasingly having non-operative management of solid organ injuries, facilitated by CT scanning, instead of operative treatment. However, there are growing concerns that CT scanning may be overused, both for trauma and non-trauma presentations.[1,4,10]

The shorter time to CT after the installation of ED-MDCT in this hospital reduces the time for initial diagnosis and management. The time remains shorter even after adjusting for injury severity and ED admission physiology. More rapid diagnosis may facilitate better planning for definitive care and potentially lead to better quality of care of trauma patients. A further advantage is that there are less potentially hazardous transfers of seriously ill patients from the wards to the hospital CT scanner following admission from the ED. This has beneficial effects for ward staff, porters and most importantly, patients.

Mortality was shown to decrease after the introduction of EDCT in one other study[9]; however, there was no such decrease in the mortality in our study. Since the current study was retrospective, there is little chance of a Hawthorne effect, which may spuriously improve outcomes. In future, a prospective and ideally randomised study should be performed to eliminate any confounding factors. Such a study should be powered adequately to detect these outcomes, which this observational study was not.

The installation of EDCT outside the trauma room has led to a significant increase in the length of stay in the trauma room. This is not surprising. This difference persisted even after adjusting for injury severity and ED admission physiology. This may be due in part to the fact that a higher proportion of patients have an immediate CT within the ED now, so their 'ED departure time' is later than it would have been in the pre-installation phase of the study. Assuming though that the extra time is not related to the higher proportion of ED scans, the extra time in the trauma room may be offset by the more rapid definitive diagnosis, and there was no evidence of any adverse effects on time to operation for any time-critical trauma surgical procedures. With the trend of full integration of EDCT into the trauma room,[6,9] transforming it into a 'one stop shop' for urgent diagnosis, the length of time in the trauma room would be expected to decease markedly.

Conclusion

After installation of the EDCT, more trauma patients had diagnostic CT scanning before definitive care and scans were done sooner. There was no significant increase in the number of unnecessary scans. To further decrease the time required for CT, the physical integration of EDCT into the trauma room would be desirable.

Conflict of interest statement

The authors report that there are no financial and personal relationships with other people, or organisations, that could inappropriately influence their work within 3 years of the beginning this study.

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The role of early multislice computed tomography in major trauma

TE Wurmb and W Kenn

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The role of early multislice computed tomography in major trauma

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Abstract

Whole-body multislice spiral computed tomography (MSCT) has become a very important dignostic tool in the management of patients with multiple injuries. Many reports exist which demonstrate the feasibility and the benefit when using whole-body MSCT in the early phase of in-hospital management of trauma patients. Even in hemodynamically instable patients (except cardiac arrest), whole-body MSCT can be used and is a safe diagnostic procedure. While the diagnostic superiority of multislice computed tomography is proven for different organ regions (e.g. head/brain, chest, abdomen, pelvis and spine), its use as a single whole-body scan is still part of an ongoing discussion. Especially concerns about radiation exposure are the reason for uncertainty about when using whole-body trauma scan. Predefined scan protocols and individual positioning of patients may help to keep radiation dose as minimal as possible. To justify higher radiation dose, the indication must be chosen appropriately. Therefore, the use of a sensitive and specific triage scheme seems to be reasonable. Overscanning patients with minor trauma needs to be avoided, while the benefit for patients with severe multiple injuries is obvious.

Keywords

Multiple trauma, multislice computed tomography, trauma management, resuscitation time, emergency room, radiation dose

Introduction

The early in-hospital management of patients with multiple injuries and major trauma is generally based on three principles: (1) life-threatening conditions have to be treated according to their priority, (2) complete diagnostic workup of the head, neck, chest, abdomen and pelvis is mandatory and (3) an interdisciplinary 'next-hours'-treatment plan based on patient's clinical conditions and the findings of the radiological

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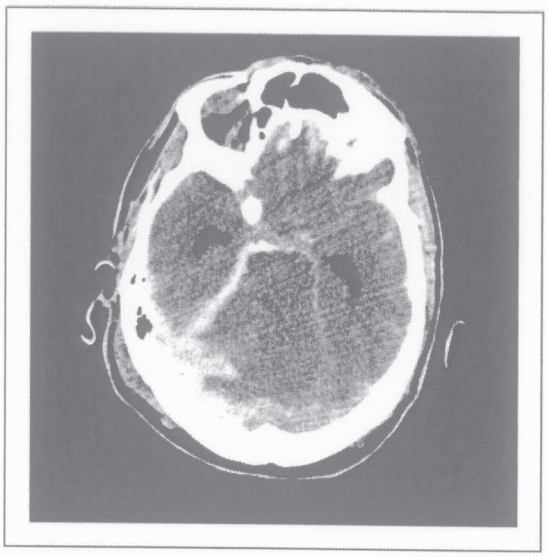

Figure 1. Severe traumatic brain injury with tentorial herniation.

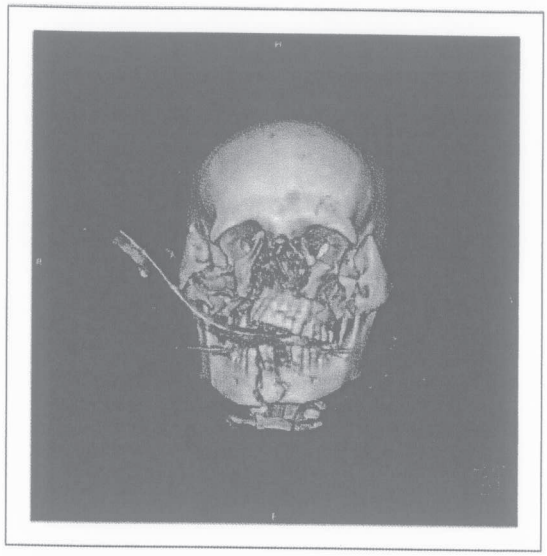

Figure 2. Severe maxillofacial trauma.

examination has to be created (Beck et al., 2004; Bernhard et al., 2007; Clarke et al., 2002; Harris, 2001; Nast-Kolb and Ruchholtz, 1999; Nast-Kolb et al., 1994; Van Olden et al., 2004). Therefore, the initial diagnostic workup is one important element of a well-defined trauma management.

Traditionally, conventional radiography and ultrasound is completed by organ-focused computed tomography (CT) (conventional trauma protocol). Usually, the trauma suite is equipped with an X-ray unit and a mobile ultrasound system. With arrival of the patient, the trauma team starts with priority orientated resuscitation (in general, according to the ATLS® approach). After life-threatening problems are resolved, the diagnostic work-up starts with plain films of the chest, the pelvis and the cervical spine and a focused abdominal ultrasound on trauma (FAST). Additional plain films are made depending on further suspected injuries. Reassessment of the patient is carried out and necessary emergency interventions are performed before the patient is transferred to the radiology department for organ-focused CT. The diagnostic period is finished with the end of the CT examination. The patient's condition and the findings on the CT scan define the further treatment plan (Beck et al., 2004; Kuhne et al., 2004; Nast-Kolb et al., 1994; Ruchholtz et al., 2002).

In the last few years, CT has gained importance in the early diagnostic phase of trauma care, especially the development of multislice spiral computed tomography (MSCT) has led to substantial refinement in the diagnostic work-up (Kanz et al., 2004; Kloppel et al., 2002; Low et al., 1997; Philipp et al., 2003; Rieger et al., 2002). One of the most important technical improvements is time gain using predefined scan protocols and standardized scan parameters (Kulama, 2004). Whole-body MSCT produces high-resolution images; volume imaging allows multiplanar reconstruction and three-dimensional imaging. Such whole-body MSCT can rapidly reveal all relevant injuries (Figures 1 to 7) (Albrecht et al., 2004; Kloppel et al., 2002; Low et al., 1997; Rieger et al., 2002), resulting in an immediate treatment plan. As a result, a growing number of trauma centres have started to use whole-body MSCT as the primary diagnostic tool,

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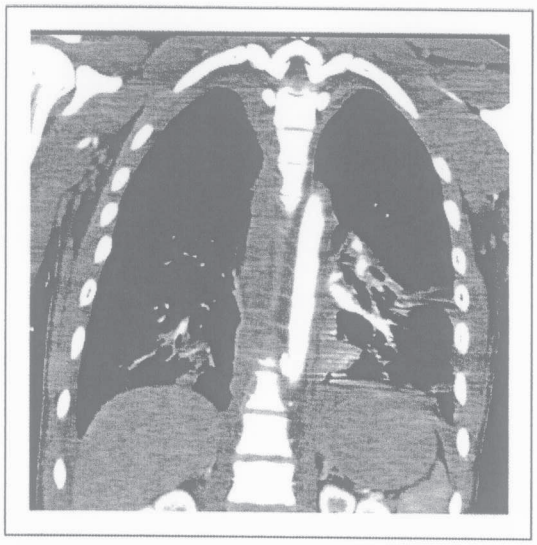

Figure 3. Traumatic aortic rupture.

Figure 4. Associated B-injury of the spine.

even in haemodynamically instable patients (Bernhard et al., 2007; Hilbert et al., 2007; Weninger et al., 2007; Wurmb et al., 2005).

History and development of whole-body MSCT trauma protocols

Low et al. (1997) first described the use of whole-body helical CT for rapid primary diagnostic in multiple injured patients. The authors found that helical CT was a reliable and rapid method to diagnose the most important injuries and that CT scanning in early trauma care is a valuable tool to improve management of the severely injured patient. Moreover, the authors found a markedly reduced number of conventional X-ray examinations in those patients (Low et al., 1997). Over the next decade, several reports were published that demonstrated a benefit from early whole-body MSCT in trauma patients. In a retrospective analysis, Rieger et al. (2002) demonstrated a time gain of up to 50% when using whole-body MSCT in trauma patients. Kloppel et al. (2002) found a reduction in treatment time after changing their trauma protocol from one- to four-slice helical CT. Their opinion was that integrating whole-body MSCT in an interdisciplinary management concept would be a good compromise between examination times, diagnostic quality, emergency interventions and therapy planning. Kanz et al. (2004) prospectively evaluated a series of 125 trauma patients obtaining whole-body MSCT after a basic diagnostic with chest X-ray and FAST. Complete diagnostic work-up was finished within 30 min after admission. No life-threatening adverse event related to the CT scan was described. The authors concluded that the primary survey was not affected by the CT scan and that the time to obtain the most relevant diagnosis was markedly reduced using whole-body MSCT early in the trauma treatment course.

The first concepts with early use of whole-body MSCT had conventional radiography and FAST prior to the CT scan with the CT scanner located in the radiology department. The next step was the integration of the CT scanner directly in the trauma suite of the emergency room. Kuhnigk et al. (2004) described this new approach. A 16-row CT scanner was installed in the trauma suite. Transport of the patient to the radiology department was no longer

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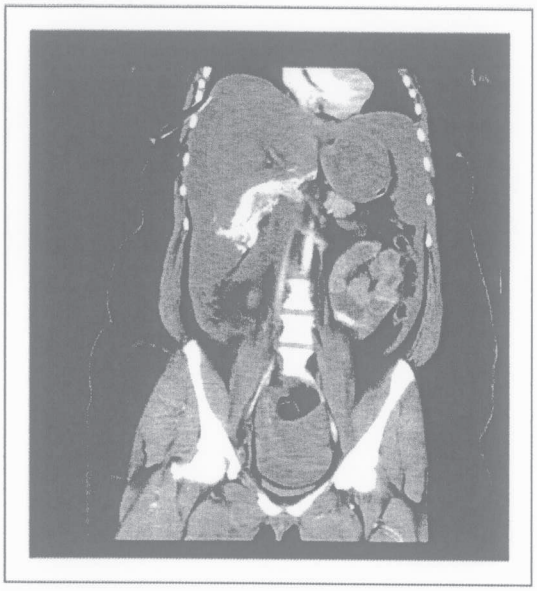

Figure 5. Traumatic rupture of the coeliac arteries.

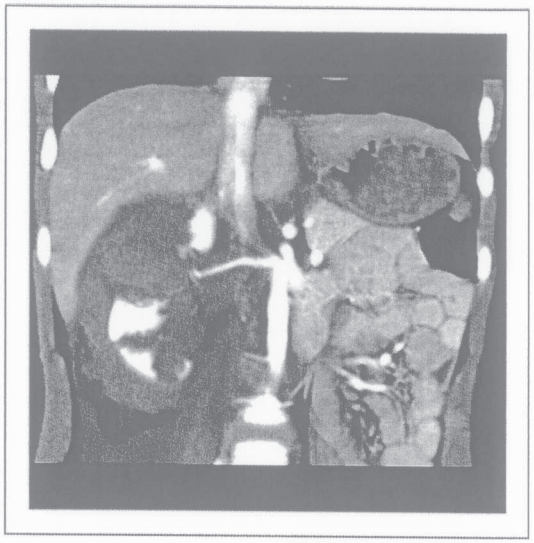

Figure 6. Traumatic rupture of the renal artery with extensive retroperitoneal haematoma.

necessary. The same concept was described by Hilbert et al. in 2007. This new approach had the goal of further reducing treatment time, eliminating redundant diagnostic studies and avoiding additional transfer of the seriously injured patient. The authors were successful in integrating the CT scan in an ATLS® approach. The primary survey was done immediately after the patients' arrival in the emergency room and before starting the CT scan. Conventional X-ray or FAST is completely eliminated from the algorithm (Hilbert et al., 2007). Wurmb et al. (2005) published an almost identical protocol. An MSCT with a 16-row scanner was directly installed in the resuscitation room of the trauma suite (Figure 8). Any technical equipment needed for the management of severe trauma (e.g. anaesthesia machine, ventilator, complete monitoring, rapid infusion system, blood supplies, etc.) was available in the same location. Once placed on the special carbon CT and intervention table, the patient's position does not need to be modified. Any life-saving procedure, including airway management, emergency laparotomy or thoracotomy, can be performed on the table if necessary. Before starting the CT scan, an ATLS®-based work-up was done for an initial assessment. In contrast to the algorithm published by Hilbert et al., FAST was performed in haemodynamically unstable patients prior to the CT scan. The CT scan was started when life-threatening problems had been resolved. Any device, such as respirator tubing, central venous lines, etc., was left unchanged in their position, while the mobile sliding CT gantry was moving from the head to toe of the patient (Wurmb et al., 2005) (Figure 8).

Diagnostic value of MSCT (related to organ regions)

Traumatic brain injury

The influence of traumatic brain injury on the morbidity and mortality of trauma patients is well known and there is no doubt that CT is currently the diagnostic of choice as it allows the exact assessment of the entire brain and the skull (Kaups et al., 2004; Shackford et al., 1992; Stiell et al., 2001).

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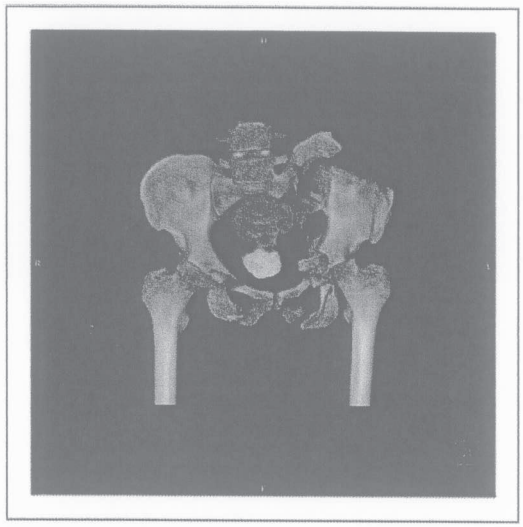

Figure 7. Vertical trauma with C-injury of the pelvis.

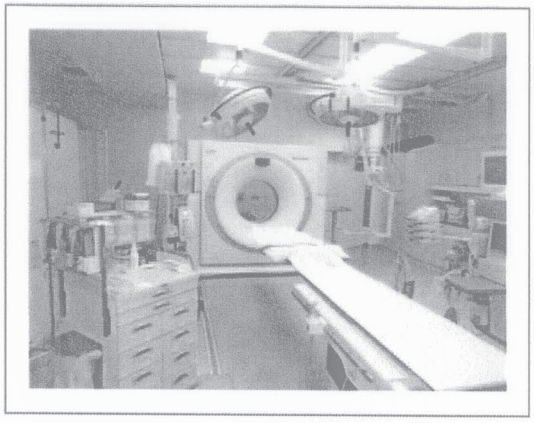

Figure 8. CT scanner and X-ray unit in the resuscitation room.

Thoracic injuries

The value of the thoracic CT in the assessment of trauma patients with blunt chest trauma was demonstrated by Trupka et al. (1997). In a prospective study, trauma patients with clinical or radiological signs of chest trauma were diagnosed by conventional chest X-ray and thoracic CT, and the results were compared looking for additional findings in the CT scan. It was concluded that thoracic CT was highly sensitive in detecting thoracic injuries after blunt chest trauma and was superior to routine chest X-ray in visualizing lung contusions, pneumothorax and haematothorax. The authors found a significant change in therapeutic management caused by CT scan results. They recommended thoracic CT in the initial diagnostic work-up of patients with multiple injuries and with suspected chest trauma (Trupka et al., 1997). It is well known that most injuries missed in the early phase of trauma management are abdominal or thoracic in origin (Hirshberg et al., 1994; Ledgerwood and Lucas, 1990; Nast-Kolb et al., 1993), representing the leading causes for preventable deaths in trauma patients (Johnson et al., 1986; Rieger et al., 2002). There is evidence that MSCT is superior to conventional X-ray in the diagnosis of thoracic injuries (Exadaktylos et al., 2001; Low et al., 1997; Rieger et al., 2002; Trupka et al., 1997) and therefore MSCT in trauma patients might be justified to reveal serious isolated organ injury.

Abdominal injuries

Intra-abdominal injuries are a common finding in blunt major trauma. Evaluation of the abdomen is difficult during the initial assessment of the trauma patient, and missed abdominal injuries are one of the leading causes of preventable death in trauma patients (Gruen et al., 2006; Houshian et al., 2002; Ochsner et al., 2000). Therefore, a proper diagnostic work-up of the abdomen is mandatory. Diagnostic peritoneal lavage, ultrasound and the CT scan are the diagnostic options for ruling out intra-abdominal injuries. While ultrasound and peritoneal lavage rely on the presence of blood or intestinal fluid in the abdomen, the CT scan might show abdominal injuries without active bleeding (Ochsner et al., 2000). Albrecht et al. (2004) compared the diagnostic accuracy of whole-body MSCT with FAST and

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conventional radiography. For the diagnosis of intra-abdominal injuries, they found a sensitivity of 92% for CT scan, while abdominal ultrasound had a sensitivity of 22%. Maurer et al. (2008) performed a retrospective analysis to determine the added diagnostic benefit of using whole-body MSCT in multiple trauma patients. In 275 patients, they report 112 additional relevant injuries in the abdomen that were not diagnosed by ultrasound (Maurer et al., 2008). Buhne et al. (2001) compared prospectively the impact of CT scanning and abdominal ultrasound on therapeutic decisions in patients with suspected abdominal injuries. The authors concluded that if the ultrasound is abnormal, CT scan will have an important impact on therapeutic decisions. After a negative ultrasound, a change in therapy was found in 8 out of 105 patients (Buhne et al., 2001). Houshian et al. (2002) analysed missed injuries in a level I trauma centre. They found 8.1% missed injuries in 786 patients. Missed abdominal injuries were predominant in requiring surgery. Most missed injuries were not suspected by the trauma team (60.5%), while the results of the ultrasound, radiographs and CT scan were misinterpreted by the radiologists in 34.9%. Miller et al. (2003) evaluated FAST in haemodynamically instable patients with suspected blunt abdominal injury. The authors found that the use of FAST in those patients will lead to underdiagnosis of intra-abdominal injury. They recommended the routine use of CT in haemodynamically stable patients with blunt abdominal trauma. In a review article, McGahan (2002) concluded that if free abdominal fluid is detected by ultrasound, this may indicate serious intraabdominal injury. In the absence of free fluid, there is still a significant risk for relevant injury that is not diagnosed by FAST (McGahan et al., 2002). Having the highest sensitivity and specificity, the S3-guideline of the German Society of Trauma Surgeons clearly recommends the routine use of MSCT in patients with blunt abdominal trauma (S3-Guideline German Society of Trauma Surgeons, www.awmf.org).

Injuries of the spine

MSCT is invaluable in the evaluation of the traumatized spine; it is superior to plain films delineating extension of fracture fragments into the spine canal (Gestring et al., 2002; McGahan et al., 2002; Watura et al., 2004). For clearing the cervical spine, MSCT is superior to plain film radiography (Daffner, 2001; Griffen et al., 2003; Jelly et al., 2000; Obenauer et al., 2002; Watura et al., 2004), especially in intubated patients where the craniocervical junction and the lower cervical spine is often difficult to evaluate (Watura et al., 2004). Wintermark et al. (2003) conducted a prospective study to determine whether MSCT might replace conventional radiography and be performed alone in severe trauma patients for depiction of thoracolumbar spine fractures. They concluded that MSCT can replace plain radiography and can be performed alone in patients who have sustained severe trauma. For that reason, MSCT seems to be justified in all trauma patients where there is a suspicion of spine fractures, especially in sedated and intubated patients. A different procedure was proposed by Watura et al. (2004). The authors stated that replacing plain films with MSCT would significantly increase radiation exposure of whom the vast majority will have normal spines that are adequately examined by plain film radiographs. They recommended MSCT in patients with either abnormal plain radiographs requiring further evaluation or in trauma patients with nondiagnostic plain radiographs and possible fractures. Brown et al. (2005) adopted spiral CT as the primary modality for the diagnosis of spine fractures. The authors stated that routine plain radiographs of the spine are not necessary in the evaluation of blunt trauma patients when spiral CT is used. In a recent meta-analyses, Holmes and Akkinepalli (2005) found no randomized controlled trial but ample evidence that CT significantly outperforms plain radiography as a screening test in patients with high risk of cervical spine injury.

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Table 1. Triage scheme to set indication for whole-body MSCT (modified by Nast-Kolb et al., 1994).

Category I Mechanism of trauma	Category II Clinical apparent injuries	Category III Vital signs
Falls >5m	Open chest	Ventilated patient with an initial GCS <9 on scene
High-speed crash	Flail chest	Respiratory rate <10 or >29/min
Crash against a truck		
Pedestrian run over		
Patient trapped in the car	Open abdominal wound	Blood pressure <80 mm Hg
Roll over		
Head-on collision		
Ejection from car		
Death in same passenger compartment		
Explosion, burried person	Major pelvic injury	Pulse oxymetry <90%
	Two or more proximal long-bone fractures	
	Amputation proximal to wrist or ankle	

GCS: Glasgow coma scale.

Injury of the pelvis

Haemorrhage from pelvic injuries is a potential lethal complication in major trauma victims. In haemodynamically instable patients, it is often difficult to prioritize the major site of bleeding especially when suspected abdominal injuries are present in combination with pelvic injuries. In those cases, FAST can reveal free abdominal fluid and this finding might initiate immediate laparotomy. This might be fatal if haemoperitoneum is found to be secondary to intraperitoneal leakage of retroperitoneal bleeding (Tien et al., 2007). Plain radiographs alone have limited sensitivity for detection of pelvic fractures compared with CT (Guillamondegui et al., 2002; Watura et al., 2004), and the visualization of the pelvic vascular and organ structures by CT is invaluable (Berg et al., 1996; Resnik et al., 1992). Plain films as a routine screening device seem to be unnecessary in patients with suspected multiple injuries who are to be imaged immediately by CT (Stewart et al., 2002).

Indication for whole-body MSCT

As discussed, the superiority of MSCT is widely accepted for organ-focused diagnostics after trauma; however, the appropriate indication for initial whole-body MSCT remains unclear (Wurmb et al., 2007) and is part of an ongoing discussion. When whole-body MSCT is used for initial diagnostic work-up in trauma patients, it is important to identify patients with suspected serious injuries in order to justify the higher radiation dose. In our level I trauma centre, the indication for whole-body MSCT is set using a systematic triage rule. It is based on a triage system that was published by Nast-Kolb et al. (1994). Using our trauma protocol, we screen trauma patients in a standardized manner to decide on diagnostic measures.

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The scheme consists of three categories with different parameters in each category. The triage rule is shown in Table 1. If one single parameter is found to be positive, serious injuries in one or more organ systems are suspected (Nast-Kolb et al., 1994). The CT trauma protocol will be initiated. If the patient fails to meet one of the criteria, the conventional trauma protocol including conventional plain film radiography of the cervical spine, the chest, the pelvis and ultrasound of the abdomen is initiated. If the conventional trauma protocol is inconclusive or reveals injuries that need to be addressed with CT, an organ-focused CT examination is performed afterwards.

Wurmb et al. (2007) performed a retrospective data analysis to evaluate the accuracy of the triage scheme. The authors defined overtriage as the use of MSCT trauma protocol in patients with an Injury Severity Score (ISS) <16 and undertriage as conventional trauma protocol used in patients with ISS ≥ 16. Appropriate indication was assumed when patients had ISS ≥ 16 and the whole-body MSCT was used. A total of 59 (70%) patients undergoing the CT trauma protocol ($n=85$) had ISS values ≥ 16. Overtriage (ISS <16) occurred in 26 (30%) patients with 9 patients suffering from significant injuries. Undertriage (ISS ≥ 16) occurred in 2 of 35 patients (6%). It was concluded that overtriage seemed to be acceptable since 35% of the overtriaged patients had significant injuries diagnosed by whole-body MSCT. In order to find the most relevant and independent predictive factors helping in reducing the risk of overscanning trauma patients, further research is necessary. A different way to initiate whole-body MSCT in trauma patients was described by Salim et al. (2006). The authors hypothesized that liberal use of whole-body MSCT based on trauma mechanism alone is warranted, even in evaluable patients with no obvious sign of chest and abdominal injuries. In 592, evaluable patients without clinical signs for chest or abdominal injuries, they found significant abnormalities up to 19% of patients and a change in therapy in 19%. With these findings, the authors concluded that liberal use of whole-body MSCT in trauma patients is justified (Salim et al., 2006).

The authors of this article believe that further research is warranted to find the most relevant and independent predictive factors for the need of a whole-body MSCT, in order to define a favourable ratio of benefit to risk and to avoid overscanning trauma patients.

Whole-body MSCT and outcome

The use of whole-body MSCT during trauma resuscitation is a time-saving procedure (Boehm et al., 2004; Hilbert et al., 2007; Low et al., 1997; Weninger et al., 2007; Wurmb et al., 2009). Moreover, several studies demonstrated a benefit in outcome in those patients receiving early whole-body MSCT. Weninger et al. (2007) reported a significant reduction in in-hospital stay, in ICU stay and in ventilation days for trauma patients initially scanned with whole-body MSCT. The authors also found a significantly lower rate of organ failure in those patients. Fung Kon Jin et al. (2008) evaluated the influence of an MSCT-based trauma algorithm on the outcome of patients with severe traumatic brain injury. They found a significant reduction in mortality in favour of those trauma patients treated according to the CT-based algorithm. They also described a trend towards earlier neurosurgical intervention. In a retrospective study, Wurmb et al. (2011) investigated the influence of a whole-body MSCT trauma algorithm on the time interval before starting emergency surgery. They found that emergency surgery of patients with major trauma was initiated significantly earlier when using an MSCT trauma scan. An influence on survival was not found in this study. Hilbert et al. (2007) and Bernhard et al. (2007) reported a trend towards reduction of mortality while using initial trauma scan in their trauma algorithm and Huber-Wagner et al. (2009) were the first authors who clearly demonstrated an increased probability of survival in patients with multiple traumas when using whole-body

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CT as a standard diagnostic tool in the early resuscitation phase.

Radiation dose and MSCT

Main concern when using whole-body MSCT for screening trauma patients is the higher radiation dose. One appropriate measure to reduce radiation dose is the use of well-defined scan protocols (Fanucci et al., 2007; Ptak et al., 2003). A comparison of radiation exposure from whole-body MSCT and conventional radiography with organ-specific CT was published by Wedegartner et al. (2004). These authors calculated the radiation dose of different diagnostic procedures. First was whole-body MSCT, second was conventional plain film radiography including chest, cervical, thoracic and lumbar spine in two views, as well as pelvis, third was conventional radiography in combination with organ-specific CT. The CT examination included head with cervical spine (combination a), head with cervical spine and chest (combination b) or head with cervical spine and abdomen (combination c). The effective doses were 20 mSv for whole-body MSCT, 2 mSv for conventional radiography, 6.8 mSv for combination a, 10.3 mSv for combination b and 18 mSv for combination c. Considering the superiority of MSCT to plain film radiography in clearing the spine, the chest and the abdomen, the possible higher radiation dose, which is associated with MSCT employed as a diagnostic screening tool, in trauma patients might be justified.

Nevertheless, it remains a difficult question: what is best for the individual trauma patient with regard to the potential hazard of a higher radiation dose and the risk of missing pertinent injuries which might contribute to fatal outcome? Corresponding to the data of the annual report of the International Commission on Radiological Protection, the risk of fatal cancer per 10 mSV radiation dose is 1/1777 patients. In 1777 patients, we find a risk for the spontaneous development of fatal cancer in 355/1777. The risk of missing serious injuries in patients with multiple trauma is described by Houshian et al. (2002). The authors report a number of 86 missed injuries in 786 trauma patients. Four patients died due to missed injuries, seven had a fatal outcome. Most missed injuries were not suspected by the trauma team, but in 34.9% of the reported cases, the results of radiographs, ultrasound or CT scan were misinterpreted by radiologists. Therefore, 65% of the injuries probably would not have been missed using whole-body MSCT as a screening method; the risk benefit ratio is that one whole-body MSCT per 302 patients might have saved one life, while 10 mSV might be responsible for the development of one fatal cancer in 1777 patients. Gruen et al. (2006) reported two missed intra-abdominal injuries responsible for fatal outcome in 2594 trauma deaths. Hence, MSCT might have saved one life in 1297 patients as it is supposed to be the gold standard in diagnosis of the traumatized thorax and abdomen, especially in those blunt abdominal injuries with minimal or even without intraperitoneal fluid, which are at high risk of being missed by conventional diagnostic tests.

Despite the possible benefit for patients with severe trauma, an indiscriminate use of CT for patients with minor trauma is not justified (Fabian, 2009). Furthermore in patients with suspected major trauma, the CT-related dose in the individual patient needs to be as low as possible (Brenner and Hall, 2007). In this context, several studies have recently been published (Brink et al., 2008; Karlo et al., 2011; Loewenhardt et al., 2011). Loewnhardt et al. (2011) reported a reduction of effective dose up to 22% when the patients' arms were raised during the chest and abdomen scan. The authors concluded that an individual positioning algorithm may lead to relevant reduction of radiation dose in severely injured patients receiving MSCT.

Summary

Whole-body MSCT is a valuable diagnostic tool in patients with multiple injuries. It is a

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time-saving procedure with the powerful opportunity to reveal all the relevant diagnoses very early during trauma resuscitation. For an appropriate setup, the use of MSCT needs to be part of a well-defined trauma algorithm and the scanner needs to be placed in or very close to the resuscitation area. To justify the higher radiation dose, the indication must be appropriately chosen. Therefore, the use of a sensitive and specific triage scheme seems to be reasonable. Overscanning patients with minor trauma needs to be avoided, while the benefit for patients with severe multiple injuries is obvious.

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The Journal of TRAUMA® Injury, Infection, and Critical Care

Whole-Body Multislice Computed Tomography as the First Line Diagnostic Tool in Patients With Multiple Injuries: The Focus on Time

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Objective: Whole-body multislice helical computed tomography (MSCT) becomes increasingly important as a diagnostic tool in patients with multiple injuries. We describe time requirement of two different diagnostic approaches to multiple injuries one with whole-body-MSCT (MSCT Trauma-Protocol) as the sole radiologic procedure and one with conventional use of radiography, combined with abdominal ultrasound and organ focused CT (Conventional-Trauma-Protocol).

Methods: Observational study with retrospective analysis of time requirements for resuscitation, diagnostic workup and transfer to definitive treatment after changing from conventional to MSCT Trauma-Protocol. Group I: data from trauma patients imaged with whole-body MSCT. Group II: data of trauma patients investigated with conventional trauma protocol before the introduction of MSCT-Trauma-Protocol.

Results: The complete diagnostic workup in group I (n = 82) was finished after 23 minutes (17–33 minutes) [median; interquartile range (IQR)] and after 70 minutes (IQR, 56–85) in group II (n = 79). The definitive management plan based on a completed diagnostic workup was devised after 47 minutes (IQR, 37–59) in group I and after 82 minutes (IQR, 66–110) in group II.

Conclusion: A whole-body MSCT-based diagnostic approach to multiple injuries might shorten the time interval from arrival in the trauma emergency room until obtaining a final diagnosis and management plan in patients with multiple injuries and might, therefore, contribute to improvements in patient care.

Key Words: Multiple injuries, Multislice computed tomography, Trauma management, Resuscitation time, Trauma emergency radiology.

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Time management is one of the most important issues in the early phase of multiple trauma care.[1,2] Life-threatening conditions have to be treated immediately according to their priority.[3–6] To provide appropriate surgical care, a rapid and complete diagnostic workup of the head and trunk is mandatory. Therefore, the diagnostic approach of most trauma concepts is based on conventional radiography and abdominal ultrasound completed by organ-focused computed tomography (CT).[7–9]

During the last years, CT has gained importance in the early diagnostic phase of trauma care.[10–13] Especially the development of multislice helical computed tomography (MSCT) has led to substantial refinement in the diagnostic workup.[14,15] For many institutions, it has become an essential part of the imaging of the traumatized patient.[12,13,16] Whole-body MSCT can reveal most injuries[11,14,17–19] resulting in an immediate treatment plan. Whether whole-body MSCT or conventional radiography combined with ultrasound and organ focused CT-scans should be used as the primary diagnostic tool remains subject of an ongoing discussion.[12,15,17,20] If whole-body MSCT is used for initial radiologic diagnostic workup in trauma patients, it is mandatory to identify patients with suspected serious injuries to justify the higher radiation dose, e.g., by using a systematic triage rule.[21] Another important aspect is to treat life-threatening conditions before starting whole-body MSCT. Therefore, implementation of a CT-diagnostic phase in a priority-based trauma algorithm seems to be reasonable.[10,22,23] Improved timeliness of a completed diagnostic workup might be one possible advantage of whole-body MSCT.[11] Whether a definitive treatment plan, based on a completed diagnostic workup, could be devised earlier by using whole-body MSCT is an important question but is not sufficiently evaluated yet. After changing our trauma protocol from using conventional diagnostic adjuncts to a whole-body MSCT based algorithm,[21,23] we analyzed the two concepts with regard to time.

Objective of this article was to describe time requirement of two different diagnostic approaches to multiple trauma, one with whole-body-MSCT (MSCT-Trauma-Protocol) as the sole diagnostic procedure and one with conventional use of radiography, combined with abdominal ultrasound and organ-focused CT (Conventional-Trauma-Protocol).

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PATIENTS AND METHODS

Protocol Design

This investigation is a retrospective data analysis based on a chart review. Exemption was obtained by the institutional review board.

Two abstractors were trained in the use of the medical charts, the hospitals clinical information system and the picture archiving and communication system. The abstractors, checking the trauma registration, identified all patients, who were treated by the trauma team in the resuscitation area. Patients' data were anonymized and subsequently entered in a standardized abstraction form. The variables of interest were three time periods, demographics and the Injury Severity Score (ISS). These variables are objective numbers, which are routinely registered in the chart of any trauma patient, which is treated in the trauma resuscitation room. Meetings were not scheduled regularly but meetings took place in case of unexpected problems or questionable data. The investigators performed spot checks to monitor the performance of the chart abstractors. There was no blinding of the reviewers.

Setting

Since 2004, our Level I trauma center uses whole-body MSCT for initial and sole radiologic diagnostic workup of patients with suspected multiple injuries.[23,24] The CT scanner is located directly in the trauma resuscitation room. Before the introduction of MSCT in our trauma algorithm, conventional radiography in combination with abdominal ultrasound and organ-focused CT were the diagnostic measures used in the early treatment phase of multiple trauma care. The change in concept was due to the new construction of the Wuerzburg University Surgical center. The two different algorithms are described as follows.

MSCT-Trauma-Protocol

The diagnostic part of our polytrauma algorithm is now based on whole-body MSCT as the first line diagnostic tool in trauma patients who are supposed to be major trauma victims according to a triage rule (Table 1).[21,25] Trauma patients who fail to meet the triage criteria are supposed to be minor trauma victims and are managed with a focused plain film-based concept.

A multislice CT with a 16-row-scanner ("Sliding Gantry"—Somatom Sensation 16; Siemens AG Medical Solutions, Forchheim, Germany) is located directly in the resuscitation area of the trauma suite. Any life-saving procedures including airway management, emergency laparotomy, or thoracotomy can be performed on the carbon CT-examining and intervention table.[23] Before starting the MSCT, history is taken from the prehospital referring emergency team and a physical examination is performed according to priority based standard of care and life threatening conditions are treated immediately. Focused assessment with sonography for trauma (FAST) is performed in hemodynamically unstable patients.

The CT-scan starts, when life-threatening problems have been resolved. Any devices like respirator tubing, central

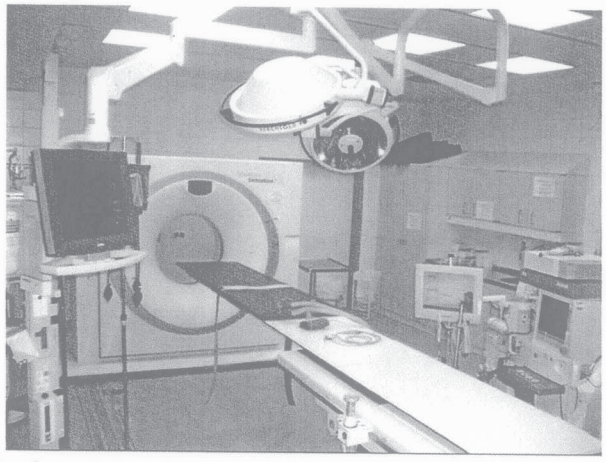

Fig. 1. *Resuscitation area with multislice CT (16-row-scanner) ("Sliding Gantry"—Somatom Sensation 16; Siemens AG Medical Solutions, Forchheim, Germany).*

Table 1 Triage Scheme for Whole-Body MSCT Indication

Category I Mechanism of Trauma	Category II Clinical Apparent Injuries	Category III Vital Signs
Falls >5 m	Open chest	Intubated patient with an initial GCS <9 on scene
High speed crash	Flail chest	Respiratory rate <10 or >29
Crash against a truck		
Pedestrian run over		
Patient trapped in the car	Open abdominal wound	Blood pressure <80 mm Hg
Roll over		
Head-on collision		
Ejection from auto		
Death in same passenger compartment		
Explosion, buried person	Major pelvic injury	Pulse oxymetry <90%
	Two or more proximal long-bone fractures	
	Amputation proximal to wrist or ankle	

If one parameter is positive, serious injuries in one or more organ systems are suspected and MSCT is initiated.
GCS indicates Glasgow coma scale.

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Table 2 Predefined Scan-Protocol of the Whole-Body Multislice Computed Tomography

	Series 1 (Head and Cervical Spine)	Series 2 Thorax and Abdomen (Early)	Series 3 Thorax and Abdomen (Late)
Slice thickness	2 (spine)–5 mm	3 (spine)–5 mm	5 mm
Collimation	16 × 0.75	16 × 0.75	16 × 0.75
Contrast media	No	Yes	Yes
Contrast media flow	No	3 mL/s	3 mL/s
Total contrast media			150 mL

venous lines, etc can be left unchanged in their position, while the mobile "sliding CT-gantry" is moving from toe to head of the patient (Fig. 1).

The whole-body MSCT is performed according to a predefined standardized protocol (Table 2). After the scans have been completed, the algorithm continues with a physical reassessment of the patient and necessary emergency interventions. In the meantime, the acquired data of the CT-scans are processed and evaluated by a staff radiologist. The patient's condition and the findings on the CT-scan define the further treatment plan. The patient is transferred either to the operating room (OR) or to an intensive care unit (ICU).

Conventional-Trauma-Protocol

The former emergency room was equipped with an X-ray unit and a mobile ultrasound system. With arrival of the patient, the trauma team started with priority orientated resuscitation. After life-threatening problems had been resolved, the diagnostic workup was started with plain films of the chest, the pelvis and the cervical spine and FAST. Additional plain-films were made depending on further suspected injuries. Reassessment of the patient was done and necessary emergency interventions were performed before the patient was transferred to the radiology department for organ-focused CT. The CT scanner, that was used in group II for organ focused CT, was a single slice helical CT (Somatom plus 4 Siemens AG Medical Solutions, Forchheim, Germany). The technical details are shown in Table 3.

The diagnostic period was finished with the end of the CT examination. CT-scans were processed, hard copies had to be generated and evaluated by a staff radiologist. The patient's condition and the findings on the CT-scan were defining the further treatment plan.

The structure, composition, and the training of the trauma team kept unchanged over time. Therefore one might assume that there was no difference in experience and decision making capability. To guide therapy all patients received an arterial and a central venous line during their course in the resuscitation area. Acquisition of laboratory results was similar in both groups as samples were drawn early in the resuscitation phase and were brought to the laboratory by emergency courier. Physical examination is conducted because of clinical priorities in both groups (airway, breathing, circulation, neuro examination) similar to the primary survey of the Advanced Trauma Life Support.

Table 3 CT Specifications of the Scan Protocol Used in Group II

	Head	Spine	Trunk (Chest and Abdomen)
KV	120	140	120–140
Tube current (mA)		170	170
Detector configuration	1 × 5/8	1 × 3	1 × 8
Table speed/gantry rotation	×	4.5	12
Reconstructed Slice thickness	5/8	3	8
Gantry rotation time (s)	1,5	1.5	0.75
Contrast media (mL)	×	×	120
Contrast media flow (mL/s)	×	×	3

The trauma team in both groups consists of

- two anesthesiologists (attending and resident)
- two surgeons (attending and resident)
- one trauma surgeon (attending)
- one radiologist (attending)
- one to two anesthesia nurses, one to two surgical nurses, and two radiology technicians.

Neurosurgery, Heart and Thoracic Surgery, Urology, Pediatric Surgery, Maxillofacial Surgery, and Otorhinolaryngology are consultant specialities. They are available within 15 minutes 24 hours/day.

Selection of Participants

Two groups of patients were analyzed retrospectively. Group I: Patients with suspected multiple trauma treated with the MSCT-Trauma-Protocol in 2004. Group II: Patients with multiple trauma treated with the Conventional-Trauma-Protocol in 2002.

Inclusion criteria for patients of group I: Suspicion of blunt multiple trauma according to triage (Table 1), which triggers the admission to the trauma resuscitation area and the use of whole-body MSCT-Trauma-Protocol.

Inclusion criteria for patients of group II: Suspicion of blunt multiple trauma according to the triage (Table 1), which triggered the admission to the trauma resuscitation area and the use of Conventional-Trauma-Protocol.

Exclusion criteria: Patients who required immediate emergency laparotomy or thoracotomy were excluded from the analysis. Patients who were treated by Conventional-Trauma-Protocol (group II) and did not require organ focused CT examination were also excluded from data analysis.

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Methods and Measurement

Three time periods were analyzed for both groups:

- Resuscitation time (period A): time from patient's arrival in the resuscitation area to the end of life saving procedures. This point is determined by the staff anesthesiologist who signals, when there are no more unresolved problems in the categories airway, breathing, and circulation. Period A was chosen to analyze whether resuscitation speed was adequate in both groups.
- Diagnostic time (period B): time from patient's arrival to the end of diagnostic procedures including CT. Also included are the first online image interpretations by the radiologist. Period B was taken to compare the time requirement of both algorithms to complete all diagnostic procedures.
- Total stay in the trauma resuscitation area (period C): time from patient's arrival until announcement of the definitive diagnosis and treatment plan (ICU, OR, etc.). The definitive treatment plan is devised by the staff surgeon, staff trauma surgeon and the staff anesthesiologist. They decide on further treatment options. In the case of traumatic brain injury, the neurosurgeon is involved in the decision process.
- In group II, the anatomic area, which was scanned by computed tomography, was documented.
- To assess whether there are any differences related to the severity of injury, patients were divided in three different subgroups according to their ISS. An ISS from 1 to 15 was considered as light injury, from 16 to 24 as moderate injury and from 25 to 75 as severe injury.[26–29]
- To evaluate the cost-efficiency of the two methods, we calculated the costs for a single whole-body MSCT, the costs for the complete diagnostic workup of group II and the costs of the trauma team per minute.

Data Collection and Processing

A chart review was performed. Data collection included demographics, the ISS and the duration of the time periods A–C.

Primary Data Analysis

Normal distribution of the data could not be demonstrated with the Kolmogorow-Smirnow test. Therefore, data are shown as median with interquartile range (IQR, 25% to 75% percentile). A nonparametric test (Mann-Whitney Rank Sum Test) was used. A p value less than 0.05 was considered significant.

RESULTS

By checking the trauma registration, we found 161 trauma patients meeting the inclusion criteria, with 82 patients in group I and 79 patients in group II.

All patients were treated by the trauma team in the resuscitation area. All patients of group I received a whole-body MSCT. All patients of group II underwent an organ-focused CT after finishing the diagnostics with plain film radiographs and abdominal ultrasound.

Table 4 Anatomic Sites of Injury with an AIS ≥3

Anatomic sites (AIS ≥3)	Group I	Group II
Head	34	32
Face	5	6
Thorax	38	39
Abdomen	23	20
Spine	13	15
Pelvis	14	12
Extremities	25	20

In group I, there were 25 women (30%) and 57 men (70%), with an average age of 39 years (range, 8–82). The ISS in group I was 24 (11–33) (median and IQR). In group II, there were 19 women (24%) and 60 men (76%), with an average age of 36 years (range, 3–91). The ISS in this group was 22 (11–32) (median and IQR). The groups were comparable with respect to demographics and ISS. In group I, there were 55 patients with an ISS ≥16, whereas in group II there were 46 patients with an ISS ≥16. Those were considered to be major trauma victims. The difference was not significant. No difference was found in the distribution of the injured body regions with an AIS ≥3 (Table 4).

In patients with ISS 1 to 75, the total stay in the emergency department (period C) was 47 minutes (37–59 minutes) (median and IQR) in group I and 82 minutes (66–110 minutes) (median and IQR) in group II, respectively. This was a significant ($p < 0.001$) 47% absolute reduction in time needed to devise a definitive treatment plan and to transfer the patient from the emergency room to definitive treatment. The diagnostic workup (period B) was finished after 23 (17–33) minutes (median and IQR) in group I and after 70 (56–85) minutes (median and IQR) in group II ($p < 0.001$). Period A (resuscitation time) took 13 (10–17) minutes (median and IQR) in group I and 10 minutes (8–12 minutes) (median and IQR) in group II ($p < 0.001$). The results of the three subgroups (ISS 1–15; 15–24; and 25–75) are shown in Table 5. The time needed for conventional plain film diagnostics in group II was 30 minutes (19–40 minutes) (median and IQR). The different anatomic areas which were examined by organ-focused CT for patients of group II, the estimated radiation dose for the patients of group II and the calculated costs for their CT-scans are shown in Table 6.

According to the exclusion criteria, there were 19 patients who were excluded from analysis in group II, since they did not undergo organ focused CT. For these patients, the time for getting radiologic tests was 25 minutes (14–34 minutes) (median and IQR). Their total stay in the resuscitation area was 52 minutes (32–64 minutes) (median and IQR).

The costs for a single whole-body MSCT examination are calculated with 680 Euro. The costs for the conventional plain films with abdominal ultrasound are 176 Euro, the costs

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Table 5 ISS, Data for Periods A–C Are Shown in Minutes With Median and Interquartile Range

ISS 1–15	Group I (n = 27)	Group II (n = 33)	*p*
Period A	12 (10–16)	10 (8–12)	<0.015
Period B	18 (14–24)	61 (54–70)	<0.001
Period C	41 (37–54)	70 (65–95)	<0.001
ISS	6 (3–11)	9 (6–12)	0.057
ISS 16–24	**Group I (n = 14)**	**Group II (n = 11)**	***p***
Period A	12 (8–15)	10 (9–15)	1.0
Period B	25 (20–32)	80 (71–107)	<0.001
Period C	49 (36–55)	115 (84–123)	<0.001
ISS	19 (18–22)	22 (18–22)	0.443
ISS 25–75	**Group I (n = 41)**	**Group II (n = 35)**	***p***
Period A	14 (11–19)	9 (8–11)	<0.001
Period B	27 (20–36)	70 (57–90)	<0.001
Period C	50 (40–64)	80 (66–118)	<0.001
ISS	33 (27–38)	33 (28–36)	0.715

ISS is shown as median and interquartile range.

Table 6 Anatomic Areas Investigated by Organ Focused CT in Group II

Anatomic Areas (Organ Focused CT) Group II	Number of Patients	Radiation Dose (Including 2 mSV Calculated for Conventional Radiography)	Costs (Euro)
cCT	44	7	230
cCT + spine	13	8	218
cCT + chest	10	10	493
cCT + abdomen	10	18	528
Whole-body CT	2	20	680

cCT, cranial computed tomography; radiation does and calculated costs.

for organ focused CT are shown in Table 6. The calculated costs for a physician averages 0.59 Euro/min, for a nurse and radiology technicians 0.43 Euro/min, respectively (Finical Times Germany, September 2007). According to this, the estimated personal costs for the trauma team is 6.12 Euro/min (seven physicians, four nurses, two radiology technicians).

DISCUSSION

The time needed to move patients with major trauma from the resuscitation area to definitive treatment was 47 minutes in group I (MSCT-Trauma- Protocol) and 82 minutes in group II (Conventional-Trauma-Protocol). These findings suggest a more rapid diagnostic workup when using whole-body MSCT as a primary diagnostic tool in patients with suspected multiple injuries, which is associated with a more speedy decision for further treatment and an earlier transfer from the emergency room (period C). The reason for some of the observed differences might be explained by the different logistic conditions in the both groups. After resuscitation and completion of the plain film radiologic tests, the patients of group II had to be transferred to the CT room, which was located on the second floor of the emergency department (the average transfer took less than 10 minutes). Therefore, the patient had to be moved from the intervention stretcher to the transport stretcher and back to the CT-examination table. These circumstances highlight the advantages of the whole-body MSCT concept while hazardous and time wasting repositioning and transport of patients is avoided. Furthermore, all patients of group II had emergency ultrasound (FAST) and conventional X-ray studies before the CT-Scan, which might explain the longer duration of period B in that group. It is a methodological problem, that two different CT scanners were used in that study. In contrast, only the development of MSCT has led to such substantial refinement in the diagnostic workup that the chance was brought up to use this diagnostic device in the early phase of trauma care. To address this confounder, we calculated the time needed for conventional plain film diagnostics in group II. In median, this workup took 30 minutes (19–40 minutes). Adding the time needed for resuscitation, there are approximately 40 minutes needed before organ-focused CT could be initiated in group II. At this time, group I has already finished the diagnostic workup after 23 minutes (17–33 minutes). Even if MSCT would have been used for organ-focused CT in group II, it remains evident, that without conventional radiographs the diagnostic workup can be substantially accelerated.

It was part of both protocols that all patients who remained hemodynamically unstable despite sufficient resuscitation measures (fluid, chest drain, etc.), received FAST. Those are the patients potentially requiring immediate abdominal surgery, without further diagnostic tests to be performed. Therefore, the risk for delay in patients who require emergency celiotomy or thoracotomy should be minimized in group I and group II. In the hemodynamically stable patients with abdominal injuries, the management decisions are largely based on CT findings as CT classification and monitoring of hepatic and splenic trauma have led to greatly reduced operative management of these injuries.[30]

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The time between completion of the diagnostic workup and formulation of the definitive management plan was twice as long in group I as in group II (24 minutes vs. 12 minutes). This might be explained by the fact, that in group II, the diagnostic results of the radiologic examinations are sequentially acquired and, therefore, the management plan is growing over time with the last information obtained after finishing the CT examination. In group I, a huge amount of data are acquired in a short period of time and it takes a considerable time to generate results. Therefore, the diagnostic period is so much faster, while the time between completion of the diagnostic workup and formulation of the definitive management plan is longer, respectively.

We found a reduced resuscitation time in group II, which is unlikely to be related to the radiologic approach since the diagnostic procedures were started after resuscitation. Although period A was shorter in group II, the time requirement for resuscitation in both groups are comparable with the results of other investigators.[2,31]

To our knowledge, there are no randomized and prospective trials comparing whole-body MSCT-based trauma concepts with conventional protocols. Nevertheless, there are a considerable number of published studies which demonstrate that a whole-body MSCT based algorithm is a time saving diagnostic approach in patients with multiple injuries. Rieger et al.[11] found a 40% reduction of diagnostic workup time when using MSCT without getting prior plain film radiography. Kanz et al.[10] needed 21 minutes (median) before finishing the cranial CT. In their trauma algorithm, whole-body MSCT is performed directly in the emergency room with a minor transfer from the trauma resuscitation area to the CT room.[10] These results are comparable with our findings where whole-body MSCT is finished after 23 minutes (median). Hilbert et al.[16] recently reported a significant reduction of treatment time in the emergency room while using a MSCT-based trauma algorithm. Their patients were transferred after 38 ± 19.1 minute (mean/SD) with a complete diagnostic workup.

A possible bias in our study might be caused by exclusion of those patients in group II, who did not receive organ-focused CT. This might have resulted in an overestimation of the time differences.

As the superiority of MSCT is widely accepted for organ-focused diagnostics after trauma,[11,14,17,32,33] its appropriate indication as a sole and primary diagnostic tool remains unclear, especially in those patients with only suspected major trauma. In a recent study, we found overtriage in 30% of our patients (ISS < 16 retrospectively and initial use of whole-body MSCT).[21] In the group of overtriaged patients were 9 of 26 (34%), who had relevant findings in the whole-body MSCT. Eight of them had pulmonary contusions and one had vertebral fractures. The triage criterion, which triggered whole-body MSCT for those patients, was the mechanism of trauma in all cases. From this data we can conclude, that the whole-body scan was of value for these nine patients, since injuries were detected, which probably would have been missed by conventional approach. Although it is well known that most injuries missed in the early phase of trauma management are abdominal or thoracic in origin,[34–36] representing the leading causes for preventable deaths in trauma patients,[12,37,38] we found an overtriage of 30% still acceptable in patients with suspected multiple injuries. Nevertheless the triage rule has to be further optimized by identifying those parameters predicting the optimal indication for whole-body MSCT to reduce the risk of overscanning.

Main concern while using whole-body MSCT for screening trauma patients is higher radiation dose. A comparison of radiation exposure from whole-body MSCT and conventional radiography with organ-specific CT was published by Wedegartner et al.[39] On the basis of this data, we calculated the average radiation dose for group II with 9.2 mSv (Table 6) and is therefore about 10 mSv less when compared with group I (whole-body MSCT approximates 20 mSv). This data corresponds to the results of other investigators.[40] How can we identify those patients who might really benefit from the early use of whole-body MSCT and what is best for the individual patient with regard to potential hazard of a higher radiation dose and the risk of missing pertinent injuries, which might contribute to fatal outcome? Corresponding to the data of the annual report of the International Commission on Radiologic Protection (ICRP), the risk of fatal cancer per 10 mSv radiation dose is 1/1,777 patients. In 1,777 patients, we find a risk for the spontaneous development of fatal cancer in 355/1,777. The risk for missing serious injuries in patients with multiple injuries is described by Houshian et al.[41] The authors report 86 missed injuries in 786 trauma patients. Of the patients with missed injuries, 31.4%, mostly abdominal, needed surgery. Four patients died because of missed injuries, seven had fatal outcome. Most missed injuries were not suspected by the trauma team, but 34.9% of the reported cases the results of radiographs, ultrasound or CT-scan were misinterpreted by radiologists. Therefore, 65% of the injuries probably would not have been missed when whole-body MSCT would have been used as a screening method; the risk benefit ratio is that 1 whole-body MSCT per 302 patients might have saved one life, whereas 10 mSV might be responsible for the development of one fatal cancer in 1,777 patients. Gruen et al.[42] reported two missed intraabdominal injuries responsible for fatal outcome in 2,594 trauma deaths. So MSCT might have saved one life in 1,297 patients as it is supposed to be the gold standard in diagnostic of the traumatized thorax and abdomen,[11,12] especially in those blunt abdominal injuries with minimal or even without intraperitoneal fluid, which are at high risk to be missed by conventional diagnostic tests.[43]

Our presented data are invalid to give direct information with regard to outcome. Although time requirement does not measure outcome, the examined time intervals (period A–C) in our study are established benchmarks in clinical care.[6,8,16,44–46] Furthermore, a delay in proper surgical care is a major cause for preventable deaths in trauma care and the

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earliest possible identification of potential lethal injuries is mandatory for optimal trauma care.[1,47–49] Therefore, rapid depiction and therapy of injuries which are well known to cause fatal outcome in the first 24 hours after trauma[47–49] is mandatory. Our data do provide a frame of reference for times associated with different trauma protocols and indicate that whole-body MSCT in the early phase of multiple trauma care might speed up trauma diagnostics.

Economic evaluation of the whole-body MSCT program might be performed on the basis of a cost-effectiveness analysis. The estimated personal costs for the resident trauma team are 6.12 Euro/min. The costs for a single whole-body MSCT examination are calculated with 680 Euro. Because the operating time of the entire trauma team in the trauma emergency room is shortened significantly (median, 35 minutes), a cost saving effect of 214.20 Euro per trauma patient has to be considered. The costs for the conventional plain films with abdominal ultrasound are 176 Euro. According to Table 6, the average costs for each patients of group II are calculated with 490 Euro. The costs for each patient of group I, who received whole-body MSCT are 680 Euro and, therefore, 190 Euro more expensive when compared with group II. In contrast, in group I, total expenditure is reduced by 214 Euro, because the operating time of the trauma team in the trauma emergency room is shortened significantly (median 35 minutes). With regard to the total costs and time expenditure, no significant difference between those two concepts can be established.

It is a major limitation of our investigation, that it was performed as retrospective study based on data of a chart review. Prospective, randomized and controlled trials will be necessary to further evaluate whether MSCT based diagnostic approach is superior to conventional approach with plain film radiography and further research will be necessary to learn identifying those trauma patients who will benefit from using whole-body MSCT in the early phase of multiple trauma care.

CONCLUSION

Whole-body MSCT is a valuable diagnostic tool in patients with multiple injuries. It might speed up the diagnostic workup and might shorten the total stay in the emergency department. A final recommendation, which diagnostic approach should be employed, cannot be delineated from our results.

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New aspects in the emergency room management of critically injured patients: A multi-slice CT-oriented care algorithm

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KEYWORDS
Critically injured patient;
Multi-slice computed tomography;
Emergency room;
Algorithm;
Time

Summary

Background: Time-critical care of seriously injured patients is gaining more and more significance. The availability of the multi-slice CT allows a complete diagnostic assessment of injured patients in 90–240 s, but is presently carried out only at the conclusion of basic diagnostics. We investigated the effects of a clinical algorithm using multi-slice CT scanning ahead of other measures in the clinical care of seriously injured patients.
Methods: Availability of a trauma admitting room with integrated multi-slice CT scanner enabled a new algorithm for patient care. We prospectively examined the time taken to reach established benchmarks in clinical care (completion of diagnosis, completion of resuscitation, exit from the trauma room) under this new approach. Data were collected for consecutive patients with serious injury (estimated injury severity score >15), and compared to historical data from the previous 2 years.
Results: The new algorithm was employed in 139 patients with a mean ISS of 26.93. CT scanning was initiated 8 min (S.D. 5.7) after patient arrival, and concluded 13 min (S.D. 8.4) after patient arrival. Stabilising measures (initial resuscitation) were completed an average of 36 min from patient arrival. The length of stay in the trauma room was reduced to an average of 38 min (S.D. 19.1). Four patients required

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life-saving interventions after admission to the trauma room but before CT scanning began.

Conclusions: A new algorithm for trauma patient care that integrates high resolution CT scanning into the early diagnostic protocol reduces the length of stay in the trauma room markedly, and will facilitate rapid therapeutic intervention in patients with unstable haemorrhagic shock or neurosurgical emergencies.

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Introduction

Time taken to complete diagnostic tests and initiate definitive therapy, the "golden hour" of Cowley,[2] is frequently mentioned in the care of seriously injured patients. Surgical care during the first hour is of the utmost importance to increase the chances of survival.[2] Cowley believed that many injured patients could be saved if bleeding could be stopped and blood pressure stabilised during the first hour of shock. Others, following the concept of the "golden hour," have also postulated that lethality in poly-trauma can be reduced by decreasing the time of treatment.[1,6,8,17]

When studying the pathophysiological changes that occur during shock, with the appearance of low or no-flow states, anaerobic glycolysis, ATP reduction under low energy,[11] and reperfusion damage, one realises that the shorter the interval of shock, the higher the survival rate in poly-traumatised patients. Treatment of the seriously injured should always be considered a time-critical process.

This concept gains significance as patients with more severe injuries survive to reach the hospital, and as diagnostic modalities multiply. Despite an understanding of the need for expedited therapy, many trauma centres prove to have difficulty in the timely optimisation of early clinical treatment. Further development of diagnostics, particularly of the multi-slice CT scanner, may offer a new approach to early trauma care. Can a new trauma-algorithm, modeled around the multi-slice CT, shorten the diagnostic interval for suspected victims of poly-trauma?

Our goal in developing this algorithm was the reduction of primary treatment time, by elimination of redundant diagnostic studies (initial ultrasound and plain film radiography) and the need to relocate the patient for CT. In prospectively studying the application of this algorithm we have sought to define the time taken to identify life-threatening injuries, complete the diagnostic work-up, and prepare the patient for the next phase of care (operating room or intensive care unit).

Methods

Prerequisite to this work was the integration of a multi-slice CT (16 slices) into the trauma room. Further, the trauma room was prepared to allow complete primary diagnosis and treatment in one place. Afterwards, the process of treating seriously injured patients was changed according to a newly compiled algorithm (Fig. 1). We enrolled victims of high velocity road traffic accidents suspected of

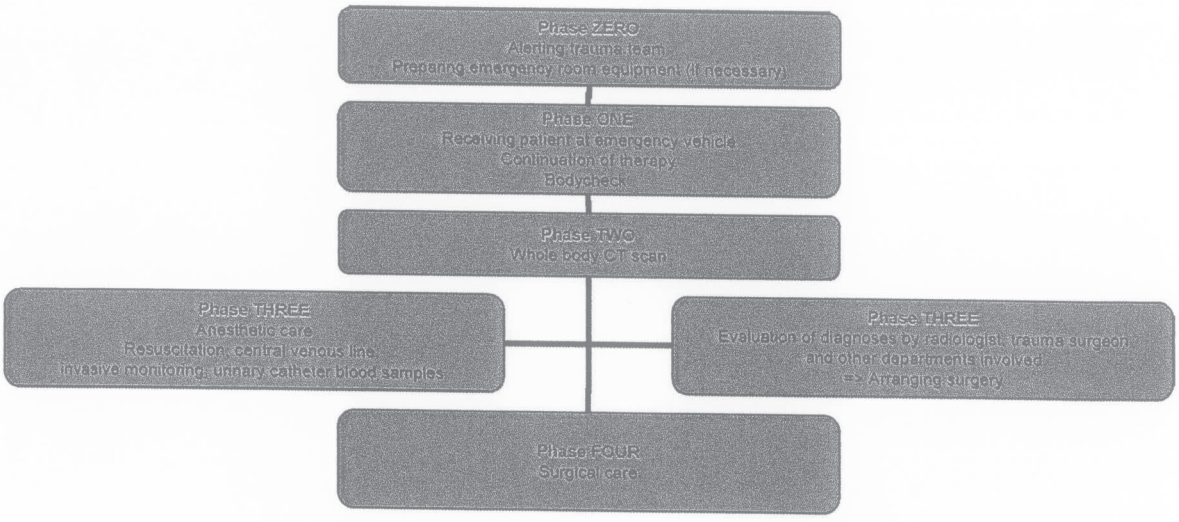

Figure 1 Polytrauma algorithm at BG-Hospital Bergmannstrost.

having serious injuries (Injury Severity Score [ISS] >15). These patients required primary intubation and ventilation, and were admitted by the emergency doctor. They were enrolled based on the severity of the accident, or because of the clinical impression of severe injury, and were treated in accordance with the new algorithm. All other patients were treated according to the current recommendations issued by the German Society of Trauma Surgery.

Provision of care is as follows: the anaesthesia team and trauma surgeon receive the patient at the respective emergency vehicle (Fig. 2). The patient's condition is evaluated on the basis of previously provided information (accident details, injuries suspected by the emergency doctor, vital parameters collected at the scene of accident, etc.), and an initial visual assessment. Therapy initiated by the emergency doctor is continued, and the patient is moved into the trauma room accompanied by the emergency and the clinic teams.

In the trauma room, a brief examination of the undressed patient is made by the trauma surgeon, and the patient is put onto the gantry of the CT table, which is especially designed for this purpose. Moving the patient further is not necessary until the time of transfer to surgery or intensive care. The procedure up to the time of moving the patient onto the CT board is based on the "ABCDE" of the ATLS® (Advanced Trauma Life Support). The anaesthetist is responsible for task A (airway), task B (breathing), and task C (circulation). The trauma surgeon is responsible for task D (disability), and task E (exposure/environment). Obviously life-threatening A, B or C problems (e.g. tension pneumothorax) are treated immediately, if required. Prior to inducing other stabilising measures, contrast medium-supported CT scanning is completed in the bravo phase of the current algorithm.[13,18] Resuscitative fluid therapy is continued throughout. Based on the information gathered and an initial brief clinical examination, the trauma surgeon, in his position as trauma leader, decides if CT of head and trunk (skull, thorax, abdomen, pelvis, including the spinal cord) is sufficient or if a complete CT, down to the bottom of the feet, is necessary. A non-contrast CT of the head is done first, followed by a contrast medium-supported spiral CT.

CT diagnosis is started during the so-called bravo phase of the current German trauma algorithm,[13,18] and concluded by the time this phase ends. Further measures to stabilise the patient begin after the conclusion of CT scanning (Fig. 3). While the patient is receiving intensive medical attention and is being stabilised, the trauma surgeon, radiologist, and attending specialists from different departments (neurosurgery, etc.) evaluate the pattern of injury based on the available clinical information, the initial examination, and images of the CT. A plan for further therapy and potential diagnostic procedures is established.

Patients with severe traumatic brain injury undergo invasive intracranial pressure monitoring or trepanation in the trauma room, if indicated. Laparotomy or thoracotomy may also occur in the trauma room, in the unstable patient, or may be initiated in the delta phase of the previous algorithm, after transfer of the patient to the OR. The

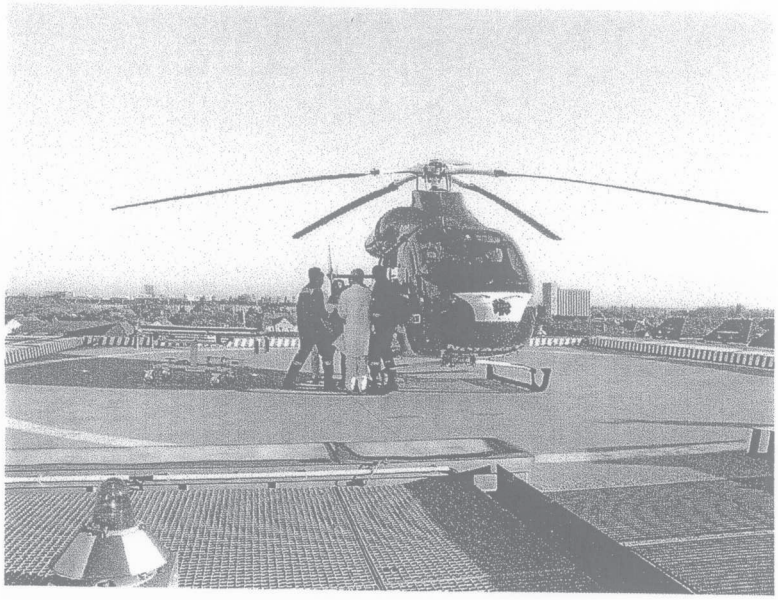

Figure 2 Trauma surgeon and anaesthetists receive patient at the rescue helicopter.

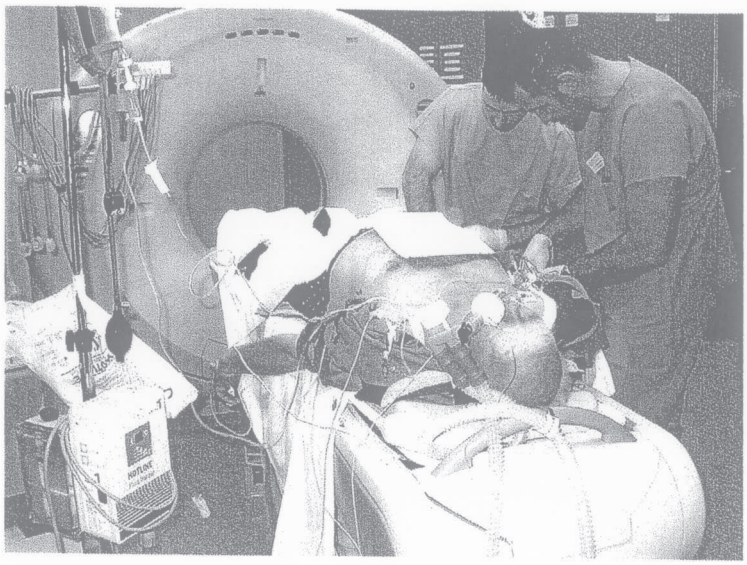

Figure 3 Caring for patient on CT table.

trauma room and diagnostic unit are rapidly vacated and ready for further use.

Results

Between January and December 2004, 139 patients (30 female/109 male) were treated in the trauma room according to the aforementioned procedure. The mean age was 42.2 years and the mean ISS of the treated patients was 26.93.

Twelve of the 139 patients died (8.6%). Four patients who were undergoing CPR before arriving at the clinic died in the trauma room within minutes of arrival. Three patients died of uncontrollable bleeding within the first hours of care, three died from unmanageable intracranial pressure and two from multiple organ failure during intensive therapy. One emergency thoracotomy and one laparotomy were required in the trauma room.

Twenty-five of the enrolled patients were found to having an ISS <15 despite meeting the inclusion criteria.

Length of stay in the trauma room (from the time of patient arrival at the clinic up to relocating the patient to the operating room or ICU) was significant reduced from 87 min (own data from 2000 and 2001) to 38 min (S.D. ±19.1) on average.

Mean duration of complete CT diagnostics (native head CT + contrast medium-supported whole-body CT) was 4 min (S.D. ±5.71). Technical problems during the application of contrast media were the principal cause of delay. From the time of patient arrival up to CT initiation required 8 min (S.D. ±5.7) on average (Fig. 4). Diagnostics were thus completed an average of 13 min (S.D. ±8.4) after patient arrival. Life-threatening injuries (e.g. epidural haematoma, intrathoracic vascular injuries, injuries of the liver and/or spleen with heavy bleeding) were diagnosed within 15 min of arrival.

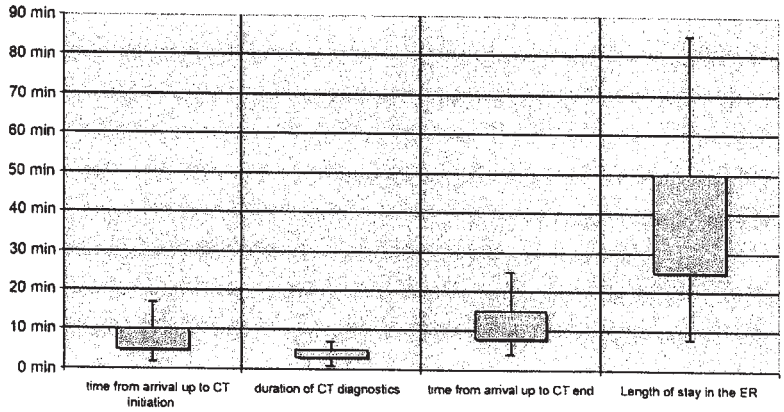

Figure 4 Box plots of the different times in the ER.

No relevant or life-threatening injuries were diagnosed in any patient after the end of the trauma room algorithm.

Seventy-five percent of the patients required initial surgery and were transferred to the OR all other patients were transferred to the ICU.

Anaesthetic care and stabilising measures included confirmation of endotracheal intubation and adequate ventilation, invasive measurement of arterial blood pressure, placement of a central venous catheter, and initiation of volume therapy. These measures took 24 min (minimum 4 min/maximum 75 min) on average, and were undertaken concurrently with the process of CT scanning.

Discussion

Diagnosis of a critically injured patient must detect life-threatening injuries, find relevant dysfunction-threatening organ lesions, and evaluate systemic distress as rapidly as possible.[4] To meet these requirements, a structured and time-critical procedure is necessary. The poly-trauma algorithm of Nast-Kolb[13] has gained acceptance in most German clinics.[3]

In our estimation, the evolution of multiple-slice CT as the most important diagnostic study in trauma care should force a re-evaluation with respect to early primary clinical treatment. The existing criteria: a "prerequisite for CT examination is a stable patient not requiring emergency surgery"[9] cannot be maintained with respect to the new CT technique. With complete examination with multiple-slice technique requiring only 2–4 min, the CT can carry the burden of diagnosis. The quality of images is excellent, and the content of information and the speed at which the information is provided surpasses all previous diagnostic modalities. Life-threatening injuries are shown within minutes and the final report of the injuries by the radiologist is finished 45–60 min after patient arrival. Conventional X-rays of thorax, pelvis, spine and extremity are no longer required, and even early ultrasound is not necessary. In 1996, Navarrete-Navarro et al.[14] demonstrated the benefit of the CT and current data by Kanz et al.,[10] Wurmb et al.[20] and Hessmann et al.[7] demonstrate the benefit of multiple-slice CT when employed in the care of seriously injured patients.

The data collected by the multi-slice CT allows calculating X-ray like images of all parts of the body, so there is no need for conventional plain X-rays of the extremities. Even early ultrasound (FAST) is not necessary in our approach. The CT scan is almost as fast as the FAST done by an experienced investigator but the quality of the images and the information of the contrast medium abdominal CT surpasses the ultrasound. The ultrasound remains an important diagnostic tool in the further course of patients with abdominal trauma.

Elimination of the need to move the patient from the trauma room to the location of the CT scanner is an enormous benefit. Anaesthetic procedures are markedly simplified by treating the patient in the trauma room, and by avoiding additional transportation and therefore minimising the chance of iatrogenic injury. The speed and focus of therapeutic procedures also benefits from the rapid and immediate interpretation of CT images by the radiologist and trauma team leader. Parallel involvement of all departments in the care of the patient is clearly an advance, e.g. stabilising the patient by the anaesthetic team on the one hand and on the other hand securing diagnosis and planning surgery by the trauma surgeon, neurosurgeon, radiology and others (vascular, ENT, facial surgery, etc.). By reducing the time of diagnosis, the surgical procedure may be initiated earlier, and may therefore lower the rate of mortality in seriously injured patients. By integrating a multi-slice CT into the trauma room of the University at Leipzig, the time required for CT examination was reduced from 28 to 16 min, with an associated decrease in mortality rate of 4%.[12]

We observed, compared to the time before the ER-CT, that the mortality decreased from almost 15% to 8.6%. We are unable to say if it is only the ER-CT or the progress in the ICU-treatment that lead to the lower mortality. We believe it is the combination of both.

Concern has been expressed that early total-body CT will increase the radiation dose received by the patient, but this issue must be taken in context. First, many conventional X-rays can be avoided with rapid CT, and second, newer generation CT scanners can obtain high resolution images at much lower total radiation and contrast doses than previously required. Wedegärtner et al.[19] showed that a whole body multi-slice CT scan compared with conventional X-rays, while organ specific CT scan may lead to a total radiation dose as much as three times greater.

Conventionally, an average of 15 min[16,17] is required for basic radiologic diagnosis (sonography, cervical spine, thorax, pelvis), even in tightly structured programs. Next to the time needed for diagnosis, the need for patient relocation for CT causes an unnecessary loss of time, not to mention the additional risk of transportation trauma. Häuser et al.[5] showed in their patients that a total of 31.9 min passed unused which could be spent on diagnosis. If diagnosis is completed faster, as in the

algorithm presented, this time can be better spent in life-saving therapeutic maneouvres such as intracranial evacuation or haemostatic surgery.

Previous algorithms do not conform to current diagnostic resources, and reorientation is therefore urgently required. In our estimation, the algorithm studied here seems sensible for seriously injured patients. Whenever possible, the following should occur prior to arrival of the patient (called Phase ZERO at our clinic): alerting the trauma room team, preparation of CT and trauma room equipment (e.g. contrast medium, Level One®, CATS®), and availability of surgical capacity. Phase ONE follows subsequently with: receiving the patient in the emergency vehicle, continuation of therapy initiated by the emergency doctor, application of life-saving measures (if necessary), and brief physical examination (ABCDE-ATLS®). Phase TWO includes complete CT diagnostics with contrast medium, and should take approximately 4 min. The subsequent Phase THREE combines ongoing anaesthetic care (start of invasive monitoring, resuscitation and stabilisation measures) and, in parallel, review of the diagnostic information by the radiologist and trauma surgeon, and planning of necessary therapeutic procedures. In Phase FOUR, surgery is initiated and if surgery is not required the patient is transferred to the ICU.

Use of CT prior to intensive medical care raises questions. The algorithm described delayed intensive medical care of patients by 4–5 min only, while significantly advancing the diagnostic information available to the clinicians. During CT diagnosis, basic therapeutic activities, such as ventilation, analgesia and sedation, and volume-replacement therapy can continue. The algorithm mentioned could be employed successfully even during CPR. Omitting conventional X-rays and initial ultrasound provide a substantial benefit.

Integration of the CT directly into the trauma room is a basic prerequisite for the employment of the algorithm introduced. Relocation is omitted, integrated trauma room care is ensured and transport trauma[15] minimised. Diagnosis and therapy are carried out in one location. Only hospitals meeting this respective requirement may employ the algorithm described. In hospitals not meeting this requirement, the current algorithm[13] is probably still the safest. Critical examination of this topic will result in the optimisation of patient care.

Conclusion

Care of seriously injured patients must be carried out as rapidly as possible, and reducing the time needed for pre-clinical and clinical care is always desirable. Rapid CT scanning is sensible and practicable. In consequence, departure from the so-called "traditional" care algorithm is essential. Rapid and complete initial CT diagnosis reduces the length of time in the trauma room markedly, and should significantly improve clinical outcomes. Life-threatening injuries are identified within a matter of minutes and appropriate therapy initiated. A prerequisite for the employment of the concept introduced is the integration of a multi-slice CT into the trauma room, transforming it into a "one stop shop" for diagnosis and therapy. We believe that this model should be the norm for future trauma centres and trauma programs.

Conflict of interest statement

There is no conflict of interest.

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Emergency Room Management of Patients With Blunt Major Trauma: Evaluation of the Multislice Computed Tomography Protocol Exemplified by an Urban Trauma Center

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Background: The early clinical management of patients with major trauma still represents a challenge. To clinically evaluate the full extent of a patient's injuries is difficult, especially when the patient is unconscious. Before December 2002, trauma patients admitted to our emergency room (ER) underwent a diagnostic protocol including physical examination, conventional radiography (CR), sonography and further procedures if necessary. After the installation of a MSCT scanner, all trauma patients underwent the "MSCT protocol" immediately after admission. The aim of the study was to compare the "MSCT-protocol" as it is performed at our institution, with the "Pre-MSCT-protocol".

Methods: We compared 185 patients undergoing the "Pre MSCT-protocol" with 185 patients undergoing "MSCT protocol". We evaluated the efficacy, speed and accuracy of the "MSCT protocol" using several variables. Time periods from admission to the ER to admission to the intensive care unit were compared as well as outcome parameters such as length of ICU stay, ventilation period and rates of organ. Dichotomous data were analyzed by Chi-square analysis; continuous data were analyzed by Student's t test. Any values of $p < 0.05$ were considered significant for any test.

Results: No significant differences were found regarding demographic data. The full extent of injuries was definitively diagnosed after 12 ± 9 minutes in 92.4% of the "MSCT protocol" cohort. In only 76.2% of "Pre-MSCT protocol" cohort definitive diagnosis was possible after 41 ± 27 minutes. Total ER time was 104 ± 21 minutes with the "Pre-MSCT protocol" and 70 ± 17 minutes with "MSCT protocol" ($p < 0.05$). "Pre-MSCT protocol" patients had a significantly longer ICU stay than "MSCT protocol" patients ($p < 0.05$). "MSCT protocol" patients had significantly fewer ventilation days (14.3 vs. 10.9 days). Furthermore, rates of organ failure were lower in patients undergoing the "MSCT protocol".

Conclusion: We could demonstrate that immediate MSCT in patients with blunt major trauma leads to more accurate and faster diagnosis, and reduction of early clinical time intervals. We also observed a reduction in ventilation, ICU, and hospital days, and in organ failure rates, though this might have been partly due to small differences in case mix. The "MSCT protocol" algorithm seems to be safe and effective.

Key Words: Multislice computed tomography, Blunt major trauma, Outcome.

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The early clinical management of patients with major trauma still represents a challenge for trauma teams. Adequate treatment during the first "golden hour" may influence outcome. Advanced Trauma Life Support (ATLS) has been accepted as standard in many countries.[1] ATLS clearly states that, after a quick "first survey", resuscitation of the patient has priority over advanced diagnostic procedures. Thus, after the patient has been admitted to the emergency room (ER), vital signs are checked and resuscitation is started. After initial resuscitation, further diagnostic procedures are performed. These may include physical examination, diagnostic peritoneal lavage (DPL), conventional radiography (CR), focused assessment with sonography for trauma (FAST), and finally, computed tomography (CT). This approach, of course, is not applicable to patients with major penetrating trauma, but is still standard for blunt trauma patients in many centers.

To clinically evaluate the full extent of a patient's injuries is difficult, especially when the patient is unconscious. CR is often performed routinely to diagnose fractures[2] but may miss spinal injuries,[3–5] is of limited value in thoracic trauma (lung contusion),[6,7] and is useless in abdominal and brain trauma.[8–11] DPL has low specificity and a significant complication rate.[12,13] FAST is a valuable screening tool but may underestimate intra-abdominal injuries in hemodynamically stable patients.[14–16] For traumatic brain injuries the CT scan is a standard procedure. Frequently, CT scans are also performed after CR or FAST to obtain information on thoracic and intra-abdominal organs. Regarding blunt trauma recent studies suggest that multislice CT (MSCT) protocols are superior to all other examination methods.[17–22] However, even in trauma centers that have MSCT scanners, patients with blunt major trauma are usually admitted to the ER first,

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and then transferred to the MSCT after initial stabilization, CR, DPL, and FAST.

The goal of this study was to investigate the effects of a new management algorithm ("MSCT protocol") where patients with blunt major trauma underwent whole body MSCT scan immediately after admission. The effects of this algorithm were compared with those of a conventional algorithm ("Pre-MSCT protocol") where patients were examined clinically, and then underwent diagnostic procedures (CR, FAST, conventional CT scans).

MATERIALS AND METHODS

The Trauma Hospital Lorenz Boehler, a 130-bed facility founded in 1926, is one of the oldest freestanding trauma hospitals in the world. Annually, there are more than 60,000 patients seen, and more than 6,000 admitted. More than 97% of all patients admitted with major injuries have blunt trauma. Because all cases of major trauma are treated by emergency physicians in the field, almost all patients arrive monitored with an intravenous line in place. Cases that are more serious arrive intubated and ventilated. In December 2002, a new 16-line MSCT (Somatom Sensation Plus 16, Siemens) was installed in the Trauma Hospital Lorenz Boehler, and this led to the development of a new management algorithm for patients with blunt major trauma.

Before December 2002, patients with blunt major trauma were admitted to the ER, vital signs were checked, and resuscitation, including fluid administration, oxygenation or ventilation, and monitoring, was started. The patients were completely undressed and examined clinically followed by examination under whole-body fluoroscopy (Integris, Phillips) to verify or exclude major skeletal injuries. Routinely, CR of head, cervical spine, chest, and pelvis was performed. CR was also done on all regions where long bone or spinal fractures were suspected. The abdomen was checked by FAST. After stabilization of the patients and completion of CR and FAST, the patients were transferred to the CT that was located next to the ER. A CT scan of the brain was routinely done for all patients who were unconscious or neurologically not assessable from other reasons. CT scans of other body regions (e.g. chest, abdomen) were done if lesions were suspected after clinical examination, CR, or FAST. These CT scans were focused on the region of interest only, and were done with or without contrast medium depending on the injury suspected. The whole series of CT scans (including transfer to and from the CT) took from 15 minutes (for brain CT only) to 30 minutes. The patients usually stayed on the CT table during this time. Once images had been analyzed and treatment plans had been made, the patients were transferred to the operating room (OR) or to the Intensive Care Unit (ICU). The hemodynamically unstable patients were moved to the OR shortly after arrival in the ER, usually after clinical examination, chest X-ray, and FAST, and had CT scans after emergency surgery.

Under the new management algorithm, the patients were transported directly to the MSCT located in the center of the ER. During transport from the helicopter or ambulance to the MSCT the attending anesthesiologist checked oxygen saturation (Sao_2), electrocardiogram (ECG), heart rate (HR), and blood pressure (BP) using a small portable monitor, and oxygen administration or ventilation were continued. All patients were placed on the CT table in supine position with the arms alongside the body. The MSCT was started immediately for patients whose vital signs were within an acceptable range (Sao_2 >90%; HR <130 b/min, systolic BP >70 mm Hg). In those few patients whose vital signs were not acceptable, the problem was corrected by intubation and ventilation, or administration of up to 250 mL of hypertonic saline before the start of the scan. This resuscitation protocol with small volume resuscitation (SVR) was performed for all patients and not just for patients with head injury. To patients with prolonged hypovolemia that could not be corrected via SVR and to patients with hematocrit <30%, blood components were administered. O negative blood stored in the ER was administered to patients requiring immediate transfusion.

The full MSCT-protocol (Table 1) was preprogrammed; if parts of the program were not necessary they were cancelled. The first phase was the examination of head and upper cervical spine (to C4/C5) without any contrast medium; cervical collars were left in place. If possible, the patient's arms were then positioned above the head, and the torso was examined after intravenous administration of nonionic contrast medium (Scanlux 370 mg/mL, Sanochemia, Vienna). Arterial contrasted phase for examination of thoracic, abdominal, and pelvic organs (C4 to lesser trochanters) started with a delay of 25 seconds (thoracic scan with "bolus tracking" of the descending aorta at 120 HU). After a 35-second delay the venous perfusion phase was started to examine abdomen and pelvis from the diaphragm to the lesser trochanters (abdominal scan during portal venous phase). Scanogramms were available immediately after data acquisition ("real time MSCT") thus allowing immediate diagnosis of organ lesions. Major organ lesions and pneumothoraces were either excluded or verified almost immediately. After data acquisition, which took less than 10 minutes, the CT table was moved to the most distal position, and the trauma team (anesthesiologist, trauma surgeon, nurse anesthetist, and surgical nurse) started to work on the patient while the multiplanar reconstruction (MPR) of the scans were under way. Images were analyzed and treatment was planned while the patients were resuscitated. During this time of MPR, CR was performed if limb fractures were suspected after rapid clinical survey. Then the patients were transferred either to the OR or to the ICU.

To evaluate the effects of this new treatment algorithm, data from two cohorts of patients were analyzed. The "MSCT protocol" cohort included all 185 patients with blunt trauma admitted between February 1, 2003, and December 31, 2004 with an Injury Severity Score (ISS) ≥17 and at least one life threatening injury of head, thorax, or abdomen with an ab-

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Table 1 MSCT Protocol (Preprogrammed in the ER)

Region	Collimation Voltage Tube Current Rotation Time	Slice Thickness Reconstruction	Contrast Medium Flow	CM-Phase
Head/midface	Sequence 4.5 × 1.5 mm angulated orbitomeatal 120 kV; 320 mAs; 0.5 s	4.5 mm 0.75 mm MPR	None	No CM
Cervical spine	Spiral 16 × 0.75 mm 120 kV; 150 mAs; 0.5 s	3 mm/2 mm 1 mm/0.5 mm MPR coronar and sagittal	None	No CM
Chest	Spiral 16 × 1.5 mm 120 kV; 110 mAs; 0.5 s	5 mm/4 mm 2 mm/1 mm MPR of thoracic spine coronar and sagittal 5 mm/4 mm volume rendering ribs/sternum	110 mL, 3 mL/s; bolus tracking; 120 HU in aorta descendens	Arterial
Abdomen/pelvis	Spiral 16 × 1.5 mm 120 kV; 150 mAs; 0.5 s	5 mm/4 mm 2 mm/1 mm MPR of lumbar spine coronar and sagittal 5 mm/4 mm MPR pelvis coronar	65 s after infusion	Venous with contrasted aorta descendens

MPR, multiplanar reconstruction; CM, contrast medium; HU, Houndsfield Units; kV, kiloVolt; mA, milli Ampere; s, seconds.

breviated injury score (AIS) ≥4, who survived at least until admission to the ICU. The "Pre-MSCT protocol" cohort included 185 patients treated between February 1, 2001 and November 30, 2002 with the same degree of trauma severity, who also survived at least until admission to the ICU. During both periods, 451 patients were admitted to the ER of our institution; 81 of these were not included in this evaluation for various reasons. There were 47 patients who had minor injuries and received outpatient treatment or were transferred to normal wards, 9 patients were dead at admission, another 13 patients died in the ER, and 12 patients with cardiac trauma or aortic lacerations were immediately transferred to the University Department of Cardiothoracic Surgery. The number of deaths, transfers, and minor trauma patients was similar in both periods.

ICU data were extracted from the database of the ICU that contains information on all patients admitted since 1998. Other relevant data were extracted from the hospital information system (Table 2). TRISS[23] and SAPS II[24] analysis was performed to obtain mortality predictions in both collectives. Furthermore, data on organ dysfunction and organ failure were analyzed. Adult respiratory distress syndrome (ARDS) was defined according to the criteria of Murray et al.[25] Presence of multiple organ failure syndromes (MOFS) was evaluated according to the criteria of Goris et al.[26] Renal dysfunction was defined as a decrease in creatinine clearance to <70 mL/min; renal failure was defined as requirement of organ support (hemofiltration or hemodialysis); and liver dysfunction was defined as a >fivefold increase in liver function tests.

All data underwent statistical analysis using standardized SPSS software (SPSS, Inc., Chicago, Ill). Dichotomous data were analyzed by χ^2 analysis; continuous data were analyzed by Student's t test. Any values of $p < 0.05$ were considered significant for any test. Our institutional review board approved the study. However, because no interventions were done, informed consent was not required.

Table 2 Data Extracted From ICU Documentation and Hospital Information System

ICU Documentation System	Hospital Information System
ISS	Diagnoses:
GCS	Conventional radiography
TRISS	FAST
SAPS II	CT
ER time	MSCT
ER-OR time	Minor trauma patients
OR-ICU time	ER mortality
ER-ICU time	Surgical procedures
Fluid load (first 24 h)	
ICU stay	
Ventilation	
ICU mortality	
Total inhospital stay	
Hospital mortality	

ISS, Injury Severity Score; GCS, Glasgow Coma Scale; TRISS, Trauma Score/Injury Severity Score; SAPS, Simplified Acute Physiology Score; ER, emergency room; OR, operating room; ICU, Intensive Care Unit; FAST, focused assessment with sonography for trauma; CT, computed tomography (conventional); MSCT, multi-slice computed tomography.

RESULTS

Overall Collective

The mean ISS[27] of the study population (n = 370) was 27.1 ± 10.9 and 77.6% of the patients were male (22.4% female) with a mean age of 42.1 ± 17.7 years. Motor vehicle crashes (MVC) were the leading cause of trauma (45.4%), followed by falls from heights (32.2%) and other causes

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(22.5%). The mean GCS at arrival was 10.4 ± 4.2; 211 patients (57.0%) arrived intubated, 12 patients (3.2%) arrived ventilated but not intubated (bag/mask). Chest tubes were placed in the field in 31 patients (8.4%). Of the patients, 112 (30.3%) had a systolic blood pressure <100 mm Hg at admission. Main diagnoses were head injuries (71.9%; AIS ≥4 in 41.6%), chest injuries (48.4%; AIS ≥4 in 23.0%), abdominal injuries (28.4%; AIS ≥4 in 11.6%), and injuries to the extremities (58.1%, mostly long bone fractures). A total of 59.5% underwent urgent surgical procedures with a mean time from arrival in the ER to surgery (ER-OR) of 117.0 ± 77.0 minutes. Fourteen patients required immediate surgery to control hemorrhage or evacuate intracranial hematomas. Patients who underwent surgery were transferred to ICU within 172.5 ± 130.5 minutes after the beginning of surgery. ER to ICU time (ER-ICU) in these patients was 278 ± 132.0 minutes. Patients who did not require surgery had an ER-ICU time of 115.5 ± 58.0 minutes. Mean ICU stay was 15.1 days and mean ventilation time was 12.3 days. Of the patients, 15.1% developed organ dysfunction syndromes during ICU stay. The mean overall in-hospital stay was 30.6 ± 31.3 days. In-hospital mortality rate was 16.0%; 8% died of major bleeding or lethal brain injury within the first 24 hours after admission and 8% died of mono- or multiorgan failure syndrome and associated complications. SAPS II score calculated after transfer to ICU was 31.0 ± 16.7. Mortality predicted by SAPS II was 19.2% (21.2% for patients who underwent surgery; 17.1% for patients treated conservatively). Probability of survival (Ps) according to TRISS was 0.81 (0.77 for patients after surgical procedures, 0.85 for patients directly admitted to ICU).

Comparison Between the "Pre-MSCT Protocol" and the "MSCT Protocol" Cohorts

Demographic Data

Demographic data of the two cohorts are presented in Table 3; no significant differences were found. Male to female ratio as well as ISS, patterns of injury, and physiologic parameters were comparable. Requirement of blood products showed no significant difference. Intubation rate on scene was similar in both groups and GCS was 9.8 and 11.1, respectively. Mortality predicted by SAPS II and TRISS was equal in both cohorts.

Diagnostic Procedures

MSCT was started immediately after arrival in 178 of 185 patients; 3 patients required intubation and 4 patients required fluid therapy before MSCT. Efficacy and sensitivity of diagnostic procedures were significantly higher in "MSCT protocol" patients (Table 4). The full extent of injuries was definitively diagnosed after 12 ± 9 minutes in 92.4% of the "MSCT protocol" cohort. In only 76.2% of the "Pre-MSCT protocol" cohort, a definitive diagnosis was possible after 41 ± 27 minutes; in 23.8%, the full extent of injuries was not diagnosed with the "Pre-MSCT protocol", and missed injuries were detected after more specific diagnostic procedures or during surgery. The "MSCT protocol" decreased ER time: total ER time (resuscitation and diagnostic procedures) was 104 ± 21 minutes with "Pre-MSCT protocol" and 70 ± 17 minutes with "MSCT protocol" (Table 5). All these differences were statistically significant ($p < 0.05$).

Table 3 Demographic Data of the 2 Cohorts: Mean Values and SD

Parameter	Pre-MSCT Protocol (mean ± SD)	MSCT Protocol (mean ± SD)	*p* Value
Number of patients	185	185	
Age	40.7 ± 18.2	43.5 ± 17.2	n.s.
Gender	26.6% female	27.6% female	n.s.
ISS	27.6 ± 11.5	26.6 ± 10.3	n.s.
AIS head/neck	3.5	3.4	n.s.
AIS face	2.1	2.3	n.s.
AIS chest	3.7	3.8	n.s.
AIS abdomen	3.4	3.5	n.s.
AIS extremity	2.5	2.5	n.s.
AIS external	1.7	1.6	n.s.
Hemoglobin (g/dL)	10.3 ± 5.9	10.1 ± 5.4	n.s.
Hematocrit (%)	28 ± 18	27 ± 19	n.s.
Fibrinogen (mg/dL)	227 ± 34	231 ± 37	n.s.
GCS	9.8 ± 4.3	11.1 ± 4.0	n.s.
SAPS II	31.0 ± 16.6	31.1 ± 16.8	n.s.
SAPS II mortality	19.2 ± 23.7	19.2 ± 22.7	n.s.
TRISS survival	0.82 ± 0.27	0.81 ± 0.23	n.s.

SD, standard deviation; n.s., not significant; ISS, Injury Severity Score; AIS, Abbreviated Injury Score; GCS, Glasgow Coma Scale; SAPS, Simplified Acute Physiology Score; SAPS mortality, mortality predicted by SAPS; TRISS, Trauma Score/Injury Severity Score; TRISS mortality, mortality predicted by TRISS.

Surgical Procedures

Of the "Pre-MSCT protocol" patients, 116 underwent surgery, and 69 patients were directly transferred to the ICU. Of the "MSCT protocol" patients,104 required surgery, and 81 patients were treated conservatively. With regard to surgical procedures (fracture fixation, laparotomy, osteoclastic trepanation, thoracotomy) no significant differences were found between the cohorts. All patients were transferred to

Table 4 Diagnostic Accuracy in the 2 Cohorts: Number of Injured Regions, and Percentage of Correctly Identified Injuries by Diagnostic Tools Used

Pre-MSCT Protocol	CR	FAST	CT	MSCT Protocol	MSCT
Head (n = 143)	12.6	—	84.6	Head (n = 123)	94.3
Chest (n = 81)	38.3	13.6	76.5	Chest (n = 98)	92.9
Abdomen (n = 50)	20.0	76.2	84.0	Abdomen (n = 55)	92.7

CR, conventional radiography; FAST, focused assessment with sonography for trauma; CT, computed tomography (conventional); MSCT, multi-slice computed tomography.

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Table 5 Times, Durations, and Outcomes for the 2 Cohorts

Parameter	Pre-MSCT Protocol (mean ± SD)	MSCT Protocol (mean ± SD)	*p* Value
Number of patients	185	185	
ER time (min)	104 ± 21	70 ± 17	0.025
ER-OR (min)	132 ± 93	103 ± 61	0.009
ER-ICU (min)	202 ± 90	192 ± 100	0.045
OR-ICU (min)	186 ± 147	159 ± 114	0.038
Fluid load first 24 h (mL)	4761 ± 2698	5251 ± 3588	n.s.
Packed red cells (mL)	426 ± 136	453 ± 142	n.s.
Fluid balance first 24 h (mL)	1766 ± 1954	1791 ± 2165	n.s.
ICU stay (days)	16.8 ± 18.7	13.6 ± 14.3	0.042
Ventilation (days)	14.3 ± 15.9	10.9 ± 15.3	0.042
Total inhospital stay (days)	32.5 ± 33.3	29.0 ± 29.4	0.046
Hospital mortality rate	0.16	0.17	n.s.

ER, emergency room; OR, operating room; ICU, Intensive Care Unit; SD, standard deviation; n.s., not significant.

the ICU after surgery. Compared with "Pre-MSCT protocol", ER-OR time was significantly shorter in "MSCT protocol" patients ($p < 0.05$); these patients also had shorter surgical procedures (Table 5).

Intensive Care

As shown in Table 5, "Pre-MSCT protocol" patients had a significantly longer ICU stay than "MSCT protocol" patients ($p < 0.05$). A significant difference was found for patients who underwent surgery (ICU stay 21.3 days vs. 15.2 days); the difference was not significant in patients who did not undergo surgery (ICU stay 12.4 days vs. 11.6 days). "MSCT protocol" patients had significantly fewer ventilation days (14.3 vs. 10.9 days). Total fluid load, fluid balance, and number of packed red cells transfused did not differ between cohorts.

Outcome

Total in-hospital stay was shorter in "MSCT protocol" patients (Table 5). Table 6 shows the rates of organ dysfunction and organ failure in both groups. Almost one-fifth (18.9%) of the "Pre-MSCT protocol" patients developed MOFS or isolated organ dysfunction; this rate was significantly lower in "MSCT protocol" patients (11.4%). In both groups, these patients had significantly longer ICU stays and durations of ventilation than patients without MOFS did.

Table 6 Organ Dysfunction Rates in the 2 Cohorts: Percentage of Patients With Dysfunction

Organ	Pre-MSCT Protocol (%)	MSCT Protocol (%)	*p* Value
Lung	32	20	0.005
Kidney	20	9	0.003
Liver	9	3	0.03

For definitions of organ dysfunction see text.

DISCUSSION

Compared with MSCT, all traditional techniques of diagnostic evaluation have some limitations. Clinical examination has limited diagnostic accuracy; in one study physical examination of abdominal trauma was accurate in only 65%,[28] and in another study 37% of patients with negative physical examination had positive CT findings.[17] DPL was introduced in 1965,[29] reducing the rate of unnecessary laparotomies dramatically. DPL has high sensitivity, but it is not specific and provides no information on the nature of lesions or injuries to retroperitoneal organs.[30] FAST, introduced around 1990, gained widespread acceptance and replaced DPL.[31,32] With FAST it became possible to clear the abdomen and most of the thorax by a noninvasive, comprehensive, and quick examination that could be repeated if necessary. FAST is a good screening tool.[33] The ATLS Subcommittee of the American College of Surgeons, Committee on Trauma has suggested an increased role for FAST examination in the evaluation of blunt abdominal trauma and in the initial evaluation of patients with pelvic fractures.[1] However, FAST is not without limitations. Chiu et al.[14] demonstrated a significant number of patients with intra-abdominal bleeding who had negative sonograms, Ochsner et al.[15] documented a 28% incidence of CT-verified liver and spleen injuries despite negative FAST. However, FAST is not suitable for the evaluation of hollow-organ injuries, retroperitoneal structures, and bony injuries, and may even miss certain intra-abdominal injuries.[34] With FAST, Miller et al. have reported a significant number of missed injuries in hemodynamically stable patients and have thus suggested routine CT scanning for this population.[16] After the introduction of CT in the 1970s, diagnostic accuracy and strategies of treatment improved, especially for solid organ injuries. Today MSCT has been established as state of the art in many trauma centers worldwide. Recently, a number of authors have contributed information about their experience with MSCT in trauma care.[3–5,7,15,17–22] The improvement of diagnosis with MSCT can be related to improved multiplanar reconstruction with a resulting decrease in slice thickness. Improved clearance of the spine has been repeatedly pointed out as one of the advantages of MSCT.[3–5,21] All of these studies suggest that MSCT is an excellent technique for examination of hemodynamically stable patients.

In the present study, we considered a systolic BP >70 mm HG to be sufficient for immediate MSCT scanning. This level of BP was chosen because during all previous CT scans no cardiac arrests had been observed at or over this level. In five patients who were exsanguinated at arrival, small volume resuscitation was performed before

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MSCT was started. Two patients required thoracotomy and open-heart compression because of persistent circulatory instability; both died in the ER and were not included in the study cohort.

To our knowledge, this is the first study analyzing the effects of immediate MSCT. We analyzed data from two cohorts of comparable age, injury severity, and injury patterns. The demographic data of our patients were similar to those from other studies describing multiply injured patients.[35] When we designed the study we expected a significant effect of the "MSCT protocol" on speed and accuracy of diagnosis, and shorter ER-ICU and ER-OR times; we also assumed that this might have an effect on the amount of fluids and blood given during the first 24 hours. Although we decided to evaluate some outcome parameters, we did not expect any effects. The results were quite surprising.

As expected, one main result was improved speed as well as diagnostic accuracy in the "MSCT protocol" patients. Because of the fact that the MPR was done while the patients were being resuscitated, "MSCT protocol" patients had significantly shorter ER, ER-OR, and ER-ICU times. According to Klöppel et al., patients examined by 1-row detector CT need a median range of 28 minutes.[36] Our results show a significantly higher accuracy in "MSCT protocol" patients with an examination time of only 12 minutes. Immediate MSCT was much better in detecting injuries of the head, chest, and abdomen. We were able to detect over 90% of the injuries to these regions immediately after MSCT, whereas the detection rates with CR and FAST were significantly worse and the rate of missed injuries was higher. Even after examination with single slice CT in the "Pre-MSCT protocol" cohort (if indicated after physical examination) the detection rate was lower in all organ regions. However, it should be pointed out that the speed of MSCT diagnosis may be a drawback: in patients with intracranial bleeding or parenchymal intra-abdominal injuries, early detection may result in underestimation of the extent of injury. Therefore, we recommend repeating MSCT scanning after some hours of surgery or after 12 hours on the ICU for patients with brain trauma who had immediate MSCT.

Contrary to our expectations there was no effect on fluid or blood requirements. Unexpectedly, the "MSCT protocol" patients who underwent surgery had shorter operation times. The whole cohort had significantly fewer ventilation, ICU, and hospital days, and the rate of MOFS was significantly lower. It is difficult to explain how the shorter ER time, the earlier and more accurate diagnosis, and the lower number of missed injuries could have such effects. Naturally, the "Pre-MSCT protocol" cohort is by definition a historical control group, but the two cohorts did not differ regarding age, case mix, severity and region of injuries, and treatment protocol in the ER (apart from the treatment algorithm under study). In the ICU, there was no difference between the "Pre-MSCT protocol" years (2001–2002) and the "MSCT protocol" years (2003–2004). Although it seems unlikely that the patients in the "Pre-MSCT protocol" cohort were more seriously injured (no significant differences in any of the severity scores) this might still be a possible explanation as the GCS was lower in this cohort. A small difference in the number of patients with prolonged treatment after brain trauma might have caused the effects we observed. It seems justified, however, to state that the "MSCT protocol" is safe and effective; whether it actually shortens ICU and hospital stay must remain open until confirmed or refuted by further studies.

When reporting on the effects of the "MSCT protocol" we need to refer to the emergency medical system in Austria. Much of the initial evaluation and therapy (chest tubes, intubation) of multiply injured patients is performed in the field by trained and experienced emergency physicians and paramedic teams even before patients arrive in the ER. Most of our patients received sophisticated prehospital treatment. Though "stay and play" strategy was performed in most blunt trauma patients, response time, and prehospital time was quite short. This fact can be explained by the common use of helicopters in rural areas as well as short transportation times in urban areas. We were able to proceed directly to the CT scan thanks to the initial work done by the prehospital physician.[37] Our algorithm may not be applicable to other trauma centers with different prehospital conditions.

One interesting finding of this study was the lack of side effects of contrast medium in the "MSCT protocol" patients. Because of the short prehospital times in the Vienna area, most blunt trauma patients receive little or no fluids in the field and during transport. Thus, in many "MSCT protocol" patients contrast medium was the first fluid they received. Traditionally, hypovolemia and shock are thought to contribute to renal failure after administration of contrast medium.[38] Yet, after analyzing organ failure rates in both cohorts we found that the rate of renal failure or dysfunction was lower after "MSCT protocol". Therefore, we conclude that it is safe to administer contrast medium to patients in traumatic shock if this is followed by adequate fluid resuscitation. To reliably demonstrate the possible effect of administered contrast medium in the early clinical phase, our findings should be verified in a controlled prospective approach where renal parameters (creatinin clearance, urea, electrolytes) should be monitored continuously to provide information on the correlation between contrast medium and renal function.

On the one hand, we are able to point out various improvements in the early clinical management of multiply injured patients that might be related to the installation of a MSCT scanner. On the other hand, however, we also need to discuss various limitations of our study.

The study actually examines two separate changes in practice. The first change concerns the timing of the CT scan (after initial resuscitation vs. immediately after admission), the second change concerns the technology used (single slice CT vs. MSCT). Although it can be suggested that the improved times from ER to OR and/or to ICU are because of the timing of the CT scan and the improved diagnostic accuracy

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is because of multislice technology, the reductions in ICU and hospital stay, ventilator days, and organ failure may be attributable either to faster diagnosis, to better diagnostic accuracy, to both, or to none of these. The results of our study need to be confirmed in a prospective trial.

Furthermore, there might be some uncertainty concerning the indiscriminate use of MSCT. As described in recent literature, MSCT has limited value in detection of extremity injuries. The rate of extremity injuries was not significantly different in both groups (55% "Pre-MSCT protocol"; 61% "MSCT protocol"). In both cohorts, the rate of missed fractures was similar and could be related either to inadequate clinical examination or to missing clinical symptoms. In patients with suspected fractures, CR was performed after clinical survey in "Pre-MSCT protocol" or after "MSCT-protocol". In patients with long bone fractures requiring surgery our detection rate was 100%. All missed fractures did not urgently require fixation and were either treated surgically within 7 days after admission or conservatively with cast fixation. Another criticism of our MSCT algorithm could be that an increased number of unnecessary CT studies was performed. Six patients underwent "MSCT-protocol" without any abnormal findings: four of these were intubated and sedated and could not be evaluated clinically, and two patients had multiple lower limb fractures and peritoneal symptoms at admission. In all patients with negative MSCT, high-energy trauma (high speed MVC; falls from >5 meters) was reported and severe extremity injuries were diagnosed by CR.

Considering the fact that the number of "unnecessary" scan seems to be quite low, we can recommend the installation of a scanner in the ER. A cost analysis that was performed 1 year after installation of the MSCT has shown significant financial benefit of the "MSCT protocol", and the benefits of shorter ICU and hospital stay have to be considered as well.

Based on our experience we can recommend MSCT for all patients suffering from high-kinetic trauma resulting in suspected multiple injuries in such areas as the head, chest, and abdomen. Furthermore, MSCT seems to be preferable when patients are intubated, sedated, and thus clinically not invaluable. The "MSCT protocol" should not replace other reliable and effective methods (e.g. FAST) if they appear warranted or if they are preferred by an experienced examiner.

CONCLUSION

We have demonstrated that immediate MSCT for patients with blunt major trauma leads to more accurate and faster diagnosis, and reduction of ER, ER-OR, and ER-ICU times. We also observed a reduction in ventilation, ICU and hospital days, and in organ failure rates, though this might have been partly because of small differences in case mix. The "MSCT protocol" algorithm seems to be safe and effective. If followed by adequate fluid resuscitation, the administration of contrast medium to patients in traumatic shock has no negative effects on renal function.

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Stroke

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American Stroke Association

A Division of American Heart Association

Comprehensive Overview of Nursing and Interdisciplinary Care of the Acute Ischemic Stroke Patient. A Scientific Statement From the American Heart Association

Debbie Summers, Anne Leonard, Deidre Wentworth, Jeffrey L. Saver, Jo Simpson, Judith A. Spilker, Nanette Hock, Elaine Miller, Pamela H. Mitchell and on behalf of the American Heart Association Council on Cardiovascular Nursing and the Stroke Council

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AHA Scientific Statement

Comprehensive Overview of Nursing and Interdisciplinary Care of the Acute Ischemic Stroke Patient

A Scientific Statement From the American Heart Association

Debbie Summers, MSN, RN, FAHA, Chair; Anne Leonard, MPH, RN, FAHA, Co-Chair; Deidre Wentworth, MSN, RN; Jeffrey L. Saver, MD, FAHA; Jo Simpson, BSN, RN; Judith A. Spilker, BSN, RN; Nanette Hock, MSN, RN, FAHA; Elaine Miller, DNS, RN, FAHA; Pamela H. Mitchell, PhD, RN, FAHA; on behalf of the American Heart Association Council on Cardiovascular Nursing and the Stroke Council

Ischemic stroke represents 87% of all strokes.[1] As worldwide initiatives move forward with stroke care, healthcare providers and institutions will be called on to deliver the most current evidence-based care. The American Heart Association/American Stroke Association (AHA/ASA) charged a panel of healthcare professionals from several disciplines with developing a practical, comprehensive overview of care for the patient with acute ischemic stroke (AIS). This article focuses on educating nursing and allied healthcare professionals about the roles and responsibilities of those who care for patients with AIS.

Nurses play a pivotal role in all phases of care of the stroke patient. For the purposes of this article, the writing panel has defined 2 phases of stroke care: (1) The emergency or hyperacute care phase,[2,3] which includes the prehospital setting and the emergency department (ED), and (2) the acute care phase, which includes critical care units, intermediate care units, stroke units, and general medical units.

Stroke is a complex disease that requires the efforts and skills of all members of the multidisciplinary team. Nurses are often responsible for the coordination of care throughout the continuum.[4–9] Coordinated care of the AIS patient results in improved outcomes, decreased lengths of stay, and decreased costs.[10]

In developing this comprehensive overview, the writing panel applied the rules of evidence and formulation of strength of evidence (recommendations) used by other AHA writing groups[11] (Table 1). We also cross-reference other AHA guidelines as appropriate.

Overview of Stroke

It is important that nurses understand the burden of stroke as a public health issue in the United States. This will guide them in developing appropriate skills to care for AIS patients and to educate patients and families about secondary stroke prevention.

Epidemiology of Stroke

The AHA estimates that ≈780 000 strokes occur each year; 600 000 of these are new strokes, and ≈180 000 are recurrent strokes.[1] Eighty-seven percent are ischemic strokes, 10% are intracranial hemorrhages (ICH), and 3% are subarachnoid hemorrhages (SAH). In 2007, the overall mortality rate from stroke was 273 000, which makes stroke the third-leading cause of death in the United States.[1] Between 1979 and 2005, the annual number of hospital discharges with stroke as the diagnosis was ≈900 000.[1] Direct and indirect costs associated with stroke are estimated to be approximately $65.5 billion.[1] Direct costs are attributed to the initial hospitalization, skilled nursing care, physician and nursing care, medications and durable medical equipment, home health care, and acute rehabilitation. Indirect costs include loss of productivity (loss of future earnings) due to morbidity and

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This statement was approved by the American Heart Association Science Advisory and Coordinating Committee on February 12, 2009. A copy of the statement is available at http://www.americanheart.org/presenter.jhtml?identifier=3003999 by selecting either the "topic list" link or the "chronological list" link (No. LS-2045). To purchase additional reprints, call 843-216-2533 or e-mail kelle.ramsay@wolterskluwer.com.

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Table 1. Applying Classification of Recommendations and Levels of Evidence

ESTIMATE OF CERTAINTY (PRECISION) OF TREATMENT EFFECT ↓ / SIZE OF TREATMENT EFFECT →	CLASS I *Benefit >>> Risk* Procedure/Treatment **SHOULD** be performed/administered	CLASS IIa *Benefit >> Risk* *Additional studies with focused objectives needed* **IT IS REASONABLE** to perform procedure/administer treatment	CLASS IIb *Benefit ≥ Risk* *Additional studies with broad objectives needed; additional registry data would be helpful* Procedure/Treatment **MAY BE CONSIDERED**	CLASS III *Risk ≥ Benefit* Procedure/Treatment should **NOT** be performed/administered **SINCE IT IS NOT HELPFUL AND MAY BE HARMFUL**
LEVEL A Multiple populations evaluated* Data derived from multiple randomized clinical trials or meta-analyses	■ Recommendation that procedure or treatment is useful/effective ■ Sufficient evidence from multiple randomized trials or meta-analyses	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from multiple randomized trials or meta-analyses	■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from multiple randomized trials or meta-analyses	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Sufficient evidence from multiple randomized trials or meta-analyses
LEVEL B Limited populations evaluated* Data derived from a single randomized trial or nonrandomized studies	■ Recommendation that procedure or treatment is useful/effective ■ Evidence from single randomized trial or nonrandomized studies	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from single randomized trial or nonrandomized studies	■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from single randomized trial or nonrandomized studies	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Evidence from single randomized trial or nonrandomized studies
LEVEL C Very limited populations evaluated* Only consensus opinion of experts, case studies, or standard of care	■ Recommendation that procedure or treatment is useful/effective ■ Only expert opinion, case studies, or standard of care	■ Recommendation in favor of treatment or procedure being useful/effective ■ Only diverging expert opinion, case studies, or standard of care	■ Recommendation's usefulness/efficacy less well established ■ Only diverging expert opinion, case studies, or standard of care	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Only expert opinion, case studies, or standard of care
Suggested phrases for writing recommendations†	should is recommended is indicated is useful/effective/beneficial	is reasonable can be useful/effective/beneficial is probably recommended or indicated	may/might be considered may/might be reasonable usefulness/effectiveness is unknown/unclear/uncertain or not well established	is not recommended is not indicated should not is not useful/effective/beneficial may be harmful

*Data available from clinical trials or registries about the usefulness/efficacy in different subpopulations, such as gender, age, history of diabetes, history of prior myocardial infarction, history of heart failure, and prior aspirin use. A recommendation with Level of Evidence B or C does not imply that the recommendation is weak. Many important clinical questions addressed in the guidelines do not lend themselves to clinical trials. Even though randomized trials are not available, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

†In 2003, the ACC/AHA Task Force on Practice Guidelines developed a list of suggested phrases to use when writing recommendations. All guideline recommendations have been written in full sentences that express a complete thought, such that a recommendation, even if separated and presented apart from the rest of the document (including headings above sets of recommendations), would still convey the full intent of the recommendation. It is hoped that this will increase readers' comprehension of the guidelines and will allow queries at the individual recommendation level.

mortality and loss of esteem (place in family and society) due to disability.

Demographics of Stroke

Each year, women experience ≈60 000 more strokes than men do.[1] American Indian/Alaskan Native persons have the highest prevalence of stroke (6.7%), followed by persons of multiple races (4.6%). Black men and women have twice the prevalence of stroke as whites (4.0% versus 2.3%).[1] Blacks lead all races or ethnic groups for first-ever stroke. The prevalence of stroke in Hispanic or Latino populations is 3.1% for men and 1.9% for women compared with 2.4% for non-Hispanic white men and 2.7% for non-Hispanic white women.[1] Epidemiologists note the increasing risk of stroke with advancing age, comparable to the risk of Alzheimer's disease. Unless individuals change modifiable risk factors, the large aging American population is faced with rising stroke morbidity and a greater than ever public healthcare burden.[9]

Etiology of Stroke (Stroke Subtypes)

Strokes caused by blocked blood vessels to the brain, or ischemic strokes, lead to cerebral infarction, whereas hemorrhagic strokes caused by ruptured vessels in and around the brain lead to ICH and SAH. The AHA has published guidelines for the medical management of patients with ischemic stroke[12,13] and strokes caused by ICH[14] and SAH.[15] Nursing and allied health management is not provided in these guidelines and thus is outlined here.

Ischemic strokes are commonly caused by atherosclerotic disease of extracranial or intracranial vessels that circulate blood to the brain. Approximately 20% of ischemic strokes are caused by large-vessel atherosclerosis (extracranial or intracranial segments of carotid or vertebrobasilar arteries), and ≈25% of ischemic strokes are due to penetrating artery disease (small-vessel disease) that causes lacunar or subcortical strokes. Another 20% are caused by cardiogenic embo-

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lism, most frequently from atrial fibrillation.[16] Approximately 30% of ischemic strokes are termed cryptogenic, for which the exact cause of stroke remains unknown.[16]

Hemorrhagic stroke is commonly caused by either primary ICH or SAH. Overall, ICH accounts for ≈10% of all strokes and SAH for ≈3%.[1] Common causes and risk factors for ICH are hypertension (the number 1 cause), bleeding disorders, African-American ethnicity, aging, vascular malformations, excessive use/abuse of alcohol, and liver dysfunction.[17–20] The primary cause of SAH is a ruptured cerebral aneurysm.

Crossing the Continuum of Care

Phase 1 of stroke care, the emergency or hyperacute phase, encompasses the first 3 to 24 hours after onset of stroke. This phase generally incorporates the prehospital (activation of emergency medical services [EMS]/9-1-1 and response) and ED care protocols. The focus is on identifying stroke symptoms and infarct location, assessing the patient for risk of acute and long-term complications, and determining treatment options.

Phase 2 includes acute care, which encompasses the period from 24 to 72 hours after onset of stroke. In this phase, the focus is on clarifying the cause of stroke, preventing medical complications, preparing the patient and family for discharge, and instituting long-term secondary prevention modalities.

The Emergency or Hyperacute Phase of AIS Care

Optimal management of the AIS patient in the emergency or hyperacute phase of AIS care requires an accurate and systematic evaluation that is coordinated and timely. Once a potential stroke is suspected, EMS personnel and nurses must determine the time at which the patient was last known to be well (last known well time). This time is the single most important determinant of treatment options during the hyperacute phase.

The Nurse's Role

In the prehospital setting, the leading healthcare team member is the emergency medical technician (EMT) or paramedic. Nurses may work as EMTs and paramedics, radio providers of online medical control to EMS personnel from base stations, and educators who teach EMS personnel about stroke and the care of stroke patients.

The key elements of prehospital care are stabilization of the airway, breathing, and circulation (the ABCs); identification of signs and symptoms of stroke; establishment or verification of the last known well time; provision of supplemental oxygen to patients with hypoxemia; checking the blood glucose level; avoidance of the administration of glucose-containing fluids (unless the patient is hypoglycemic); rapid initiation of transport (load and go); and delivery of patients to receiving centers capable of rapidly caring for acute stroke.[21] When recombinant tissue plasminogen activator (rtPA) was approved as the first acute treatment for AIS, the paradigm of care of the stroke patient shifted, and emergency care of the stroke patient in the field emerged.[22] The role of time in determining treatment eligibility and patient outcome has generated a body of literature and knowledge about appropriate care for AIS patients,[22–35,37–45] from which healthcare providers have developed measures to quickly and easily identify and assess stroke patients.[46,47] Textbooks and training courses for EMTs and paramedics discuss stroke pathophysiology and identify stroke as a medical emergency. Understanding and recognizing specific stroke symptoms can be challenging.[22–24,28,47–50] Evaluation of EMS practices has shown that stroke-specific knowledge has been deficient[38] but that both overall knowledge[28] and identification of stroke symptoms by EMTs and paramedics can be improved with additional stroke-specific education.[19–25,28,31,47–50]

In many community and academic institutions, education of EMS providers has become a function of the nurse educator, a role that has expanded to the community. The most widely available stroke teaching tool for this purpose[21] is chapter 9 of the AHA stroke module.[44,51] Educational videos and other tools are also available for the EMS audience.[52]

Before beginning an EMS stroke education program, the nurse educator should verify local policies and regulations governing acceptable practice for paramedics and EMTs in that region or state. For example, in some communities, EMS providers are not permitted to perform some recommended practices for acute stroke care, such as determining fingerstick glucose levels and starting intravenous lines. In other communities, higher standards that require specific assessment skills have been developed for EMS to enable them to respond more aggressively to AIS.[10,27,47]

As a part of their continuing education, EMS personnel must also be provided with accurate information about acute stroke care and treatment capabilities in their community.[47] EMS units should know which hospitals are equipped to provide specific emergency stroke care, such as those certified by the Joint Commission or their state health agencies.[10,53–56]

Continuing education of EMS personnel is challenging and requires frequent updates. The nurse educator should keep in mind that a typical EMS provider cares for 4 to 10 stroke patients in a given year.[44] As a result, field experience may be limited, and reinforcement of knowledge and practice in caring for acute stroke patients will be necessary. One study concluded that the knowledge gained from stroke training decreased by ≈50% over 1 year[57]; therefore, educational programs about stroke might be repeated from 1 to several times per year. In some states with mandated stroke systems of care, EMS updates in stroke education will be required.[21] The National Institutes of Health (NIH) proceedings *Improving the Chain of Recovery for Acute Stroke in Your Community* is a useful resource for planning and organizing stroke educational programs.[47]

Education Regarding Prehospital Assessment for Acute Stroke

Although accurate identification of stroke symptoms is a critical success factor in early stroke treatment, the nurse educator needs to include additional aspects of prehospital stroke patient management.[28,58,59] Recognition of stroke symptoms is an important factor in successful delivery of

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Table 2. Components of Selected Prehospital Assessment Tools

Cincinnati Prehospital Stroke Scale[32]	Los Angeles Prehospital Stroke Screen[60]	Los Angeles Motor Scale[34]	Face Arm Speech Test[61]	SNIHSS-5[65]
Facial droop	Facial weakness	Facial weakness	Facial palsy	Right leg motor
Arm weakness	Arm strength	Arm strength	Arm weakness	Left leg motor
Speech	Grip	Grip	Speech impairment	Gaze
	Screening criteria (4 items)			Visual fields
	Blood glucose			Language

SNIHSS indicates shortened National Institutes of Health Stroke Scale.

proven acute therapies. Prehospital assessment tools have been developed to help enhance recognition of stroke symptoms and improve the ability to identify stroke patients in the field (Table 2). The most common and well-investigated tools are the Cincinnati Prehospital Stroke Scale and the Los Angeles Prehospital Stroke Screen.[22,30,32,60] Newer stroke identification tools include the Face Arm Speech Test[61] (Table 3), which is similar to the Cincinnati Prehospital Stroke Scale, and the Melbourne Prehospital Stroke Scale,[62–64] which is similar to the Los Angeles Prehospital Stroke Screen. Tools to rate stroke severity in the field have been developed, including a shortened version of the NIH Stroke Scale (NIHSS)[65] and the Los Angeles Motor Scale.[34] If a specific tool has not been identified for use within a community, the nurse educator should review the common signs and symptoms of stroke such as those identified on the Brain Attack Coalition's World Wide Web site (http://www.stroke-site.org/index.html). These tools may also be used to teach a quick stroke screening evaluation to hospital personnel, because in-hospital strokes also require prompt recognition and action.

EMS personnel have long understood the implications of time to treatment for myocardial infarction and trauma, but the concept of time dependency in AIS is relatively new. The nurse educator must emphasize the importance of obtaining the last known well time.

Stroke education should emphasize that stroke requires high-priority status and that the load-and-go philosophy has now become a part of mainstream acute stroke care in the field.[41] rtPA is the only treatment for AIS approved by the US Food and Drug Administration, and it ideally is administered within 3 hours of symptom onset.[13,59,66,67] On-site stroke patient assessments should be performed expeditiously, and transport should be initiated as soon as the patient's condition is assessed as stable.[41,66,68,69] Although the symptoms listed in the formal prehospital stroke assessment tools are classic, other stroke symptoms should also be described to EMS personnel. Table 4 lists neurological symptoms associated with strokes that occur in the different cerebral territories.

Table 3. Sample Face Arm Speech Test (FAST)[61]

Facial palsy affected side	Yes RT LT	No	Unknown
Arm weakness affected side	Yes RT LT	No	Unknown
Speech impairment	Yes	No	Unknown
Time of onset			

RT indicates right side; LT, left side.

Recommendations

Class I

1. To increase the number of stroke patients who receive timely treatment, educational programs for physicians, hospital personnel, and EMS personnel are recommended (***Class I, Level of Evidence B***).
2. Stroke education of EMS personnel should be provided on a regular basis, perhaps as often as twice per year, to ensure proper recognition, field treatment, and delivery of patients to appropriate facilities (***Class I, Level of Evidence C***).

Table 4. The 5 Key Stroke Syndromes: Classic Signs Referable to Different Cerebral Areas

Left (dominant hemisphere)
Left gaze preference
Right visual field deficit
Right hemiparesis
Right hemisensory loss
Right (nondominant hemisphere)
Right gaze preference
Left visual field deficit
Left hemiparesis
Left hemisensory loss neglect (left hemi-inattention)
Brainstem
Nausea and/or vomiting
Diplopia, dysconjugate gaze, gaze palsy
Dysarthria, dysphagia
Vertigo, tinnitus
Hemiparesis or quadriplegia
Sensory loss in hemibody or all 4 limbs
Decreased consciousness
Hiccups, abnormal respirations
Cerebellum
Truncal/gait ataxia
Limb ataxia, neck stiffness
Hemorrhage
Focal neurological deficits as in AIS
Headache (especially in SAH)
Neck pain
Light intolerance
Nausea, vomiting
Decreased level of consciousness

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Education Priorities for Assessment and Treatment in the Field

Neurological assessment of the AIS patient should always include the ABCs, vital signs, cardiac monitoring during transport, and baseline neurological assessment. Because the field neurological examination will serve as a baseline for assessment of neurological improvement or worsening, the use of a prehospital stroke scale is recommended.

EMS personnel on the scene should ask the patient's family or bystanders when the patient was last known to be normal or without neurological deficits, ie, the last known well time. Documentation of this report of onset can be helpful in establishing an accurate time of stroke symptom onset.[44,46,47,69] Ideally, standardized definitions should be developed in EMS systems to define the specific onset date and time. The date and time should be defined as the time when the stroke symptoms that brought the patient to the hospital first occurred. A specific time can be identified within a reasonable amount of certainty within ±15 minutes. When possible, the information should be obtained directly from the patient. If the patient is unable to give this information, EMS personnel should look to another reliable source for this information.[70] If the time of onset of stroke symptoms is not identifiable, a standard method of time parameters should be used, such as morning (6:00 AM to 11:59 AM), afternoon (noon to 5:59 PM), evening (6:00 PM to 11:59 PM), and overnight (midnight to 5:59 AM).[70] EMS providers must emphasize to families the importance of traveling to the hospital with the patient, particularly if symptom onset is within the time frame for rtPA administration and the patient's language or decision-making capability is compromised. When family members cannot accompany the patient, EMS personnel should document the family's contact information and provide it to the emergency physician.[13]

The current guidelines recommend the use of continuous cardiac monitoring during transport of a suspected stroke patient to determine the presence of cardiac arrhythmias.[13] If there is no standing field protocol for management of cardiac conditions, EMS personnel should contact the base station or receiving institution if the electrocardiogram demonstrates possible acute myocardial ischemia or atrial fibrillation. Blood pressure should be monitored every 15 minutes, or more often if severe hypertension (systolic blood pressure >200 mm Hg) or relative hypotension (systolic blood pressure <110 mm Hg) is observed during transport. Administration of antihypertensive drugs in the field is not recommended, because induced hypotension carries a possible risk of extending the area of cerebral infarct.[47,58,68,71] Supplemental oxygen should be given to hypoxic patients; in ambulances without oximetry capabilities, oxygen can be administered at low levels, eg, 2 to 3 L/min. If pulse oximetry is available and the patient's oxygen saturation is >92%, additional oxygen is not needed.[13] Transport with the head of the bed elevated ≈30° may help with oxygenation and may minimize the possibility of aspiration.[44,71,72] To decrease the risk of aspiration, the patient should receive nothing by mouth (NPO).

Hypoglycemia, a common stroke mimic, can be identified quickly by measuring blood glucose during transport. Fingerstick tests can be performed if the emergency vehicle is appropriately equipped and personnel are trained. Treatment of severe hypoglycemia should be instituted promptly by EMS personnel. Intravenous access can be established in the field, and non–glucose-containing intravenous fluids can be started if the patient is hypotensive. Establishment of intravenous access should not delay transport.[44,46,47,57,69,71]

Finally, the nurse educator should emphasize the value of early notification of the receiving ED of the arrival of a potential acute stroke patient. Historic cardiac trials have shown that prearrival notification of the ED enhances rapid diagnostic workup, reducing time between symptom onset and treatment.[23,25,73]

Recommendations

Class I

1. EMS personnel should be trained to administer a validated prehospital stroke assessment, such as the Cincinnati Prehospital Stroke Scale or the Los Angeles Prehospital Stroke Screen (***Class I, Level of Evidence B***).
2. EMS personnel should be trained to determine the last known well time using standardized definitions to collect the most accurate information (***Class I, Level of Evidence B***).
3. EMS personnel should use the neurological/stroke assessment approach to gather basic physiological information about the patient and communicate the patient's condition to the receiving hospital (***Class I, Level of Evidence B***).

From the Field to the ED: Stroke Patient Triage and Care

Emergency personnel initiate basic triage and care modalities in the field. Once the stroke patient arrives in the ED, patient triage is usually a function of nursing staff. The Emergency Nurses Association and the American College of Emergency Physicians recommend a 5-level Emergency Severity Index as a preferred system for triage in a busy ED.[52] This index puts all stroke patients in the level 2 or "needs immediate assessment" category, the same as for an unstable trauma patient or a critical care cardiac patient.[46,52,69] The emergency nurse must be able to recognize neurological symptoms that suggest stroke and rapidly assess the initial time of symptom onset or the last known well time.[44,46,57]

The triage nurse should use specialized checklists, protocols, and other tools to identify stroke patients.[10,44,47,57,74] Once stroke is confirmed, the nurse uses these procedures and protocols that define who contacts the acute stroke team or appropriate neurological consultant. Emergency nurses understand that time is critical and are trained in rapid assessment and treatment of stroke patients. Studies have shown that the sooner thrombolytic therapy is started, the greater the benefit.[23,44,46,75] It is critical that all emergency nurses and other emergency professional staff know that the NIH-National Institute of Neurological Disorders and Stroke (NINDS) benchmark treatment time for AIS with intravenous rtPA is within 60 minutes of arrival in the ED[46] (Table 5). In some cases, this time will need to be shortened to successfully initiate thrombolytic therapy within 3 hours of stroke onset, although there is growing evidence of safety and effective-

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Table 5. NINDS Time Targets for Organized Triage of Acute Stroke Patients[44]: Key Evaluation Time Targets for the Potential rtPA Candidate

Maximum intervals recommended by NINDS	
Door-to–doctor first sees patient	10 min
Door-to–CT completed	25 min
Door-to–CT read	45 min
Door-to–thrombolytic therapy starts	60 min
Physician examination	15 min
Neurosurgical expertise available*	2 h
Admitted to monitored bed	3 h

CT indicates computed tomography.
*On-site or by transfer to another facility.

ness beyond the 3-hour window from stroke onset.[76,77] The AHA AIS Writing Committee has issued a Science Advisory stating that some eligible patients may be treated between the 3- and 4.5-hour window after stroke. The recommendation comes with several caveats and follows the inclusion criteria described in the ECASS III results. The exceptions include persons >80 years of age, those taking oral anticoagulants with an international normalized ratio of <1.7, persons with an NIHSS score >25, and those with a history of stroke and diabetes.[77a]

Recommendations

Class I

1. EDs should establish standard operating procedures and protocols to triage stroke patients expeditiously (***Class I, Level of Evidence B***).
2. Standard procedures and protocols should be established for benchmarking time to evaluate and treat eligible stroke patients with rtPA expeditiously (***Class I, Level of Evidence B***).
3. Target treatment with rtPA should be within 1 hour of the patient's arrival in the ED (***Class I, Level of Evidence A***).
4. Eligible patients can be treated between the 3- to 4.5-hour window when evaluated carefully for exclusions to treatment (***Class I, Level of Evidence B***).

Emergency Nursing Interventions in the Emergency/Hyperacute Phase of Stroke

The First 24 Hours

Stroke symptoms typically begin suddenly (but can evolve over minutes to hours) and are referable to the affected region of the brain. Ischemic stroke symptoms are generally divided into those that affect the anterior and posterior cerebral circulation (Table 4). To properly triage patients for AIS therapies such as rtPA, emergency nurses should be familiar with both typical and unusual stroke presentations.

As in the prehospital phase, initial patient assessments made by the emergency nurse are based on the principle of assessing the ABCs, vital signs, and neurological assessment. The majority of AIS patients will present to the ED in a hemodynamically stable condition; however, ischemic strokes involving the posterior circulation can require aggressive airway management, especially if the patient has an altered level of consciousness.[26,78]

Circulatory collapse or cardiac arrest, although possible, is uncommon in isolated ischemic stroke.[79] The occurrence of either may indicate other medical conditions such as acute myocardial infarction, atrial fibrillation, or congestive heart failure. Cardiac monitoring of all suspected stroke patients in the ED helps identify these conditions.[69]

Initial ED documentation of the stroke patient begins with the recording of all information included in the neurological/stroke assessment. Vital signs, including temperature, may be measured frequently as clinically indicated but not less than every 30 minutes while the patient is in the ED. Hyperthermia is associated with poor outcome in stroke patients[13,80–82]; therefore, it is important to consider treating any fever >99.6°F. During the 60-minute infusion of thrombolytic therapy, pulse and blood pressure should be checked at least every 15 minutes. Table 6 summarizes nursing care associated with thrombolysis and nonthrombolysis treatment of patients with acute cerebral ischemia on the basis of the original NIH-NINDS study protocol and AHA/ASA guidelines.[2,29,83–86]

Brain Imaging

The overriding objective of emergency evaluation of the stroke patient is to determine whether the stroke is an ischemic infarction or ICH and to exclude a nonvascular lesion as the cause of symptoms. Additional objectives are to localize the lesion, determine its age and extent, and document its mechanism. Both computed tomography (CT) and magnetic resonance imaging (MRI) are acceptable initial imaging modalities for acute evaluation. The most commonly obtained study remains an immediate unenhanced (noncontrast) head CT scan.[13] The emergency nurse prepares the patient for CT or MRI by explaining the test and may help transport the patient to the scanner. The nurse should prenotify [illegible] suspected acute stroke is in transport. This will allow technicians to reserve the scanner so that the patient can be imaged immediately on arrival. The CT scan should be completed in ≤25 minutes in patients who are eligible for treatment with rtPA. The initial scan is one of the most important diagnostic tests in the emergency phase after stroke. Rapid acquisition and results of imaging will define treatment.

Oxygenation, Positioning, and Oral Intake

Patients with AIS are at risk of hypoxemia and oxygen desaturation. Maximization of oxygenation of all acute stroke patients has been examined in 1 quasi-randomized trial and did not show clear findings of benefit from supplemental oxygen.[87] There is general agreement, however, that hypoxic patients will benefit from supplemental oxygen.[13]

Positioning of the head of the bed must be individualized for each patient. The traditional positioning at 25° to 30° is often used for potentially increased intracranial pressure (ICP), at least until large lobar, ICH, space-occupying lesions or other causes of increased ICP can be ruled out by imaging.[88] Stroke patients with increased ICP and chronic respiratory conditions may need head elevation for maximum

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Table 6. Schedule of Neurological Assessment and Vital Signs and Other Acute Care Assessments in Thrombolysis-Treated and Nonthrombolysis–Treated Patients[2,29,83–86]

Thrombolysis-Treated Patients	Nonthrombolysis–Treated Patients
Neurological assessment and vital signs (except temperature) every 15 min during rtPA infusion, then every 30 min for 6 h, then every 60 min for 16 h (total of 24 h) Note: Frequency of BP assessments may need to be increased if systolic BP stays ≥180 mm Hg or diastolic BP stays ≥105 mm Hg. Temperature every 4 h or as required. Treat temperatures >99.6°F with acetaminophen as ordered	In ICU, every hour with neurological checks or more frequently if necessary. In non-ICU setting, depending on patient's condition and neurological assessments, at a minimum check neurological assessment and vital signs every 4 h
Call physician if systolic BP >185 or <110 mm Hg; diastolic BP >105 or <60 mm Hg; pulse <50 or >110 per min; respirations >24 per min; temperature >99.6°F; or for worsening of stroke symptoms or other decline in neurological status	Call physician for further treatment based on physician and institutional preferences/guidelines: Systolic BP >220 or <110 mm Hg; diastolic BP >120 or <60 mm Hg; pulse <50 or >110 per min; temperature >99.6°F; respirations >24 per min; or for worsening of stroke symptoms or other decline in neurological status
For O_2 saturation <92%, give O_2 by cannula at 2 to 3 L/min	For O_2 saturation <92%, give O_2 by cannula at 2 to 3 L/min
Monitor for major and minor bleeding complications	N/A
Continuous cardiac monitoring up to 72 h or more	Continuous cardiac monitoring for 24 to 48 h
Measure intake and output	Measure intake and output
Bed rest	Bed rest
IV fluids NS at 75–100 mL/h	IV fluids NS at 75–100 mL/h
No heparin, warfarin, aspirin, clopidogrel, or dipyridamole for 24 h, then start antithrombotic as ordered	Antithrombotics should be ordered within first 24 h of hospital admission
Brain CT or MRI after rtPA therapy	Repeat brain CT scan or MRI may be ordered 24 to 48 h after stroke or as needed

BP indicates blood pressure; ICU, intensive care unit; N/A, not applicable; IV, intravenous; NS, normal saline; and MRI, magnetic resonance imaging.

oxygenation.[89] The bed should be elevated at least 30° if the patient is at risk of aspiration or airway obstruction due to dysphagia.[27] The optimal position for the head of the bed has not been identified.[89–91] Recent studies have suggested that positioning of the head of the bed can facilitate an increase in cerebral blood flow and maximize oxygenation to cerebral tissue.[92–94] A study using transcranial Doppler technology found that the head-flat position maximized blood flow to the brain.[94] Further studies on head positioning of the AIS patient need to be completed; if the patient has a lower risk of increased ICP and is not at risk for aspiration, the head-down position has been shown to be beneficial.[94]

When significant hemiparesis is present, positioning on the paretic side may be more desirable to allow the patient to communicate and to prevent aspiration.[72] AIS patients are more prone to atelectasis as a result of immobility regardless of position. The patient's neck should be kept straight, airway patency maintained, and slumped sitting avoided to prevent hypoxia.[89]

Patients are kept NPO, including no oral medications, until ability to swallow can be assessed. Emergency nurses may be trained to perform a bedside swallowing assessment to establish whether the patient can safely receive oral intake and swallow ED medications such as aspirin.[13,27,89] If swallowing is impaired, medications can be administered rectally or by nasogastric tube.

Laboratory Assessments

An electrolyte imbalance can sometimes produce strokelike symptoms. A comprehensive metabolic panel indicates fluid and electrolyte status. The blood and hemostatic system can be assessed by a complete blood count with platelet and coagulation studies such as prothrombin time, international normalized ratio, activated partial thromboplastin time, and fibrinogen. Urinalysis assesses renal function and coexisting urinary tract infection (UTI). Emergent laboratory specimens should be labeled STAT to expedite processing, if the patient is in the time window to receive thrombolytics. Table 7 lists the most commonly ordered stroke laboratory tests to measure eligibility to receive rtPA.

Intravenous Access

Ideally, 2 to 3 intravenous sites should be established if the acute stroke patient will receive thrombolytic therapy. One site is used for administration of intravenous fluids, another for administration of thrombolytic therapy, and the third for administration of intravenous medications.[13] Diagnostic laboratory blood specimens should be drawn before intravenous fluids are started. Collection of specimens before the patient undergoes imaging allows simultaneous processing of both laboratory and imaging data and facilitates rapid turnaround.

Intravenous Fluids

Glucose can have detrimental effects in acute brain injury of all types. Therefore, intravenous solutions with glucose (such as D_5W [dextrose 5% in water]) should be avoided in AIS patients in the ED.[13,27] An infusion rate that maintains normovolemia (75 to 100 mL/h) can help facilitate normal circulating blood volume. Stroke patients often present in a hypovolemic state, which may produce hypotension and cerebral hypoperfusion. In these instances, intravenous fluid

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Table 7. Emergency Stroke Workup

All patients
Noncontrast brain CT or brain MRI
Blood glucose
Serum electrolytes/renal function tests
ECG
Markers of cardiac ischemia
Complete blood count, including platelet count*
Prothrombin time/INR*
aPTT*
Oxygen saturation
Selected patients
Hepatic function tests
Toxicology screen
Blood alcohol level
Pregnancy test
Arterial blood gas tests (if hypoxia is suspected)
Chest radiography (if lung disease is suspected)
Lumbar puncture (if SAH is suspected and CT scan is negative for blood)
EEG (if seizures are suspected)

ECG indicates electrocardiogram; INR, international normalized ratio; aPTT, activated partial thromboplastin time; and EEG, electroencephalogram.

*Although it is desirable to know the results of these test before rtPA is given, thrombolytic therapy should not be delayed while waiting for the results unless (1) there is clinical suspicion of a bleeding abnormality or thrombocytopenia, (2) the patient has received heparin or warfarin, or (3) use of anticoagulants is not known.

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boluses may be administered, with concomitant close evaluation of the patient's cardiovascular response.

Patient Medical History

It can be challenging and time-consuming to obtain a stroke history in the emergency phase. As part of the stroke team, emergency nurses can play a key role in helping obtain a pertinent clinical history from the AIS patient and family members (Table 8).

Neurological Assessment

The NIHSS (Table 9) is a valid, efficient, and reliable measure of the patient's status after a stroke and in assessing outcome after treatment. Among stroke neurologists and neuroscience nurses, it is the most widely used stroke deficit scale. Developed by stroke neurologists from the University of Cincinnati, the University of Iowa, and the NIH-NINDS,[26] the NIHSS contains parameters for observing changes in the patient's neurological status and measuring stroke severity. To ensure reliability, formal training and certification in use of the scale are recommended (www.strokeassociation.org or www.ninds.nih.gov). The NIHSS is a valid functional outcomes measure and should become the standard to measure neurological functional improvement over time, both in the hospital and during the poststroke period of follow-up.

Ruling Out Stroke Mimics

Various conditions that mimic stroke should be ruled out quickly when stroke is suspected. Postseizure patients may present with unilateral weakness (Todd's paralysis), and strokelike deterioration can occur in a patient with a brain neoplasm. Migrainous aura may be confused with a transient ischemic attack or stroke.[44]

Table 8. Important Stroke/Medical History Questions

Time patient last known well (will be used as presumed time of onset)
Time symptoms were first observed (if different from time last known well)
Was anyone with patient when symptoms began? If so, who?
History of diabetes?
History of hypertension?
History of seizures?
History of trauma related to current event?
History of myocardial infarction or angina?
History of cardiac arrhythmias? Atrial fibrillation?
History of prior stroke or TIA?
What medications is patient currently taking? Is patient receiving anticoagulation therapy with warfarin?

TIA indicates transient ischemic attack.

Blood Pressure Evaluation and Management

Blood pressure measurement is critical in the hyperacute phase of stroke. A history of hypertension is common in AIS patients. A transient rise in blood pressure can also be found in previously normotensive patients; these elevations are expected and may represent the body's compensatory response to the acute cerebrovascular occlusion, enhancing collateral flow.[95–98] Unless blood pressure elevations are in the range to cause hypertensive encephalopathy, they are generally not treated, to facilitate adequate cerebral perfusion pressure. The AHA Stroke Council recommends that emergency administration of antihypertensive agents be withheld unless diastolic blood pressure is >120 mm Hg or systolic blood pressure is >220 mm Hg in AIS patients who are not treated with thrombolytics.[13]

For patients treated with intravenous thrombolysis, key data about treatment of hypertension in the emergent phase of stroke come from the 2 NIH-NINDS rtPA trials.[67] In these patients, systolic blood pressure was maintained at <185 mm Hg and diastolic blood pressure at <110 mm Hg. If 2 consecutive readings showed systolic blood pressure >185 mm Hg or diastolic blood pressure >110 mm Hg, fast-acting intravenous agents were used cautiously to lower blood pressure.[13]

Normally, an intrinsic process in cerebral blood vessels maintains constant brain blood flow regardless of systemic blood pressure, a concept known as autoregulation. In stroke, however, autoregulation may be impaired, particularly in the penumbra, where the cerebral blood flow is determined by systemic blood pressure. In such cases, it may be necessary to regulate systemic blood pressure. The attending physician will choose short-acting continuous infusion agents with a reliable dose-response relation and safety profile.[99] When reduced blood pressure is desired, labetalol is preferred if the patient has tachycardia at baseline, whereas nicardipine, a pure peripheral vasodilator, is preferable if the patient has bradycardia, congestive heart failure, a history of bronchos-

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Table 9. National Institutes of Health Stroke Scale

Item Tested	Title/Domain	Response/Score
1A	LOC	0–Alert
		1–Drowsy
		2–Obtunded
		3–Coma/unresponsive
1B	Orientation	0–Answers both correctly
		1–Answers 1 correctly
		2–Answers none correctly
1C	Response/commands (2)	0–Performs both correctly
		1–Performs 1 correctly
		2–Performs none correctly
2	Gaze	0–Normal horizontal movements
		1–Partial palsy
		2–Complete gaze palsy
3	Visual fields	0–No visual field defect
		1–Partial hemianopia
		2–Complete hemianopia
		3–Bilateral hemianopia
4	Facial movement	0–Normal
		1–Minor facial weakness
		2–Partial facial weakness
		3–Complete unilateral palsy
5	Motor function (arm)	0–No drift
	a. Left	1–Drift before 5 seconds
	b. Right	2–Falls before 10 seconds
		3–No effort against gravity
		4–No movement
6	Motor function (leg)	0–No drift
	a. Left	1–Drift before 5 seconds
	b. Right	2–Falls before 10 seconds
		3–No effort against gravity
		4–No movement
7	Limb ataxia	0–No ataxia
		1–Ataxia in 1 limb
		2–Ataxia in 2 limbs
8	Sensory	0–No sensory loss
		1–Mild sensory loss
		2–Severe sensory loss
9	Best language	0–Normal
		1–Mild aphasia
		2–Severe aphasia
		3–Mute or global aphasia
10	Articulation	0–Normal
	Dysarthria	1–Mild dysarthria
		2–Severe dysarthria
11	Extinction or inattention	0–Absent
		1–Mild (loss of 1 sensory modality)
		2–Severe (loss of 2 modalities)
Total NIHSS score:_____(0–42)		

LOC indicates level of consciousness.

pasm, or chronic obstructive pulmonary disease. Neither of these agents appears to adversely affect ICP. Sodium nitroprusside has theoretical drawbacks related to cerebral venodilation, with exacerbation of any elevations of ICP and impairment of normal autoregulation.[100,101]

The AHA guidelines recommend that blood pressure should not be treated in the hyperacute period unless 1 of the following exists: Systolic blood pressure >220 mm Hg or diastolic blood pressure >120 mm Hg after repeated measurements; cardiac ischemia, heart failure, or aortic dissection is present; thrombolytic therapy is planned; or ICH is identified.[13] Table 10 lists approaches to treatment of elevated blood pressure in AIS.

If blood pressure does not decrease and cannot be maintained below the target levels of 185/110 mm Hg, rtPA should not be administered. Blood pressure management during and after treatment with rtPA or other acute recanalization therapy includes monitoring every 15 minutes during treatment and then for another 2 hours, then every 30 minutes for 6 hours, and then every hour for 16 hours.

Administration of Thrombolytic Therapy

The nurse is responsible for administration of rtPA to eligible patients. The rt-PA dose for AIS is less than the recommended dose for myocardial infarction or pulmonary embolism treatment. rtPA is packaged as a crystalline powder and reconstituted with sterile water. After reconstitution, the preparation is 100 mg total. The total dose for an individual patient is calculated by multiplying the patient's weight per kilogram (up to 100 kg) by 0.9 mg. The total maximum dose for a patient with AIS is 90 mg. (The remaining portion of the preparation that will not be infused should be discarded to prevent accidental overdose.) To prevent accidental overdose, it is important to draw the waste dose from the bottle and verify the waste amount with another nurse before the rtPA bottle is connected to the intravenous pump tubing and administered to the patient. rtPA is administered in divided doses: 10% is given as a bolus over 1 minute, and the remaining 90% is administered as a continuous infusion over the next 60 minutes.

Before administering rtPA, the nurse should make sure that all intravenous lines are inserted. If needed, a Foley catheter and any other indwelling lines or tubes, including endotracheal tubes, should be inserted as well. There has been 1 report of fatal hemorrhage due to traumatic intubation.[102] However, placement of lines and tubes should be rapid and should not delay administration of rtPA by more than a few minutes.

Intra-Arterial Thrombolysis

The use of intra-arterial thrombolysis as an alternative to intravenous rtPA is becoming more widespread. Intra-arterial therapy is based on the principle of delivering thrombolytic therapy at higher concentrations directly into the thrombus. The intra-arterial approach gives AIS patients more treatment options and should be initiated by specially trained interventional radiologists. In selected cases, intra-arterial thrombolysis extends the window of intervention to 6 hours after the onset of ischemic stroke symptoms.[13] The intra-ar-

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Table 10. Recommendations for Treatment of Elevated Blood Pressure in Acute Ischemic Stroke

Blood Pressure Level	Treatment
Not eligible for thrombolytic therapy	
Systolic <220 mm Hg *or* diastolic <120 mm Hg	Observe unless there is other end-organ involvement, eg, aortic dissection, acute myocardial infarction, pulmonary edema, hypertensive encephalopathy. Treat other symptoms of stroke such as headache, pain, agitation, nausea, and vomiting. Treat other acute complications of stroke, including hypoxia, increased ICP, seizures, or hypoglycemia.
Systolic >220 mm Hg *or* diastolic <121–140 mm Hg	Labetalol 10–20 mg IV over 1–2 min. May repeat or double every 10 min (maximum dose 300 mg) *or* Nicardipine 5 mg/h IV infusion as initial dose; titrate to desired effect by increasing 2.5 mg/h every 5 min to maximum of 15 mg/h. Aim for a 10% to 15% reduction of blood pressure
Diastolic >140 mm Hg	Nitroprusside 0.5 μg/kg per min IV infusion as initial dose with continuous blood pressure monitoring. Aim for a 10% to 15% reduction of blood pressure.
Eligible for thrombolytic therapy	
Pretreatment	
Systolic >185 mm Hg *or* diastolic >110 mm Hg	Labetalol 10–20 mg IV over 1–2 min; may repeat ×1 *Or* Nitropaste 1–2 in *Or* Nicardipine drip, 5 mg/h, titrate up by 0.25 mg/h at 5- to 15-min intervals (maximum dose 15 mg/h). If blood pressure is not reduced and maintained at desired levels (systolic ≤185 mm Hg and diastolic ≤110 mm Hg), do not administer rtPA.
During and after treatment	
1. Monitor blood pressure	Check blood pressure every 15 min for 2 h, then every 30 min for 6 h, and then every hour for 16 h.
2. Diastolic >140 mm Hg	Sodium nitroprusside 0.5 μg/kg per min IV infusion as initial dose and titrate to desired blood pressure level.
3. Systolic >230 mm Hg *or* diastolic 121–140 mm Hg	Labetalol 10 mg IV over 1–2 min, may repeat every 10–20 min (maximum dose 300 mg) *or* labetalol 10 mg IV followed by infusion at 2–8 mg/min. *Or* Nicardipine 5 mg/h IV drip as initial dose, titrate up to desired effect by increasing 2.5 mg/h every 5 min to maximum dose of 15 mg/h. If blood pressure is not controlled by labetalol, consider sodium nitroprusside but avoid if possible.
4. Systolic 180–230 mm Hg *or* diastolic 105–120 mm Hg	Labetalol 10 mg IV over 1–2 min. May repeat or double labetalol every 10–20 min to a maximum dose of 300 mg *or* give initial labetalol 10 mg IV followed by infusion at 2–8 mg/min.

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terial approach is commonly used for treating stroke due to a large thrombus in the middle cerebral artery, a life-threatening vertebrobasilar stroke in the posterior circulation, and when intravenous rtPA is contraindicated.[12,103] An emergent cerebral angiogram is required to place the delivery catheter at the site of the thrombus. The nurse should educate patients and their families about this treatment and should also watch for treatment-related complications.

In 1998, the PROlyse in Acute Cerebral Thromboembolism II (PROACT II) trial tested the effectiveness of the intra-arterial approach using prourokinase in patients with onset of stroke symptoms of <6 hours as a result of occlusion of the middle cerebral artery.[104] The primary analysis, intention to treat, was based on a modified Rankin Scale score of 0 to 2 at 3 months. The results were significant at $P=0.04$. Sixty-six percent of middle cerebral arteries were recanalized in patients treated with recombinant prourokinase compared with 18% in the control group ($P<0.001$). The ICH rate was 10% in the prourokinase group compared with 2% in the control group. There was no difference in death rate. On the basis of this single phase III trial, the Food and Drug Administration did not approve prourokinase for intra-arterial treatment of stroke, and it has not been marketed. Other thrombolytics, including rtPA and urokinase, have been extrapolated as intra-arterial therapy within 6 hours of symptom onset in selected cases of AIS.

The results of the cerebral angiogram and other radiological findings such as a hyperdense artery sign can help determine treatment options. Some authors have suggested that patients with a dense middle cerebral artery sign did better with intra-arterial thrombolysis than with intravenous thrombolysis, but there are no direct comparisons in clinical trials to prove this.[103,105,106]

Combined therapy with intravenous thrombolysis and then intra-arterial thrombolysis is used occasionally. The Interventional Management of Stroke study is evaluating the combination of intravenous/intra-arterial administration of low-dose intravenous (0.6 mg/kg) rtPA followed by 22 mg of intra-arterial rtPA therapy. Currently, phase III of the study is comparing conventional intravenous rtPA alone

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with rtPA plus endovascular interventions.[103,107] Further studies will provide more data on the efficacy of intra-arterial thrombolysis.

Mechanical Devices

The Merci Retriever (Concentric Medical, Mountain View, Calif) was the first retrieval device approved for clot retraction in AIS patients who were not candidates for rtPA or who had failed intravenous therapy.[108–110] The Penumbra System (Penumbra Inc, Alameda, Calif) was the second retrieval device approved to remove blood clots in patients with AIS.[111] These devices have been used in combination with intravenous or intra-arterial therapy. Noser et al[109] have suggested that aggressive mechanical clot disruption may help increase recanalization rates compared with intra-arterial thrombolysis. This information is not yet supported by clinical trials.

Several other approaches to recanalization with device catheters are available. The EKOS catheter (EKOS Corp, Bothell, Wash) used in the Interventional Management of Stroke phase I and II trials delivered intra-arterial rtPA with concurrent intra-arterial low-energy ultrasound. Use of transcranial Doppler ultrasound to enhance the thrombolytic activity of intravenous rtPA is being evaluated in phase II clinical trials.[112] These device catheters have been evaluated in safety and technical efficacy trials. Randomized, controlled clinical trials of both the Merci and EKOS devices must be completed to evaluate their clinical efficacy.[107,113]

Recommendations

Class I

1. Emergency personnel should be highly trained in stroke care (***Class I, Level of Evidence B***).
2. Frequent neurological/stroke assessments should be done (***Class I, Level of Evidence C***); these should be done more frequently for patients receiving rtPA.
3. Supplemental oxygen should be given to patients with an oxygen saturation of <92% and a decreased level of consciousness (***Class I, Level of Evidence C***). There is little evidence that supplemental oxygen should be provided routinely.
4. The stroke patient's head should be positioned in neutral alignment with the body, and the head of the bed should be elevated 25° to 30° to help the patient handle oral secretions, especially if dysphagia is present (***Class I, Level of Evidence C***).
5. Stroke patients in the ED should be kept NPO (not given anything orally) until ability to swallow is assessed (***Class I, Level of Evidence B***).
6. Intravenous access should be obtained in at least 2 sites, with 1 site for administration of rtPA and 1 site for delivery of intravenous fluids or other medications if the patient is a candidate for rtPA (***Class I, Level of Evidence C***).
7. Only nondextrose, normotonic intravenous fluids such as normal saline should be used in the AIS patient (***Class I, Level of Evidence C***).
8. Intravenous rtPA should be administered without delay and should not be excluded in an eligible patient (***Class I, Level of Evidence A***).
9. See Table 11 for additional medical recommendations.

Table 11. Medical Recommendations

Recommendation	Class and Level of Evidence
Class I:	
CT or MRI of the head should be performed emergently in patients who present to the ED within the 3-h window.	Class I, Level of Evidence A
In the ED setting, laboratory tests should be obtained and processed rapidly to facilitate rapid assessment of the stroke patient, especially one who is a candidate for rtPA. At a minimum, the following tests should be performed: CBC, including platelets, blood chemistries, and coagulation studies (PT, aPTT, and INR).	Class I, Level of Evidence A
The use of intra-arterial thrombolysis is reasonable in select patients with a large MCA clot presenting within 6 h of stroke onset or who have contraindications to intravenous thrombolysis.	Class I, Level of Evidence B
Interventional treatment should be provided by a qualified interventionalist in centers that meet the guidelines for comprehensive stroke centers.	Class I, Level of Evidence C
When intra-arterial rtPA is considered, intravenous rtPA should always be given if the patient is eligible.	Class I, Level of Evidence C
Class IIa:	
The Merci Retriever and Penumbra System is a reasonable intervention for extraction of thrombi, but both require further evaluation of clinical efficacy.	Class IIa, Level of Evidence B
Intra-arterial thrombolysis is reasonable in patients with contraindications to use of intravenous thrombolysis, such as recent surgery.	Class IIa, Level of Evidence B

CBC indicates complete blood count; PT, prothrombin time; and MCA, middle cerebral artery.

Phase 2: Acute Care

During the acute care phase, nursing care should focus on continued stabilization of the stroke patient through frequent evaluation of neurological status, blood pressure management, and prevention of complications. Medical management focuses on establishing the cause or etiology of AIS, prevention of treatment-related complications, and evaluation of secondary prevention strategies. There is considerable evidence that dedicated stroke teams, units, and coordinated care improve clinical outcomes in the acute care phase.[5,7,57,114–121]

Clinical Pathways and Stroke Order Sets

Specific order sets (standing orders) that address issues such as control of blood glucose, parameters to treat fever, and consultations with other multidisciplinary team members should be developed. The Brain Attack Coalition recommends succinct, organized stroke care in its recommendations for the development of primary stroke centers.[10]

Specific Care in the Acute Phase: Immediate Medical and Nursing Management

A key element of the management of patients with acute stroke is to prevent deterioration and medical complications,

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such as respiratory problems associated with smoking or pneumonia, hypertension, hyperglycemia, dehydration, malnourishment, fever, coronary artery disease, cerebral edema, infection, and thromboembolism (deep vein thrombosis [DVT] or pulmonary embolism). These all worsen overall patient outcome.[13,82,122–131]

To provide high-quality care, nurses must coordinate the activities of the multidisciplinary team. Clinical pathways or physician standing orders can guide the team in managing stroke patients and are useful for coordinating diagnostic tests and appropriate therapies and care issues. Clinical pathways improve coordination of acute stroke care and discharge planning, decrease hospital costs, decrease readmission rates, reduce length of hospital stay, and enhance usefulness of outcome measurement and quality improvement.[114,132,133] Examples of professional resources including clinical pathways, guidelines, and standing orders can be found on the AHA Web site (http://www.americanheart.org/presenter.jhtml?identifier=3047992) and the Brain Attack Coalition Web site (http://www.stroke-site.org).

Intensive Management

Experts estimate up to 30% of all stroke patients will deteriorate in the first 24 hours.[13,129] This statistic supports the need for intensive monitoring by nurses specifically trained in acute stroke care. Patients who receive thrombolytic therapy should also be monitored closely for at least 24 hours after treatment. Care may be provided in a designated intensive care unit or a stroke unit with continuous cardiac telemetry. In either area, nurses are trained in the care of patients after thrombolysis, are aware of bleeding complications, are trained in the use of appropriate neurological assessment tools, and are adept at recognizing the signs of increasing ICP often related to large stroke lesions.[86] The nurse-patient ratio is 1:2 for the first 24 hours; then, if the patient's condition is stable, the ratio is 1:4 as appropriate.[53,134]

Bleeding assessment after administration of rtPA is the responsibility of the clinical nurse, who monitors the patient for major and minor bleeding complications in the first 24 to 36 hours after administration of rtPA.[84,135] ICH is the major bleeding complication associated with thrombolytic therapy.[83,135] In the NINDS trials, 6.4% of treated patients had symptomatic ICH, which is defined as "any CT-documented hemorrhage that was temporally related to deterioration in the patient's clinical condition in the judgment of the clinical investigator" within 36 hours of treatment.[135] Studies have shown that there is a natural rate of hemorrhagic transformation in ischemic stroke, and some studies suggest that petechial hemorrhages are frequently found in almost all cerebral infarcts.[135–138] The use of thrombolytics increases the risk of serious hemorrhagic transformation. The nurse must identify which patients are at higher risk of ICH. One study has shown that only 3% of patients with an NIHSS score of <10 who were treated with rtPA had symptomatic ICH compared with 17% of those with an NIHSS score >20.[135] Other studies have shown that hemorrhagic transformations are more frequent when there has been a deviation from the national guidelines treatment protocol.[139–142] Age >80 years was determined to be an independent factor in development of hemorrhage after administration of rtPA.[75,143] Hemorrhagic transformation should be suspected if there is a change in level of consciousness, elevation of blood pressure, deterioration in motor examination, onset of new headache, or nausea and vomiting. If hemorrhage is suspected, the rtPA infusion should be discontinued immediately.[84] Management of ICH includes immediate physician notification and attainment of rapid brain imaging and laboratory work, including prothrombin time/international normalized ratio, activated partial thromboplastin time, fibrinogen level, complete blood count with platelets, and, if not already done, type and cross-match. The nursing staff must be prepared to administer 6 to 8 U of cryoprecipitate containing factor VIII and 6 to 8 U of platelets.[83,84] The physician will decide on further action in collaboration with other team members, such as the consulting neurosurgeon. Facilities that treat patients with thrombolytics should have a hemorrhage algorithm (Table 12) and clinical guidelines to expedite assessment and management of a new ICH. Other major bleeding complications observed after thrombolytic therapy are retroperitoneal, genitourinary, and gastrointestinal hemorrhages. Minor bleeding complications are common, such as oozing from gums and venipuncture sites, as well as hematuria and hemoptysis.[84] Assessment of the patient's skin may identify hematomas or areas of ecchymosis or purpura. If the patient has antecubital venous access, automatic blood pressure cuffs should be used with caution to prevent formation of a hematoma in the patient's arm. The cuff site should be checked frequently, rotated, and repositioned every 2 hours. If petechiae are noticed under the automatic blood pressure cuff, use of the cuff should be discontinued. To prevent trauma during oral care, soft sponges should be used instead of toothbrushes in the first 24 hours. Invasive procedures such as arterial punctures or insertion of catheters or nasogastric tubes should also be avoided in the first 24 hours after treatment.[84]

Neurological Stroke Assessment, Including the NIHSS

Intensive monitoring of stroke patients includes frequent monitoring of neurological assessment, including blood pressure, heart rate, and respirations. In patients treated with thrombolysis, blood pressure should be assessed at 15-minute intervals for 2 hours, every 30 minutes for the next 6 hours, and then once per hour until 24 hours after initiation of thrombolytic therapy. A complete bedside NIHSS assessment may be performed on admission to the intensive care unit, and an abbreviated version can be performed with more frequent assessments (Table 9).[86] The complete scale should be used if there is a decline in the abbreviated scale score.[65,84]

The NIHSS provides valuable prognostic information and has been correlated with infarct volume.[13,86,144] Patients with an NIHSS score of <10 have a much more favorable outcome at 1 year than patients with an NIHSS score of >20.[144] The nurse can use the NIHSS to identify patients who are at higher risk for ICH after thrombolytic treatment. In the NINDS rtPA trial, patients with an NIHSS score of >22 had a 17% risk of ICH, whereas those with an NIHSS score of <10 had only a

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Table 12. ***Nursing Alert!*** **Critical Actions for Suspected ICH or Systemic Bleeding After rtPA Administration[84]**

Care Element	Suspect ICH or Systemic Bleed	2–24 h After ICH	24–36 h After ICH
Consultations	Neurosurgery if ICH suspected Hematology if ICH suspected General surgery if systemic bleed suspected	Same	Same
Nursing assessments	Vital signs every 15 min Neurological examination, signs of ICP every 15 min Continuous ECG monitoring Look for other bleeding sites	Vital signs every 1 h and as necessary Signs of ICP, neurological examination GCS/pupil check every 1 h and as necessary Monitor ECG Monitor SVo_2, ICP	Advance vital signs as necessary Advance neurological examination Consider discontinuing ECG
STAT diagnostics	CT head, noncontrast or MRI with GRE sequence Labs: PT/aPTT/INR, fibrinogen, CBC with platelets, type and cross-match Pulse oximetry, consider SVo_2, brain oximeter Consider ICP monitor Consider hemodynamic monitoring Check stool for occult blood	Labs: Na^{2+}, osmolality (if on mannitol) Glucose every 6 h and as necessary (in patients with history of DM) ABGs Co_2 30–35 (hyperventilation if ordered) Consider ICP monitor	Consider discontinuing O_2 monitoring
Treatments	If receiving thrombolytics, STOP INFUSION Consider hyperventilation Consider mannitol Consider blood products (cryoprecipitate, FFP, PLTs, PRBCs, other meds such as factor VIIa) Consider surgery Apply pressure to compressible sites for major or minor systemic bleeds	Keep Po_2 >90 mm Hg Consider hyperventilation Consider mannitol 25 g every 4–6 h Consider surgery; treat DKA/HOC with insulin drip as necessary	Keep Po_2 >90 mm Hg Wean hyperventilation Wean mannitol Wean blood pressure drips, add oral agent as tolerated
Activity	Bed rest Change position every 1–2 h as tolerated	Same	Advance as tolerated
Nutrition	Feed as soon as possible NPO Consider enteral feedings with NGT or DHT	Same	Consider feeding as swallowing screen defines, consider TPN or other enteral feeding

NINDS rtPA Stroke Study Group hemorrhage algorithm.[83,84]

GCS indicates Glasgow Coma Scale; GRE, gradient refocused echo; DM, diabetes mellitus; ABGs, arterial blood gases; DHT, Dobhoff tube; FFP, fresh frozen plasma; PLTs, platelets; PRBCs, packed red blood cells; DKA, diabetic ketoacidosis; HOC, hyperosmolar coma; NGT, nasogastric tube; and TPN, total parenteral nutrition.

3% risk of ICH.[13] The NIHSS may be useful for working with families on discharge planning needs.[145,146] In 1 study of ischemic and hemorrhagic stroke patients, a 24-hour NIHSS score of <5 increased by nearly 5-fold the likelihood of discharge to home rather than inpatient rehabilitation or a skilled nursing facility.[145,146]

Ongoing Blood Pressure Management

Blood pressure is a critical vital sign in the AIS patient. It is not uncommon to see variations in blood pressure after AIS.[96] Blood pressure is elevated in ≈40% to 80% of all AIS patients,[96] especially in the first 24 to 48 hours after stroke, and will fall 10 to 14 days after the acute phase.[147] Elevated blood pressure may increase cerebral perfusion in the ischemic zone, where autoregulation is lost and perfusion is pressure dependent.[148] The current guidelines recommend maintaining blood pressure at <180/105 mm Hg for 24 hours in patients who have received thrombolytic therapy.[13] It is recommended that antihypertensive treatment be initiated for nonthrombolytic candidates only if systolic blood pressure is >220 mm Hg or diastolic pressure is >110 mm Hg.[13]

Blood pressure should be monitored and assessed continually for causative factors of rises. Elevated blood pressure may be due to a physiological response to hypoxia, increasing ICP, hemorrhagic transformation, full bladder, pain, nausea, a loud environment, or preexisting hypertension.[13,149,150] The ASA blood pressure guidelines may be included in standing physician orders to expedite treatment of elevated blood pressure in the phase that immediately follows thrombolytic therapy.[13] At present, the optimum blood pressure in the immediate poststroke period is unclear and controversial, and further scientific evidence is needed.[151,152] There is evidence, however, that rapid lowering of blood pressure may induce worsening of neurological symptoms by inducing lowered perfusion pressures to the area of ischemia.[149,153,154]

Arterial hypotension is rare in the AIS patient but may be associated with volume depletion or decreased cardiac output related to arrhythmias or myocardial ischemia. Patients with hypotension require evaluation with advanced neurological nursing assessment and telemetry monitoring. Treatment consists of volume replacement with normal saline and correction of arrhythmias.

Temperature Management

Fever appears to exacerbate the ischemic injury to neurons and is associated with increased morbidity and mortality,

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particularly in acute stroke.[155] Data from additional meta-analyses found a correlation between temperature elevation and cerebral infarct volume.[80] Even an increase of 1°F is a predictor of poorer patient outcome and is an independent factor in short- and long-term mortality rates.[82,129,156,157] The rationale for this additional injury may be related to increased metabolic demands and free radical production. Immediate treatment of the source of the fever will reduce its duration.[82,157] One approach to maintaining normothermia is to immediately begin acetaminophen at 99.6°F.[158,159] Even more rapid induction of cooling can be achieved by additionally treating temperature elevation with indwelling catheter temperature control systems or surface cooling systems.[158,159]

Continuous Cardiac Monitoring

Cardiac monitoring is recommended for all ischemic stroke patients.[13,160,161] Studies suggest that insular lesions can lead to cardiac arrhythmias and sudden cardiac death.[13] Arrhythmias such as ventricular ectopy, tachycardia, and heart blocks have been associated with AIS.[162] Right hemispheric infarcts have been associated with a higher incidence of arrhythmias, possibly due to sympathetic and parasympathetic nervous system dysfunction.[163] Atrial fibrillation, often paroxysmal, is commonly first detected only after it has caused cardioembolic stroke. If cardiac output is compromised, arrhythmias may further aggravate an already compromised cerebral blood flow. If not completed as part of the initial ED workup, a 12-lead ECG can be completed on admission. Many stroke patients have underlying cardiac problems and are at risk for an acute myocardial infarction during the acute stages of stroke. Patients may also need a cardiac evaluation by a cardiologist during the acute stages of stroke. If telemetry is unavailable, a Holter monitor can be used to check for arrhythmias.[13]

Assessment of Oxygenation

Monitoring of oxygen saturation will reduce the risk of neurological deterioration related to hypoxemia. Supplemental oxygen at 2 to 4 L/min is recommended for an oxygen saturation of <92%.[13,164] Many factors compromise adequate oxygenation, for example, decreased level of consciousness, aspiration, and atelectasis. Vigilant assessment of the patient's lung sounds and ability to swallow will keep the nurse aware of pending threats to adequate oxygenation.[13,135,165] If an oxygen saturation of 92% cannot be maintained, arterial blood gases and a chest radiograph are recommended. In the absence of hypoxemia, supplemental oxygen is not recommended.[87]

Angioedema

Large prospective cohort studies have shown that orolingual angioedema occurs in a small proportion (1% to 2%) of patients with AIS or acute myocardial ischemia treated with rtPA. This was more commonly seen in patients with frontal cortex and insular ischemia, in patients who had received alteplase and were concurrently taking angiotensin-converting enzyme (ACE) inhibitors.[102] In most cases, symptoms were mild and transient. The pharmacological insert that accompanies rtPA addresses this and recommends that patients be monitored during infusion and for several hours afterward for signs of allergic reaction that exhibits as orolingual angioedema (http://www.gene.com/gene/products/information/cardiovascular/activase/insert.jsp). Treatment includes immediate discontinuation of rtPA and administration of antihistamines, intravenous corticosteroids, or epinephrine. It is important for emergency and intensive care unit nurses to evaluate patients closely for throat or mouth edema and look for any difficulty in breathing due to angioedema.

Blood Glucose Monitoring: Hyperglycemia

Hyperglycemia in critically ill patients has long been associated with complications. Infarct expansion, hemorrhagic conversion, and poor clinical outcomes have been reported in the AIS population.[134] Even the benefit of recanalization after use of thrombolytics may be reduced.[166–168] Increased blood glucose provides additional substrate for anaerobic metabolism, which promotes lactic acidosis and free radical production. Elevated serum glucose is common in the acute phase of stroke and may be related to uncontrolled or undetected diabetes mellitus or stress-induced hyperglycemia associated with cortisol and norepinephrine release at the time of insult.[167,169–174] In 1 study, elevated glucose was present in two thirds of AIS patients.[175] Treatment with insulin confers a protective effect in critically ill patients.[164,165] The ASA 2007 "Guidelines for the Early Management of Adults With Ischemic Stroke" recommend the use of rapid-acting insulin for a blood glucose level >140 mg/dL.[13]

Several studies have shown that elevated blood glucose is an independent factor in poor functional outcomes, increased infarct size, increased length of stay (7 versus 6 days), increased mortality at 30 days, and increased cost ($6611 versus $5262).[176–178] Not only did patients have poorer outcomes associated with hyperglycemia, but in an analysis of the NINDS rtPA trial, it was found that the risk of hemorrhagic transformation increased by 75% per 100 mg/dL of blood glucose.[167,177–180] Poorer outcomes were also seen in patients with a glucose level >140 mg/dL after administration of rtPA. There is speculation that elevated glucose levels may prevent early reperfusion and eliminate the benefit of rtPA.[166–168]

Several nonrandomized studies have suggested improved outcome if there is an acute reversal of hyperglycemia.[167,181–184] The Glucose Insulin in Stroke Trial (GIST), a multicenter, randomized trial, recruited 933 patients and evaluated the use of variable-dose glucose and potassium insulin (GKI) versus saline infusions in stroke patients with glucose levels of 6.0 to 17.0 mmol/L (≈300 mg/dL and defined as mild to moderate hyperglycemia).[185] The purpose of the GKI infusion was to maintain glucose at 4 to 7 mmol/L (euglycemic); there was no glucose intervention in the control group after stroke. Most patients were entered in the study within 24 hours after onset of stroke symptoms. The primary outcome was death at 90 days. The study was stopped early owing to low recruitment. Based on the intention-to-treat data, there was no significant reduction in morbidity or mortality at 90 days in the intervention group (GKI versus control: odds ratio 1.14, 95% confidence interval 0.86 to 1.52, $P=0.37$). Plasma glucose

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concentrations and blood pressure were significantly reduced in the GKI group. The investigators' interpretation of this study was that although the intervention group had lower glucose and blood pressure levels, there was not a significant clinical benefit. The study was underpowered, and an alternative result could not be excluded.[186] More randomized clinical trials are needed to understand the optimal level of blood glucose and best treatment modalities to produce the best clinical outcomes in stroke patients.

The nurse should monitor the blood glucose level based on the patient's glucose level at admission.[176] If blood glucose is >140 mg/dL and the patient has received thrombolytic therapy, it may be prudent to monitor glucose every 1 to 2 hours, because there is evidence that these patients are more prone to ICH. Treatment for hyperglycemia may be instituted, depending on individual hospital insulin or oral hypoglycemic treatment protocols. In patients who have not received thrombolysis, glucose may be monitored every 6 hours in the first 24 to 48 hours and continued if the patient is known to have diabetes. It is also important to evaluate the need for diabetic education whether or not the patient is a known or newly diagnosed diabetic.

Hypoglycemia

Hypoglycemia can uncommonly cause focal neurological deficit and mimic stroke. If present, it should be corrected promptly with administration of 1 ampule of 50% dextrose.

Cerebral Edema After Stroke

Cerebral edema is a common complication of large multilobar infarctions. It usually peaks 3 to 5 days after AIS and is not a significant problem in the first 24 hours except in patients with large cerebellar infarcts or in younger stroke patients. Young people usually do not have significant cerebral atrophy, thereby allowing no room for swelling. ICP increases as a result of cerebral edema, and monitoring for increased ICP should be part of the ongoing assessment of AIS patients. When invasive ICP monitoring is not available, the nurse must rely on the less accurate clinical signs of increasing pressure, which can include change in level of consciousness, worsening neurological deficits, new pupillary changes, or changes in respiratory patterns.[13] Changes in level of consciousness are an early sign of increasing ICP, whereas pupillary changes are a late sign. Hydrocephalus may also develop as a result of obstruction of the cerebral spinal fluid pathways. Imaging studies will identify mass effect, which includes frontal horn compression, or shift of the septum pellucidum or the pineal gland. These signs demonstrate that the patient is at risk of clinically worsening and increasing pressure that can lead to brain herniation. The treatment plan goals should be to (1) reduce ICP, (2) maintain cerebral perfusion pressure to prevent worsening cerebral ischemia, and (3) prevent secondary brain injury[13] (Table 13).

Hypotonic fluids containing excess free water should be avoided in patients who have or are at risk for cerebral edema.[13] The nurse must evaluate the patient for hypoxia, hypercarbia, or hypothermia that may lead to elevated ICP. The head of the bed should be elevated 20° to 30°, the neck should be in a neutral position to facilitate venous drainage, and the airway should be assessed for patency. As ICP increases, the patient's blood pressure may rise to maintain adequate cerebral perfusion pressure. The use of an aggressive antihypertensive agent with venodilating effects, such as nitroprusside, should be avoided because it can cause cerebral venodilation and can lead to a more elevated ICP. For cerebellar infarcts and hemorrhages in which hydrocephalus and a generalized increase in ICP are an issue, an ICP catheter is usually not inserted. For large hemispheric infarcts and hemorrhages, herniation rather than generalized increased ICP is the main concern, and ICP monitoring is generally not helpful. ICP treatment may include modest hyperventilation to decrease Pco_2 by 5 to 10 mm Hg to produce enough vasoconstriction to temporarily lower ICP.[13] However, hyperventilation is only a temporary measure, and brain perfusion may be compromised as vasoconstriction occurs. Frequent neurological assessments must be done to look for potential changes in brain perfusion.[13] On the basis of studies conducted primarily among the head injury patient population, it has become clear that some nursing care activities increase ICP transiently in some patients; however, it is not possible to identify any given activity that is uniformly detrimental to patients with increased ICP. Therefore, nurses need to evaluate each patient's physiological response to routine care.[187,188]

Osmotic diuretics such as furosemide or mannitol can be used to treat cerebral edema. Intravenous mannitol (0.25 to 0.50 g/kg) administered over 20 minutes can be given every 6 hours. Serum and urine osmolality should be monitored if mannitol is used; however, a Cochrane systematic review found no evidence that routine use of mannitol reduced cerebral edema or improved stroke outcome in AIS.[189] Lasix 40 mg can be used as adjunctive therapy but should not be used long-term. Barbiturates can be used for severe cerebral edema. Continuous electroencephalographic monitoring

Table 13. Nursing Alert: Recognizing Increased ICP

Signs and symptoms of increasing ICP–a medical emergency
Early signs: decreased level of consciousness, deterioration in motor function, headache, visual disturbances, changes in blood pressure or heart rate, changes in respiratory pattern
Late signs: pupillary abnormalities, more persistent changes in vital signs, changes in respiratory pattern with changes in arterial blood gases
Intervention: thorough neurological assessment, notify physician immediately, emergency brain imaging, maintain ABCs
General measures to prevent elevation of ICP
HOB up 30° or as physician specifies; reverse Trendelenburg position may be used if blood pressure is stable. Head position may be one of the single most important nursing modalities for controlling increased ICP
Good head and body alignment: prevents increased intrathoracic pressure and allows venous drainage.
Pain management: provide good pain control on a consistent basis
Keep patient normothermic

HOB indicates head of bed.

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should be performed if barbiturates are administered. Hypothermia can also be used to treat elevated ICP.[13] Unfortunately, all of these modalities are short-lived and palliative at best. The recommendations for reducing cerebral edema need further study with regard to AIS. Currently, there is no clinical evidence that the measures discussed reduce cerebral edema or improve outcome in patients with ischemic brain swelling.[13,189]

If hydrocephalus is present, fluid drainage through an intraventricular catheter can rapidly reduce ICP. Surgical decompression (hemicraniectomy) is the most definitive and invasive treatment of massive cerebral edema. Large cerebellar infarctions and hemorrhages that cause direct cerebellar compression of the brain stem are best treated with surgical decompression.[190–192] Surgical evacuation may be done in patients with large hemispheric infarcts, but survivors have severe residual neurological deficits.[193–200] Subsequent to a 2002 Cochrane review that found some evidence for benefit from surgical decompression,[201] larger nonrandomized prospective trials have shown a reduction in the mortality rate of patients who have hemicraniectomy of large lesions involving the middle cerebral artery territory.[193–200,202] A recent pooled analysis of 3 randomized, controlled clinical trials (DEcompressive Craniectomy In MALignant middle cerebral artery infarcts [DECIMAL], DEcompressive Surgery for the Treatment of malignant INfarction of the middle cerebral arterY [DESTINY], and Hemicraniectomy After Middle cerebral artery infarction with Life-threatening Edema Trial [HAMLET]) in patients with malignant middle cerebral infarct showed that decompressive surgery performed within 48 hours of stroke onset reduced mortality and yielded more favorable outcomes.[123,203]

Seizures

Seizures are a possible complication of large cortical strokes and can be potentially life-threatening if not controlled. They can occur at the time of AIS, during the first few days after the event, or several months later. No study has specifically tested the usefulness of anticonvulsant medications in preventing or controlling seizures after stroke. Drugs proven to be of value in preventing seizures from other causes, however, are recommended for patients who have had more than 1 seizure after stroke.[204] Routine prophylactic administration of anticonvulsant drugs to stroke survivors who have not had seizures should be avoided.[13] A study of 3552 SAH patients in 21 countries found that anticonvulsant drugs were commonly used but were associated with more in-hospital complications and poorer outcomes.[205] No similar studies were found regarding AIS.

If an anticonvulsant drug is required, the nurse must educate the patient and family about the seizure condition, pharmacological management, the medication regimen for treatment of seizures, and the side effects and precautions. The patient must be told to never adjust or take additional medications without consulting the physician. Patients may not have another seizure, but they and their families should be educated that the risk is ongoing.

Recommendations

Class I

1. Stroke neurological assessments should be performed every 4 hours after the hyperacute phase of stroke, and then frequency should be based on the patient's stability and other comorbid conditions (***Class I, Level of Evidence B***).
2. Temperatures >99.6°F should be managed aggressively (***Class I, Level of Evidence C***).
3. Continuous cardiac monitoring of the stroke patient should be provided for at least 24 to 48 hours after stroke to detect potential cardiac problems (***Class I, Level of Evidence B***).
4. Careful, frequent monitoring and assessment for worsening of neurological deficits or bleeding should be performed for up to 24 hours after thrombolytic therapy (***Class I, Level of Evidence B***).
5. Hyperglycemia should be treated in patients with a serum glucose concentration >140 mg/dL (***Class I, Level of Evidence C***).
6. Management of arterial hypertension in the acute phase should be approached with caution because of the lack of data available to guide management (***Class I, Level of Evidence C***).
7. Oxygenation should be evaluated with an oxygen saturation monitor (***Class I, Level of Evidence C***).
8. To prevent aspiration pneumonia, the patient's lungs should be auscultated, and the patient should be evaluated for signs of respiratory compromise and dysphagia (***Class I, Level of Evidence C***). Nurses should report seizure activity, and treatment should begin immediately (***Class I, Level of Evidence B***). Prophylactic treatment of seizures should not be given.

Class IIa

1. It is reasonable to use clinical pathways, protocols, or preprinted stroke order sets to organize care of the stroke patient (***Class IIa, Level of Evidence B***).

Diagnostic Testing During the Acute Phase

Overview of Neuroimaging in Stroke

Diagnostic imaging techniques include CT, MRI, magnetic resonance angiography, CT angiography, conventional angiography, and carotid and transcranial ultrasound of the cervical and cephalic arteries.[13] Imaging of extracranial and intracranial cerebral blood vessels may be essential for understanding the mechanism of AIS. The presence of a high-grade stenosis, occlusion, dissection, or vascular anomaly indicates the events that led to the stroke. The nurse will need to educate the patient and family regarding each test and what to expect.

Computed Tomography

Imaging in the hyperacute phase was discussed above. A repeat CT or MRI brain scan should be done 24 hours after the initial stroke event in patients treated with thrombolysis or in any situation in which the patient is clinically deteriorating to assess hemorrhagic transformation and infarct progression. The CT scan is still considered the gold standard in AIS

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treatment, although recent technology has led to more sophisticated multimodal approaches in stroke imaging with CT evaluation. CT perfusion and CT angiography provide a map of cerebral blood volume, cerebral blood flow, and mean transit time. These studies identify the ischemic core and pneumbra regions that can guide the decision for further interventional treatment.

Magnetic Resonance Imaging

MRI demonstrates evidence of ischemic injury to the brain earlier than CT for all ischemic stroke subtypes. Magnetic resonance angiography is a useful noninvasive procedure for evaluating extracranial and intracranial vessels. Newer multimodal techniques (eg, diffusion-weighted imaging and perfusion-weighted imaging) have further increased the sensitivity of MRI. The advantage of diffusion-weighted imaging is early identification of the ischemic area within minutes of onset of acute stroke. Perfusion-weighted imaging indicates the hemodynamic status of cerebral blood flow. A diffusion-perfusion mismatch shows an ischemic penumbra change in perfusion without a diffusion abnormality. This is an opportunity to identify irreversible versus reversible cerebral tissue. If there is no mismatch, the hope of salvageable tissue is less. Treatment modalities and time to treatment may change as more is learned about the ischemic penumbra.[13,206–208]

Ultrasonography

Carotid duplex scanning is the standard ultrasound test initially used to screen for cervical internal carotid stenosis. Demonstration of stenosis >60% is highly accurate; however, differentiation between severe (95% to 99%) stenosis and 100% occlusion is not completely reliable.

Cerebral Angiography

Cerebral angiography is the best tool to accurately evaluate the surface characteristics of a stenosed artery and is considered the "gold standard" for measuring the degree of stenosis of a cervical or cephalic artery. After the procedure, the nurse will perform frequent measurement of vital signs, neurological assessment, femoral and pedal pulse checks, and groin checks. The radiologist should be notified if a groin hematoma or change in velocity of the pedal pulse develops. Postprocedure activity is restricted according to the closure device used and the patient's status.

Transesophageal and Transthoracic Echocardiography

All patients with ischemic stroke or transient ischemic attack should undergo a comprehensive assessment of cardiovascular risk to identify those with the highest likelihood of morbidity and mortality due to unrecognized coronary heart disease or the presence of a cardioembolic source of stroke.[13,209,210] Transthoracic echocardiography is excellent for identifying ventricular sources, such as a dyskinetic ventricular wall segment, whereas transesophageal echocardiography excels at identifying atrial and aortic sources, such as patent foramen ovale or aortic arch atherosclerosis. A transesophageal echocardiogram is sensitive for detecting apical thrombi and atrial septal defects or patent foramen ovale.

Transthoracic echocardiography is the less invasive of the 2 procedures and is the most commonly ordered initial test to evaluate for a cardioembolic source of stroke. During a transesophageal echocardiogram, the nurse must monitor the patient closely and position the patient to decrease risk of aspiration if nausea or vomiting occurs.[210,211]

Chest Radiograph

A chest radiograph is no longer routinely recommended during the ED evaluation of stroke unless an underlying pulmonary or cardiac problem is suspected. Obtaining a chest radiograph may take valuable time that is needed to administer rtPA within the 3-hour window. Therefore, a chest radiograph is not a high priority in the ED but is done during the acute phase of hospitalization.

Recommendation

Class I

1. All nurses should be familiar with the basic neuroimaging testing for stroke patients so that they can educate and prepare patients and families (***Class I, Level of Evidence C***).

General Supportive Care of Stroke: Remembering the Basics

Medical and nursing management both focus on the prevention of subacute complications of stroke, including malnutrition, aspiration, pneumonia, UTI, bowel or bladder dysfunction, DVT, pulmonary embolism, contractures, joint abnormalities, and skin breakdown.[130] Depression is also common after stroke.[212] Even in specialized stroke units, up to 63% of patients experience 1 or more complications after acute stroke. The most common complications during the first week in a Norwegian stroke unit were pain, fever, progressing stroke, and UTI; immobilization-related complications, such as pressure ulcers and clinical signs of DVT and pulmonary embolism, had a very low incidence in this modern stroke unit.[213] However, many stroke patients are not cared for in specialized units, so it behooves nurses to continue to be vigilant for the following areas of care related to prevention or rapid detection of complications.[5,7,57,114–121,132,214–223]

Infection

Pneumonia and UTI are frequently seen in the acute phase after stroke. Fever or a change in level of consciousness should give the nurse a high index of suspicion for infection. Stroke patients frequently present to the hospital with a compromised chest radiograph or a UTI.

Pneumonia is a serious complication occurring in the first 48 to 72 hours after AIS and accounts for approximately 15% to 25% of deaths associated with stroke.[13,224] Stroke-associated pneumonia increases length of stay, mortality, and hospital costs.[224] The most common cause of pneumonia is aspiration due to dysphagia.[225] Immobility and atelectasis can also lead to development of pneumonia. The patient's airway and oxygenation must be monitored closely; some patients may require endotracheal intubation and mechanical ventilation. Early mobility and good pulmonary care can help prevent pneumonia.[224] Preventive measures in intubated pa-

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tients include ventilation in a semirecumbent position, positioning of the airway, suctioning, early mobility, and shortened use of intubation, if feasible.[226] In a randomized trial, early prophylaxis with levofloxacin was beneficial in preventing systemic infections.[227] Nursing management includes prompt recognition and reporting of fever; the source of the fever should be sought and treatment begun immediately. Early management of nausea and vomiting can help prevent aspiration pneumonia; use of antiemetic medications is warranted in this situation. Suctioning of the airway should be done carefully if increased ICP is present.[228]

UTIs are common, occurring in approximately 15% to 60% of stroke patients, and independently predict poor outcome.[122,130,229–231] The use of an indwelling catheter and changes in sphincter control increase the risk of UTI. Indwelling catheters should be avoided if possible but are often required in the acute phase of stroke. The catheter should be removed as soon as the patient is medically and neurologically stable. Intermittent catheterization may lessen the risk of infection. External catheters, incontinence pants, and intermittent catheterization are alternatives to an indwelling catheter. The patient should be assessed for UTI if there is a change in level of consciousness and no known reason for neurological deterioration. A urinalysis and urine culture should be obtained if UTI is suspected.[13,229,232,233]

Bowel and Bladder Care

Constipation is the most common bowel problem. The nurse should assess the patient's premorbid bowel elimination pattern, bowel sounds, and abdominal distention, if present. The patient should also be evaluated for hydration and impaction. The nurse must request medications if needed or develop a bowel program, which can integrate the use of stool softeners, laxatives, and enemas to prevent constipation early after stroke.

The most common urinary complication is incontinence, which occurs 30% to 60% of the time in the early recovery period.[234] An infarct in the frontal lobe or the pons can lead to incontinence. Voiding problems include neurogenic bladder; hyperreflexia with urge incontinence, urgency, and frequency; and urinary retention with or without overflow incontinence. After the indwelling catheter is removed, intermittent catheterization may be necessary to retrain the bladder. Intermittent catheterization should occur every 4 to 6 hours to prevent filling of the bladder beyond 500 mL and to stimulate normal physiological filling and emptying. Intermittent catheterization is recommended if postvoid residual urine volume is >100 mL.[235]

Urinary incontinence can increase the incidence of dermatitis, skin breakdown, UTIs, and perineal thrush. Urinary incontinence also interferes with rehabilitation and is the major factor in patients being discharged to nursing homes.[236] Voiding strategies should be incorporated into the daily plan of care. The nurse must initiate a bladder-training program to decrease the number of incontinent episodes. The patient should be offered a commode, bedpan, or urinal every 2 hours during waking hours and every 4 hours at night. Neurological deficits may complicate the task of going to the bathroom. High fluid intake during the day and decreased fluid intake in the evening should be encouraged.

Mobility and the Musculoskeletal System

Stroke patients may be initially kept on bed rest but should be mobilized when they are hemodynamically stable. Early mobilization reduces risk of atelectasis, pneumonia, DVT, and pulmonary embolism. Complications from immobility account for up to 51% of deaths in the first 30 days after ischemic stroke.[237,238] Immobility can also lead to contractures, orthopedic complications, atrophy, and nerve pressure palsies. The nurse should monitor the first transfer from bed to an upright position, because some patients may have neurological worsening during movement. Joints on the paralyzed side must be positioned higher than joints proximal to it. The nurse must assess for deformities that may be found on the affected side (eg, shoulder adduction). Subluxation of the affected shoulder is common, and special care should be taken to avoid pulling on the affected arm and shoulder when repositioning or moving the patient. Nursing interventions, including range-of-motion and positioning techniques, can prevent joint contractures and atrophy.[237,239]

Pulmonary Embolism and DVT

Pulmonary embolism occurs more commonly than is suspected clinically and accounts for a substantial number of deaths after AIS. Wijdicks[240] found a sudden death rate of 50% in patients with pulmonary embolism that occurred between 3 and 120 days after the initial stroke event. In that study, prophylaxis for DVT was noted in only 4 of 30 patients. Pulmonary embolism was associated with DVT diagnosed clinically or at autopsy in 11 patients and in the paralyzed leg. More recently, Indredavik and colleagues[213] found pulmonary embolism in fewer than 2.5% of patients during the first week in a specialized stroke unit. DVT and pulmonary emboli were more likely to occur in the first 3 months after stroke, with an incidence of 2.5% and 1.2%, respectively.

Both ischemic and hemorrhagic stroke patients are at risk for developing DVT, especially as a result of paralysis or impaired mobility. Prevention of DVT is one of the core performance measures for primary stroke center certification, and initiation of prevention has become a quality indicator in several populations.[241,242] Safe ambulation should be started as soon after stroke as possible. Pneumatic compression devices and compression stockings can be used to prevent pulmonary embolism.[243,244]

Until recently, anticoagulants such as low-molecular-weight heparinoids and unfractionated heparin were also used.[245,246] The results of the Prevention of VTE after Acute Ischemic stroke with LMWH enoxaparin (PREVAIL) Trial showed that a 40-mg injection of enoxaparin once daily was more effective than 5000 IU of unfractionated heparin twice a day for prevention of DVT in AIS patients.[247] Stroke patients taking anticoagulants should be assessed for bleeding daily.

Falls

Falls are a common cause of injury in stroke patients, with hip fractures the most prevalent injury.[248] Hip fractures in the first

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7 days after stroke are associated with a poor prognosis and have been recognized as a consequence of hemiplegia since the 1950s.[249] Most fractures occur on the paretic side.[250] Patients with right hemispheric infarcts that cause neglect or inattention have the highest fall risk.

Minimization of fall risk is a global responsibility. Nurses must implement fall-prevention programs and educate other staff and family members about risks and fall precautions. These may include identifying patients at risk, use of alarm systems, use of special equipment (eg, enclosure beds), and placing call buttons and the patient's belongings near the patient to prevent the patient from reaching for something and risking a fall. Voiding times should be scheduled to prevent falls that occur when a patient tries to go to the bathroom. In some cases, it may be necessary to have a sitter stay with the patient to ensure the patient's safety.[249]

Skin Care

Stroke patients are at risk for skin breakdown because of loss of sensation and impaired circulation, older age, decreased level of consciousness, and inability to move themselves because of paralysis.[239] Related complications such as incontinence can accelerate skin breakdown. Major pressure areas are the heels, sacrum, and lateral malleoli. Patients should be examined for skin breakdown when repositioned and after sitting. Special care should be taken when moving patients to avoid excessive friction or pressure.[239] Patients should not be left in 1 position for >2 hours. The skin must be kept clean and dry, and special mattresses should be used where indicated. The Braden Scale is commonly used to predict the risk of the development of pressure ulcers (decubitus). Nursing personnel can use this predictive model to design the care of stroke patients with immobility and those who are at risk for the development of skin breakdown.[251–253]

Detection of Dysphagia and Prevention of Aspiration

Aspiration is frequently a result of dysphagia. In 2001, Galvan[254] found that approximately half of all aspirations due to dysphagia are "silent" and go unrecognized until there is a pulmonary manifestation or complication. Order sets should include a swallow assessment before oral intake, performed by a nurse; evaluation by a speech language pathologist; and institution of NPO status with intravenous normal saline at 75 to 100 mL/h until evaluation by the speech language pathologist. Swallow assessment requires an evidence-based tool.[225] The Massey Bedside Swallowing Screen has been successfully evaluated for interrater reliability and predictive validity.[255]

Optimally, swallow assessment is performed soon after the patient's arrival in the ED. Until then, the patient should remain on NPO status, which means no ice chips, no oral medications, no water, and no exceptions.[256] The nurse should assess swallowing by direct observation, looking for the presence of choking, coughing, a wet voice, a delay in initiating swallow, uncoordinated chewing or swallowing, extended time eating or drinking, pocketing of food, and loss of food from the mouth. When oral intake is authorized, the nurse should follow the speech language pathologist's recommendations,[257] which include improving the patient's ability to concentrate while eating with minimal distractions. These assessments and interventions may make the difference between improved recovery and increased morbidity or even mortality.[256]

Nutritional Compromise

Fifty percent of patients with severe strokes were reported to be malnourished at 2 to 3 weeks after the stroke.[258] Malnutrition was associated with higher complications and poorer functional outcomes.[259,260] To avoid nutritional compromise, nutritional intervention should occur no later than 3 to 4 days after diagnosis of dysphagia.[5] The Ontario Heart and Stroke Association suggests that early gastrostomy should be considered[5] if it is anticipated that dysphagia will continue beyond 6 weeks; however, dysphagia resolves in at least 87% of stroke patients.[257]

A nutritional assessment of a patient can be performed by taking a diet history, with simple assessments such as body mass index or more complex anthropometric measures such as midarm circumference or triceps skin-fold thickness. In the stroke patient, it can be difficult to obtain a diet history because of communication problems, and anthropometric measures may not be accurate owing to paralysis of the arm.

When compromise of the patient's nutritional health is suspected, serum albumin levels may be checked; this is often cited as an index for long-term maintenance but may not be reflective of nutritional status.[261,262] Serum albumin falls in acute illness owing to increased catabolism. No specific tool has been developed or tested in acute stroke patients to evaluate nutritional assessments.[263]

A dietitian can provide a more accurate assessment of nutritional health and nutrient needs. Without adequate nutrition, there is a risk of weight loss, impaired immune system, increased weakness, increased length of stay, and mortality. Nutritional assessment should be performed on the stroke unit at the time of admission and throughout the hospital stay. The simplest but most valuable thing the nurse can do to monitor nutrition is to monitor the patient's weight and weight change over time and monitor the patient's dietary intake.[263–265]

Stroke may compromise the patient's ability to self-feed, which can impact self-esteem. A pleasant environment that encompasses patience and encouragement fosters hope in the stroke patient. Use of seasonings, the serving of foods at appropriate temperatures, and augmentation of food presentation may enhance appeal and compensate for the patient's loss of taste or smell. An interdisciplinary approach to treating dysphagia will result in early detection and early intervention to minimize the impact on the patient's life, family, and healthcare costs.

Recommendations

Medical complications after stroke are common. The basics of care become critical care in the stroke patient. An overriding concept is patient and family education at all steps of the acute care process.

Class I

1. Infections, such as pneumonia and UTI, should be identified and treated immediately with antibiotics (***Class I, Level of Evidence B***).

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2. Early bowel and bladder care should be instituted to prevent complications such as constipation and urinary retention or infection (***Class I, Level of Evidence A***). Use of indwelling catheters should be avoided if possible because of the risk of UTI (***Class I, Level of Evidence A***).
3. Early implementation of anticoagulant therapy or physical compression modalities should be considered for all stroke patients who cannot ambulate at 2 days and who are at risk for DVT or pulmonary embolus (***Class I, Level of Evidence A***). Early mobility should always be attempted if safe for the patient (***Class I, Level of Evidence B***).
4. Fall precautions should be initiated, and the stroke patient should be told not to ambulate without assistance (***Class I, Level of Evidence B***).
5. Frequent turning should be instituted in bedridden patients to prevent skin breakdown (***Class I, Level of Evidence A***). Use of the Braden Scale in nursing practice can assist in the prediction of stroke patients at high risk of developing pressure ulcers (***Class I, Level of Evidence A***). Range-of-motion exercises should start in the early phase of acute stroke care once risk has been assessed (***Class I, Level of Evidence C***).
6. A swallow screen should be performed in the first 24 hours after stroke, preferably by the speech language pathologist (***Class I, Level of Evidence B***). Nurses should be familiar with bedside swallow assessment if a formal evaluation cannot be done within the specified period. Stroke patients should be kept NPO until the screen has been performed (***Class I, Level of Evidence B***). Further studies of dysphagia in the setting of acute stroke should be performed.
7. Patients who cannot swallow should have a nasogastric tube placed, or if severity warrants, a percutaneous endoscopic gastrostomy tube should be placed (***Class I, Level of Evidence B***). Assessment of proper hydration is included in this recommendation.

Class IIa

1. If an indwelling catheter is required, excellent pericare and prevention of infection modalities should be instituted to prevent complications (***Class IIa, Level of Evidence C***).
2. The stroke patient can be fed either by intravenous infusion or through nasogastric or percutaneous endoscopic gastrostomy tubes (***Class IIa, Level of Evidence B***).

Class IIb

1. Nurses may provide passive range-of-motion exercises between physical therapy visits to help patients maintain joint mobility and prevent complications of immobility (***Class IIb, Level of Evidence C***).

The Nurse's Role in Secondary Prevention of Stroke

Nurses historically have played an important role in patient and family education, both at the bedside and in the outpatient setting. Stroke education includes explaining stroke, discussing risk factors (with emphasis placed on those risk factors that are modifiable[266]), and describing secondary prevention measures, including compliance with prescribed medications. The AHA guidelines for secondary prevention of stroke are being revised. Pertinent recommendations from the 2006 guidelines are provided in Table 14.[267] Nurses play a significant role in education and lifestyle modification strategies, and therefore, they must stay current with changing standards and how they translate into practice. Suggestions for reducing blood pressure include adopting the DASH (Dietary Approaches to Stop Hypertension) diet, engaging in regular aerobic activity, and moderating alcohol intake.[268–273] Nurses should be familiar with smoking cessation programs and materials and should include this information in the discharge plan of care.[274] Guidelines for smoking cessation for both the clinician and the consumer are available from the Office of the Surgeon General (www.surgeongeneral.gov/tobacco/default.htm) and the Agency for Health Care Policy and Research.

For the stroke patient with atrial fibrillation, the nurse should explain that use of warfarin (to maintain an international normalized ratio of 2 to 3) is recommended for prevention of stroke unless an absolute contraindication to anticoagulation exists. The nurse should also discuss the potential side effect of bleeding, interactions between warfarin and other drugs or certain foods, and the importance of compliance. The patient should be informed that weekly testing is required when warfarin is begun, then monthly testing when the international normalized ratio is stable. Specific educational aids are found in Table 15.

Nurses can educate stroke patients about secondary prevention modalities. Patient education is a standard performance measure in primary stroke center certification (see http://www.jointcommission.org/CertificationPrograms/PrimaryStrokeCenters/stroke_measure_set.htm or http://www.jointcommission.org/CertificationPrograms/PrimaryStrokeCenters/guide_table_contents.htm). Patients should be taught the rationale for administration of an antiplatelet drug and its potential side effects. They should also be taught that antiplatelet therapy is lifelong, not short term.

Discharge Planning

The discharge destination of stroke patients requires comprehensive planning.[275] The NINDS suggests that 30% of stroke survivors will recover almost completely or with minor impairments.[67,276] Another 40% will require subacute care, and 10% will require care in a skilled nursing facility. The remaining 15% will die soon after stroke onset. Of all survivors, ≈14% will experience recurrent stroke within 1 year of the primary event. Eventually, 68% to 74% of stroke survivors will require the care of family members in the home.[277] Detailed planning for postacute stroke care will optimize outcomes and reduce risk and may control financial burden.

The average length of hospital stay for a stroke patient in 2006 was 4.9 days, which may not be enough time to learn the true impact of a stroke.[278] Order sets that include stroke team referrals will lead to initiation of early rehabilitation intervention. Such referrals include physiotherapy, occupational therapy, speech therapy, nutritional assessment, psychology,

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Table 14. Recommendations for Secondary Stroke Prevention[267]

Risk Factor	Recommendation	Class/Level of Evidence
Recommendations for treatable vascular risk factors		
Hypertension	Antihypertensive treatment is recommended for prevention of recurrent stroke and other vascular events in persons who have had an ischemic stroke and are beyond the hyperacute period.	I/A
	Because this benefit extends to persons with and without a history of hypertension, this recommendation should be considered for all ischemic stroke and TIA patients.	I/B
	An absolute target BP level and reduction are uncertain and should be individualized, but benefit has been associated with an average reduction of <10/5 mm Hg, and normal BP levels have been defined as <120/80 by JNC-7.	I/B
	Several lifestyle modifications have been associated with BP reductions and should be included as part of a comprehensive approach antihypertensive therapy.	I/C
	Optimal drug regimen remains uncertain; however, available data support the use of diuretics and the combination of diuretics and an ACEI. Choice of specific drugs and targets should be individualized on the basis of reviewed data and consideration, as well as specific patient characteristics (eg, extracranial cerebrovascular occlusive disease, renal impairment, cardiac disease, and DM).	I/A
Diabetes	More rigorous control of blood pressure and lipids should be considered in patients with diabetes.	I/B
	Although all major classes of antihypertensive medications are suitable for the control of BP, most patients will require >1 agent. ACEIs and ARBs are more effective in reducing the progression of renal disease and are recommended as first-choice medications for patients with DM.	I/A
	Glucose control is recommended to near-normoglycemic levels among diabetics with ischemic stroke or TIA to reduce microvascular complications.	I/A
	The goal for Hb A1c should be ≤7%.	I/B
Cholesterol	Ischemic stroke or TIA patients with elevated cholesterol, comorbid CAD, or evidence of an atherosclerotic origin should be managed according to NCEP III guidelines, which include lifestyle modification, dietary guidelines, and medication recommendations.	I/A
	Statin agents are recommended, and the target goal for cholesterol lowering for those with CHD or symptomatic atherosclerotic disease is an LDL-C of <100 mg/dL and LDL-C <70 mg/dL for very-high-risk persons with multiple risk factors.	I/A
	Patients with ischemic stroke or TIA presumed to be due to an atherosclerotic origin but with no preexisting indications for statins (normal cholesterol levels, no comorbid CAD, or no evidence of atherosclerosis) are reasonable to consider for treatment with a statin agent to reduce the risk of vascular events.	IIa/B
	Ischemic stroke or TIA patients with low HDL-C may be considered for treatment with niacin or gemfibrozil.	IIb/B
Recommendations for modifiable behavioral risk factors		
Smoking	All ischemic stroke or TIA patients who have smoked in the past year should be strongly encouraged not to smoke.	I/C
	Avoid environmental smoke.	I/C
	Counseling, nicotine products, and oral smoking cessation medications have been found to be effective for smokers.	IIa/B
Alcohol	Patients with prior ischemic stroke or TIA who are heavy drinkers should eliminate or reduce their consumption of alcohol.	I/A
	Light to moderate levels of ≤2 drinks per day for men and 1 drink per day for nonpregnant women may be considered.	IIb/C
Obesity	Weight reduction may be considered for all overweight ischemic stroke or TIA patients to maintain the goal of a BMI of 18.5 to 24.9 kg/m^2 and a waist circumference of <35 in for women and <40 in for men. Clinicians should encourage weight management through an appropriate balance of caloric intake, physical activity, and behavioral counseling.	IIb/C
Physical activity	For those with ischemic stroke or TIA who are capable of engaging in physical activity, at least 30 min of moderate-intensity physical exercise most days may be considered to reduce risk factors and comorbid conditions that increase the likelihood of recurrence of stroke.	IIb/C

(Continued)

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Table 14. Continued

Risk Factor	Recommendation	Class/Level of Evidence
Physical activity	For those with disability after ischemic stroke, a supervised therapeutic exercise regimen is recommended.	IIB/C
Recommendations for interventional approaches to patients with stroke caused by large-artery atherosclerotic disease		
Extracranial carotid disease	For patients with recent TIA or ischemic stroke within the past 6 months and ipsilateral severe (70% to 99%) carotid artery stenosis, CEA is recommended by a surgeon with a perioperative morbidity and mortality of <6%.	I/A
	For patients with recent TIA or ischemic stroke and ipsilateral moderate (50% to 69%) carotid stenosis, CEA is recommended, depending on patient-specific factors such as age, gender, comorbidities, and severity of initial symptoms.	I/A
	When degree of stenosis is <50%, there is no indication for CEA.	III/A
	When CEA is indicated, surgery within 2 weeks rather than delayed surgery is suggested.	I/B
	Among patients with symptomatic severe stenosis (>70%) in whom the stenosis is difficult to access surgically, medical conditions are present that greatly increase the risk for surgery, or when other specific circumstances exist such as radiation-induced stenosis or restenosis after CEA, CAS is not inferior to endarterectomy and may be considered.	IIb/B
	CAS is reasonable when performed by operators with established periprocedural morbidity and mortality rates of 4% to 6%, similar to that observed in trials of CEA and CAS.	IIa/B
	Among patients with symptomatic carotid occlusion, EC/IC bypass surgery is not recommended routinely.	III/A
Extracranial vertebrobasilar disease	Endovascular treatment of patients with symptomatic extracranial vertebral stenosis may be considered when patients are having symptoms despite medical therapies (antithrombotics, statins, and other treatments for risk factors).	IIb/C
Intracranial arterial disease	The usefulness of endovascular therapy (angioplasty and/or stent placement) is uncertain for patients with hemodynamically significant intracranial stenoses who have symptoms despite medical therapies (antithrombotics, statins, and other treatments for risk factors) and is considered investigational	IIb/C
Recommendations for patients with cardioembolic stroke types		
Atrial fibrillation (AF)	For patients with ischemic stroke or TIA with persistent or paroxysmal (intermittent) AF, anticoagulation with adjusted-dose warfarin (target INR, 2.5; range, 2.0–3.0) is recommended.	I/A
	In patients unable to take oral anticoagulants, aspirin 325 mg/d is recommended.	I/A
	Acute MI and LV thrombus For patients with an ischemic stroke caused by an acute MI in whom LV mural thrombus is identified by echocardiography or another form of cardiac imaging, oral anticoagulation is reasonable, aiming for an INR of 2.0 to 3.0 for at least 3 months and up to 1 y.	IIa/B
	Aspirin should be used concurrently for the ischemic CAD patient during oral anticoagulant therapy in doses up to 162 mg/d, preferably in the enteric-coated form.	I/A
Cardiomyopathy	For patients with ischemic stroke or TIA who have dilated cardiomyopathy, either warfarin (INR, 2.0 to 3.0) or antiplatelet therapy may be considered for prevention of recurrent events.	IIb/C
Valvular heart disease, Rheumatic mitral valve disease	For patients with ischemic stroke or TIA who have rheumatic mitral valve disease, whether or not AF is present, long-term warfarin therapy is reasonable, with a target INR of 2.5 (range, 2.0–3.0).	IIa/C
	Antiplatelet agents should not be routinely added to warfarin in the interest of avoiding additional bleeding risk.	III/C
	For ischemic stroke or TIA patients with rheumatic mitral valve disease, whether or not AF is present, who have a recurrent embolism while receiving warfarin, adding aspirin (81 mg/d) may be indicated.	IIa/C
Mitral valve prolapse (MVP)	For patients with MVP who have ischemic stroke or TIAs, long-term antiplatelet therapy is reasonable.	IIa/C
MAC	For patients with ischemic stroke or TIA and MAC not documented to be calcific, antiplatelet therapy may be considered.	IIb/C
	Among patients with mitral regurgitation resulting from MAC without AF, antiplatelet or warfarin therapy may be considered.	IIb/C

(Continued)

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Table 14. Continued

Risk Factor	Recommendation	Class/Level of Evidence
Aortic valve disease	For patients with ischemic stroke or TIA and aortic valve disease who do not have AF, antiplatelet therapy may be considered.	IIb/C
Prosthetic heart valves	For patients with ischemic stroke or TIA who have modern mechanical prosthetic heart valves, oral anticoagulants are recommended, with an INR target of 3.0 (range, 2.5–3.5).	I/B
	For patients with mechanical prosthetic heart valves who have an ischemic stroke or systemic embolism despite adequate therapy with oral anticoagulants, aspirin 75 to 100 mg/d, in addition to oral anticoagulants, and maintenance of the INR at a target of 3.0 (range, 2.5–3.5) is reasonable.	IIa/B
	For patients with ischemic stroke or TIA who have bioprosthetic heart valves with no other source of thromboembolism, anticoagulation with warfarin (INR, 2.0–3.0) may be considered.	IIb/C

JNC-7 indicates Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; ACEI, angiotensin-converting enzyme inhibitor; ARBs, angiotensin receptor blockers; Hb, hemoglobin; CAD, coronary artery disease; NCEP, National Cholesterol Education Panel; CHD, coronary heart disease; LDL-C, low-density lipoprotein cholesterol; BMI, body mass index; CEA, carotid endarterectomy; CAS, carotid angioplasty and stenting; EC/IC, extracranial/intracranial; AF, atrial fibrillation; MI, myocardial infarction; LV, left ventricular; MVP, mitral valve prolapse; and MAC, mitral annular calcification.

and social services. Once assessed by each discipline, the patient's discharge planning process may begin.

Neurological findings identified during the acute phase and throughout recovery will direct medical management, rehabilitation, and the nursing plan of care. Deficits include altered level of consciousness, confusion, behavioral disturbances, cognitive deficits in higher functions such as memory and ability to learn, motor deficits, disturbance in balance and coordination, somatosensory deficits, disorders of vision, unilateral neglect, speech and language deficits, swallowing disorder (dysphagia), and affective disorder. The rehabilitation medicine team (physiatrist, and speech, physical, and occupational therapists) will evaluate the patient during the acute hospitalization and develop a rehabilitation plan for discharge that will address the neurological deficits and appropriate rehabilitation needs. In addition, the rehabilitation team will give recommendations on the next level of care placement. The nurse caring for the patient must communicate the discharge plan to the patient and family and be the liaison between the patient/family and rehabilitation team and discharge planners. Table 16 identifies key strategies or components that will help nurses to facilitate successful discharge planning and transition to the next level of care.[266,279,280]

The goal of discharge planning is to ensure a safe transition between the acute care facility, rehabilitation, outpatient settings, primary care physician, and community while maintaining a continuity of care that will optimize rehabilitation potential and ensure proper secondary prevention as appropriate. Discharge planners (eg, social workers, case managers) will integrate the concerns and expectations of the interdisciplinary team with those of the patient, family, and associated support system(s). Meeting the discharge needs for less obvious deficits (eg, memory problems) may pose as great a challenge as addressing needs related to overt hemiparesis or aphasia. Teaching patients, families, and support systems how to identify and deal with the nuances of stroke will facilitate community reintegration and optimize outcomes. A study from a Cochrane review[281] found that recovering stroke patients placed on a structured care pathway demonstrated significant improvement in functional ability and quality of life. Another study found that improved patient outcomes were highly dependent on support systems, including family support and an organized systems approach to meeting the discharge needs of the patient and family.[282]

What if the stroke victim is too disabled to participate in or benefit from rehabilitation? Hospital staff plays a crucial role in discharge decisions.[283] Continued care options are skilled nursing care to assess for future rehabilitation potential, skilled nursing care alone, palliative care, or hospice care.

In a 2003 report on public health and aging, the Centers for Disease Control and Prevention noted that among the Medicare population, postacute care was one of the fastest-growing categories, and stroke had the highest number of post–acute care beneficiaries.[284] Additional findings suggest that after adjustment for stroke severity, organized home health care for this population resulted in overall improved functional outcomes and increased cost-effectiveness compared with other discharge facility options.[284] Reported costs of nursing home care approached $15.2 billion compared with a home healthcare cost of $3.8 billion.[285] These 2 resources should alert discharge planners to the potential for and challenges of an increasing trend to home discharge.

Although outcomes for home care of stroke survivors are positive, home care may be associated with negative health outcomes for caregivers.[277] Therefore, appropriate referrals to community resources, physician follow-up, support groups, governmental agencies, free services, faith-based communities, and research opportunities must be incorporated into discharge planning. However detailed it may be, discharge planning may not address all family questions or prepare family members for future issues. It is, however, the backdrop against which healing continues.

The Advanced Practice Nurse's Role in Acute Stroke Care

The role of the nurse-practitioner or clinical nurse specialist is vital to the care of AIS patients throughout the continuum.

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Table 15. Stroke Educational Programs

ASA/AHA (www.strokeassociation.org and www.americanheart.org)
Stroke: Patient Education Tool Kit
Power to End Stroke
African American Power to End Stroke
Power to End Stroke—Family Reunion Toolkit
Stroke Connection magazine
How Stroke Affects Behavior: Our Guide to Physical and Emotional Changes
Living With Atrial Fibrillation: Our Guide to Managing a Key Stroke Risk Factor
Living With Disability After Stroke
Sex After Stroke: Our Guide to Intimacy After Stroke
Stroke: Are You at Risk? Our Guide to Stroke Risk Factors
Understanding Stroke: Our Guide to Explaining Stroke and How to Reduce Your Risk
Caring for Someone With Aphasia
High Blood Pressure and Stroke
Warning Signs of Stroke: Our Easy-Reading Guide to Emergency Action
Being a Stroke Family Caregiver
Smoking and Your Risk of Stroke
Just Move: Our Guide to Physical Activity
Diabetes, Heart Disease, and Stroke
NINDS (www.ninds.nih.gov)
What You Need to Know About Stroke
Stroke Risk Factors and Symptoms
Brain Basics: Preventing Stroke
Neurological Diagnostic Tests and Procedures
Questions and Answers About Stroke
Questions and Answers About Carotid Endarterectomy
National Stroke Association (www.stroke.org)
Stroke Smart magazine
Stroke Fact Sheet
African Americans and Stroke Brochure
Cholesterol Brochure
Explaining Stroke Brochure
Intracranial Atherosclerosis Brochure
Recurrent Stroke Prevention Brochure
Reducing Risk and Recognizing Symptoms Brochure
Transient Ischemic Attack Brochure
Stroke Rapid Response EMS/Prehospital Education
Hip Hop Stroke–Brainiac Kids Stroke Education
Brain Attack Coalition (www.stroke-site.org)

These roles will be referred to as advanced practice nurses (APNs) for the purpose of the present report.

The APN plays an essential role in planning and leading a team to develop clinical tools, organizing team members and departments to expedite activities in the care of the AIS patient, and monitoring outcomes and initiating quality initiatives to improve care. The Brain Attack Coalition recommends that a primary stroke center have at least 1 APN to implement and coordinate program activities.[53]

Table 16. Effective Nursing Strategies for Successful Discharge Planning[266,279,280]

- Involve patient's family/caregiver in assessment of postdischarge needs and decision making and treatment planning.
- Family and team meeting to discuss patient progress, rehabilitation goals, discharge needs or discharge issues, explanation of next level of care, providing care and support associated with these deficits and discuss ways to cope with stress associated with these impairments (eg, cognitive loss, urinary incontinence).
- Encourage the patient's family/caregiver to participate in the rehabilitation sessions and to be trained to assist the patient with functional activities.
- Predischarge needs assessment of home before discharge performed by an occupational therapist to evaluate home environment and determine safety, need for home modification(s), and equipment needs.
- Consider availability of support services and the desires of the patient's family/caregiver.
- Caregiver training (multidisciplinary education about communication strategies if the patient is aphasic, positioning and handling, transfers, shoulder care, how to promote independence, according to individual patient's strengths and limitations).
- Postdischarge follow-up (ensure plans are made for medical care, secondary prevention, rehabilitation, social support, home care, and nursing if needed, caregiver support and education).
- Provide education for patient's family/caregivers on stroke pathology, stroke prevention, stroke signs and symptoms, actions to take, follow-up appointments/therapy, treatment plan, and community resources and how to access. Education should be provided in interactive and written format and documented in the medical record to facilitate communication of education completed to other healthcare providers.
- Liaison with community providers, linkage with appropriate resources.
- Regular review of individual patient and caregiver psychosocial and support needs.
- Provision of information on discharge plans and postdischarge management to primary care physicians and community services.
- If the patient is aphasic, the nurse and rehabilitation team should assist in establishing a communication pattern with the patient's family/caregiver before discharge.

One study showed that financial outcomes were significantly improved when APNs functioned as outcome managers and collaborated with the multidisciplinary team to care for AIS patients.[286] Patients had shorter lengths of stay, lower rates of UTI and skin breakdown, and less time until mobilization. The hospital had 2306 fewer patient-days and a total cost savings of $2 467 328.

Stroke programs have shown that APNs have been key in improving recognition and management of AIS patients.[287–290] The use of APNs in the Calgary Stroke Program enhanced patient care and patient satisfaction with continuity of care throughout hospitalization. Improvements in the care process were also noted: CT image time was reduced from 60 to 30 minutes, door-to-needle time in administration of rtPA decreased from 90 to 60 minutes, and consultation was faster.

The APN can integrate education, research, management, leadership, and consultation into the clinical role in making decisions about clinical management, in diagnostic reasoning, and in developing therapeutic interventions for the care of AIS patients. APNs are assuming leadership roles in developing programs such as dysphagia teams,

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incontinence teams, and anticoagulation clinics and are actively involved in discharge, palliative care, and secondary prevention clinics.[291–299]

The Nurse's Role in Stroke Education in the Community

A landmark study evaluating the knowledge of patients presenting to the ED was first conducted in 1997 and repeated in 1998 and 2003.[300] The first study showed that 40% of patients admitted did not know the signs, symptoms, or risk factors of stroke. A need for further public education to increase awareness of stroke warning signs was identified, and all healthcare professionals were encouraged to become involved in community education.[300] In 1998, a population-based interview was conducted in the greater Cincinnati, Ohio, area to establish the public's knowledge of risk factors and warning signs of acute stroke.[301] Fifty-seven percent correctly named only 1 of the 5 warning signs of stroke defined by the NINDS, and 68% could identify only 1 stroke risk factor. Only 57% of patients with hypertension said that they were at risk for stroke. Sixty percent of patients <75 years of age correctly identified 1 warning sign of stroke compared with only 47% of patients >75 years of age.[301] As a result of organized community education in the greater Cincinnati region, community awareness of stroke warning signs significantly improved over time, but knowledge of risk of stroke based on individual risk factors did not improve.[302]

Studies have shown that some groups have less knowledge about stroke, delay seeking medical attention, and do not phone 9-1-1. These groups include the elderly, women, those with lower levels of education, and racial/ethnic populations such as blacks and Latinos. Healthcare professionals must educate the public about stroke warning signs and risk factors and actions to take when symptoms occur.[303,304]

The effect of stroke screening on knowledge and behavioral changes has been studied.[305] One screening used the National Stroke Association guidelines. Participants were evaluated before and after screening and 3 months after the event. Knowledge increased from 59% to 94% immediately after the event but at 3 months was only 77%. Only 27% of patients attending the screening had implemented an intervention to decrease stroke risk.[305] Similar studies showed that ≈50% of those attending a stroke screening made at least 1 behavioral change to reduce stroke risk and that community education improved the participant's knowledge of stroke warning signs and symptoms.[306–308]

The National Stroke Association states that "80% of strokes can be prevented" (http://www.stroke.org/site/PageServer?pagename=PREVENT). This should compel nurses to educate the public about primary and secondary stroke prevention, including stroke awareness and stroke risk factors, and to call 9-1-1 if warning signs of stroke occur. The acronym FAST (Face, Arm, Speech, Time) is being used as a way to educate the public. "The Beauty Shop Project" educated beauticians on the FAST acronym and asked them to educate their clients about acute stroke signs by emphasizing the FAST acronym. After the project, 51% of participants could identify at least 3 stroke warning signs compared with 41% at the beginning of the project. Ninety-three percent recognized the need to call 9-1-1 compared with 85% before the project began (http://www.webmd.com/stroke/news/20070207/hip-hop-to-stroke-awareness).

Table 17. Specific Roles of Nursing in the Joint Commission Primary Stroke Center Certification

Bring team together toward common goal.
Organize team to accomplish stroke center certification.
Educate in-house nursing personnel, medical personnel, and ancillary personnel on stroke-related issues and philosophy of the Joint Commission stroke center certification.
Understand the Joint Commission requirements and understand deficits hospital may have in achieving goal.
Develop preprinted or standing order sets and critical pathways as required by the Joint Commission.
Develop stroke care procedures for strategic in-hospital units that care for stroke patients.
Appoint quality-assurance nurse to collect data on execution of performance measures.
Understand whether hospital is capable of responding to recommendations of Brain Attack Coalition.
Understand hospital's medical record coding to ensure it is appropriately capturing ICD-10 and DRGs for proper billing for optimum reimbursement potential.
Recognize that nursing personnel play an important role in the application process for Joint Commission certification in pulling together required documents for the site visit.
Ensure that hospital personnel are prepared for the Joint Commission reviewer.
Monitor performance measures established by the Joint Commission.

ICD indicates International Classification of Diseases; DRGs, Diagnosis-Related Groups.

The Massachusetts Health Promotion Clearinghouse Catalog has a 3-minute video on stroke awareness titled *Stroke Heroes Act FAST*. Three scenarios educate viewers about recognizing and responding to the signs of stroke using the FAST model (http://www.maclearinghouse.com/CatalogHDSP.htm).

In 2004, the National Stroke Association created "Hip Hop Stroke," a stroke education program for school-aged children. The interactive program is presented for 1 hour a day for 3 days. Hip-hop music and the character "Brainiac" teach children about lifestyle changes, warning signs of stroke, and the importance of calling 9-1-1 (http://www.stroke.org/site/PageNavigator/HipHopStroke).

Nurses have many avenues through which to educate the public: Churches, schools, and community and professional organizations. The AHA/ASA and National Stroke Association have educational information on their Web sites, as well as materials for stroke education (Table 15). Stroke education can be done through blood pressure, lipid, and glucose screenings; health education forums; and smoking cessation, exercise, and nutritional programs.

The Nurse's Role in Certification of Primary Stroke Centers

Certification of stroke centers has gained national recognition since publication of the Brain Attack Coalition recommendations in June 2000[10] amid concern that stroke centers should

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require certification by a rigorous examining body. The Joint Commission, with the support of the AHA and ASA, developed a certification program using the ideas proposed in the Brain Attack Coalition paper as the template for the model (http://www.jointcommission.org/CertificationPrograms/PrimaryStrokeCenters/). In 2004, the certification program was rolled out. More than 200 hospitals were certified by the end of 2006.[5]

Nurses will play an important role in obtaining and maintaining stroke center certification (Table 17), just as they do in the Joint Commission's general hospital accreditation. Nurses will ensure that hospital personnel are properly trained and knowledgeable about all aspects of stroke care and will interact with the multidisciplinary team throughout the care continuum. Nurses ensure that a patient's needs are met by all the disciplines involved in care and in many cases help integrate this care so that patients are discharged having received optimum care through best practices. Nurses will work to ensure that all aspects of this complicated disease are managed in a way that will produce positive outcomes (Table 18).

The AHA/ASA patient education toolkit is available to assist nurses and other healthcare professionals in providing patient and family education about stroke. The toolkit can be ordered online through the AHA/ASA Web site (www.strokeassociation.org) or by calling the AHA/ASA directly (1–888-4-STROKE). Information about Joint Commission primary stroke center certification can be found at the Joint Commission Web site (www.jointcommission. org/CertificationPrograms/PrimaryStrokeCenters/).

The Nurse's Role in Quality Improvement Initiatives

Nurses historically have been at the forefront of inpatient hospital quality improvement programs. This role will continue to expand as nurses institute quality improvement programs for secondary prevention such as Get With the Guidelines Stroke, a patient management tool, or the Coverdale registry, both of which are used to collect data for primary stroke center certification.[309,310] Get With the Guidelines Stroke offers evidence-based, best-practice information that can be compared with other hospitals using this quality improvement tool. Information derived from this data collection program can also assist in patient and family education.

In summary, the present scientific statement describes nursing's vital role in the first 2 phases of stroke, the emergency or hyperacute phase and the acute phase. Using strength of evidence, the recommendations on the organization and integration of care are designed to improve outcomes, decrease lengths of stay, decrease costs, and decrease event recurrence.[10]

Table 18. Performance Measures From the Joint Commission Primary Stroke Center Certification Program

Stroke-1	Deep vein thrombosis prophylaxis
Stroke-2	Discharged on antithrombotic therapy
Stroke-3	Patients with atrial fibrillation receiving anticoagulation therapy
Stroke-4	Thrombolytic therapy administered
Stroke-5	Antithrombotic therapy by end of hospital day two
Stroke-6	Discharged on statin medication
Stroke-7	Dysphagia screening
Stroke-8	Stroke education
Stroke-9	Smoking cessation/advice/counseling
Stroke-10	Assessed for rehabilitation

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*Modest.

†Significant.

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*Modest.

†Significant.

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KEY WORDS: AHA Scientific Statements ■ stroke, ischemic ■ stroke management ■ emergency service, hospital ■ tissue plasminogen activator ■ nursing care

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Evaluation of a 16-MDCT Scanner in an Emergency Department: Initial Clinical Experience and Workflow Analysis

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OBJECTIVE. MDCT is especially suited for emergency purposes because it allows rapid high-resolution scans of large areas, fast high-quality reformatting in every orientation, and 3D illustration of the data set. In a prospective study, we evaluated the reliability and workflow of a dedicated emergency department 16-MDCT scanner in the management of patients presenting to the emergency department.

SUBJECTS AND METHODS. The use of a 16-MDCT scanner for 503 patients in the emergency department of a university clinic was evaluated. For reasons of workflow analysis, seven precise time intervals were recorded during the emergency examinations. A new setting for repositioning multiple-trauma patients after imaging of the head and neck from the head-first position to the feet-first position was introduced.

RESULTS. Six (1.2%) of the 503 patients were excluded because of technical malfunction or patient noncompliance. Image quality in the remaining 497 cases, including CT angiography and CT of multiple-trauma patients, was outstanding. Positioning of the patients took from 3 to 13 min depending on the body region examined, representing 33–67% of the mean room time, which ranged from 8 to 21 min. In multiple-trauma patients, the initial positioning took a mean of 6 min and repositioning took 8 min, representing 19% and 26% of total room time, respectively.

CONCLUSION. The use of a dedicated 16-MDCT scanner in the emergency department resulted in short examination times even for examinations of multiple body regions under emergency conditions. The introduced setting—repositioning of multiple-trauma patients—allowed high image quality to be maintained. The trade-off in multiple-trauma patients was prolonged room time because of patient repositioning.

Diagnostic imaging in tertiary care emergency services relies mainly on CT [1]. Recent publications report that CT is performed in up to 67% of patients presenting to emergency departments [1, 2]. Many centers are therefore equipped with dedicated CT scanners to allow fast access for trauma patients and various medical emergencies [2, 3].

The dedicated emergency CT scanner is usually located close to the emergency department, sometimes even in a room prepared specifically for use during a fast intervention. The recent introduction of MDCT with 8 or 16 detector rows has changed CT from a transaxial sectional technique to a 3D imaging technique [4, 5]. Prokop [6] reported that the performance of a 16-MDCT scanner is up to 20 times better than that of a conventional helical CT scanner. This is due to the shorter rotation time, as also reported by other investigators [7–9]. This huge gain in performance reduces scanning time and section collimation and therefore favors MDCT for emergency purposes because it allows high-resolution scans of large areas to be obtained in a short time, fast high-quality reformatting in every orientation, and 3D illustration of the data set [10, 11].

In emergency situations, the patient's room time in the CT suite and the early diagnosis and initiation of treatment have an especially profound influence on the patient's outcome [8, 12]. The correct choice of protocols and optimized workflow in the CT room are therefore of vital importance. Surprisingly, the literature to date contains but scant data on the workflow of MDCT scanners [3, 13].

In this prospective study, we evaluated the reliability and workflow of a dedicated 16-MDCT scanner in the management of patients presenting to the emergency department.

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Subjects and Methods

Emergency MDCT Scanner and Equipment

The MDCT scanner (Somatom Evolution 16, Siemens Medical Solutions) was installed in the emergency department and was prepared specifically for fast interventions and minor surgery through its placement a short distance from the medical and surgical emergency admission units. The MDCT scanner is equipped with 16 detector rows and has a minimal rotation time of 0.5 sec given a collimation of between 0.75 and 1.5 mm. This allows rapid scanning of large body segments in relatively short scanning times.

Data acquisition and planning of examinations and printing of axial images and standardized multiplanar reconstructions were performed by a technologist on a workstation (Volume Navigator, Somaris 5 VA, Siemens Medical Solutions). Two satellite consoles (Volume Wizard and Somaris 5 VA, Siemens Medical Solutions) allowed radiologists immediate access for visualization and further multiplanar and 3D reformatting. Additional reconstructions, necessary to clarify the diagnosis or demanded by the referring clinician (e.g., 2D and 3D reconstructions of complex fractures), were performed and printed by radiologists. The examinations and additional reconstructions were sent via a fast 100-MB/sec local area network–Ethernet to the PACS. All examinations were printed on hard copies including 8-mm axial reconstructions, 2D and 3D reconstructions, and additional images depending on the radiologist. The radiologic evaluation process was based exclusively on image interpretation at the workstation rather than on hard copies or PACS.

An experienced emergency radiologist was present at the examination to confirm the correct choice of protocol, to alter the protocol in response to initial pathologic findings, to administer the contrast agent, and to provide immediate image interpretation for the emergency physician. Because of the study design and concurrent evaluations of emergency patients, a group of experienced emergency radiologists was involved. The emergency examination protocols were standardized for different body regions, and the choice of protocols was up to the radiologist. The scanning protocol for multiple-trauma patients included an examination of the head and neck and scanning of the thorax, abdomen, and pelvis using a multiple bolus application of contrast agent. This allowed evaluation of images in different contrast phases (portal venous and arterial phases) within a single helical scan (Tables 1 and 2).

In most emergency centers, the examination of multiple-trauma patients is a whole-body scan including the head, cervical spine, and thorax to pelvis. In the conventional setting, the patient is usually examined in the head-first position. This allows fast single-pass scanning but compromises image quality with beam-hardening artifacts due to the position of arms and cables [14].

To maintain the high quality of imaging, we introduced a new setting for this study. Multiple-trauma patients were studied as follows: for examination of the head, skull base, and cervical spine, the patient was positioned head-first in the scanner. For subsequent thoracic and abdominal imaging, the patient was then turned to the feet-first position. This procedure is time-consuming, but it is likely to improve the imaging quality because it reduces to a minimum possible artifacts caused by the positioning of arms, electrodes, and cables in the scan field.

Data Acquisition

For reliable and high-quality acquisition of data, the workflow intervals were measured by staff members not involved in the emergency treatment. The data were entered into a database (Excel 2000, Microsoft) using the program's autoformat function to avoid typing mistakes. The internal computed time was, because of the expected length of time intervals, entered in full minutes. This setup allowed precise recording of time intervals during emergency examinations.

Seven time intervals were recorded. Interval 1, which we referred to as the "positioning interval," was the time from the patient's entrance into the MDCT room until the start of the first measurement (scout). Interval 2, the "acquisition interval," was measured from the start of the first measurement until the radiologist's decision to conclude the examination (including all unenhanced and contrast-enhanced studies). Interval 3, the "repositioning interval," was a subdivision of the acquisition interval in multitrauma cases during which the patient was rotated from the head-first position to the feet-first position. Interval 4, the "reformatting interval," was from the end of the examination until all the data, including reconstructions, were available at the satellite console. Interval 5, the "evaluation interval," was from the end of the fourth interval (the reformatting interval) until the radiologist's final diagnosis. Interval 6, "room time," was from the patient's entrance into the scanner room until completion of the examination—that is, the sum of intervals 1, 2, and 3 in multitrauma patients. Interval 7, "diagnostic time," was from the patient's entrance into the scanner room to the final diagnosis (i.e., the sum of intervals 1–5). By that time, the radiologist had evaluated all images and had reported all diagnoses, including secondary findings, and was therefore no longer occupied by that case. Of course, initial findings such as life-threatening injuries were immediately reported to the referring clinician sometimes even before the end of the CT examination to facilitate optimal patient care (Fig. 1).

The following additional data were documented: patient characteristics, indication for examination, protocols used, total number of images acquired (including scout, thick and thin axial slices, and reconstructions), and the types of reformatting (2D, 3D). In case of technical failure of the CT scanner, the emergency patients were examined in another CT scanner in the hospital and the time for the evaluation was not included in the study.

TABLE 1: Standard Scanning Protocols Applied in This Study for the CT Examinations of Adults

Body Region	Scanning Mode	Collimation (mm)	Rotation Time (sec)	Approximate Scanning Time[a] (sec)	Pitch	Table Feed (mm/rotation)
Head	Sequential	1.5	1.5	30	1	6
Cervical spine	Helical	0.75	0.75	14.3	2	6
Thorax	Helical	1.5	0.5	7.6	1.3	30
CT angiography of the thorax	Helical	1.5	0.5	8	1.3	21.5
Abdomen	Helical	1.5	0.5	10	1.3	24
Pelvis	Helical	1.5	0.5	5	1.3	24
Extremity	Helical	0.75	0.75	8	2	13

[a]Depending on length of region; here, an approximation for adult patients.

TABLE 2: Reformatting Protocols Applied in This Study for the CT Examinations of Adults

Body Region	Routine 2D Reconstructions (mm)			Additional Reconstructions	
	Axial	Coronal	Sagittal	2D	3D
Head	4			Coronal, 1-mm slice thickness	
Cervical spine	4	2	2		Volume rendering
Thorax	8				
CT angiography of the thorax	8	4	5		Volume rendering
Abdomen	8				
Pelvis	8			Coronal, 4-mm slice thickness	Volume rendering
Extremity	4	2	2		Volume rendering

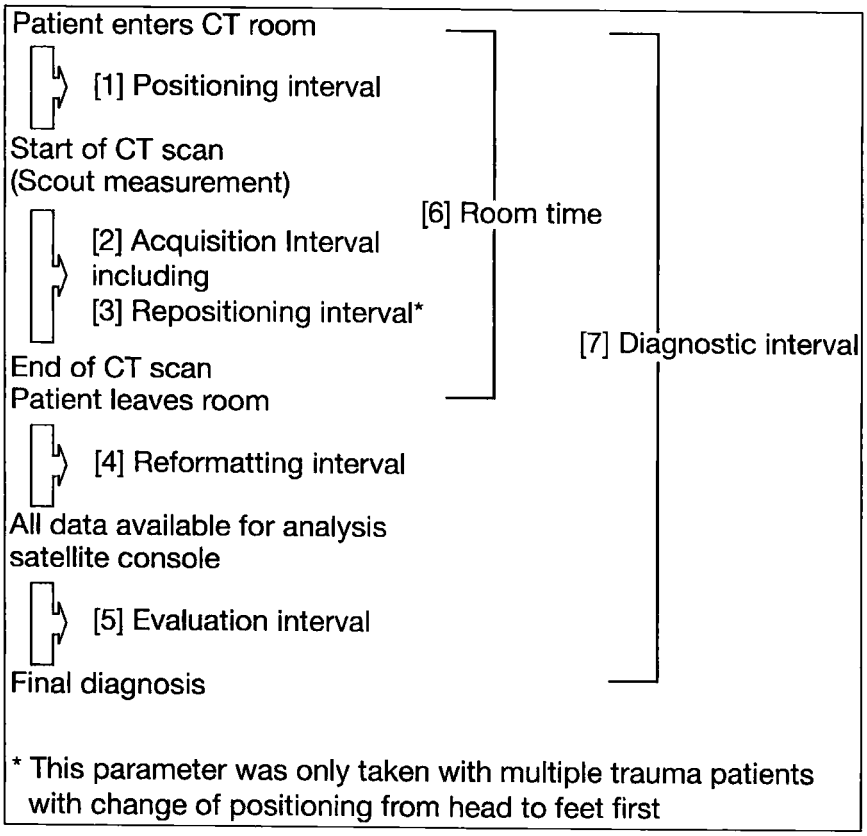

Fig. 1—Diagram shows recorded time intervals during emergency CT study.

Patients

Five hundred three patients from the surgical and medical emergency admissions were studied. Patients from the clinical wards experiencing emergency situations were not included in this study. The patients were recorded consecutively within a period of 6 weeks.

The patient population and their age distribution, ranging from 1.8 to 97.3 years (SD, 22.3 years), were representative of the spectrum of patients in the emergency unit. Thirty-nine of the patients had multiple traumas requiring MDCT of more than two body regions (e.g., head and thorax–abdomen). These patients were admitted in critical condition and underwent CT after initial stabilization of circulation. Scanning was not performed within the first 6 min after admission, corresponding to phases alpha and beta of the advanced trauma life-support concept [8, 15]. The study design (Fig. 2 and Table 3) is in accord with the guidelines of the institute's ethics committee and was performed according to the revised Declaration of Helsinki of 1998 [16].

Results

Dropouts and Delays

For three (0.6%) of the 503 patients, the MDCT scanner malfunctioned and imaging had to be performed with a different CT scanner at the hospital. In all cases, the malfunction was linked to an internal software problem that was solved by rebooting the system. During rebooting, the scanner was not available for 15–20 min.

The low compliance of two restless patients (0.4%) did not allow CT, and anesthesiologic problems in another patient (0.2%) forced interruption of the examination. A total of six patients (1.2%) therefore were excluded from the study, leaving 497 emergency patients who completed the study. In three (0.6%) of these 497 patients, a CT malfunction caused a delay in the examination; in these cases, scans from the second examination were evaluated. Scanning in four patients (0.8%) with minor injuries was delayed to give priority to a multiple-trauma patient. In another three cases (0.6%), immediate intervention in the scanner room led to a prolongation of room time.

Time Evaluation and Reformatting

In 350 (70.4%) of the 497 cases, only one body region was scanned. The mean room times for these most frequent types of CT examination were 8 min for imaging the neck and cervical spine and 21 min for CT angiography. CT angiography was performed in 56 patients (11.3%); in 36 of these 56 patients, CT angiography was performed to search for pulmonary embolism. The bolus-tracking protocol of the scanner was successful in all cases.

The mean number of images for single-region examinations ranged from 161 for head imaging to 674 for the extremities. Table 4 summarizes the results for the time intervals for single-region CT.

TABLE 3: Patient Characteristics

Patient Characteristics	All Emergency Cases	Multiple-Trauma Cases
No. of patients	497	39
Sex (male/female)	304/193	29/10
Age (yr)		
Mean	59.9	49.2
Range	1.8–97.3	18.3–89.1

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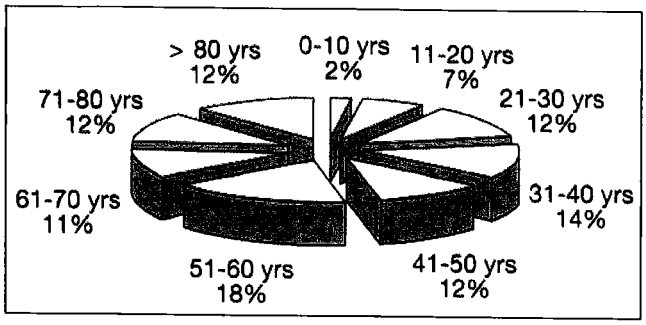

Fig. 2—Chart shows age distribution of patients presenting to emergency department.

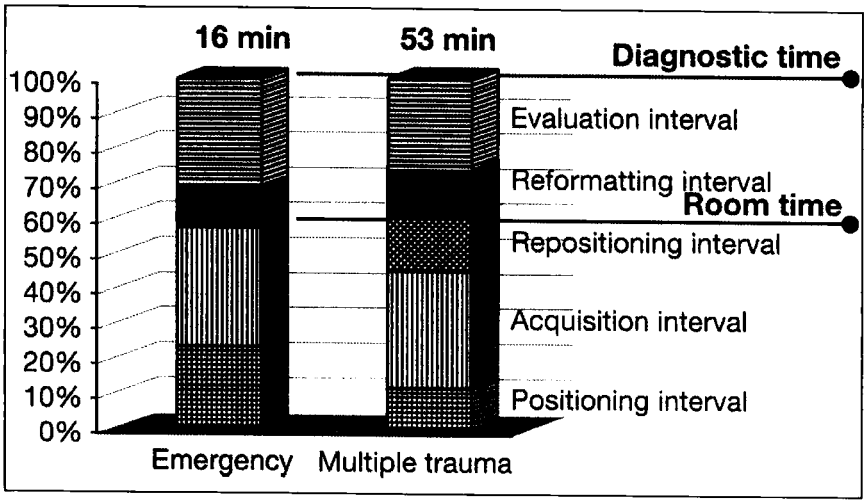

Fig. 3—Bar graph shows time distribution as percentage of diagnostic time for all emergency cases and for subgroup of multiple-trauma patients.

Multiplanar reformatting was routinely performed after examinations of the spine, neck, extremities, and vessels. Three-dimensional reconstructions were often performed in bone imaging (72%) and CT angiography (30%). The positioning interval for these single-region examinations, including preparation of the examination (interval 1), accounted for 37% of the room time for spinal imaging and for up to 67% for CT angiography (Fig. 3).

The mean positioning time for multiple-trauma patients was 6 min, representing 19% of the room time. Patients were turned after head and spine imaging to the feet-first position to reduce artifacts. This repositioning required a mean of 8 min, representing 26% of the room time. Because of the fast scanning time and low collimation, especially for trauma protocols, the number of images ranged from a minimum of 88 in head imaging to 4,637 in multiple-trauma patients. However, the reformatting interval, including calculation and reconstruction of thin sections and transfer to the satellite console, was low (mean, 3–7 min) (Table 5).

Discussion

Principal Findings of the Study

Diagnostic imaging of emergency patients requires a fast and dependable imaging technique. The 16-MDCT protocol described fulfilled these demands: The dropout and delay rate due to technical malfunction was only 0.6%. The 16-MDCT scanner is therefore ideally suited for use as a dedicated emergency scanner. The short acquisition time results in the low dropout rate of 1.2%; reduces artifacts; and allows sufficient imaging of even restless or noncompliant patients, who are frequently encountered among emergency patients.

Technical Aspects

Even scanning of large body segments—as is necessary, for example, in CT angiography of the chest and abdomen—was possible under emergency conditions without major artifacts. Moreover, the short scanning time allowed older patients or patients in serious condition to hold their breath during the examination and thus minimized artifacts. The 56 CT angiography examinations that we performed in a relatively short period may suggest that the high temporal resolution and nearly isotropic imaging expanded the indications for CT and made it applicable to emergency examinations [3, 7] (Fig. 4).

Multiplanar reconstructions of the spine in sagittal and coronal orientations were performed in all cases of multiple trauma. The large number of images required for this subgroup also demands fast 3D reformatting, for which the data reconstruction—including calculation of different slice thicknesses—was technically sufficient. All reconstructions were available at the satellite consoles an average of 3 min (or 7 min for multiple-trauma patients) after completion of scanning and could therefore be prepared for evaluation by the radiologist (interval 4). This interval is significantly shorter than the delay of 14 min for image processing and reconstruction reported by Kloppel et al. [17] for multiple-trauma patients. It also reflects improvements in the hardware over time.

The presence of two satellite consoles providing access to the images is useful in emergency imaging because it permits the presentation of previous patients to the treating physicians without disturbing current examinations. The ability to perform surface-rendered 3D reformatting in a reasonable time allows often superior imaging of fractures and dislocations (Fig. 5).

Clinical Aspects

Emergency patients requiring single-region CT—The data provided here quantifies the mean room time and work of the technician and radiologist for specific examinations involving scans of a single body region. Room time for single-region scans varied between 11 and 22 min depending on the body region, with CT angiography requiring the longest room time as reported in a previous study [13]. In that study, researchers used a 4-MDCT scanner (Somatom Volume Zoom, Siemens Medical Solutions), and the positioning of the patient and the triggering of CT angiography were not specified [13].

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TABLE 4: Evaluation of Time Intervals for Single-Region CT

Interval	16-MDCT of the					CT Angiography of the Thorax and Pelvis
	Head	Neck and Cervical Spine	Extremity	Thorax	Abdomen	
Positioning interval (min)						
Mean	5	4	5	6	7	13
SD	3	1	3	2	4	11
Acquisition interval (min)						
Mean	5	4	4	7	8	9
SD	5	1	4	4	7	6
Reformatting interval (min)						
Mean	2	3	3	3	3	4
SD	1	1	1	1	2	3
Evaluation interval (min)						
Mean	2	7	11	8	11	6
SD	1	1	9	6	10	4
Room time (min)						
Mean	10	8	9	13	15	21
SD	6	4	4	5	9	12
Diagnostic time (min)						
Mean	14	18	23	24	29	32
SD	9	4	10	10	15	15
No. of images (mean)	161	411	674	281	367	640
Percentage (per no. of patients)						
2D reconstruction	8.1	100	100	12	16.4	100
3D reconstruction	1.3	28	72	—	—	30

Note—Dash (—) indicates not applicable.

The relatively long room time for CT angiography may be caused by two factors: First, the often poor clinical condition of patients demands multiple methods of patient monitoring. This may lead to a more complicated and time-consuming positioning and explains the findings of a prolonged positioning interval of 13 min, compared with 6 min for a regular thoracic scan (Table 4). Second, the triggering of the bolus needs additional preparations by technicians and also may explain the prolonged acquisition interval compared with a regular thoracic scan (Table 4).

For all scan regions, a mean interval of 4–13 min was needed for positioning the patient and preparing for the scan (Table 4). This represents a mean of 32% of the room time, a finding that accords with the 7.34 min reported in the only other data available on the time distribution in routine MDCT examinations [13].

Multiple-trauma patients—Emergency patients with multiple traumas generally arrived in critical condition and were difficult to transport. Surprisingly, the mean positioning interval for these patients was equal to the total CT examination time for emergency patients and was significantly shorter than that for patients undergoing CT angiography. This is probably due to the transportation technique used by our center: All multiple-trauma patients remain in a vacuum cushion until the end of the CT examination and are therefore relatively easy to move to the scanner table.

The setting for multiple-trauma patients described here was designed to maximize image quality. The patients were therefore rotated to the feet-first position after head and cervical spine imaging. This study is, to our knowledge, the first one to report experiences using this setting for multiple-trauma patients. The main advantage is to scan a body region in an optimal position and exclude artifacts from arms and cables. Furthermore, this protocol allows the anesthesiologist to use regular equipment without extensions for tubes and cables.

In all examinations of multiple-trauma patients, the image quality was sufficient with low artifacts, especially on the thoracic scans. However, the present study does not directly compare the image quality between the conventional setting with a rigid head-first position and the presented setting with rotating the patient. It remains to further investigations to quantify the effect of rotating the patient on artifact reduction.

The time evaluation shows that turning the multiple-trauma patient caused a mean delay of 8 min (interval 3, the repositioning interval) or 26% of room time, which is disputable in multiple-trauma patients.

The only previous study on examination times for multiple-trauma patients in an emergency CT unit reports a room time of 16 min using a 4-MDCT scanner and head-first single-pass positioning of the patient for the total examination [17]. The mean room time in our study was significantly longer (32 min). This difference is only partially due to repositioning the patient. Another important factor is that in every case the radiologist in our study had to decide whether imaging of the head and cervical

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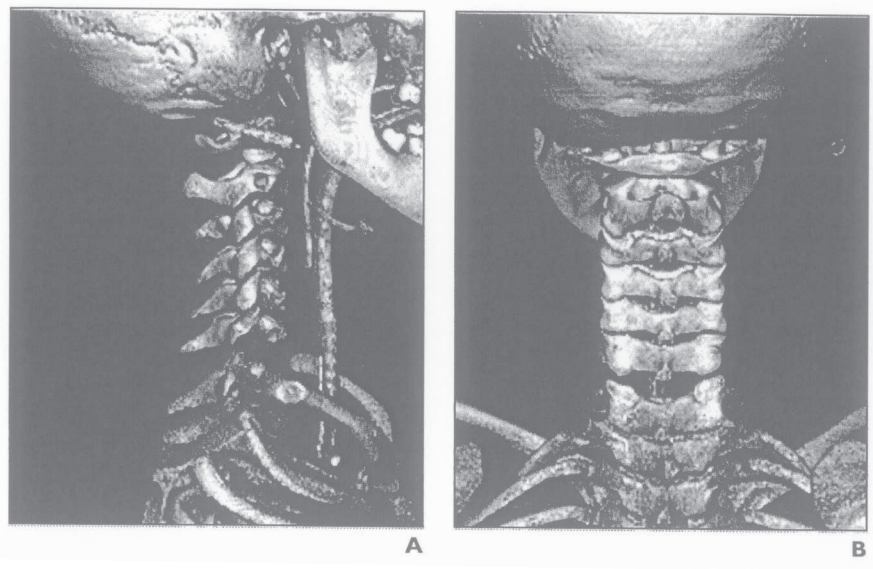

Fig. 4—Three-dimensional reconstruction images of cervical spine in 26-year-old man. **A** and **B**, Lateral (**A**) and dorsal (**B**) projections show cervical spine distraction.

TABLE 5: Evaluation of Time Intervals for MDCT Examinations of Emergency Patients

Interval	All Emergency Patients	Multiple-Trauma Patients
Positioning interval		
Mean (min)	6	6
% of room time	40	19.3
Acquisition interval	9	25
Mean (min)	60	80.7
% of room time		
Including repositioning interval		
Mean (min)	—	8
% of room time		26
Reformatting interval (min)		
Mean	3	7
Evaluation interval (min)		
Mean	8	13
Room time (min)		
Mean	15	31
Diagnostic time (min)		
Mean	26	51
No. of images		
Mean	664	2,588
Range	88–4,637	1,293–4,637

Note—Dash (—) indicates not applicable.

spine was sufficient and the patient could be turned to the feet-first position. Therefore, part of the evaluation was already performed during the repositioning interval, which extended room time. This also explains the relatively short evaluation interval of 13 min for an average of 2,588 images (3.3 images/sec) in multiple-trauma patients compared with 8 min for an average of 664 images (1.4 images/sec) in the entire emergency group.

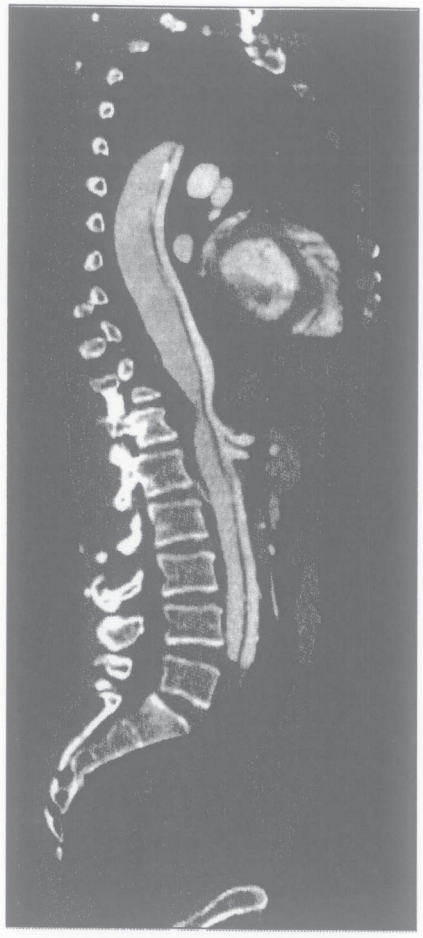

Fig. 5—Multiplanar reconstruction of CT angiogram in 52-year-old man shows extended dissection of abdominal aorta and contrast enhancement in lumina.

The room time is an especially critical factor for multiple-trauma patients because no additional diagnostic procedure is performed and gaining access to the patient is complicated. On the other hand, the fast-scanning technique time of approximately 90 sec for multiple-trauma patients comprised a negligible part of the total room time. Further optimization of patient transport and positioning in multiple-trauma cases may contribute to a reduction of the room time in the future without compromising image quality by beam-hardening artifacts due to the position of arms and cables.

It is up to further studies to examine the time gain and effects on quality of such changes (Fig. 6).

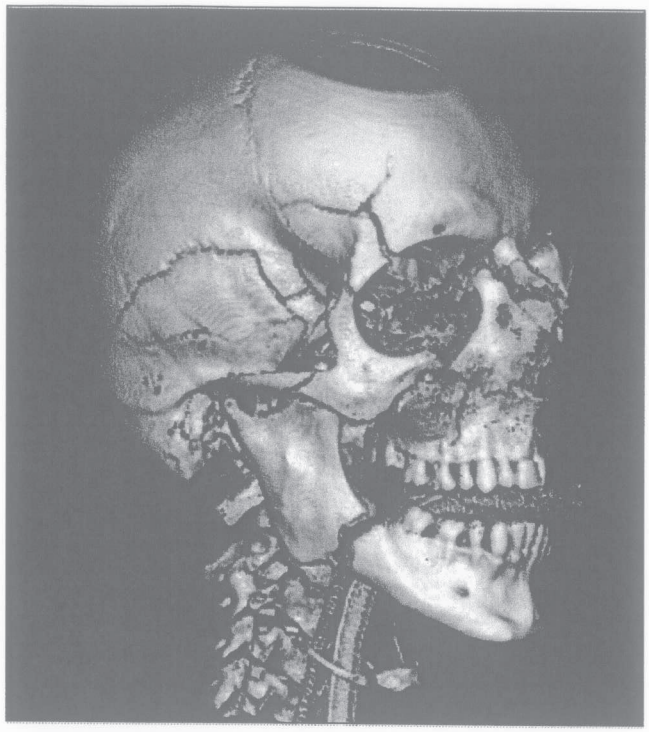

Fig. 6—19-year-old man with multiple traumas. Three-dimensional reconstruction image shows complex maxillofacial and skull fractures.

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Limitations

To a certain extent, our findings are necessarily center-specific because the particular setup and individual technician, radiologist, and patient all have a major influence on the workflow. Moreover, because our evaluation of time intervals in emergency imaging started only 1 month after installation of the scanner, our results still reflect a learning curve. The present study also does not compare the image quality with that attained in other settings—for example, scanners with 1–4 detector rows or scanning patients in one defined position for all body regions. Furthermore, although the present setup allowed excellent imaging, especially for chest and abdominal CT, it remains for future studies to elucidate its applicability to immediate imaging within the first 6 min, corresponding to the alpha and beta phases (first 2–6 min) of the advanced trauma life-support concept [8, 15].

In conclusion, the new generation of 16-MDCT scanners are suited for application as dedicated emergency scanners and their low rate of technical malfunction favors them as a reliable imaging technique. Their high level of performance reduces movement artifacts and allows fast scanning with high spatial resolution under emergency conditions.

The protocol described here for emergency scanning of multiple-trauma patients helped to avoid beam-hardening artifacts but prolonged room time because of the repositioning procedure. Based on the present findings, further advances in emergency CT should focus on the development of transportation and positioning equipment because scanner performance is already of sufficient quality for emergency use.

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Radiation Dose from Single-Heartbeat Coronary CT Angiography Performed with a 320–Detector Row Volume Scanner[1]

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Purpose: To determine radiation doses from coronary computed tomographic (CT) angiography performed by using a 320–detector row volume scanner and evaluate how the effective dose depends on scan mode and the calculation method used.

Materials and Methods: Radiation doses from coronary CT angiography performed by using a volume scanner were determined by using metal-oxide–semiconductor field-effect transistor detectors positioned in an anthropomorphic phantom physically and radiographically simulating a male or female human. Organ and effective doses were determined for six scan modes, including both 64-row helical and 280-row volume scans. Effective doses were compared with estimates based on the method most commonly used in clinical literature: multiplying dose-length product (DLP) by a general conversion coefficient (0.017 or 0.014 $mSv \cdot mGy^{-1} \cdot cm^{-1}$), determined from Monte Carlo simulations of chest CT by using single-section scanners and previous tissue-weighting factors.

Results: Effective dose was reduced by up to 91% with volume scanning relative to helical scanning, with similar image noise. Effective dose, determined by using International Commission on Radiological Protection publication 103 tissue-weighting factors, was 8.2 mSv, using volume scanning with exposure permitting a wide reconstruction window, 5.8 mSv with optimized exposure and 4.4 mSv for optimized 100-kVp scanning. Estimating effective dose with a chest conversion coefficient resulted in a dose as low as 1.8 mSv, substantially underestimating effective dose for both volume and helical coronary CT angiography.

Conclusion: Volume scanning markedly decreases coronary CT angiography radiation doses compared with those at helical scanning. When conversion coefficients are used to estimate effective dose from DLP, they should be appropriate for the scanner and scan mode used and reflect current tissue-weighting factors.

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Coronary computed tomographic (CT) angiography has generated great enthusiasm in recent years, owing to its high diagnostic accuracy efficacy in the assessment of patients known to have or suspected of having coronary artery disease (1). It has been estimated that 2.3 million coronary CT angiography examinations are performed annually in the United States (2). Nevertheless, the enthusiasm about this test has been tempered by concern about the potentially high radiation dose received by patients undergoing coronary CT angiography and its attendant cancer risks (3). In the largest U.S. registry of coronary CT angiography dose information, median effective dose from coronary CT angiography was 21 mSv, equivalent to over 1000 posteroanterior chest radiographs or 7 years of background radiation, prior to an intervention aimed at lowering dose (4). In the past 2 years, a number of methods have been introduced to decrease radiation dose from coronary CT angiography, including sequential or "step-and-shoot" imaging (5,6) and new dual-source protocols (7).

An appealing approach to coronary CT angiography in general, and to dose reduction in particular, is the use of a volume CT scanner. Traditional multidetector CT scanners acquire data over an interval of time, during which the patient table translates so that the scanner's detectors obtain data from the most cranial to the most caudal portion of the heart. In contrast, the detector array of a volume scanner contains sufficient craniocaudal coverage such that the entire length of the heart can be imaged simultaneously, with the patient stationary. By imaging the entire heart in one piece, volume scanning eliminates stair-step artifacts due to seams or gaps between image sections caused by interheartbeat variations in the locations of coronary arteries, as well as artifacts due to temporal changes in coronary opacification by iodinated contrast material. Moreover, because of the brief duration during which the x-ray tube needs to be left on (as little as 0.35 second; ie, a full gantry rotation), volume scanning offers the theoretic possibility of markedly decreasing radiation dose in comparison with traditional helical scanning. However, concerns have been raised about the ability of the first generation of volume scanners to optimally achieve this potential dose reduction. The wider x-ray beam raises the possibility of higher dose due to overbeaming or increased scattered radiation, as does the requirement that the beam remain on for a full gantry rotation during coronary CT angiography rather than the one-half gantry rotation typical of traditional multidetector CT scanners. It thus remains uncertain how the technological advances of volume scanning affect radiation dose.

The primary goal of the present study is to accurately characterize radiation dose to patients from coronary CT angiography performed by using the first-generation volume CT scanner, a 320–detector row scanner. We consider six different scan modes incorporated into the scanner, and for each mode

Advances in Knowledge

- By using 100-kVp volume scanning, effective dose from coronary CT angiography can be decreased by up to 91% in comparison with standard helical scanning, with no change in image noise.
- Effective dose from coronary CT angiography by using volume scanning with an optimized exposure time was 5.8 mSv at 120 kVp and 4.4 mSv at 100 kVp, using International Commission on Radiological Protection (ICRP) publication 103 tissue-weighting factors.
- Organ dose to the lungs and female breasts, the critical organs for coronary CT angiography, can be decreased to as low as approximately 9 mGy by using volume scanning.
- Effective dose of coronary CT angiography, calculated with the current definition of effective dose, in ICRP publication 103, is 33%–42% higher than that calculated with the previous definition, in ICRP publication 60.
- The conversion factors commonly used to estimate effective dose from dose-length product, which are derived from single-section scanners, underestimate effective dose in coronary CT angiography for both volume scanning and 64–detector row helical imaging.

Implications for Patient Care

- Coronary CT angiography can be performed by using volume scanning to decrease radiation dose to patients.
- For a volume scanner, the scan mode chosen for coronary angiography is critical in determining the radiation dose received by the patient.
- Scanner- and scan mode–appropriate conversion factors that reflect current tissue-weighting factors should be used to accurately estimate effective dose from dose-length product.

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Abbreviations:
DLP = dose-length product
ESTCM = electrocardiographically synchronized tube current modulation
ICRP = International Commission on Radiological Protection
MOSFET = metal-oxide–semiconductor field-effect transistor

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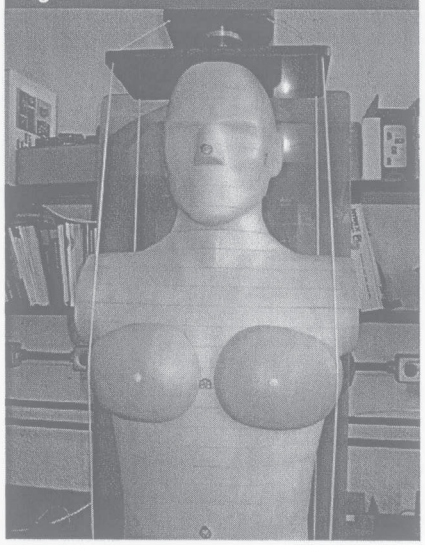
See Materials and Methods for pertinent disclosures.

Figure 1



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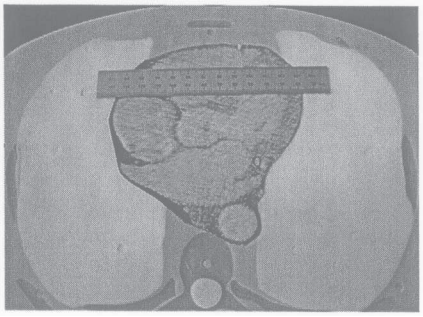
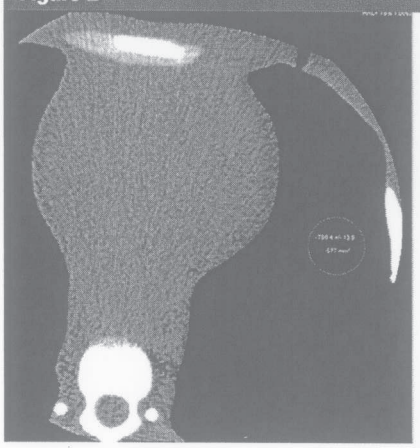


b.

Figure 1: Modified physical anthropomorphic phantom (ATOM 701; CIRS). Views of **(a)** torso and **(b)** cross section through chest.

Figure 2



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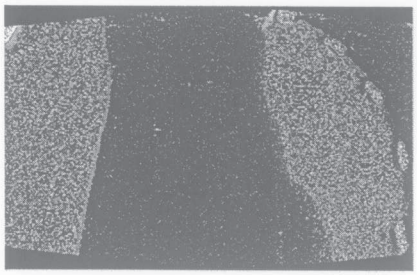

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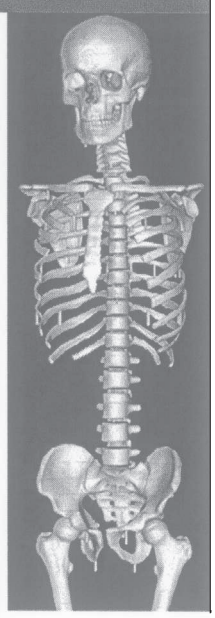


c.

Figure 2: CT scans of modified anthropomorphic phantom. **(a)** Multiplanar reformation of axial image obtained at coronary CT angiography. **(b)** Volume-rendered image with cut plane, illustrating the 14 cm scanned simultaneously. **(c)** Volume-rendered image with bone windows of the modified phantom.

we use standard clinical protocols used in practice that are in accordance with manufacturer's recommendations. Our approach is to measure organ doses in a custom-adapted phantom by using solid-state metal-oxide–semiconductor field-effect transistor (MOSFET) dosimeters and determine effective dose by using the methods specified in the current (2007) recommendations of the International Commission on Radiological Protection (ICRP) (8). These results are compared with effective dose determination based on the methods specified in previous ICRP guidelines (9) as well as with estimates based on conversion factors found in the European Guidelines on Quality Criteria for Computed Tomography (10,11).

Materials and Methods

Relation to Industry

No industry support was received for this study; costs were covered by intramural (A.E.A.) and extramural (A.J.E.) National Institutes of Health funding. One author (R.M.), who is an employee of Toshiba America Medical Systems, did not have control of inclusion of any data or information that might present a conflict of interest.

Phantoms

A whole-body dosimetry verification phantom, made of tissue-equivalent polymers and resins that simulate soft tissue, spinal cord, spinal disks, lung, brain, and bone, was used (Fig 1). The same phantom was used for all scans. Photon attenuation values for all substitutes are within 3% of the value for actual tissue. The phantom is sectional, consisting of a series of 25-mm-thick contiguous sections. In each section, 5-mm-diameter holes, drilled in the craniocaudal direction, are located at positions optimized for dosimetry in more than 20 internal organs. Tissue-equivalent holders are used for MOSFET detector placement within these holes. With the use of human anatomic data, this phantom has been modified from a commercially available anthropomorphic phantom (ATOM 701; CIRS, Norfolk, Va). Additional holes were drilled so that absorbed dose could be determined for each organ with a significant tissue-weighting factor in the ICRP 2007 guidelines. Medium-sized tissue-equivalent breast phantoms, constructed based on CT data from an actual patient imaged in the supine position, were attached to the phantom for scans of female phantoms. This phantom is not only physically similar to a human (weight, 73 kg; height, 173 cm; thorax, 23 × 32 cm without breasts) but is also radiographically similar to a human (Fig 2), thereby enabling realistic simulation of a person undergoing a CT examination.

MOSFET Dosimeters

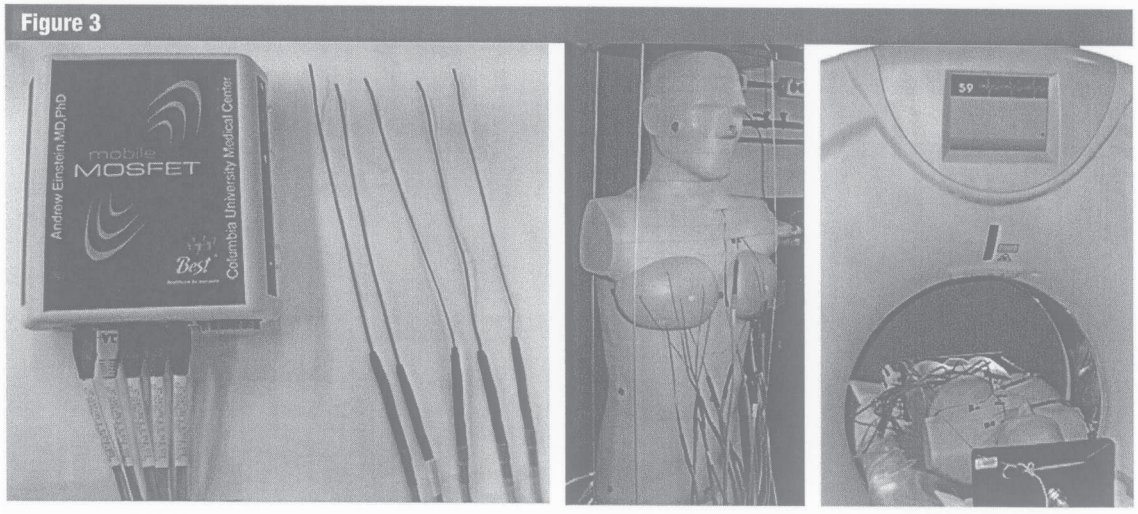
A mobile MOSFET dose verification system (TN-RD-70W; Best Medical,

Table 1

The Six Scan Modes Evaluated

Mode	Detector Rows	Collimation per Row (mm)	Total Scan Length (mm)	Tube Voltage (kVp)	Maximum Tube Current (mA)	Exposure Time (sec)	Pitch
Retrospectively gated helical	64	0.5	140	120	430	9.28	0.20
Retrospective helical with ESTCM	64	0.5	140	120	430	9.28	0.20
Prospectively triggered helical	64	0.5	140	120	430	2.55–2.95	0.27
Prospectively triggered volume							
Standard exposure time	280	0.5	140	120	430	0.55	
Optimized exposure time	280	0.5	140	120	430	0.40	
Low-voltage prospectively triggered volume: optimized exposure time	280	0.5	140	100	550	0.40	

Figure 3



a. b. c.

Figure 3: **(a)** Reader with five attached MOSFETs. **(b)** Modified anthropomorphic phantom with MOSFETs placed for dosimetry measurements in the thorax. **(c)** Phantom is shown in the CT scanner with MOSFETs placed, ready for acquisition of dose measurements.

Ottawa, Canada) reader was coupled with high-sensitivity MOSFETs (TN-1002RD; Best Medical). MOSFETs were calibrated to relate voltage readout to absorbed dose of radiation by using an electrometer and ionization chamber combination (model 1015; Radcal, Monrovia, Calif). MOSFETs were positioned in locations corresponding to the heart, lungs, breast, esophagus, thyroid, thymus, colon, small intestine, stomach, ovary, testes, bladder, liver, uterus, prostate, brain, spleen, pancreas, salivary glands, adrenal glands, extrathoracic airways, gall bladder, kidneys, oral mucosa, and bone/bone marrow of the phantom (Fig 3). Up to 20 MOSFETs were placed in the phantom for any individual scan. Each scan protocol was repeated separately with MOSFETs placed in one of three regions—the thorax, cranial to the thorax, and caudal to the thorax—thus enabling MOSFETs in a total of 46 locations to be used to characterize the dosimetry of each scan mode.

CT Scans

CT examinations were performed with a 320–detector row scanner (Aquilion ONE; Toshiba Medical Systems, Otawara, Japan). A patient heart rate of 60 beats per minute was simulated by using a "chicken heart" electronic device incorporated into the scanner's cardiac monitor. Scan protocols, typical of those used clinically at the National Heart, Lung, and Blood Institute, were determined prior to scanning (A.J.E., A.E.A., M.Y.C.). Gantry rotation time was 0.35 second in each mode. Tube current was selected with a clinically used table based primarily on patient weight.

Six coronary CT angiography scan modes were considered, as summarized in Table 1. All helical modes are currently implemented by using only the middle 64 rows, while volume modes enable up to 320 rows to be utilized. For electrocardiographically synchronized tube current modulation (ESTCM), tube current remained at its maximal value between 70% and 80% of the cardiac cycle, and dropped to 20% of maximum outside of this temporal window. Prospectively triggered

helical scanning is similar to the "step-and-shoot" scan mode incorporated into other manufacturers' scanners, in leaving the x-ray tube on only during a brief window during diastole, but differs in that the scanner operates in a helical rather than axial mode.

For volume scanning, the middle 280 detector rows were used, attaining 14-cm craniocaudal coverage, which is greater than the median scan length used in practice and usually sufficient for cardiac scanning (12). Two different 120-kVp volume scanning modes were considered. To have enough data to reconstruct a given cardiac phase, it is necessary to obtain some data before and after the desired phase. In the first volume mode, referred to as volume imaging with standard exposure time, a phase window from 65% of the cardiac cycle to the subsequent R wave was prespecified, which in practice results in a reported exposure time of 0.55 second and enables reconstruction from 61% to 82% of the cardiac cycle at a heart rate of 60 beats per minute. Works-in-progress enhancements to cardiac reconstruction algorithms reduce the necessary amount of data surrounding the desired phases, therefore enabling shorter exposure times. In the second volume scanning mode, referred to as volume imaging with optimized exposure time, a 75%–75% phase window was prespecified, which in practice results in a reported exposure time of 0.40 second. This exposure time currently enables reconstructions for a single phase at 75% of the cardiac cycle, but with the enhanced cardiac reconstruction algorithm enables reconstructions from approximately 69%–81% of the cardiac cycle, at a heart rate of 60 beats per minute. Optimized exposure time volume scanning was also performed by using a 100-kVp protocol; this represents the lowest-dose volume scanning mode which still enables multiple phase reconstructions.

Separate scans were obtained for male and female phantoms. Two to 10 repetitions of the scan protocol were performed for each combination of scan mode, sex, and set of MOSFET placements. The number of repetitions was selected for each combination such that the dose to the MOSFETs was sufficient to ensure reproducibility, so as to minimize this source of error in effective dose estimates. In addition, doses were determined separately for bolus tracking, by using a tube voltage of 120 kVp and a current of 150 mA with the four middle detectors. For bolus tracking, acquisition of at least 50 seconds was performed for each set of MOSFET positions; doses are reported as dose per 10 seconds of acquisition. No scout or aortic localizer scans were obtained; these generally contribute less than 5% of total dose.

Organ Dose Calculations

Organ doses were determined from MOSFET measurements. Cumulative point doses were determined at one to six locations for each organ, divided by the number of scans performed for each combination of scan mode and sex, and averaged to determine the absorbed dose to the organ. For lung, a weighted average was calculated, with the weighting of each MOSFET measurement determined by the percentage of the organ's volume closest to that MOSFET. The percentage of bone and active marrow in different locations was approximated by using separate weighting factors as specified by Eckerman et al (13).

Effective Dose Calculations

Effective dose was calculated from organ absorbed doses by using radiation and tissue-weighting factors specified in ICRP publication 103 (8), as well as those in the older ICRP publication 60 (9).

Conversion Factor Determination and Effective Dose Estimation

Dose-length product (DLP), defined according to International Electrotechnical Commission standards (14), was recorded for each scan from the scanner console. The "k factor," or conversion factor relating DLP to effective dose, was determined by dividing effective dose by DLP. The effective dose determined by using MOSFET measurements was also compared with that estimated by using DLP multiplied by European Commission chest conversion factors. These factors, based on Monte Carlo simulations modeling single-section scanners, were 0.017 $mSv \cdot mGy^{-1} \cdot cm^{-1}$ in the 2000 European Commission guidelines (10) and 0.014 $mSv \cdot mGy^{-1} \cdot cm^{-1}$ in appendix C of the 2004 guidelines (11).

Image Noise

Axial images from coronary CT angiographic scans of a female phantom performed with each of the six scan protocols were reconstructed with a section thickness of 0.5 mm, standard cardiac kernel (FC04), and adaptive noise reduction algorithms (QDS and Boost3D; Toshiba Medical Systems). Image noise was assessed for each scan, in the same 14 locations within the heart, as the standard deviation of CT number in the region of interest. Difference in noise among the six protocols was assessed by using repeated-measures analysis of variance, with Box epsilon used to correct the degrees of freedom. Statistical calculations were performed by using statistical software (Stata 10.1; Stata, College Station, Tex).

Results

Effective Doses

Effective doses for the six protocols are summarized in Table 2. There was a marked difference in effective dose between protocols. With standard 64-row helical scanning without ESTCM as the benchmark, effective dose was reduced by 91%, from 35.4 to 4.4 mSv, by using 100-kVp optimized volume scanning. Effective doses varied up to twofold between methods used to determine effective dose. Effective doses determined by using organ doses and ICRP publication 103 tissue-weighting factors were the highest, ranging from 33% to 42% higher than effective doses determined by using the older ICRP publication 60 tissue-weighting factors. Estimating effective dose from DLP by using a generic chest conversion factor resulted in its underestimation, even in comparison with that from the older ICRP 60 definition.

Table 2

Effective Doses of the Six Scan Protocols

Method Used	Effective Dose Derived from	Helical	Helical ESTCM	Prospective Helical	Volume with Standard Exposure Time	Volume with Optimized Exposure Time	Volume 100 kVp: Optimized Exposure Time	Bolus Tracking*
ICRP publication 103†	Organ doses	35.4	22.3	9.3	8.2	5.8	4.4	0.8
ICRP publication 60	Organ doses	26.5	16.6	7.0	5.9	4.1	3.1	0.7
2000 European guidelines	DLP × *k* factor	20.4	14.0	5.9	4.8	3.2	2.2	0.8
2004 European guidelines	DLP × *k* factor	16.8	11.6	4.9	4.0	2.7	1.8	0.7
DLP (mGy·cm)		1201.3	826.2	348.9	284.7	189.8	128.6	48.4
Dose reduction from helical (ICRP publication 103) (%)			37.0	73.7	76.8	83.6	91.2	

Note.—Except where otherwise indicated, data are the effective dose in millisieverts. Skin dose is not included.

* Bolus tracking doses are for 10 seconds of tracking.

† For remainder organs, average dose to all organs listed in ICRP 103, except for lymph nodes and muscle, is used.

Table 3

Conversion Factors k for the Six Scan Modes

Method Used	Helical	Helical ESTCM	Prospective Helical	Volume with Standard Exposure Time	Volume with Optimized Exposure Time	Volume 100 kVp: Optimized Exposure Time	Bolus Tracking*
ICRP publication 103†	0.029	0.027	0.027	0.029	0.031	0.034	0.017
ICRP publication 60	0.022	0.020	0.020	0.021	0.022	0.024	0.014
European guidelines 2000	0.017	0.017	0.017	0.017	0.017	0.017	0.017
European guidelines 2004, appendix C	0.014	0.014	0.014	0.014	0.014	0.014	0.014

Note.—Data are the ratio of effective dose to DLP, in $mSv \cdot mGy^{-1} \cdot cm^{-1}$. Skin dose is not included.

* Bolus tracking doses are for 10 seconds of tracking.

† For remainder organs, average dose to all organs listed in ICRP 103, except for lymph nodes and muscle, is used.

Conversion Factors

By using effective dose determined with its current definition (based on organ doses measured and tissue-weighting factors specified in ICRP publication 103), conversion factors relating DLP to effective dose from coronary CT angiography ranged from 0.027 to 0.034 $mSv \cdot mGy^{-1} \cdot cm^{-1}$, depending on the scan mode (Table 3). Even with the older ICRP publication 60 definition of effective dose, these conversion factors would range 0.020–0.022 $mSv \cdot mGy^{-1} \cdot cm^{-1}$ for 64-row helical scanning and 0.021–0.024 $mSv \cdot mGy^{-1} \cdot cm^{-1}$ for volume scanning. In contrast, the conversion factors commonly used are uniformly 0.014 (2004 guidelines) or 0.017 $mSv \cdot mGy^{-1} \cdot cm^{-1}$ (2000 guidelines), independent of the scan mode used.

Organ Doses

Organ doses for the six scan modes and bolus tracking are summarized in Table 4. Organs that contributed most to effective dose were the female breasts, lungs, red bone marrow, stomach, and esophagus, for which weighted equivalent doses (15) (portions of effective dose attributable to a specific organ) were 2.0, 1.4, 0.8, 0.5, and 0.3 mSv, respectively, for 120-kVp optimized volume scanning. Organ doses to these critical organs varied markedly between protocols; doses to female breasts and to female and male lungs all decreased by 87% by using 100-kVp optimized volume scanning, in comparison with 64-row helical scanning.

Image Noise

While there was a statistically significant difference in image noise among the six protocols ($P = .004$), mean and median noise were similar between the six scan protocols (Fig 4), with median values ranging between 25.0 and 30.9 HU. While the highest median noise was that for 100-kVp optimized volume scanning (30.9 HU), in six of the 14

Table 4

Organ Absorbed Doses, in Milligrays

Organ	Helical	Helical ESTCM	Prospective Helical	Volume with Standard Exposure Time	Volume with Optimized Exposure Time	Volume 100 kVp: Optimized Exposure Time	Bolus Tracking*
Female Phantom							
Heart	96.1	58.2	25.6	22.3	17.2	13.5	1.5
Lung	66.3	42.7	18.2	15.5	11.2	8.6	2.2
Breast	64.8	42.9	18.1	15.7	11.2	8.5	1.5
Esophagus	43.9	28.6	12.5	9.3	6.7	5.0	2.6
Liver	39.0	23.0	9.8	7.4	4.8	4.1	0.4
Remainder organs (ICRP 103)	28.0	16.9	7.4	5.8	4.2	3.3	0.6
Red bone marrow	37.3	22.4	9.9	9.6	6.5	5.2	0.4
Stomach	36.3	21.1	8.5	5.3	3.8	2.6	0.3
Remainder organs (ICRP 60)	24.9	15.0	6.5	5.0	3.5	2.7	0.6
Male Phantom							
Heart	113.2	71.3	30.5	27.8	19.5	15.8	1.6
Lung	70.8	44.8	18.3	18.1	12.1	9.4	2.3
Esophagus	46.9	31.1	13.0	9.8	7.0	5.3	3.2
Liver	39.0	23.0	9.8	7.4	4.8	4.1	0.4
Remainder organs (ICRP 103)	29.6	18.6	8.0	6.5	4.5	3.5	0.7
Red bone marrow	37.8	24.3	10.6	9.8	7.0	5.4	0.4
Stomach	36.3	21.1	8.5	5.3	3.8	2.6	0.3
Remainder organs (ICRP 60)	24.9	15.7	6.8	5.2	3.5	2.7	0.7

Note.—Only organs contributing at least 3% of effective dose for volume scan are shown.

* Bolus tracking doses are for 10 seconds of tracking.

Figure 4

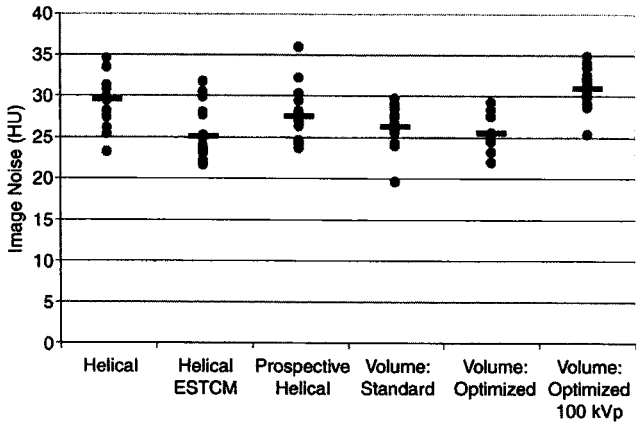


Figure 4: Graph of image noise for the six scan protocols. Points represent individual noise measurements in the 14 cardiac regions of interest, and the horizontal bars denote median values for each protocol.

regions of interest this scan had less image noise than or equal image noise to the standard helical scan (median, 29.6 HU). For each scan protocol, there was at least one region with less image noise and one region with more image noise than that with standard helical scanning.

Discussion

Sixty-four–section coronary CT angiography using a helical technique has shown outstanding diagnostic performance. Meta-analysis of 45 studies evidenced per-patient pooled sensitivity of 99% and specificity of 89%, with median positive and negative predictive values of 93% and 100%, respectively (16). However, 64-section helical coronary CT angiography has also been associated with some of the highest radiation doses of any diagnostic radiologic procedure (15), and, specifically, higher radiation doses than those from any generation of scanners preceding it. Thus, while the initial 64-section scanners demonstrated improved diagnostic performance over previous generations of scanners, it is widely recognized that improved scanners, affording comparable or improved diagnostic performance at lower cost in terms of radiation exposure, are needed. In this context, volume scanning represents an important potential advance.

Nevertheless, concerns have been raised about the potential for overbeaming and increased scattered radiation in volume scanning, as well as its need for a full gantry rotation for coronary CT angiography, and their implications in terms of increased dose. In fact, the

only previous article addressing radiation dose from volume coronary CT angiography reported a mean effective dose of 7.2 mSv (range, 4.9–16.5 mSv) in an initial experience with 34 patients (17); this dose was based on the DLP, using a modified conversion factor (18). While somewhat lower than typical effective doses for helical coronary CT angiography, these doses are considerably higher than those described with sequential protocols on 64-section scanners (5,6). Accounting in part for this discrepancy is lack of protocol optimization in these initial scans performed using volume coronary CT angiography. In 82% of patients scanned prospectively, full tube current was maintained over 40% of the cardiac cycle, enabling reconstruction from 60%–100% of the R-R interval, thus generating a wide range of coronary images for evaluation at the price of increased radiation dose.

The effective dose determined in our study from volume coronary CT angiography with standard exposure time (using the ICRP publication 103 definition) was 8.2 mSv, which is comparable to the mean dose in the aforementioned pilot series. Effective doses, however, were lower by using volume scanning with optimized exposure time: 5.8 mSv at 120 kVp and 4.4 mSv at 100 kVp.

Of note is the difference in effective dose we calculated from the same scan between different calculation methods for effective dose. Effective dose is defined by the ICRP, which updated its definition in 2007 (8). The approximately 40% higher effective doses that were determined by using this new formulation largely reflect the increased tissue-weighting factor assigned to the female breast (from 0.05 to 0.12) and, to a much lesser degree, the increase in the tissue-weighting factor to the "remainder organs" and their redefinition to include the heart. In published literature (5–7,12), the most commonly used method to estimate effective dose from a coronary CT angiography procedure has been to multiply the scanner-reported DLP by a conversion factor (denoted "*k* factor" or "E_{DLP}") specified in European guidelines (10,11). Effective doses estimated here by using these *k* factors, which were as low as 2.7 mSv at 120 kVp and 1.8 mSv at 100 kVp, were considerably lower than those determined by using the ICRP definition, even in its lower-dose ICRP publication 60 formulation.

Estimating effective dose with these conversion factors has numerous limitations. These "broad estimates" (10) were not derived for contemporary coronary CT angiography but rather for chest CT, they are based on Monte Carlo simulations modeling single-section scanners now several generations old (ie, Siemens DRH, GE 9800, and Philips LX [11]), and they were derived by using the older (9) definition of effective dose. The conversion factors determined here can be used to estimate effective dose from volume and helical scanning by using the Aquilion One scanner in the modes studied. Further studies are needed (19) to determine such conversion factors for the various scan modes (20) of other contemporary scanners. While the accuracy of estimates of effective dose in contemporary coronary CT angiography obtained by using European guideline *k* factors is thus questionable, the fact that these estimates are similar in the current study to those previously reported for sequential scanning (21) suggests that concerns of overbeaming or increased scatter as a major contributor to effective dose in volume scanning do not appear to be well founded. This observation is consistent with findings in 256-section coronary CT angiography with 8-cm craniocaudal coverage—that increasing the scan length decreases the dose of prospectively gated scans (22).

Our study had several potential limitations. The phantom was scanned with a fixed heart rate of 60 beats per minute with no significant heart rate variability. At higher heart rates and with greater heart rate variability, the volume scanner used in our study acquires data over two consecutive heartbeats to ensure image quality, which would result in higher effective dose (17). The relationship between heart rate variability and radiation dose from volume CT requires further study. The validity of using *k* factors, which we provided here for the volume scanner, has been a subject of debate in the literature, and some experts argue against their use (19). While we found no sizable difference in image noise between scan protocols, this phantom study was not designed to compare the image quality and interpretability of actual clinical scans between protocols. These could differ even at similar levels of noise. The anthropomorphic phantom used reflects a normal-sized individual, close in size to the Reference Person recommended by ICRP for determining effective dose (8). While effective dose is a population-based quantity that does not depend on a particular individual's habitus, organ-absorbed doses could vary from the values found here depending on patient habitus. For patients with increased thoracic thickness (eg, obsese patients), it would be expected that organ doses would need to be higher to maintain constant image noise (23).

In conclusion, coronary CT angiography can be performed by using volume scanning to decrease radiation dose to patients with no meaningful change in image noise, with effective doses of 4.4 mSv at 100 kVp and 5.8 mSv at 120 kVp noted in this study, by using ICRP publication 103 tissue-weighting factors. For a volume scanner, the scan mode chosen for coronary angiography is critical in determining the radiation doses received by the patient. Given volume scanning's potential for low radiation dose, further studies evaluating its diagnostic accuracy efficacy and impact on patient-important outcomes are needed. The chest conversion factors commonly used to estimate effective dose from DLP in coronary CT angiography significantly underestimated effective dose, for both volume scanning and 64-section helical imaging, and thus scanner- and scan mode–appropriate conversion factors are needed to accurately estimate effective dose.

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Research Article

Influence of Image Acquisition on Radiation Dose and Image Quality: Full versus Narrow Phase Window Acquisition Using 320 MDCT

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Purpose. To compare radiation dose and image quality using predefined narrow phase window versus complete phase window with dose modulation during R-R using 320-row MDCTA. *Methods.* 114 patients underwent coronary CTA study using 320-row MDCT scanner. 87 patients with mean age (61 + 13 years), mean BMI (29 + 6), and mean heart rate (HR) (58 + 7 bpm) were imaged at predefined 66–80% R-R interval and then reconstructed at 75% while 27 patients with mean age (63 + 16 years), mean BMI (28 + 5), and mean HR (57 + 7 bpm) were scanned throughout the complete R-R interval with tube current modulation. The effective dose (ED) was calculated from dose length product (DLP) and conversion k (0.014 mSv/mGy/cm). Image quality was assessed using a three-point ordinal scale (1 = excellent, 2 = good, and 3 = nondiagnostic). *Results.* Both groups were statistically similar to each other with reference of HR ($P = 0.59$), BMI ($P = 0.17$), and tube current mAs ($P = 0.68$). The median radiation dose was significantly higher in those scanned with complete R-R phase window versus narrow phase window ($P < 0.0001$). Independently of patient and scan parameters, increased phase window was associated with higher radiation dose ($P < 0.001$). Image quality was better among those scanned with narrow phase window versus complete phase window ($P < 0.0001$). *Conclusion.* Our study supports that good HR control and predefined narrow window acquisition result in lower radiation dose without compromising diagnostic image quality for coronary disease evaluation.

1. Introduction

MDCTA has emerged as a robust technique for the assessment of coronary artery anatomy and disease with accuracy comparable to invasive coronary angiography [1–5]. Owing to a high negative predictive value, coronary MDCTA may be suitable as a primary screening tool for those symptomatic patients with low probability of coronary artery disease [1]. While specific clinical applications of MDCTA are still the subject of some debate, improvements in temporal and spatial resolutions have substantially broadened its potential use. Nevertheless, the enthusiasm for MDCTA has been tempered by concerns about the potentially high radiation dose received while undergoing coronary MDCTA and its attendant potential cancer risks [6, 7].

LaBounty et al. showed that decreasing the phase window was associated with substantial reduction of radiation dose with preserved image quality using 64-row scanner [8]. However, a prior study using the 320 MDCTA suggested that narrowing the phase window width also has the potential to reduce diagnostic accuracy [9]. The purpose of our study was to compare the radiation dose and image quality of data captured during the cardiac cycle centered at 66–80% of the R-R interval (narrow phase window) versus complete

phase window during entire R-R interval with tube modulation (functional imaging with dose modulation) using 320 MDCTA.

2. Material and Methods

2.1. Study Population. This retrospective study was approved by our Institutional Review Board and informed consent was waived. The study population is comprised of consecutive series of one hundred and fourteen patients undergoing clinically indicated prospective ECG-triggered MDCTA (Table 1). Imaging modes were chosen based upon their respective referral reasons. (Group A) 87 patients (mean ages of 61 ± 13 years, 72% males, mean BMI of 29 ± 6 with mean HR of 58 ± 7 bpm) referred for coronary artery disease evaluation were imaged at 66–80% of R-R interval while (Group B) 27 patients (mean age of 63 ± 17, 52% males, mean BMI of 28 ± 5 and mean HR of 58 ± 7 bpm) referred to determine coronary artery disease plus functional status of heart were imaged throughout R-R interval with tube current modulation. Inclusion criteria for coronary MDCTA were atypical chest pain, suspected CAD, pathological ECG results or equivocal stress test, dyspnea, and cardiac risk factors. Clinical exclusion criteria for exam were nonsinus rhythm, severe allergy to iodine-containing contrast material, history of renal disease (calculated from creatinine levels > 1.7 mg/dL), pregnancy, hemodynamic instability, and severe respiratory or cardiac failure. Patients' DICOM images were reconstructed at Vitrea workstation to review segmental image quality.

2.2. CT Angiography. All MDCTA examinations were supervised by a cardiovascular imaging fellowship trained radiologist with seven years of clinical experience. Patients were connected to ECG leads placed in standard position to enable CT synchronization with ECG. Beta blocking medication (oral or intravenous metoprolol) was administered to achieve heart rates <65 bpm unless contraindicated to avoid motion artifacts. Sublingual nitroglycerine (0.4 mg) was administered to dilate coronaries for coronary vessel evaluation. There were no patients with contraindication to beta blockade or nitroglycerine in our study.

All MDCTA scans were performed with a 320-row scanner (Aquilion ONE, Toshiba, Tokyo, Japan). The starting point of the volume scan and coverage area was craniocaudally from one centimeter below the tracheal bifurcation to the diaphragm. Prior to the examination, all patients were instructed on quiet breathing and breathe holding in order to minimize artifacts during scanning. The Optiray 350 (Ioversol injection 74%; 70–100 mL) was injected at a rate of 5 mL/second followed by 50 mL of normal saline at 5 mL/sec. The scan parameters were determined on basis of patients BMI. All patients in both group were scanned using 120 kVp, 400 mA, gantry rotation 350 msec, 320-row (0.5 mm detectors), and 160 mm volume scan length (Table 2).

2.3. Scanning Modes

(A) Prospective Narrow Phase Window (66–80%). Figure 1 depicts the R-R interval of the cardiac cycle in seconds (abscissa) and the height of the shaded areas represents the tube current (mA). For the volume scan as depicted in the figure, the applied tube current is at a constant preset (mA value) to 66–80% of the R-R interval. This scheme will result in a lower dose to the patient compared to the other modified tube current scheme shown in Figure 2.

(B) Complete Phase Window Acquisition with Dose Modulation. Figure 2 depicts that tube current is modulated and applied throughout the R-R interval for the cardiac scanning (cardiac perfusion and functional studies). The tube current is increased between 66% and 80% of the R-R interval. However images can be reconstructed throughout the cardiac cycle for analysis.

2.4. Assessment of Image Quality. Image analysis was performed by two readers who were level-3-certified competent by the Society of Computed Cardiac Tomography. The images were reviewed at the Vitrea workstation V4 FX version. The readers were able to scroll through axial images and interactively perform multiplanar reconstructions and maximum intensity projections, as well as curved multiplanar reformats for both data sets. After blinding the examinations, the image quality of the coronary vessels was assessed subjectively by the two observers using the 16-segment American Heart Association model [10]. All patients were analyzed in a randomized manner and all segments were evaluated using an ordinal scale from 1 to 3 (1, excellent; 2, good; and 3, nondiagnostic). Segments assigned to a score of 3 were not evaluated because of marked motion artifacts, structural discontinuity, image noise, related blurring, or poor vessel opacification.

2.5. Calculation of Radiation Dose Estimates. The effective dose (ED) was selected as the best measure to assess and compare radiation dose exposure. The ED shows the nonuniform radiation absorption of partial body exposure relative to whole body radiation. For ED calculation, the dose length product (DLP) was multiplied with a conversion factor k (0.014 mSv/mGy/cm). The DLP was recorded from the scanner console (see [11–13]):

$$\text{effective dose (ED)} = \text{dose length product (DLP)} \times k. \quad (1)$$

2.6. Statistical Analysis. Median radiation doses were reported. Median radiation dose difference was compared by using Kruskal-Wallis equality of population rank test. Further regression analysis was performed for median radiation dose for both groups adjusted for other variables (age, gender, BMI, heart rate, tube voltage, and tube current). A P value < 0.05 was considered statistically significant. Ordinal scale was used to interpret the image quality from 1 (excellent) to 3 (nonevaluated). The Wilcoxon signed-rank

Table 1: Summary of patient characteristics for two groups undergoing imaging using complete versus narrow phase window acquisition at 320-row MDCTA.

Patient characteristics	Complete phase window	Narrow phase window
BMI	28 ± 5	29 ± 6
HR (bpm)	57 ± 7	58 ± 7
Age	63 ± 16	61 ± 13
Gender (male : female)	14 : 13	63 : 24

Table 2: Typical imaging and reconstruction parameters for complete versus narrow phase window acquisition at 320-row MDCTA.

	Complete phase window	Narrow phase window
Tube voltage	120 kVp	120 kVp
Tube current-time product	400 mA	400 mA
R-R phase	Complete phase with dose modulation; peak dose at 75%	66%–80%
Reconstruction filter kernel	Standard FC3	Standard FC3
Reconstruction field of view	≤250 mm	≤250 mm
Slice thickness: increment	0.5 mm : 0.3 mm	0.5 mm : 0.3 mm

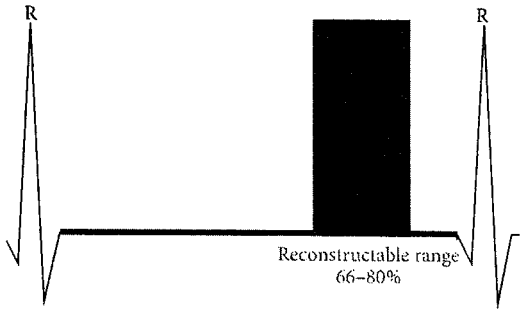

Figure 1: Narrow phase window (66–80) showing limited tube current exposure, 72 × 29 mm (300 × 300 DPI).

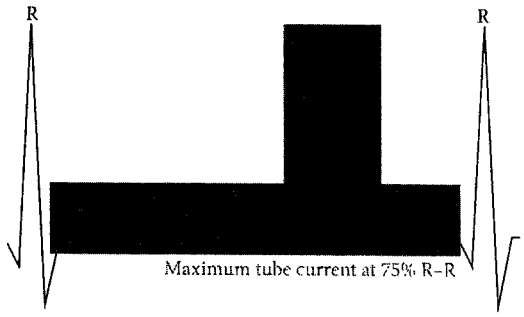

Figure 2: Complete phase window with tube modulation, 76 × 39 mm (300 × 300 DPI).

test was used to analyze the image quality in both groups using a 16-segment coronary artery model.

3. Results

Both groups were statistically comparable as no significant difference was found between them with respect to their heart rate ($P = 0.59$), BMI ($P = 0.17$), and imaging tube current mAs ($P = 0.68$). The median radiation dose (interquartile

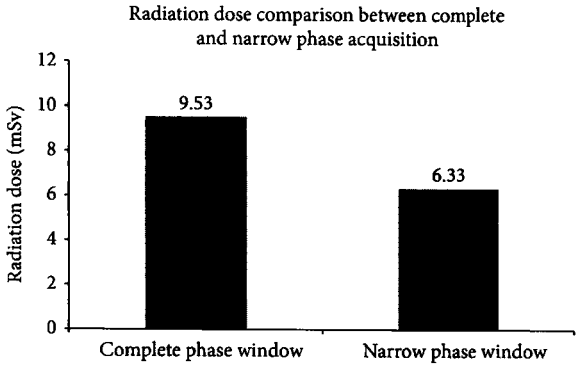

Figure 3: Radiation dose comparison between complete and narrow phase window acquisition at 320-row MDCTA.

range, IQR) was significantly higher in those patients scanned during entire cardiac cycle R-R interval (Group B) versus this set of patients (Group A) imaged with prospectively defined 66–80% phase window (9.53 (6.70–12.62) versus 6.33 (5.3–8.66) mSv, $P < 0.0001$). Even after adjusting the patient's variables and other scanning parameters in analysis, results showed that patients imaged during entire cycle (Group B) were associated with higher radiation dose (33%, $P < 0.001$) Figure 3.

3.1. Image interpretability. Image quality assessed at the segmental level was better among those patients scanned at narrow phase window, that is, excellent (85%), good (14.87%), and nondiagnostic (0.08%) versus complete phase window, excellent (65%), good (33.14%), and non-diagnostic (1.39%); $P < 0.0001$ for differences (Table 3).

4. Discussion

Our study was aimed to determine the impact of different R-R window phase acquisition on radiation dose and image

Table 3: Summary of image quality for two groups undergoing imaging using complete versus narrow phase window acquisition at 320-row MDCTA.

Image Quality (i) Excellent (ii) Diagnostic (iii) Nondiagnostic	Narrow phase window (Group A) Segments (%) Total Patients = 87 Total segments = 1244	Complete phase window (Group B) Segments (%) Total patients = 27 Total segments = 359
Excellent	1058 (85%)	235 (65%)
Diagnostic	185 (14.87%)	119 (33.14%)
Nondiagnostic	1 (0.08%)	05 (1.39%)

quality for 320-row MDCT in coronary artery evaluation. Our data adds to the prior study by Steigner et al. who using multiple phase windows demonstrated that 60–95% was most advantageous. In our use of 66–80% of the R-R interval, we have demonstrated good to excellent quality images correlated with decreased radiation exposure to the patients (33% reduction) with good image interpretability.

In the initial coronary MDCTA trials, excessive radiation exposure remained a major concern that limited wider acceptance of this imaging modality [6, 14, 15]. These concerns prompted the search for techniques to minimize radiation dose while maintaining image quality. Previous strategies have documented heart rate-independent methods that can be applied to minimize the radiation dose including anatomy-adapted tube-current modulation [16, 17] and reduction in tube voltage [18–20]. Similarly, there are several accepted heart rate-dependent methods that can be applied to reduce radiation dose: (a) decreasing tube current during the systolic phase of electrocardiogram (tube current modulation) [21], (b) decreasing tube current during the nonreconstructed phase [22], (c) using a rate-adaptive pitch [23], and (d) sequential ECG triggering [24]. All these methods are dependent and somewhat limited by the temporal resolution and the function of the CT technology.

Aquilion ONE is a cone beam MDCT with a 320-row 0.5 mm detector array. The 320-row mode, at present, functions primarily as a cardiac scanner, that is, volume scan mode. Coronary MDCTA with 320-row mode has sufficient craniocaudal coverage (160 mm) making it possible to image the entire heart in a single heartbeat and one gantry rotation. Using this approach, the patient is exposed for only 350 ms, thereby creating the possibility of reducing radiation exposure substantially when compared to the overlapping rotations employed with the traditional helical MDCTA [3, 14, 15, 25].

All patients in our study were scanned at maximum volume scan length (VSL) 160 mm (to make both groups comparable), but our previous study has shown a 33–46% reduction in radiation dose by decreasing VSL from 160 to 140 or 120 mm depending upon patient's heart length [25]. In this retrospective study, mean radiation dose noted for patients imaged using 320-row MDCT was 6.33 mSv, which is comparable to prospective gating on 64 MDCT scanners in patients with heart rates <65 bpm.

Currently, Complete phase window acquisition with tube modulation mode is also used for patients with irregular heart rates or rate variations during breathing exercise or the actual scan in addition to functional analysis. Sudden abrupt change in heart rate during the scan can result in some loss of valuable data and motion artifact. Although mean heart rate was the same in both groups, a higher or variable heart rate as described is the most likely reason for slightly better image quality in cases of narrow phase window versus complete phase window patients.

4.1. Limitation. There are limitations to our study as it was a single-center, retrospective analysis, with a small number of patients. Further prospective studies with a larger number of patients in multiple sites could better evaluate the effect of window phase selection on radiation dose and image quality related to 320 MDCT scanners. Also, the focus of the study was image quality and not diagnostic accuracy; however, adequate image quality is a prerequisite for the assessment of diagnostic accuracy. Finally, our study is subject to the bias of a single center; a multicenter study is needed to further validate the concept.

5. Conclusion

In conclusion, scan mode and imaging parameters are critical determinants of radiation exposure and image quality on 320-row MDCTA. The median radiation doses of MDCTA vary significantly between patients scanned with complete versus narrow phase window acquisition. Low radiation dose and comparable diagnostic imaging quality may suggest an increased use of narrow window selection of R-R interval in selected patients. Given the potential for low radiation dose with volume scanning, further prospective studies for evaluation of diagnostic accuracy, efficacy, and impact on patient outcomes would be advantageous.

Disclosure

Faisal Khosa is the (2013-2015) American Roentgen Ray Society Scholar.

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Comparison of Radiation Dose and Image Quality: 320-MDCT Versus 64-MDCT Coronary Angiography

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Abstract

OBJECTIVE—The purpose of this study was to compare radiation dose and image quality of 320- and 64-MDCT angiography using prospective gating.

MATERIALS AND METHODS—One hundred seventy-four patients underwent 320-MDCT, and 95 patients underwent 64-MDCT. The scan parameters for 320-MDCT were 120 kVp, 400 mA, and gantry rotation of 350 milliseconds; the parameters for 64-MDCT were 120 kVp, 600 mA, and gantry rotation of 350 milliseconds. Effective dose (ED) was calculated from the dose-length product and a conversion factor ($k = 0.014$ mSv / mGy × cm). Two observers independently assessed image quality using a 3-point scale, where 3 denotes excellent quality and 1 denotes nondiagnostic quality, using a 16-segment model. Discrepancies were settled by consensus.

RESULTS—The ED was significantly lower in patients undergoing 320-MDCT angiography, with a median ED of 4.4 mSv (interquartile range [IQR], 3.4–6.2 mSv), compared with 64-MDCT angiography, with a median ED of 6.2 mSv (IQR, 5.5–6.9 mSv) ($p = 0.0001$). In patients with a heart rate of 65 beats/min or less (92%), the median radiation dose using 320-MDCT was 4.1 mSv (IQR, 3.2–6.1 mSv), and that for 64-MDCT angiography was 6.2 mSv (IQR, 5.8–6.9 mSv) ($p = 0.0001$). In patients with heart rate greater than 65 beats/min (8%), the median dose was higher with 320-MDCT (8.7 mSv; IQR, 5.9–14.3 mSv) than with 64-MDCT (5.8 mSv; IQR, 5.3–6.7 mSv) ($p = 0.02$). Segmental image quality was significantly better for 320-MDCT (excellent or good quality, 96.66%; nondiagnostic quality, 0.1%) than for 64-MDCT angiography (excellent or good quality, 86%; nondiagnostic quality, 3.33%) (all $p < 0.0001$).

CONCLUSION—Image quality was good for both 320- and 64-MDCT angiography. Overall radiation dose was significantly lower in 320-MDCT angiography when the heart rate was 65 beats/min or less. Every effort should be made to control heart rate to minimize radiation dose.

Keywords

64-MDCT; 320-MDCT; coronary artery disease; image quality; radiation dose

With the introduction of 64- and 320-MDCT, coronary CT angiography (CTA) has become a reliable diagnostic imaging modality for the assessment of coronary artery disease (CAD) because of its noninvasive nature. However, radiation dose and image quality are the two major concerns in MDCT angiography [1]. The clinical use must therefore be weighted

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against radiation exposure and potential risks of developing cancer [2, 3]. Advances in MDCT technology have addressed these concerns with continuous improvement in temporal resolution and prospective gating [4, 5]. The specificity and sensitivity of CTA for the diagnosis of significant stenosis in coronary segments have increased along with the increasing number of detectors per scanner. Two large multicenter research studies have found high sensitivities (85% and 95%) and specificities (83–90%) for the detection of coronary artery stenosis [6, 7]. The development of wide-area-detector CT has enabled greater coverage per gantry rotation and also has enabled whole heart coverage in a single heartbeat, eliminating the stair-step artifact that is common in 64-row technology [4, 5, 8–11]. However, it remains to be seen whether this improved technology can reduce the radiation dose and improve image quality. The purpose of our study was to retrospectively compare the radiation doses and image quality of 64- versus 320-MDCT angiography for the assessment of CAD.

Materials and Methods

Informed consent for this retrospective HIPAA-compliant study was waived, and the study was approved by our institution's institutional review board. Data analysis included radiation dose, image quality, patient demographics, clinical details, heart rate, and age and sex of 268 patients scanned for suspected CAD. The pretest probability of significant CAD was calculated using the previously validated Duke Clinical Score model integrating the type of chest pain, together with clinical variables of age, sex, history of myocardial infarction, smoking, hyperlipidemia, and diabetes [12–14]. From the calculated pretest probability of significant CAD, each patient was then categorized as having low risk (< 30%), intermediate risk (30–70%), or high risk (> 70%) of having CAD. Of our study population, 14% of patients were categorized as low risk, 22% were intermediate risk, and 74% were high risk. One hundred seventy-four patients were imaged with a 320-MDCT scanner (Aquilion One, Toshiba), and 95 patients were imaged with a 64-MDCT system (LightSpeed VCT, GE Healthcare); patients were referred for coronary CTA for a variety of clinical symptoms, including atypical chest pain, suspected CAD, abnormal or equivocal stress test or ECG findings, dyspnea, evaluation of stents and grafts, and other cardiac risk factors. Clinical exclusion criteria for cardiac CT included nonsinus rhythm, severe allergy to iodine-containing contrast material, history of renal disease (calculated from creatinine levels > 1.7 mg/dL), pregnancy, hemodynamic instability, asthma, and severe respiratory or cardiac failure. For evaluation purposes, patients were divided into two groups: 320-MDCT angiography and 64-MDCT angiography.

Patients were connected to ECG leads placed in standard position to enable CT synchronization with ECG. Beta-blocker medication (oral metoprolol) was administered to patients with heart rates greater than 65 beats/min unless contraindicated according to the fixed protocol (Table 1). IV metoprolol was administered, if necessary, in the CT scanner in 5-mg doses every 5 minutes for a maximum of 20 mg. The target heart rate for scanning was below 65 beats/min and preferably 60 beats/min. Sublingual nitroglycerine (0.4 mg) was administered to all patients just before the calcium score or localization unless contraindicated before imaging. There were no patients with contraindication to beta-blockers or nitroglycerine in our study. The image acquisition and reconstruction parameters for prospective ECG-gated acquisition using both 64- and 320-MDCT are shown in Table 2 and Table 3.

64-MDCT Angiography

This technique requires approximately five to eight heartbeats to capture the entire heart with a "step-and-shoot" method. Data acquisition occurs during every alternate heartbeat, with incremental table motion of 3.5 cm in the intervening heartbeat. A 64-MDCT system

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provides 41 mm of coverage, with a gantry rotation of 0.33–0.4 s/rotation [15]. Usually, radiation exposure and data scanning are targeted toward the middiastolic phase (75% of the R-R interval is selected as the midpoint for the data acquisition). However, two cardiac cycles may not be completely identical, and banding artifacts cannot be completely avoided. This step-and-shoot acquisition technique was proposed to reduce the radiation dose by up to 20% when compared with the more traditional retrospective techniques [15, 16].

320-MDCT angiography

The number of detectors (detector row) in the *z*-axis has increased with each new scanner generation. The 320-MDCT system we used has a detector element consisting of 320 × 0.5 mm detector and provides 160 mm of coverage in the *z* direction. However scanning can also be performed using 120-, 128-, and 140-mm coverage in the *z* direction. Gantry rotation is 0.35 second. The heart can therefore be imaged in a single heartbeat, which allows comprehensive anatomic imaging of the whole heart and coronary vessels. However, if the heart rate increases above 65 beats/min, the scanner automatically changes from single-segment to multisegment reconstruction, capturing the heart in two beats and thereby doubling the radiation exposure [4].

Assessment of Image Quality

Analysis was performed for all patients by using standard axial and multiplanar reformatted images. After the examination results were blinded, the image quality of the coronary vessels was assessed subjectively by two independent level 3 certified observers using the 16-segment model of vessel disease proposed by the American Heart Association [17]. All patients were analyzed in randomized manner and all segments were evaluated using a scale from 1 to 3—where 3 is excellent, 2 is good, and 1 is nondiagnostic—by two experienced cardiovascular imaging radiologists using axial images, maximum intensity projections, and curved multiplanar reformatted images. Segments assigned a score of 1 were nondiagnostic because of marked motion artifacts, structural discontinuity, image noise–related blurring, and poor vessel opacification [1, 18].

Calculation of Radiation Dose Estimates

The radiation dose was calculated from the volume CT dose index ($CTDI_{vol}$) and the dose-length product (DLP) [15, 19]. The CTDI value is calculated as a mathematic integral under the radiation dose profile of a single rotation scan that would produce one tomographic image at a fixed table position [20]. $CTDI_{vol}$ is the average radiation dose over a specific investigated volume. The DLP was calculated by multiplying $CTDI_{vol}$ by the respective scan length (i.e., DLP = $CTDI_{vol}$ × scan volume length) [21].

The DLP is an estimation of the radiation exposure for the entire CT examination. This was the primary parameter used to calculate radiation dose in our study. The $CTDI_{vol}$ and DLP were recorded as direct data output from prospective ECG-gated examinations. The CT scanner provides a protocol summary containing the DLP for each image series. The total dose includes the dose from the scanogram, calcium score, and coronary arteriogram. The effective radiation dose (ED) was calculated as the DLP multiplied by a previously published conversion coefficient (k = 0.014 mSv / mGy × cm) [3, 22–24].

Statistical Analysis

Continuous variables within the two patient groups were compared using Bartlett's test for equal variances. Median radiation doses were reported. The differences between median radiation doses were assessed using the Kruskal-Wallis equality-of-populations rank test. Then regression analysis was performed for median radiation dose for the two groups

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adjusted for age, sex, body mass index (BMI), heart rate, tube voltage, and tube current. A p value of less than 0.05 was considered statistically significant. Image quality rankings were documented on an ordinal scale from 1 (nondiagnostic) to 3 (excellent). Wilcoxon signed rank test was used to compare the two groups with reference to vessel-based image quality (median and range) of the right coronary artery (segments 1–4), left main artery (segment 5), left anterior descending artery (segments 6–10), and left circumflex artery (segments 11–16). The statistical software packages used for data analysis were Stata and MP (version 10.0, both from StataCorp).

Results

In our study, prospectively gated axial coronary CTA was performed in 268 patients. The mean (± SD) heart rate was 58 ± 6 beats/min for patients examined by 320-MDCT and 59 ± 6 beats/min for patients examined by 64-MDCT. Individuals were younger in the 64-MDCT group, whereas no difference in sex, BMI, and heart rate between the groups was noted.

The resulting mean z-coverage was 140–160 mm for the 64-MDCT group (depending on the number of rotations used for the scan) and 120–160 mm for the 320-MDCT group (depending on the heart length size). There was no difference in volume of contrast agent between the 64-MDCT group (80 mL of ioversol [Optiray 350, Mallinckrodt Imaging] at a flow rate of 5 mL/s) and the 320-MDCT group (70–80 mL of ioversol at a flow rate of 5 mL/s). The mean DLP was 317 mGy × cm (interquartile range [IQR], 246–444 mGy × cm) for the 320-MDCT group and 440 mGy × cm (IQR, 396–491 mGy × cm) for the 64-MDCT group ($p < 0.0001$). The resulting ED was significantly lower in patients undergoing rospective 320-MDCT angiography, with a median ED of 4.4 mSv (IQR, 3.4–6.2 mSv), compared with patients undergoing prospective 64-MDCT angiography, with a median ED of 6.2 mSv (IQR, 5.5–6.9 mSv) ($p = 0.0001$).

In subanalyses of all 268 subjects, 246 patients (92%) had a heart rate of 65 beats/min or less; the median radiation dose for 320-MDCT angiography was 4.1 mSv (IQR, 3.2–6.1 mSv), and that for 64-MDCT angiography was 6.2 mSv (IQR, 5.8–6.9 mSv) ($p = 0.0001$). However, in 22 patients (8%) with a heart rate greater than 65 beats/min, the radiation dose was significantly greater with the 320-MDCT scanner (median, 8.7 mSv; IQR, 5.9–14.3 mSv) than for the 64-MDCT scanner (median, 5.8 mSv; IQR 5.3–6.7 mSv) ($p = 0.02$) (Fig. 1).

Table 4 shows the comparison of image quality between the two groups. For all vessels, we noted a significant ($p < 0.01$) improvement in subjective image quality in the 320-MDCT group, with median image quality rated as excellent in all segments, compared with the 64-MDCT group, with median image quality rated as good in all segments. When all segments were considered together, image quality assessed at segment levels was significantly ($p < 0.0001$) better for 320-MDCT angiography than for 64-MDCT angiography (excellent, 81.53% vs 32.86%; good, 18.33% vs 63.79%; and nondiagnostic, 0.12% vs 3.33%). In cases of nondiagnostic segments, one of three segments in the 320-MDCT angiography group and four of 45 segments in the 64-MDCT angiography group were not evaluated because of calcium-induced blooming artifact. Figures 2 and 3 show representative images from both groups for comparative image quality assessment.

Discussion

Radiation exposure to patients from coronary CTA and the associated risk of developing cancer is a major deterrent to wide application and acceptance of this technology [2, 3, 25, 26]. Various studies document that significant dose reduction is achievable with prospective

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ECG triggering, and radiation doses of coronary CTA are comparable with or even lower than those of conventional coronary angiography [3, 15, 19, 27]. This fact was supported by a study showing a 78% decrease in ED when a prospective gating technique was used [3]. Although marked reduction in ED is possible by using this technique, current 64-MDCT and dual-source scanners have limitations (e.g., temporal and spatial resolution, cardiac coverage, heart rate, heart rate variability, BMI, and motion artifacts), resulting in a decrease in the image quality, which prevents the widespread clinical utility of this imaging modality [16, 18, 28, 29]. Previous literature has shown that heart rate greater than 70 beats/min, heart rate variation greater than 10 beats/min, and BMI greater than 30 are all factors that result in a compromise in image quality [29, 30]. New-generation MDCT scanners have improved temporal resolution of faster image acquisition in comparison with old MDCT [4]. New imaging techniques (prospective gating) also result in a marked decrease in radiation doses in comparison with retrospective gating. Baumuller et al. [31] and Rixe et al. [32] reported mean EDs of 10.4 ± 1.7 mSv and 8.6 ± 2.8 mSv, respectively, for patients scanned with prospective gating at 64-MDCT in comparison with the previously reported radiation range (11–22 mSv) for retrospective techniques [16].

The findings of our study show that prospective MDCT angiography using 320-MDCT is clinically feasible. The ED is lower and image quality is better than with 64-MDCT. However, it is vital to note that the advantage of radiation dose reduction is only noted in patients with a heart rate of 65 beats/min or less (92% of patients in this study). However, this advantage was reversed in a minority of patients (8%) with a heart rate greater than 65 beats/min who had the complete scan in more than one heartbeat. A 320-MDCT scanner acquires the heart rate during breath exercise, and then in patients whose heart rate changes above 65 beats/min at the instant of exposure, the heart is captured in more than one beat for improved temporal resolution [4]. This important feature is clearly apparent with our results, because there is a substantial increase in radiation dose with heart rate greater than 65 beats/min versus 65 beats/min or less (8.7 vs 5.7 mSv). The role of heart rate in radiation dose exposure and image quality has been well documented [31, 33]. All possible efforts were made to achieve heart rate below 65 beats/min with beta-blockers. Heart rate control is a vital step in cardiac imaging for low radiation exposure and excellent image quality.

Our study shows that the 320-MDCT results in significantly improved image quality compared with 64-MDCT. Improved temporal resolution with fast gantry rotation not only ensures improved image quality, but also improves edge depiction of coronary vessels when compared with retrospective gated MDCT [34]. MDCT angiography diagnostic accuracy is dependent on excellent-to-good image quality, and every effort should be made to achieve this goal in addition to reducing radiation exposure [18, 22, 35].

To the best of our knowledge, this is the first study comparing the image quality in cardiac MDCT angiography between 64-MDCT and 320-MDCT in a clinical setting. Shuman et al. [18] compared the image quality for prospective and retrospective ECG gating for 64-MDCT angiography and documented similar results for both groups of patients, although that study showed that the absence of table motion usually has a beneficial effect on image quality. Wang et al. [1] discussed the image quality comparison for single-source CT versus dual-source CT and found equivalent results for both scanners at lower heart rates, but dual-source CT documented superior image quality at high heart rates (70–79 beats/min). However, our study data showed significantly better image quality among those undergoing prospectively gated 320-MDCT angiography versus 64-MDCT.

Limitations

The limitations of our study are those inherent in comparing two subject groups and two different scanners. Ours is a retrospective study of patients imaged on two different

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scanners, rather than scanning the same patient on each scanner. This practice, however, would be prohibitive because of the accumulated radiation dose to a patient undergoing two sequential scans, but accuracy studies by Budoff et al. [7] for 64-MDCT angiography and Dewey et al. [36] for 320-MDCT angiography in comparison with the reference standard (i.e., invasive catheterization) showed 99% negative predictive value for both scanners. Another limitation is our use of subjective evaluation of image quality rather than quantitative evaluation by signal-to-noise ratio and contrast-to-noise ratio. However, our image quality scoring scales have been used successfully by other investigators for cardiac image quality [1, 16]. Further prospective studies are needed to corroborate the diagnostic accuracy between the two scanners.

Conclusion

In this study, we found that prospectively gated 320-MDCT angiography provides robust diagnostic image quality at lower radiation doses than those for 64-MDCT angiography. Regardless of the scanner, good heart rate control (< 65 beats/min) plays a vital role in radiation reduction; however, the ability of the 320-MDCT scanner to image in a single heartbeat will always result in a more beneficial reduction in dose. Therefore, the 320-MDCT scanner has the potential to be used routinely in patients with suspected CAD after a standard heart rate control protocol. This lowered radiation exposure, reduced scan time, and better image quality render 320-MDCT angiography as a viable noninvasive option for cardiac imaging.

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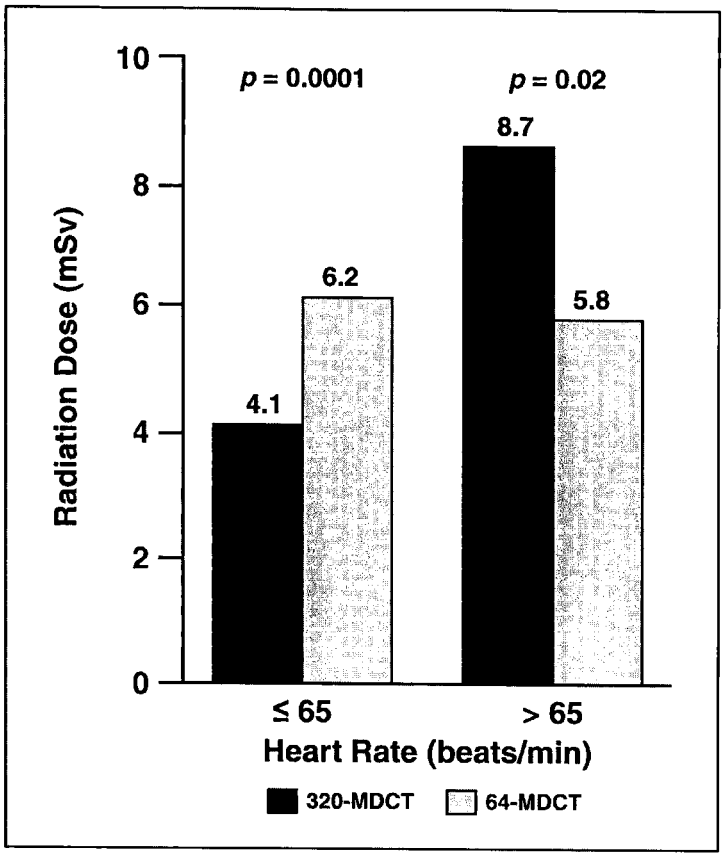

Fig. 1.
Radiation dose with two different heart rates (subgroup analysis) among patients imaged with 64- and 320-MDCT.

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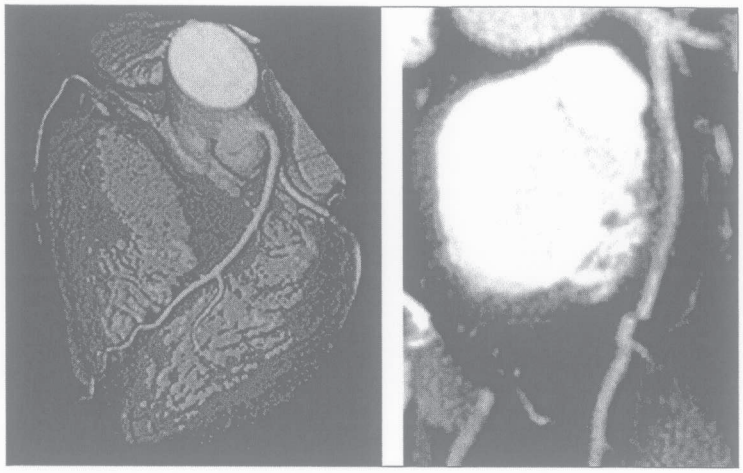

Fig. 2.
47-year-old man who underwent 64-MDCT angiography. Images show motion artifact in left anterior descending artery.

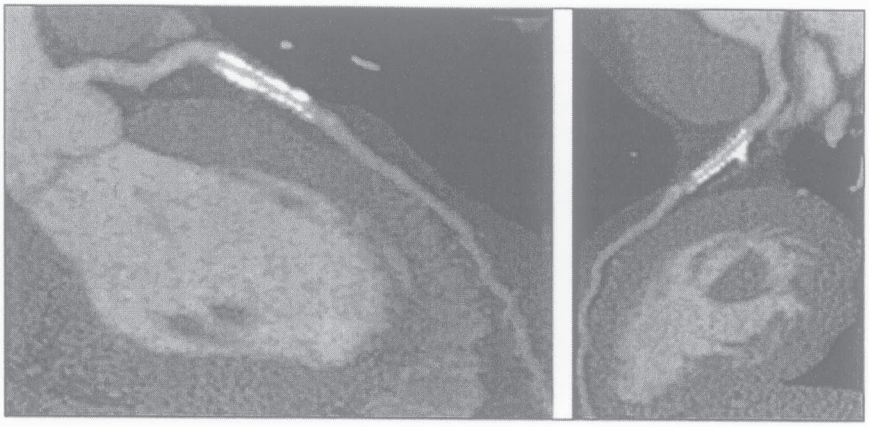

Fig. 3.
69-year-old man who underwent 320-MDCT angiography. Images show excellent image quality and provide information about patency of coronary stent.

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TABLE 1

Oral Beta-Blocker Protocol With Reference to Heart Rate

Heart Rate (Beats/Min)	Dose of Metoprolol Beta-Blocker (mg)
> 65	50
> 70	75
> 75	100
> 80	125

Note—If needed, IV metoprolol is administered at a dose of 5 mg every 5 minutes, up to a maximum of 20 mg.

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TABLE 2

Typical Imaging Parameters for Prospectively Gated Axial Coronary CT Angiography: Comparison of 64- and 320-MDCT

Parameter	64-MDCT	320-MDCT
Typical collimation (mm)	64 × 0.65 (41.6)	320 × 0.5 (160)
Dynamic z focal spot	No	Yes
Rotation time (s)	0.35	0.35
Tube voltage (kVp)	120	120
Image duration (s)	5–7	0.35
Tube current–time product (mAs)	105	80–120
ECG synchronization	Prospective ECG gating (triggering)	Prospective ECG gating (triggering)

Note—Data in parentheses indicate area covered by single rotation (mm).

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TABLE 3

Typical Reconstruction Parameters for 64- and 320-MDCT

Parameter	64-MDCT	320-MDCT
Reconstruction filter kernel	Standard FC 3	Standard FC 3
Reconstruction field of view (mm)	≤ 250	≤ 250
Matrix	512 × 512	512 × 512
Slice thickness (mm)	0.625	0.5
Reconstruction increment (mm)	0.625	0.3
Reconstruction ECG intervals (%)	75	75

Note—FC = reconstruction filter (FC03).

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TABLE 4

Image Quality Scores for Left Main Artery, Left Anterior Artery, Left Circumflex Artery, and Right Coronary Artery for 64-Versus 320-MDCT Angiography

Artery	64-MDCT Angiography	320-MDCT Angiography
Left main	3 (1–3)	3 (1–3)
Left anterior descending	2 (1–3)	3 (1–3)
Left circumflex	2 (1–3)	3 (1–3)
Right coronary	2 (1–3)	3 (1–3)

Note—Data are median (range) score. The scoring system is as follows: 3 = excellent, 2 = diagnostic, and 1 = nondiagnostic. $p < 0.05$ for all comparisons.

C

Marci D. Paulk, RT(R), CRA, MHA

CONTACT INFORMATION

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Stamford, CT 06903

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SUMMARY

Results and productivity-driven administrator with ten years of diversified leadership experience in both the academic and investor-owned sides of health-delivery with increasing responsibilities in regulatory compliance, multi-facility leadership, project management, patient satisfaction and physician recruitment. Professional activities include having served on the Board of Directors for the AHRA, which is the professional organization for imaging managers, three terms as a United Way Loan Executive, an Air Force Honorary Commander for Eglin Air Force Base, and always a healthcare advocate. I recently completed the ACHE COO Boot Camp and I am actively pursuing my FACHE.

EDUCATIONAL BACKGROUND

Masters of Health Administration — 2007
Pfeiffer University, Charlotte, NC

Bachelor of Arts in Kinesiology — 2000
University of Colorado at Boulder, CO

Associate of Science - Radiography — 1994
Middlesex County College, NJ

Associate of Business - Accounting — 1992
Tidewater Community College, VA

WORK EXPERIENCE

Executive Director of Radiology — **August 2013 - Present**
Stamford Hospital, Stamford, CT

Responsible for the growth and strategic planning for all of Radiology Services across the Stamford Health System. In collaboration with physician leadership, is accountable for development, implementation and oversight of quality improvements plans with a focus on operational and service excellence. Provides executive oversight to those managing the routine day to day operations of the respective Radiology Imaging Departments, including knowledge of key operations. http://www.Stamford hospital.org

Key Roles and Responsibilities

- Promotes a professional environment with which patient care is delivered
- Program improvements to meet the needs of patients, physicians, staff and the community.
- Forecast, prepare and monitor operating and capital budgets for system for Radiology Imaging Services
- Increasing outpatient services revenue growth.
- Fiscal management for multi-facility imaging centers.

Director of Radiology — **Oct 2009 - Present**

Fort Walton Beach Medical Center, Fort Walton Beach, FL

Provides leadership for both Fort Walton Beach Medical Center and Destin Emergency Care Center imaging departments. Responsible for Physician relations and growing revenues for outpatient services. Provides the necessary administration, guidance and mentorship of all imaging departments ensuring appropriate staffing levels and policy adherence. Initiates strategic plans through direct involvement with the Fort Walton Beach executive leadership team. Continually evaluates all departments for regulatory, non-regulatory and accreditation programs such as JCAHO, HIPAA, Press Ganey and various other acts and initiatives. http://www.fwbmc.com/

Key Roles and Responsibilities

- Responsible for adhering to Joint Commission standards.
- Program improvements to meet the needs of patients, physicians, staff and the community.
- Responsible for adhering to the UOS for appropriate staffing models.
- Increasing outpatient services revenue growth.
- Fiscal management for multi-facility imaging centers.

Director of Radiology and Cardiology Service Lines **May 2008 – Oct 2009**
Dosher Memorial Hospital, Southport, NC

Direct responsibilities include growing revenues for all Radiology and Cardiology services. Major recent projects include facilitating a permanent MRI solution within our brand new outpatient facility resulting in increased access for our MRI service line. Successfully migrated Dosher Memorial to a second generation PACS system as well as upgraded the organization to a complete digital mammography service line. Another area of emphasis is working towards completing departmental ACR accreditation. http://www.dosher.org/

Key Roles and Responsibilities

- Radiology and Cardiology physician relations.
- Fiscal accountability for Radiology and Cardiology Service Lines.
- Development and oversight of service line operating and strategic plans.
- ACR accreditation to comply with 2010 Medicare guidelines.

Assistant Director of Radiology, Registration and Scheduling **Nov 2005 – May 2008**
Hunterdon Healthcare System, Flemington, NJ

Assists the Director of Radiology in managing, planning and organizing activities in Diagnostic and Supportive sections of Radiology Services including budget development and review as well as policy development and implementation to support organizational goals such as HIPAA and Press Ganey initiatives. Direct supervision responsibility of all imaging modalities within Radiology and support staff to include registration, scheduling, transcription and archivists. Major recent projects include PACS/RIS implementation and new Pre-Registration/Verification program.
http://www.hunterdonhealthcare.org/

Key Roles and Responsibilities

- Responsible for planning, coordinating, and facilitating the use of personnel, financial, and technical resources in the daily operations of imaging services.
- Prepare work schedules, assign personnel, evaluate work performance and make recommendations for personnel actions.
- Accountable for adherence to state and federal rules and regulations on safety and quality assurance programs; ensures compliance with JCAHO, MQSA, federal, state and local agencies.

Director of Radiology **Oct 2004 – Nov 2005**
Coordinated Health (Six Campus Orthopedic Practice), Bethlehem, PA

Assists the CFO in the development of programs for increasing new business revenues for five large outpatient orthopedic facilities and one imaging and surgery center located in the Lehigh Valley. Responsible for management over all modalities within Radiology spanning six facilities including the management of support staff.
http://www.coordinatedhealth.com/

Key Roles and Responsibilities

- Monitors operations of assigned functions through supervision of key staff.
- Ensures the maintenance of quality standards, and compliance with all accreditation standards and licensure regulations.
- Direct the maintenance of department facilities, equipment, supplies and materials in a condition to promote efficiency, health, comfort, and safety of patients and staff.

Assistant Director of Radiology, Coding and Transcription **Dec 2002 – Oct 2004**
Bassett Healthcare, Cooperstown, NY

Primary responsibilities included direct supervision over all modalities within Radiology and support staff. Managed major PACS integration project from vendor selection and equipment acquisition till "go-live." Acted as Interim Director of Radiology for 5 months while department operated without a Director. http://www.bassett.org/

Key Roles and Responsibilities

- Prepare work schedules, assign personnel, evaluate work performance and make recommendations for personal actions. Hire, train, and direct the work of outpatient radiology staff.
- Generate and discuss on a regular basis management reports from the system for analysis and consultation with the Director to ensure timely course corrections to operations as needed.
- Manages the strategic planning of major facilities construction/renovation projects to ensure the safe and effective placement of imaging equipment and efficiency of operations.

Various Positions **Nov 1994 – Dec 2002**
UNC, Chapel Hill, NC, Radiographer
University Hospital, Denver, CO, Radiographer
Boulder Community Hospital, Boulder, CO, Radiographer
Cambridge College, Aurora, CO, Radiology Program Manager
Memorial Hospital, Colorado Springs, CO, Radiographer
St. Joseph's Hospital, Savannah, GA, Radiographer
Hilton Head Hospital, Hilton Head Island, SC, Radiographer
Orthopedic Reconstruction, Hilton Head Island, SC, Chief Radiographer
Associated Radiology, Plainfield, NJ, Intern Radiographer

PROFESSIONAL ACTIVITIES/CERTIFICATIONS

Professional Activities

- **Board of Directors, AHRA** – The Association for Medical Imaging Management **2009 - 2011**
- **Honorary Commanders Program** – Eglin Air Force Base **2010 - Present**
- **United Way Loan Executive** – Okaloosa United Way **2010 - Present**
- **Good Government Group** – Volunteer to increase membership **2011 - Present**
- **AHRA** – Annual Conference Design Team Member **2008 - 2009**
- **AHRA** – Spring/Fall Conference Design Team Member **2007 - 2009**
- **Partners in Learning Recipient** – Florida Hospital **2007**

Licenses, Affiliations and Publications

- **RT® (ARRT)** – The American Registry of Radiologic Technologists **1997 - Present**
- **Certified Radiology Administrator** – Professional Radiology Administrator Certification **2009 - Present**
- **AHRA** – The Association for Medical Imaging Management **2005 - Present**
- **ACHE** – American College of Healthcare Executives **2010 - Present**
- **LINK Magazine Author** – Partners in Learning Article **2007**
- **LINK Magazine Author** – Employee Satisfaction Article **2006**

REFERENCES

Available upon request.

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jpodber@stamhealth.org

WORK HISTORY

2003-present	Attending Physician, Emergency Department Stamford Hospital System. Stamford, CT. (EMP)
2006-2012	Director Quality Assurance: Emergency Dept Stamford Hospital System Stamford,,CT. (EMP)
11/2011-present	Chair & Medical Director Emergency Dept Stamford Hospital System Stamford CT (EMP)
2010-2011	Attending Physician, Emergency Department St Francis Hospital, Tulsa, OK (EMP)
8/2010-12/2010	Attending Physician, Emergency Department Brookhaven Memorial Hospital Patchogue,NY (EMP)
2/2008-11/2008	Attending Physician, Emergency Department Lawrence Memorial Hospital New London, CT (EMP)

POSTGRADUATE TRAINING

07/2002-6/2003	*Chief Resident*, Emergency Medicine
07/2000-6/2003	Wayne State University-Detroit Receiving Hospital Detroit, MI Emergency Medicine

EDUCATION

1996-2000	Ross University School of Medicine Portsmouth, Dominica West Indies Doctor of Medicine
1994-1995	New York Medical College Valhalla, New York Post-Graduate Education

1989-1993	SUNY Albany Albany, New York B.S. Human Biology

LICENSURE & CERTIFICATION

2011-present	State of Florida Medical License
2010-present	State of Oklahoma Medical License (OK 27467)
2010-present	State of North Carolina Medical License (NC 2010-00188)
2006-present	Fellow American College of Emergency Physicians
2004-present	Diplomate of the American Board of Emergency Medicine
2004-present	State of New York Medical Licensure (NY 233683)
2003-present	State of Connecticut Medical Licensure (CT 041147)
1993-present	Advanced Cardiac Life Support
2000-present	Advanced Trauma Life Support
1993-present	Basic Life Support
2000-present	Pediatric Advanced Life Support
2000-2003	State of Michigan Medical Licensure (training)
2001-2004	Neonatal Advanced Life Support

PROFESSIONAL MEMBERSHIPS

2003-present	American Medical Association
2000-present	Emergency Medicine Residents Association
2000-present	American College of Emergency Physicians
2000-present	Society of Academic Emergency Medicine

PROFESIONAL ACTIVITIES

2001-present	Instructor for Advanced Cardiac Life Support
2001-present	Instructor for Basic Life support
1993-1996	NYS Certified Emergency Medical Technician # 189861

References Available Upon Request

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PROFESSIONAL PROFILE:

Senior Healthcare Executive with extensive experience in health care system operations, strategic planning and ambulatory care system development. A knowledgeable leader with strong financial, analytical and problem solving skills. Excellent communication skills with diverse constituencies including trustees, physicians, patients, employees and the community.

PROFESSIONAL EXPERIENCE:

1/6/03 - Present **Executive Vice President/Chief Operating Officer**
Stamford Health System
30 Shelburne Road
Stamford, CT

- Responsible for operations and patient care executive leadership of 305 bed Stamford Hospital with an operating budget of $600 million dollars.
- Senior executive leading the Facility Master Plan development and plans for the replacement hospital – a $450 million dollar project.
- From 2010-2012 served as the CNO for Stamford Hospital in addition to COO.
- Achieved three successful JCAHO surveys with Distinction. Achieved JCAHO certification in Stroke, Joint Replacement and Spine. First hospital in Fairfield County to achieve all three certifications.
- Lead Womens Breast Center to receive the Gold Prize in the Connecticut Quality Improvement Award. A first step towards the Malcolm Baldridge National Quality Award.
- Implemented emergency and Elective Angioplasty and Electrophysiology Programs. Redesigned patient care delivery to reduce door to balloon time to under 90 minutes.
- Led the team to implement a full service Open Heart Surgery program with superior quality outcomes and volume tracking to budget.
- Improved inpatient satisfaction from the 20th to 90th percentile.
- Improved patient satisfaction in ED from 40th to 87th percentile.
- Improved patient experience in Hospital and Tully Surgical Centers to 91st and 93rd percentile rankings.
- Led Lean Six Sigma Management team that improved throughput in Emergency Services to reduce wait times and overall LOS.
- Led the team that performed a financial turnaround of $30 million dollars through revenue enhancements and cost reductions.
- With Board of Trustees, transferred VNHC losing $1 million per year, to independent status and later merged with Greenwich VNA.
- Orchestrated the sale of Edgehill to Benchmark Senior Living for $71.5M.
- Implemented Lab Outreach Program that aligned physician practices with the hospital. Grew volume from 70,000 to 1.5 million tests and had a net positive operating margin of $20 million dollars.

- With physician leadership developed service line growth in Heart & Vascular Institute Surgery, Orthopedics, GI, Women's Service and Cancer.
- Implemented PACS film-less all digital imaging, voice recognition technology and multiple new technologies in the Imaging areas (IMRT, IGRT, CyberKnife, 64 Slice CT/CTA).
- Opened Darien Imaging Center with Planetree model of care that exceeded business plan in first year of operations. Grew Imaging procedures from 150,000 to 180,000 procedures in three years.
- With Foundation, secured $5 million dollar gift for new Pediatric Inpatient unit and $10 million dollar gift for new Emergency Department and $6M gift for Bennett Cancer Center.

1/1/99 - 12/02

Executive Vice President and Chief Operating Officer
St. Joseph's Health Care System
703 Main Street
Paterson, NJ

- Responsible for the executive leadership of: 651 bed St. Joseph's Regional Medical Center; 151 bed St. Vincent's Nursing Home, 600,000 visit Ambulatory Care System; 200 bed St. Joseph's Wayne Hospital; 200,000 visit Visiting Health Services of New Jersey.
- Under executive leadership, Patient Care Services became one of 14 hospitals nation-wide to achieve Magnet Award Status from the ANCC.
- Responsible for an operating budget of over $500 million dollars.
- Developed and implemented strategic plan to assume sponsorship of Wayne General Hospital as part of St. Joseph's Health Care System.
- Reduced operating expenses by $45 million over two years.
- Built and occupied a new nursing home facility increasing from 141 to 151 beds.
- Developed program growth in Cardiovascular, Surgical, Renal, Geriatrics, Women's & Children's Services that achieved 1,600 increased admissions over two years.
- Built and occupied a new state of the art dialysis facility increasing from 50 to 60 stations.
- Achieved a successful JCAHO Survey.
- Built and opened a new Pediatric Emergency Room.
- Implemented several new Information Technology projects including PACS Radiology System (Picture Archiving System), Cerner Laboratory Information System, Cineless Cath Lab, SMS Pharmacy System and SMS Lifetime Clinical Record.
- Developed plans for a new Ambulatory Imaging and Women's Center.

9/94 - 1/99

Executive Director
Montefiore Medical Group
Montefiore Medical Center
Bronx, NY

- Provided executive leadership for the Montefiore Medical Group which merged and reorganized the original Medical Group and the former Ambulatory Care Network into a primary care and multi-specialty group practice of 150 physicians that provided 500,000 visits to 170,000 patients in 31 offices throughout the Bronx and Westchester. Operated the School Health and Homeless programs with 50,000 visits. The total operating budget for the Montefiore Medical Group was $72 million dollars.

- Project leader for the architectural plans and construction of over 16 new health centers and satellite offices.
- Developed a comprehensive 3 tiered physician compensation plan that rewarded physicians for meeting quality of care, patient satisfaction and income objectives.
- Developed and implemented a business plan to bring 1,000 obstetrical deliveries to Montefiore.
- Managed and negotiated full risk and primary care contracts with Oxford, US Healthcare, Aetna, Blue Cross (Healthnet & Healthease), Prucare, MetraHealth and Local 1199.
- Installed IDX Billing and Managed Care System applications to automate billing and medical management of 30,000 managed care patients, half of which were insured through full risk capitation agreements.

5/90 - 9/94

Associate Director
Montefiore Medical Center
The Jack D. Weiler Hospital of the Albert Einstein
College of Medicine, Bronx, NY

- Managed the Departments of Anesthesia, Anatomical and Clinical Pathology, Ambulatory and Same Day Surgery, Operating Room, Post-Anesthesia Care, Emergency Department, Patient Relations, Nutrition/Cafeteria, Chaplaincy, Endoscopy, Perfusion, Vascular Laboratory and Volunteers with total annual operating budgets of $27 million.
- Administratively responsible for the Clinical Departments of Surgery, Urology, Dentistry, Otolaryngology, Obstetrics/Gynecology, Pediatrics, Orthopedics, Psychiatry, Plastic, Vascular, and Cardiothoracic Surgery.
- Developed and implemented plans to expand the Ambulatory Surgery Unit from 4 to 14 beds and increased volume of Ambulatory Surgery procedures by 6,100 in two years.
- Project leader in the development of Montefiore Medical Park, a 60,000 square foot multi-specialty Medical Practice for the Departments of Medicine, Dentistry, Radiology, Surgery, Otolaryngology, Neurology, Vascular, Cardiothoracic and Plastic Surgery.

5/84 - 5/90

Assistant to Vice President of Operations
Montefiore Medical Center
The Jack D. Weiler Hospital of the Albert
Einstein College of Medicine
Bronx, NY

- Responsible for the management of the Pharmacy, Respiratory Care, Pre-Admission Testing, Anatomical and Clinical Pathology, Admitting, Radiation Oncology, Volunteers, Adult and Pediatric Dialysis Departments with total annual operating budgets of $12.5 million.

9/82 - 4/84

Assistant Director, Health Service
Iona College
New Rochelle, NY

- Cooperative operation of college health service which provided health screening, maintenance and teaching as well as community referral services to students, faculty and administration.

7/79 - 8/82	**Staff Nurse - Pediatric and Neonatal Intensive Care Units** **Montefiore Medical Center** **The Jack D. Weiler Hospital of the Albert Einstein** **College of Medicine** **Bronx, NY**

- Direct nursing management for neonates and pediatric patients requiring hospitalization

EDUCATION:

June 1984	**Iona College - Master of Science - Honors** Major in Health Care Systems Management
June 1979	**Herbert H. Lehman College - Bachelor of Science** Major in Nursing
HONORS:	Sigma Theta Tau 1985 Brother Richard Power Award for Academic Excellence in Health Care Systems Management 2008 Greenwich YWCA BRAVA Award recipient for Leadership and Community Service Chairperson of 2008 Fairfield County Heart Walk Chairperson of 2002-2008 Greenwich Scholarship Committee, Greenwich PTA Council
LICENSE:	Registered Nurse New York and Connecticut
MEMBERSHIPS:	Fellow American College of Healthcare Executives American Hospital Association Medical Group Management Association

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PROFILE

Healthcare Executive with diverse experience in tertiary and acute care organizations. Strength and experience in clinical and operations management, new program and service line development utilizing industry and organizational data for the achievement of strategic goals and objectives, quality and performance improvement, community partnering, employee and patient satisfaction, physician engagement.

PROFESSIONAL EXPERIENCE

STAMFORD HOSPITAL, Stamford, CT

305 Bed Acute Care Level 2 Trauma Center, Affiliate of New York Presbyterian Healthcare System.

Chief Nursing Officer **2011- present**
Vice President Patient Care Services

Provide Strategic Direction and Leadership for Nursing and Patient Care Services to include administrative, clinical, regulatory and quality & safety oversight for all Nursing Units, Professional Development, Pharmacy, Respiratory, Patient Relations, Infusion Center, Nursing Informatics, Emergency Department and Cardiac Cath Lab. Total FTE's 755. Annual Budget $83 million.

Selected Accomplishments

- Provided leadership & support for our Shared Governance structure resulting in - establishment of 3 new councils (Night Shift, Nurse Managers, APRN's), review of all council By-Laws and initiate Smart Goals.
- Support Research & Evidence Based Practice- Partnered with a local university to for a Nurse Scientist to provide mentoring & coaching for RN staff at all levels on related projects. 30 evidence based projects were presented during Nurses week 2013. 10 submitted to professional organizations.
- Collaborated with nursing leadership to develop nurse leadership competency assessments using AONE competencies at Director, Manager, and Clinical Coordinator level to identify opportunities for leadership development, succession planning, recruitment & retention.
- Provided direction and support to our Nurse Informatics Council providing a Nurse Informatics consultant to assist the in reviewing, evaluating and revising Nursing Documentation resulting in a evidenced based efficient & streamlined process for our EMR nursing documentation.
- Provided leadership and direction in restructuring our Graduate Education Mentoring (GEMS) - focus on new graduates to fill vacancies - Enhanced the cohort experience, added a 3rd class doubling the number of GEM's resulting in elimination of all travelers, RN turnover rate 5.3% (Baseline 7.7%), Vacancy rate 2.6% (Baseline 4.3%)

- Provided leadership, direction & support around many quality & safety initiatives resulting in improved NDNQI and national outcomes such as nurse driven protocols and evidence based initiatives for sitter utilization, reduction in falls, Pressure Ulcers, Sepsis Alerts, alcohol withdrawal, ED throughput, BMV in labor & delivery, and emergency department.
- Supported staff involvement in Quality & Safety Education and training- lean six sigma, high reliability, team training, just culture.
- Provided leadership for successful JCAHO Disease Specific Certification surveys for total joint - hip & knee, spine, and stroke
- Awarded Planetree Designation- Supported & lead nursing initiatives to meet Plantree standards and criteria for designation- bedside shift report, open medical record, care partner program.
- Initiated & provide ongoing leadership for the Patient Experience Steering Committee- continued improvement in Press Ganey and HCAHPS scores in all domains for the past 3 years.
- Provide leadership and support for the Pharmacy - Ask the Pharmacist Program for patient education of medications and Anticoagulation Clinic resulting in improved HCAHPS scores, and decrease in Heart Failure re- admissions.
- Provide leadership and collaboration for staff to participate in Community initiatives.
- Providing a leadership role in our New Hospital design, development, and implementation.
- Directed and lead initiatives around evaluating and implementing scheduling & timekeeping changes, matrix's to support Nurse Staffing & Budget resulting in reduction in overtime, staff satisfaction, consistently meeting budget at the 25% for Action OI.
- Initiated & supported the restructuring of the Pain & Palliative Care and Wound Program to an APRN/MD model - resulting in increased referrals & consults, improved revenue, response time to consults, & quality outcomes

Executive Director- **2010- 2011**
Nursing, Heart & Vascular Institute & Women's Health

Administrative and clinical responsibilities for patient care services to include Pharmacy, ICU, Supervision, Patient Representatives, Float Pool, Resource Nurses, Cardiology Unit, Intermediate Care Unit, Professional Development, Infusion Center, Nursing Informatics.

- Implementation of Best Practice initiatives to improve the patient experience and quality of care to include Discharge Phone Calls and Hourly rounding.
- Successful implementation of Bedside Medications Verification

Director - Heart & Vascular **2006 - 2010**
Institute and Women's Health
Service Line

Administrative and clinical responsibilities for all programs and services under the Heart & Vascular Institute and Women's Health Service lines including clinical, regulatory,

quality, satisfaction, and operations management. Execution and monitoring of financial and strategic organizational goals for overall growth & development.

- Cardiovascular services include the Cardiac Catheterization Lab, Vascular Interventional Radiology, Non invasive Cardiology, Open Heart, Cardiac Surgery Physician Practice, and Data Quality Management.
- Women's Health services include the Integrative Medicine and Wellness Center, Breast Center, Mobile Mammography, Women's Health programs, outreach and education.
- Participate on various nursing councils as a liaison for program and quality initiatives.
- Responsible for all JCAHO, State, and CON regulatory monitoring.
- Responsible for all quality initiatives and data registries within the Heart & Vascular Institute.
- Manage clinical programs and staff with more than 50,000 procedures/visits annually and a $25 million dollar budget.
- Ongoing collaboration with nursing & physician's in clinical and quality initiatives, program development, outreach and education.

Accomplishments

- Directed a process improvement initiative using Lean Six sigma resulting in an increase in utilization of the VIR and Cath Labs, improved throughput, on time case starts which has resulted in an increase in physician satisfaction and improved patient satisfaction scores.
- Completed the Cardiac Catheterization Labs, Prep and Holding area planning, renovation, & expansion project (2006/2008).
- Directed the operational and clinical implementation for Elective Angioplasty. Volume growth of 300 cases in year 2008/2009.
- Directed and implemented the first Cardiac Surgery program to include facility planning, operational, financial, recruitment, clinical management, training, marketing education and outreach (2008). (120 Open Heart surgery cases in year one).
- Directed a multidisciplinary quality improvement initiative for emergency angioplasty (PAMI) resulting in improvement of Door to Balloon Times below the national benchmark average. (DTBT 98% < 90min)
- Directed a Supply Chain Value Analysis Team to include all Heart & Vascular Departments achieved $1.3 million savings.
- Currently directing a multidisciplinary task force as part of a state wide collaborative with the CT Hospital Association (CHA) to reduce Heart Failure readmissions and further development of our Heart Failure Program.
- Worked with the Hospital foundation in securing philanthropy support totaling $3.5 million for the Integrative Medicine and Wellness Center and women's health programs related to Breast and Cardiovascular Disease education and prevention.
- Designed and completed The Integrative Medicine and Wellness Center (Oct 2008) to include programs and services for integrative cardiology, nutrition and wellness, acupuncture, women's health, pain management. Exceeded projected volume and revenue in the first year of operations.
- Currently developing the first Medical Advocacy Program in the State of Connecticut in collaboration with the Domestic Violence Crisis Center of Stamford, CT

- Granted a CT state based CDC grant to support Breast and Cervical screening, treatment, education and prevention programs. $528,000 for 3 years.

Director – Orthopedic and Women's Health Service Lines 2004 – 2006

New business development and management for the Orthopedic/Spine, and Women's Health service lines, including strategic planning and product line implementation, financial and clinical oversight, physician liaison, marketing, education and outreach.
Directed ongoing collaboration with intradepartmental and multidisciplinary staff for clinical program development, daily rounds and assessment, monitoring, and evaluation of clinical outcomes related to patient care, education and community outreach.

Accomplishments

- New Initiative – Developed and implemented the Total Joint Replacement Program including clinical pathways, standing orders, clinical protocols, research, quality report card and patient outcomes tool.
- New Initiative - developed and completed the financial, operations, and clinical plan for Artificial Spine Disc Replacement surgery.
- Identified and completed initiatives for spine and orthopedic surgical implant cost savings and standardization - $750,000 annual savings.
- Successfully increased inpatient/outpatient orthopedic/spine volumes 8% year 1 and 15% year 2.
- Market Share FY 05- Orthopedics increase 4.8%, Spine increase 11%
- Responsible for identifying, developing and sponsoring community outreach and professional education services and programs.

WESTCHESTER MEDICAL CENTER, Valhalla, NY

Academic Teaching Hospital and Level 1 Trauma Center with 670 acute care beds, 200 long term care beds, and revenues of 520 million dollars.

Director- Transplant Center of Excellence 2003 – 2004

Clinical and operations management, strategic planning, and business development for Heart, Liver, Kidney, and Pancreas Transplant including Heart Failure.

- Transplant Center – Administrative, clinical, and financial responsibility for the center and physician practice with 40 direct reports.
- Administrative responsibility for the 42-bed inpatient transplant unit.
- Administrative responsibility - inpatient and outpatient dialysis Services – $3 million dollar budget.
- Tissue Bone Compliance Officer
- Administrative liaison with various government and regulatory agencies, organ procurement organizations and transplant organizations.

Accomplishments

- Established the first outpatient Heart Failure Infusion Treatment Center in the Hudson Valley Region with - new revenue of $300,000 in the first 6 months
- Development of the first Organ Donation After Cardiac Death Policy in NYS

Director of Business Development for Cardiovascular Services 2002 - 2003

Program and new business development for Cardiology, Cardiac Surgery, Vascular, Heart Failure and Heart Transplant services.

- Marketing, education, community outreach
- On going collaboration with the Hospital Foundation in establishing and developing potential donor funding for community outreach initiatives and program development.

Accomplishments

- Development of the Center of Excellence and Clinical Pathway for Off Pump By- pass surgery - Decrease LOS 2 days, ancillary testing savings $100,000 annually.
- Development and implementation of short and long term clinical and financial strategic plan.
- Developed program development for Heart Failure - 15% increase in new referrals.

1997 - 2002

Director , Neuroscience Center of Excellence

Program development, budget and financial management, administration, and organization of the Neuroscience Center. The areas of responsibilities included Neurosurgery, Neurology, Orthopedics, and Rehabilitation Medicine.
Clinical and operations management of clinical and ancillary staff for Neurology, Neurosurgery, Epilepsy Monitoring Unit, and Neurophysiology lab.

Accomplishments

- Established the Neuroscience's as a Center of Excellence product line, including the development implementation of the Movement Disorder Program, and Stroke Program.
- Developed and implemented Clinical Pathway for Inpatient Stroke and Acute Rehab Program- Decreased LOS by 3 days.
- Established an affiliation agreement with Kessler Institute for clinical oversight - increased referrals by 20% and average daily census from 60 to 85%.
- Instituted FIMS for functional assessment and Medicare PPS reimbursement.
- Initiated the process for CARF Accreditation

Westchester and Putnam Hospice, Inc -Per diem On-Call RN, Mount Kisco, NY 2001 - 2003

Westchester Medical Center - Clinical Experience

Burn Center - 10 bed Adult /Pediatric ICU, and Operating Room - Nurse Manager 1992 - 1997

Neurosurgical Intensive Care Unit & Neurosurgery Step Down Unit - Nurse Manager 1989 - 1992

Emergency Department/Flight Nurse - Charge Nurse 1985 - 1989

Cardiothoracic Intensive Care Unit- Staff Nurse **1984 - 1985**

Roger Williams General Hospital, Providence, RI **1982 - 1984**
Emergency Department - Assistant Head Nurse

Nyack Hospital, Nyack, NY **1978- 1982**
Med- Surg, CCU,ICU- Staff Nurse/ Charge Nurse

EDUCATION

Pace University, White Plains, N.Y., Masters in Public Administration, Healthcare Administration; Michaelian Scholarship
Pace University, Pleasantville, N.Y., Bachelors in Science, Nursing

Healthcare - Leadership Academy (Fellow) - Advisory Board, Washington DC (2006 - 2008)

LECTURES/ABSTRACTS

1990 - Present
"**Strategies for Successful Service Line Marketing**" - Oct 2005,
Human Motion Institute Annual Advanced Partner Conference, Pittsburgh, PA
"**Marketing & Business Development**" - Feb 2006,
Human Motion Institute Capture the Power of Orthopedics, Orlando, FL
"Integrating Disease Management Into Service Line Strategies"
Feb 2009, Accelero Health Partners Annual Conference
"**Health Leaders Media - Service Line Strategies - Cardiovascular**"
September 2010, Health Leaders Media - Virtual Work shop
" **Enhancing the Patient Experience**" - Planetree Conference, Montreal Canada Oct 2013

RESEARCH/ PUBLICATIONS/GRANTS

1994 Kendall Health Care Products Inc. Research
Komar, E. & Salzberg, A., MD The treatment of donor site curasorb calcium alginate and conventional dressing, xeroform.
1998 Nursing Leadership Forum: Book Chapter. Code Blue
2007 Komar, E., RN & Richardson, B., RN; Pain Management Protocols: Total Joint Replacement Surgery.
2009 Awarded: CDC and State of CT Grant for Breast & Cervical Cancer Early Detection Program - 3 years $528,457

PROFESSIONAL ASSOCIATIONS/CERTIFICATIONS/COMMITTEES

Registered Nursing License, New York State 329505 - 1, Connecticut 092572
American Nurses Credentialing Center (ANCC) Certification – Nurse Executive Advanced (NEA-BC)
Board of Nurse Examiners – CT Board Member (1/2013 - present)
Stamford EMS – Executive Board Member 1/2012 – present)

Fairfield County Community Association – Fund for Women & Girls- Board Member (2013 - current)
American Organization of Nurse Executives
American Nurses Association – Member (current)
CT Nurses Association- Member (current)

American College of Health Care Executives

New York Organ Donor Network – Board of Directors (2003)
American Heart Association – Board of Directors (2000 – 2002)
American Heart Association – (2006 – current)

MAUREEN T. MCCAULEY

SUMMARY

Experienced, autonomous and dedicated Emergency Department leader with demonstrated capability in clinical, business and regulatory arenas. Passionate, loyal and committed nursing and patient advocate. Mentors and leads team with respect, accountability, appropriate humor and by example. Builds solid relationships with continuum of interdisciplinary team.

PROFESSIONAL EXPERIENCE

Nov2013-Present Stamford Hospital, CT

Nurse Manager Emergency Department, ICC Tully

- Responsible for the departments staffing levels, managing approx. 96 employees, oversight of nursing, techs, UC's, PCA's and travel RN's
- Maintaining budgetary parameters within the 25th percentile
- Overseeing the departments daily productivity in relation to patient throughtput and press ganey meausres
- Managing nursing compliance, unit readiness for JCAHO and quality nursing practice
- Developing strategic plan for moving into new hospital ED, staffing and patient flow
- Actively participating on the journey to excellence Magnet certification

July 1999-Nov 2013 New York Presbyterian Hospital, New York, NY

ED Staff Nurse, per diem (May 2013-Novemeber 2013)

- Provide float staff level coverage for the adult, pediatric and psychiatric ED.

Patient Safety Specialist (July 2010-Mar 2011)

- Maintain ED unit regulatory readiness
- Liason between MCIC and Cornell ED to maintain and implement best practices
- Q/A, Q/I, MERS –Documentation review and follow-up, RCA event liason

Nursing Staffing Coordinator Emergency Department (Sept 2008-July 2010)

- Arranged and organized staffing levels and schedules for 173 staff

members comprised of 120 nurses, 20 clerks, 27 techs and 6 NP's.

- Managed travel agency budget for 10-13 nurses.
- Responsible for managing budget compliance for the VP, Operations.
- Responsible for the expansion budget/staffing for a new 15-bedded addition in the ED.
- EMR rollout training and staffing schedules for the Pediatric ED.
- Managed nursing compliance for the ED including Unit readiness for JCAHO.

Clinical Manger (Apr 2006-Sept 2008)

- Developed and maintained quality nursing practice and patient care.
- Established staffing patterns and schedules based on patient volume and budget.
- Spear-headed "Making it Better" initiative for ED which consisted of monthly meetings which involved staff in a shared governance model to improve processes.
- Participated in various RCA's.
- Created Hiring Committee, which still functions, that engages a cross section of ED employees to assist in the hiring process.

Assistant Nurse Manager (Nov 2003-Apr 2006)

- Supervision of 75 RN's, 15 NA/PCT's and 16 Unit Clerks including maintaining efficient daily operations and functioning of the ED, scheduling as well as hiring and terminations.
- Worked collaboratively under the direction of the Director and Chief, Pediatric ED to improve functionality and expand the Pediatric ED to a 24 hour operation.
- Initiated the "Mile in Your Shoes" program for the new nurse residents, which exposed those nurses to in-patient units, respiratory, ccu, iv team, etc. to learn the "behind the scenes" of the hospital. This program was a year long opportunity for brand new nurses in the ED while they were oriented to the ED and worked with a preceptor.
- Led the Joint Process Committee.

Senior Staff Nurse (Mar 2002-Nov 2003)

- Acted as charge RN for the Adult, Pediatric and Psychiatric ED's
- Mentored new hires throughout their orientation to the ED

Staff Nurse (July 1999-March 2002)

- Triage and care of adult and pediatric patients at a Level I Trauma/Regional Burn Center

April 1998-June 1999 Mount Sinai Medical Center, New York, NY

Registered Nurse, Per Diem

- Triage and care of adult and pediatric patients at a Level II ED

June 1997-June 1999 Mercy Medical Center, Rockville Centre, NY
Registered Nurse
- Triage and care of adult and pediatric patients at a Level II ED

Dec 1996-May1997 St. Mary's Medical Center, West Palm Beach, FL
Registered Nurse
- Triage and care of adult and pediatric patients at a Level II ED

Aug 1993-Oct 1996 Mercy Medical Center, Rockville Centre, NY
Registered Nurse
- Triage and care of adult and pediatric patients at a Level II ED

EDUCATION

1988-1993 Mount Saint Mary's College Newburgh, NY
Bachelor of Science, Nursing

LICENSE

Registered Professional Nurse, State of New York # 455924-1

Registered Professional Nurse, State of Connecticut #107758

CERTIFICATIONS

BCLS, ACLS, PALS

REFERENCES

Available upon request

Acquisition and Operation of a

320 Slice CT Scanner at

The Stamford Hospital

30 Shelburne Road

Stamford, CT

D

Internal Revenue Service

Date: June 29, 2006

STAMFORD HEALTH SYSTEM INC
% STAMFORD HOSPITAL
P O BOX 9317
STAMFORD CT 06904-9317

Department of the Treasury
P. O. Box 2508
Cincinnati, OH 45201

Person to Contact:
Cheryl Skaggs 31-04010
Correspondence Specialist/Screener
Toll Free Telephone Number:
877-829-5500
Federal Identification Number:
22-2476636

Dear Sir or Madam:

This is in response to your request of June 29, 2006, regarding your organization's tax-exempt status.

In November 1983 we issued a determination letter that recognized your organization as exempt from federal income tax. Our records indicate that your organization is currently exempt under section 501(c)(3) of the Internal Revenue Code.

Our records indicate that your organization is also classified as a public charity under sections 509(a)(1) and 170(b)(1)(A)(vi) of the Internal Revenue Code.

Our records indicate that contributions to your organization are deductible under section 170 of the Code, and that you are qualified to receive tax deductible bequests, devises, transfers or gifts under section 2055, 2106 or 2522 of the Internal Revenue Code.

If you have any questions, please call us at the telephone number shown in the heading of this letter.

Sincerely,

Janna K. Skufca

Janna K. Skufca, Director, TE/GE
Customer Account Services

E

STATE OF CONNECTICUT

Department of Public Health

LICENSE

License No. 0059

General Hospital

In accordance with the provisions of the General Statutes of Connecticut Section 19a-493:

The Stamford Hospital of Stamford, CT d/b/a The Stamford Hospital is hereby licensed to maintain and operate a General Hospital.

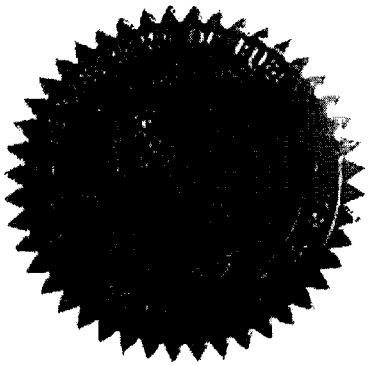
The Stamford Hospital is located at 30 Shelburne Road, Stamford, CT 06904.

The maximum number of beds shall not exceed at any time:

25 Bassinets
305 General Hospital Beds

This license expires **June 30, 2015** and may be revoked for cause at any time.
Dated at Hartford, Connecticut, July 1, 2013. RENEWAL.

Satellites:
Tully Health Center, 32 Strawberry Hill Court, Stamford, CT
1351 Washington Boulevard, Stamford, CT



Jewel Mullen, MD, MPH, MPA
Commissioner

F

12. C (i). Please provide one year of actual results and three years of projections of **Total Facility** revenue, expense and volume statistics without, incremental to and with the CON proposal in the following reporting format:

Total Facility: Description	FY 2014 Actual Results	FY 2017 Projected W/out CON	FY 2017 Projected Incremental	FY 2017 Projected With CON	FY 2018 Projected W/out CON	FY 2018 Projected Incremental	FY 2018 Projected With CON	FY 2019 Projected W/out CON	FY 2019 Projected Incremental	FY 2019 Projected With CON
NET PATIENT REVENUE										
Non-Government	$302,070	$349,979	$423	$350,401	$367,842	$587	$368,428	$386,462	$763	$387,225
Medicare	$117,132	$130,490	$67	$130,557	$134,487	$92	$134,579	$138,551	$117	$138,668
Medicaid and Other Medical Assistance	$38,402	$42,781	$8	$42,789	$44,092	$11	$44,103	$45,424	$14	$45,438
Other Government	$204	$227	$0	$227	$234	$0	$234	$241	$0	$241
Total Net Patient Patient Revenue	$457,807	$523,476	$498	$523,974	$546,654	$689	$547,343	$570,678	$894	$571,572
Other Operating Revenue	$22,613	$17,235		$17,235	$17,407		$17,407	$17,581		$17,581
Revenue from Operations	$480,420	$540,710	$498	$541,208	$564,061	$689	$564,750	$588,259	$894	$589,153
OPERATING EXPENSES										
Salaries and Fringe Benefits	$229,708	$251,920	$45	$251,964	$262,054	$62	$262,116	$272,552	$80	$272,633
Professional / Contracted Services	$52,046	$52,895	$1	$52,896	$55,023	$1	$55,024	$57,228	$1	$57,229
Supplies and Drugs	$72,145	$76,508	$10	$76,518	$79,586	$14	$79,600	$82,774	$18	$82,792
Bad Debts	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Other Operating Expense	$54,221	$59,076	$135	$59,211	$61,453	$135	$61,588	$63,915	$135	$64,050
Subtotal	$408,120	$440,399	$190	$440,589	$458,116	$212	$458,328	$476,470	$235	$476,704
Depreciation/Amortization	$24,086	$40,152	$195	$40,347	$40,833	$195	$41,028	$41,533	$195	$41,728
Interest Expense	$6,007	$17,119		$17,119	$16,815		$16,815	$16,491		$16,491
Lease Expense	$5,278	$5,381		$5,381	$5,526		$5,526	$5,675		$5,675
Total Operating Expense	$443,491	$503,051	$386	$503,436	$521,290	$407	$521,697	$540,169	$430	$540,598
Gain/(Loss) from Operations	$36,929	$37,660	$112	$37,772	$42,771	$282	$43,053	$48,090	$464	$48,554
Plus: Non-Operating Revenue	$2,718	$0		$0	$0		$0	$0		$0
Revenue Over/(Under) Expense	$39,647	$37,660	$112	$37,772	$42,771	$282	$43,053	$48,090	$464	$48,554
FTEs	2,087.12	2,223.60	0.41	2,224.01	2,268.60	0.57	2,269.17	2,313.60	0.74	2,314.34

*Volume Statistics:
Provide projected inpatient and/or outpatient statistics for any new services and provide actual and projected inpatient and/or outpatient statistics for any existing services which will change due to the proposal.

G

12.C(ii). Please provide **three** years of projections of incremental revenue, expense and volume statistics **attributable to the proposal** in the following reporting format:

Type of Service Description	CT Simulator
Type of Unit Description:	Scans
# of Months in Operation	12

FY 2017 **FY Projected Incremental** Total Incremental Expenses: **$385,617** **Total Facility by Payer Category:**	(1)	(2) Rate	(3) Units (256-244)	(4) Gross Revenue Col. 2 * Col. 3	(5) Allowances/ Deductions	(6) Charity Care	(7) Bad Debt	(8) Net Revenue Col.4 - Col.5 -Col.6 - Col.7	(9) Operating Expenses Col. 1 Total * Col. 4 / Col. 4 Total	(10) Gain/(Loss) from Operations Col. 8 - Col. 9
Medicare		$6,353	150	$952,952	$885,769	$0	$0	$67,183	$154,659	($87,476)
Medicaid		$6,353	33	$209,650	$201,592	$0	$0	$8,057	$34,025	($25,968)
CHAMPUS/TriCare		$6,353	0	$0	$0	$0	$0	$0	$0	$0
Total Governmental			183	$1,162,602	$1,087,361	$0	$0	$75,241	$188,684	($113,444)
Commericial Insurers		$6,353	181	$1,149,896	$727,336	$0	$0	$422,560	$186,622	$235,938
Uninsured		$6,353	10	$63,530	$0	$62,859	$635	$36	$10,311	($10,275)
Total NonGovernment		$6,353	191	$1,213,426	$727,336	$62,859	$635	$422,596	$196,933	$225,663
Total All Payers		$6,353	374	$2,376,028	$1,814,697	$62,859	$635	$497,836	$385,617	$112,219

12.C(ii). Please provide **three** years of projections of incremental revenue, expense and volume statistics **attributable to the proposal** in the following reporting format:

Type of Service Description	CT Simulator
Type of Unit Description:	Scans
# of Months in Operation	12

FY 2018 **FY Projected Incremental** Total Incremental Expenses: **$406,968**	(1)	(2) Rate	(3) Units (269-244)	(4) Gross Revenue Col. 2 * Col. 3	(5) Allowances/ Deductions	(6) Charity Care	(7) Bad Debt	(8) Net Revenue Col.4 - Col.5 -Col.6 - Col.7	(9) Operating Expenses Col. 1 Total * Col. 4 / Col. 4 Total	(10) Gain/(Loss) from Operations Col. 8 - Col. 9
Total Facility by Payer Category:										
Medicare		$6,512	203	$1,321,904	$1,230,073	$0	$0	$91,831	$163,917	($72,087)
Medicaid		$6,512	44	$286,521	$275,671	$0	$0	$10,850	$35,529	($24,678)
CHAMPUS/TriCare		$6,512	0	$0	$0	$0	$0	$0	$0	$0
Total Governmental			247	$1,608,425	$1,505,744	$0	$0	$102,681	$199,446	($96,765)
Commericial Insurers		$6,512	244	$1,588,889	$1,002,161	$0	$0	$586,728	$197,024	$389,704
Uninsured		$6,512	13	$84,654	$0	$83,759	$847	$48	$10,497	($10,449)
Total NonGovernment		$6,512	257	$1,673,543	$1,002,161	$83,759	$847	$586,776	$207,521	$379,255
Total All Payers		$6,512	504	$3,281,968	$2,507,905	$83,759	$847	$689,457	$406,968	$282,489

12.C(ii). Please provide **three** years of projections of incremental revenue, expense and volume statistics **attributable to the proposal** in the following reporting format:

Type of Service Description	12
Type of Unit Description:	Scans
# of Months in Operation	12

FY 2019 **FY Projected Incremental** Total Incremental Expenses: **$429,744** **Total Facility by Payer Category:**	(1)	(2) Rate	(3) Units (282-244)	(4) Gross Revenue Col. 2 * Col. 3	(5) Allowances/ Deductions	(6) Charity Care	(7) Bad Debt	(8) Net Revenue Col.4 - Col.5 -Col.6 - Col.7	(9) Operating Expenses Col. 1 Total * Col. 4 / Col. 4 Total	(10) Gain/(Loss) from Operations Col. 8 - Col. 9
Medicare		$6,675	256	$1,708,707	$1,591,743	$0	$0	$116,964	$172,979	($56,015)
Medicaid		$6,675	56	$373,780	$359,832	$0	$0	$13,948	$37,839	($23,891)
CHAMPUS/TriCare		$6,675	0	$0	$0	$0	$0	$0	$0	$0
Total Governmental			312	$2,082,487	$1,951,575	$0	$0	$130,912	$210,818	($79,906)
Commericial Insurers		$6,675	308	$2,055,788	$1,292,946	$0	$0	$762,842	$208,115	$554,727
Uninsured		$6,675	16	$106,794	$0	$105,665	$1,068	$61	$10,811	($10,750)
Total NonGovernment		$6,675	324	$2,162,582	$1,292,946	$105,665	$1,068	$762,903	$218,926	$543,977
Total All Payers		$6,675	636	$4,245,069	$3,244,521	$105,665	$1,068	$893,815	$429,744	$464,071

00201

STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH

Office of Health Care Access

May 11, 2015

VIA FAX & EMAIL

Mr. David L. Smith
Senior Vice President, Strategy
The Stamford Hospital
30 Shelburne Road
Stamford, CT 06907

RE: Certificate of Need Application, Docket Number 15-31990-CON
Acquisition of a Computed Tomography ("CT") scanner.

Dear Mr. Smith:

On April 13, 2015, the Office of Health Care Access ("OHCA") received the Certificate of Need ("CON") application filing on behalf of The Stamford Hospital ("Hospital" or "Applicant") proposing to acquire a CT scanner for use at the Hospital's new emergency department ("ED") on the main campus with an associated capital expenditure of $1,366,146.

OHCA has reviewed the CON application pursuant to Connecticut General Statutes §19a-639a(c) and requests the following additional information:

1. Utilizing the table below, provide the Hospital's primary and secondary service areas listing only official town names:

SERVICE AREA TOWNS

List the official name of town* and provide the reason for inclusion.

Town*	Reason for Inclusion

* Village or place names are not acceptable.

2. Please update Table 2a (actual/projected volume) and Table 2b (volume by exam type) on pages 22-23 of the application to include updated year-to-date volumes for FY 2015 and also to add projected volumes for FY 2016-FY 2019, inclusive. Please note the months included in FY 2015 volumes.

3. Explain the 4% decrease in CT volume from FY 2013 to FY 2014 on page 22 of the application.

4. Utilizing the table below, provide payer mix for FYs 2012-2019 for ED encounters only.

APPLICANT'S CURRENT & PROJECTED PAYER MIX – EMERGENCY DEPARTMENT

Payer	FY 2012		FY 2013		FY 2014		Projected									
							FY 2015		FY 2016		FY 2017		FY 2018		FY 2019	
	Volume	%	Volume	%	Volume	%	Volume	%	Volume	%	Volume	%	Volume	%	Volume	%
Medicare*																
Medicaid*																
CHAMPUS & TriCare																
Total Government																
Commercial Insurers																
Uninsured																
Workers Compensation																
Total Non-Government																
Total Payer Mix																

* Includes managed care activity.
** Fill in years. Ensure the period covered by this table corresponds to the period covered in the projections provided. New programs may leave the "current" column blank.

5. Please revise Financial Attachment I on page 198 to include FYs 2012- 2019, inclusive.

6. For the proposed CT scanner, please attach a vendor quote or invoice, schedule of depreciation, estimate of useful life of the equipment and anticipated residual value at the end of the lease or loan term.

7. Several articles summarized on page 16 of the application describe how multi-slice protocol patients lead to more accurate and faster diagnosis and a reduction in ER, ER-OR and ER-ICU times and hospital days. Describe in detail how the integration of CT in the trauma room will improve the cost effectiveness of health care delivery in the region.

In responding to the questions contained in this letter, please repeat each question before providing your response. Paginate and date your response, i.e., each page in its entirety. Information filed after the initial CON application submission (e.g., completeness response

letter, prefile testimony, late file submissions and the like) must be numbered sequentially from the Applicant's document preceding it. Please begin your submission using **Page 202** and reference "**Docket Number: 15-31990-CON**." Submit one (1) original and three (3) hard copies of your response. In addition, please submit a scanned copy of your response, in an Adobe format (.pdf) including all attachments on CD. If available, a copy of the response in MS Word should also be copied to the CD.

Pursuant to Section 19a-639a(c) of the Connecticut General Statutes, you must submit your response to this request for additional information no later than sixty days after the date that this request was transmitted. Therefore, please provide your written responses to OHCA no later than **July 10, 2015**, otherwise your application will be automatically considered withdrawn.

If you have any questions concerning this letter, please feel free to contact me at (860) 418-7014 or Alla Veyberman at (860) 418-7007.

Sincerely,

Brian A. Carney
Associate Research Analyst

* * * COMMUNICATION RESULT REPORT (MAY. 11. 2015 3:28PM) * * *

FAX HEADER:

TRANSMITTED/STORED : MAY. 11. 2015 3:26PM FILE MODE	OPTION	ADDRESS	RESULT	PAGE
049 MEMORY TX		92032765529	OK	4/4

REASON FOR ERROR
E-1) HANG UP OR LINE FAIL
E-2) BUSY
E-3) NO ANSWER
E-4) NO FACSIMILE CONNECTION

STATE OF CONNECTICUT
OFFICE OF HEALTH CARE ACCESS

FAX SHEET

TO: DAVID L. SMITH SENIOR VP, STRATEGY

FAX: (203) 276-5529

AGENCY: THE STAMFORD HOSPITAL

FROM: OHCA

DATE: 5/11/15 **Time:**

NUMBER OF PAGES: 4
(including transmittal sheet

Comments:
Completeness Letter for Docket Number: 15-31990-CON

PLEASE PHONE IF THERE ARE ANY TRANSMISSION PROBLEMS

Phone: (860) 418-7001 Fax: (860) 418-7053

410 Capitol Ave., MS#13HCA
P.O.Box 340308
Hartford, CT 06134

STAMFORD HOSPITAL
The Regional Center for Health

affiliate Columbia University College of Physicians and Surgeons
member New York-Presbyterian Healthcare System
A Planetree Hospital

RECEIVED
JUN 29 2015
Office of
HEALTHCARE ACCESS

June 24, 2015

Brian Carney
Associate Research Analyst
State of Connecticut
Department of Public Health
Office of Health Care Access Division
410 Capital Avenue
MS#13HCA
P.O. Box 340308
Hartford, CT 06134

Re: Certificate of Need Application to Acquire and Operate a
320-Slice CT Scanner at The Stamford Hospital in Stamford, CT.
Docket #15-31990-CON

Dear Mr. Carney,

The Stamford Hospital submits the enclosed responses to the questions posed by the Office for Health Care Access regarding the above referenced Certificate of Need ("CON") Application for the acquisition and operation of a 320-Slice CT Scanner at The Stamford Hospital for use at the Hospital's new emergency department on its main campus. At your request is one original and three hard copies of our response as well as a CD containing both .pdf and .doc versions of these responses.

Please do not hesitate to contact me at 203-276-7510 or our outside counsel, Stephen Cowherd, at 203-259-7900 if you have any further questions regarding this application. Thank you for your assistance with this application.

Sincerely,

David L. Smith
Senior Vice President, Strategy
Chief Strategy and Market Development Officer

Cc: Stephen M. Cowherd, Esq. (w/ encl.)

The Stamford Hospital

Docket Number 15-31990-CON; Certificate of Need Application for Acquisition of Computed Tomography ("CT") Scanner

Responses to May 11, 2015 Completeness Questions

1. Utilizing the table below, provide the Hospital's primary and secondary service areas listing only official town names:

SERVICE AREA TOWNS

List the official name of town* and provide the reason for inclusion.

Town*	Reason for Inclusion
Primary Service Area: Stamford Darien	Stamford and Darien are identified as the PSA because they represent the two contiguous towns from which Stamford Hospital draws 75 – 80% of its inpatient admissions (77.8% in FY14)
Secondary Service Area: Norwalk Greenwich New Canaan Westport Wilton Weston	The six (6) Secondary Service Area towns represent those contiguous towns from which Stamford Hospital draws an additional 10-15% of its inpatient admissions annually (13.3% in FY14) – for total admissions from PSA and SSA towns representing approximately 90% of the Hospital's volume.

* Village or place names are not acceptable.

2. Please update Table 2a (actual/projected volume) and Table 2b (volume by exam type) on pages 22-23 of the application to include updated year-to-date volumes for FY 2015 and also to add projected volumes for FY 2016-FY 2019, inclusive. Please note the months included in FY 2015 volumes.

See attached Exhibit 1.

3. Explain the 4% decrease in CT volume from FY 2013 to FY 2014 on page 22 of the application.

The Hospital believes that the 4% total volume decline experienced at the Hospital from FY 13 to FY14 was largely driven by the following factors:

- A shift of outpatient volume from the Hospital campus (which saw a decline of 9% from FY13 – FY14) to the ambulatory imaging sites operated by the Hospital – Tully and Darien – which, combined, experienced an increase in volume of 6.4% from FY13 – FY14

- The decline in ED scan volumes of approximately 2% may be attributed to a heightened focus and awareness on potential over-use of CT scanning for emergency patients. In the first quarter of FY14, the Emergency Department launched an aggressive campaign to decrease the number of CT's ordered in the ED so as to limit the exposure to potentially harmful radiation, while ensuring patient safety and quality of care

- The Hospital executed a contract with a new radiology group to provide radiologist services beginning in January 2013. The administration of the Hospital believes referral patterns from community physicians may have been altered for a period while the new radiology group came onboard and referring physicians developed relationships with the new radiology group and grew comfortable with the service.

As seen in Exhibit 2, it should be noted that inpatient, outpatient and ED CT scan volume at the Hospital in FY15 are all trending back up to FY13 levels – with a projected increase in volume of 4.8% over FY14. Meanwhile, volume at the two ambulatory sites (Tully and Darien) also continues to grow – with a projected increase of 7.7% over FY14.

4. Utilizing the table below, provide payor mix for FYs 2012-2019 for ED encounters only.

See attached Exhibit 3.

5. Please revise Financial Attachment I on page 198 to include FYs 2012-2019, inclusive.

See attached Exhibit 4.

6. For the proposed CT scanner, please attach a vendor quote or invoice, schedule of depreciation, estimate of useful life of the equipment and anticipated residual value at the end of the lease or loan term.

See attached Exhibit 5 for vendor quote. Please note that the capital cost for equipment utilized in this application includes the "System Price" of $1,294,671 plus the purchasable option of "Full System UPS with Battery BackUp" at $71,475 for total equipment cost of $1,366,146.

See attached Exhibit 6 for schedule of depreciation, estimate of useful life of the equipment and anticipated residual value.

7. Several articles summarized on page 16 of the application describe how multi-slice protocol patients lead to more accurate and faster diagnosis and a reduction in ER, ER-OR and ER-ICU times and hospital days. Describe in detail how the integration of CT in the trauma room will improve the cost effectiveness of health care delivery in the region.

By incorporating CT scanning capability into the emergency room at the Hospital, the Hospital will be able to significantly reduce the time required for initial diagnostic evaluation. As noted in Section 2a of the Hospital's CON application (pages 15-18), one study found that by integrating a CT into the trauma room the time required for CT examination was reduced and the mortality rate decreased from almost 15% to 8.6%. The Weninger study, as referenced in OHCA's question above, found that patient length of stay in the ICU dropped from 16.8±18.7 days (the mean plus or minus the standard deviation) to 13.6±14.3 days; the days on ventilation dropped from 14.3±15.9 days to 10.9±15.3; and the patients' total hospital stay dropped from 32.5±33.3 to 29.0±29.4.[1] These are significant reductions of approximately 10-25%.

In FY 2014, the Hospital admitted 113 trauma patients from the ED into the ICU. The mean Length of Stay (LOS) in the ICU for these patients was 2.5 days (SD – 3.7). Of these patients, 26.5% required Ventilation – resulting in a longer LOS [mean - 6.1 days (SD 5.7)], and a mean duration of ventilation of 5.3 days (SD 4.3). If the Hospital experienced only a 10% reduction in ICU and ventilation length of stays for these patients, the Hospital could expect to see a reduction of approximately 28 days in the ICU and 15 days on ventilation equipment collectively for these patients. These reductions would create substantial savings for the regional health care system, while also providing a higher standard of care to the Hospital's patients.

[1] Weninger P, Mauritz W, Fridrich P, Spitaler R, Figl M, Kern B, Hertz H., Emergency Room Management of Patients With Blunt Major Trauma: Evaluation of The Multislice Computed Tomography Protocol Exemplified by an Urban Trauma Center, J Trauma. 2007; 62:584–591. doi: 10.1097/01.ta.0000221797.46249.ee.

Exhibit 1

Table 2a: Historical, Current, and Projected Volume, by Equipment Unit

		Actual Volume (Last 3 Completed FYs)**			CFY Volume	CFY Volume (ANNUALIZED)	Projected Volume (First 3 Full Operational FYs)			
		FY 2012	FY 2013	FY 2014	FY15 YTD 5/31	FY15 ANN.	FY 2016	FY 2017	FY 2018	FY 2019
CT - Scanner 1 - 64 Slice CT and CT -Scanner 2 - 64 Slice CT (Radiology Dept.)*	Inpatient	9,853	9,414	9,099	6,296	9,444	9099	9,399	9,399	9,399
	Outpatient	7,686	6,731	6,111	4,449	6,674	6358	6,485	6,615	6,747
	Emergency Dept.	13,814	15,408	15,060	10,401	15,602	15248	n/a	n/a	n/a
CT - Scanner 3 - 160 slice (Emergency Dept.)	Emergency Dept.	n/a	n/a	n/a	n/a	n/a	n/a	15,467	15,467	15,467
Total		**31,353**	**31,553**	**30,270**	**21,146**	**31,719**	**30,705**	**31,351**	**31,481**	**31,613**

*** Note - Volume between the two scanners in Radiology Department cannot be broken out by unit**

**** Stamford Hospital's Fiscal Year is October 1 - September 30**

Table 2b: Historical, Current, and Projected Volume, by Type of Scan/Exam

	Actual Volume (Last 3 Completed FYs)**			CFY Volume	CFY Volume (ANNUALIZED)		Projected Volume (First 3 Full Operational FYs)**		
	FY 2012	FY 2013	FY 2014	FY15 YTD 5/31	FY15 ANN.	FY2 2016	FY 2017	FY 2018	FY 2019
CT - Head	8,156	8,016	7,916	5,312	7,968	8,030	8,199	8,233	8,267
CT - Abdomen	436	410	414	268	402	420	429	431	432
CT - Chest	3,936	4,146	4,166	3,000	4,500	4,226	4,315	4,333	4,351
CT - Pelvis	240	217	219	159	239	222	227	228	229
CT - Cervical	2,216	2,216	2,191	1,814	2,721	2,222	2,269	2,279	2,288
CT - Abdomen and Pelvis	14,808	14,944	13,836	9,610	14,415	14,035	14,330	14,389	14,450
CT - Other	1,561	1,604	1,528	983	1,475	1,550	1,583	1,589	1,596
Total	**31,353**	**31,553**	**30,270**	**21,146**	**31,719**	**30,705**	**31,351**	**31,481**	**31,613**

**** Stamford Hospital's Fiscal Year is October 1 - September 30**

Exhibit 2

Facility	Volume Needed	FY11	FY12	FY13	FY14	Change FY13 - FY14	% Change - FY13 - 14	FY15 - YTD MAY	Projected FY 15 ANN	Change FY14 - FY15	% Change
Stamford Hospital	Total CT Scans - Inpatient	10517	9853	9414	9099	-315	-3.3%	6296	9,444	345	3.8%
Stamford Hospital	Total CT Scans - Outpatient	6154	7686	6731	6111	-620	-9.2%	4449	6,674	563	9.2%
Stamford Hospital	Total CT Scans - ED	11161	13814	15408	15060	-348	-2.3%	10401	15,602	542	3.6%
Stamford Hospital	Total CT Scans - HOSPITAL	27832	31353	31553	30270	-1283	-4.1%	21146	31,719	1,449	4.8%
Ambulatory Sites:											
Tully	Total CT Scans - Outpatient	5324	5086	4887	5021	134	2.7%	3652	5,478	457	9.1%
Darien	Total CT Scans - Outpatient	1575	1315	1273	1531	258	20.3%	1053	1,580	49	3.2%
	Total CT Scans - Ambulatory Sites	6899	6401	6160	6552	392	6.4%	4705	7,058	506	7.7%

APPLICANT'S CURRENT & PROJECTED PAYER MIX – EMERGENCY DEPARTMENT

Payer	FY 2012		FY 2013		FY 2014		Projected									
							FY 2015		FY 2016		FY 2017		FY 2018		FY 2019	
	Volume	%	Volume	%	Volume	%	Volume	%	Volume	%	Volume	%	Volume	%	Volume	%
Medicare*	11,547	22.7%	11,499	22.6%	11,834	23.7%	11,805	23.7%	11,983	23.7%	12,155	23.7%	12,155	23.7%	12,155	23.7%
Medicaid*	15,043	29.6%	15,668	30.8%	15,890	31.9%	15,848	31.9%	16,086	31.9%	16,317	31.9%	16,317	31.9%	16,317	31.9%
CHAMPUS & TriCare	46	0.1%	39	0.1%	59	0.1%	60	0.1%	61	0.1%	62	0.1%	62	0.1%	62	0.1%
Total Government	26,636	52.4%	27,206	53.4%	27,783	55.7%	27,713	55.7%	28,130	55.7%	28,534	55.7%	28,534	55.7%	28,534	55.7%
Commercial Insurers	13,986	27.5%	13,564	26.6%	13,082	26.2%	13,049	26.2%	13,245	26.2%	13,435	26.2%	13,435	26.2%	13,435	26.2%
Uninsured	7,833	15.4%	7,868	15.4%	6,717	13.5%	6,698	13.5%	6,799	13.5%	6,897	13.5%	6,897	13.5%	6,897	13.5%
Workers Compensation	2,376	4.7%	2,320	4.6%	2,272	4.6%	2,268	4.6%	2,302	4.6%	2,335	4.6%	2,335	4.6%	2,335	4.6%
Total Non-Government	24,195	47.6%	23,752	46.6%	22,071	44.3%	22,015	44.3%	22,346	44.3%	22,667	44.3%	22,667	44.3%	22,667	44.3%
Total Payer Mix	50,831	100.0%	50,958	100.0%	49,854	100.0%	49,728	100.0%	50,476	100.0%	51,201	100.0%	51,201	100.0%	51,201	100.0%

* Includes managed care activity.

** Fill in years. Ensure the period covered by this table corresponds to the period covered in the projections provided. New programs may leave the "current" column blank.

12. C (i). Please provide one year of actual results and three years of projections of **Total Facility** revenue, expense and volume statistics without, incremental to and with the CON proposal in the following reporting format:

Total Facility: Description	FY 2012 Actual Results	FY 2013 Actual Results	FY 2014 Actual Results	FY 2015 Projected W/out CON	FY 2015 Projected Incremental	FY 2015 Projected With CON	FY 2016 Projected W/out CON	FY 2016 Projected Incremental	FY 2016 Projected With CON	FY 2017 Projected W/out CON	FY 2017 Projected Incremental	FY 2017 Projected With CON	FY 2018 Projected W/out CON	FY 2018 Projected Incremental	FY 2018 Projected With CON	FY 2019 Projected W/out CON	FY 2019 Projected Incremental	FY 2019 Projected With CON
NET PATIENT REVENUE																		
Non-Government	$309,105	$312,977	$302,070	$315,268		$315,268	$333,116	$0	$333,116	$349,979	$423	$350,401	$367,842	$587	$368,428	$386,462	$763	$387,225
Medicare	$112,070	$114,539	$117,132	$122,249		$122,249	$126,603	$0	$126,603	$130,490	$67	$130,557	$134,487	$92	$134,579	$138,551	$117	$138,668
Medicaid and Other Medical Assistance	$36,820	$38,167	$38,402	$40,079		$40,079	$41,497	$0	$41,497	$42,781	$8	$42,789	$44,092	$11	$44,103	$45,424	$14	$45,438
Other Government	$359	$202	$204	$212		$212	$220	$0	$220	$227	$0	$227	$234	$0	$234	$241	$0	$241
Total Net Patient Patient Revenue	$458,354	$465,884	$457,807	$477,809	$0	$477,809	$501,436	$0	$501,436	$523,476	$498	$523,974	$546,654	$689	$547,343	$570,678	$894	$571,572
Other Operating Revenue	$18,946	$19,192	$22,613	$16,895		$16,895	$17,064		$17,064	$17,235		$17,235	$17,407		$17,407	$17,581		$17,581
Revenue from Operations	$477,300	$485,076	$480,420	$494,704	$0	$494,704	$518,500	$0	$518,500	$540,710	$498	$541,208	$564,061	$689	$564,750	$588,259	$894	$589,153
OPERATING EXPENSES																		
Salaries and Fringe Benefits	$226,770	$244,302	$229,708	$232,172		$232,172	$242,165	$0	$242,165	$251,920	$45	$251,964	$262,054	$62	$262,116	$272,552	$80	$272,633
Professional / Contracted Services	$51,110	$54,972	$52,046	$48,749		$48,749	$50,842	$0	$50,842	$52,895	$1	$52,896	$55,023	$1	$55,024	$57,228	$1	$57,229
Supplies and Drugs	$68,453	$66,721	$72,145	$70,511		$70,511	$73,543	$0	$73,543	$76,508	$10	$76,518	$79,586	$14	$79,600	$82,774	$18	$82,792
Bad Debts	$0	$0	$0	$0		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Other Operating Expense	$47,500	$51,465	$54,221	$54,445		$54,445	$56,782	$0	$56,782	$59,076	$135	$59,211	$61,453	$135	$61,588	$63,915	$135	$64,050
Subtotal	$393,833	$417,460	$408,120	$405,877	$0	$405,877	$423,333	$0	$423,333	$440,399	$190	$440,589	$458,116	$212	$458,328	$476,470	$235	$476,704
Depreciation/Amortization	$24,839	$24,839	$24,086	$23,919		$23,919	$32,027	$98	$32,124	$40,152	$195	$40,347	$40,833	$195	$41,028	$41,533	$195	$41,728
Interest Expense	$5,641	$6,274	$6,007	$5,544		$5,544	$8,323		$8,323	$17,119		$17,119	$16,815		$16,815	$16,491		$16,491
Lease Expense	$5,873	$5,093	$5,278	$5,102		$5,102	$5,239		$5,239	$5,381		$5,381	$5,526		$5,526	$5,675		$5,675
Total Operating Expense	$430,186	$453,666	$443,491	$440,442	$0	$440,442	$468,922	$98	$469,020	$503,051	$386	$503,436	$521,290	$407	$521,697	$540,169	$430	$540,598
Gain/(Loss) from Operations	$47,114	$31,410	$36,929	$54,262	$0	$54,262	$49,578	($98)	$49,480	$37,660	$112	$37,772	$42,771	$282	$43,053	$48,090	$464	$48,554
Plus: Non-Operating Revenue	($10,098)	$1,089	$2,718	$0		$0	$0		$0	$0		$0	$0		$0	$0		$0
Revenue Over/(Under) Expense	$37,016	$32,499	$39,647	$54,262	$0	$54,262	$49,578	($98)	$49,480	$37,660	$112	$37,772	$42,771	$282	$43,053	$48,090	$464	$48,554
FTEs	2,034.60	2,084.40	2,087.12	2,124.60		2,124.60	2,179.13	-	2,179.13	2,223.60	0.41	2,224.01	2,268.60	0.57	2,269.17	2,313.60	0.74	2,314.34

*Volume Statistics:
Provide projected inpatient and/or outpatient statistics for any new services and provide actual and projected inpatient and/or outpatient statistics for any existing services which will change due to the proposal.

TOSHIBA
Leading Innovation

Exhibit 5

TOSHIBA AMERICA MEDICAL SYSTEMS, INC.

2441 Michelle Drive, Tustin, CA 92780
Phone: (714) 730-5000

STAMFORD HOSPITAL NEW HOSPITAL CT PROJECT

Toshiba Aquilion ONE 320 Series CT System
Aquilion ONE 320 Series can acquire up to 8cm of anatomy in a single rotation of the gantry.
Field upgradeable from 320 slice to 640 slice to Aquilion ONE Vision
Latest generation of Adaptive Iterative Dose Reduction(AiDR3D)
Aquilion ONE 320 Series meets the National Electrical Manufacturers Association's (NEMA) Medical Imaging & Technology Alliance (MITA) standards XR 25, XR 26 and XR 29
Single Energy Metal Artifact Reduction (SEMAR)
Tech Assist Lateral Table Slide
SURECardio with PhaseXact and Variable Helical Pitch
System Price: $1,294,671

Purchasable Options:
Dynamic Volume CT Upgrade Kit Aquilion ONE 320 to Aquilion ONE 640: $169,355
Aquilion ONE Fast Scan and Power Upgrade Kit: $338,710
4D Neuro Perfusion Package with SURESubtraction DSA Technology: $43,630
Full system UPS with Battery Backup: $71,475
Vitrea Extend with 3 Concurrent Users, Cardiac, and TAVR Analysis: $183,449

We appreciate your consideration and interest in Toshiba America Medical Systems' latest CT technology, and we look forward to discussing your diagnostic imaging needs.

Sincerely,

Jason Dolger
Toshiba America Medical Systems
Account Exectutive

Scott Casolo
Toshiba America Medical Systems
Zone Business Manager, CT

1/15/2015

Stamford Hospital
CON Schedule of Depreciation

CT scanner depreciation assumptions

Quote:	$	1,366,146
Useful life (# of years)		7

1/2 year in first year of operations with no residual value

FY		Depreciation
2016	$	97,582
2017		195,164
2018		195,164
2019		195,164
2020		195,164
2021		195,164
2022		195,164
2023		97,582
	$	1,366,146

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC HEALTH
Office of Health Care Access

VIA EMAIL ONLY

July 29, 2015

Mr. David L. Smith
Senior Vice President, Strategy
The Stamford Hospital
30 Shelburne Road
Stamford, CT 06907

RE: Certificate of Need Application, Docket Number 15-31990-CON
The Stamford Hospital
Acquisition of a Computed Tomography ("CT") scanner

Dear Mr. Smith:

This letter is to inform you that, pursuant to Section 19a-639a (d) of the Connecticut General Statutes, the Office of Health Care Access has deemed the above-referenced application complete as of July 29, 2015.

If you have any questions regarding this matter, please feel free to contact me at (860) 418-7014 or Alla Veyberman at (860) 418-7007.

Sincerely,

Brian A. Carney
Associate Research Analyst

* * * COMMUNICATION RESULT REPORT (JUL. 29. 2015 9:15AM) * * *

FAX HEADER:

TRANSMITTED/STORED : JUL. 29. 2015 9:14AM FILE MODE	OPTION	ADDRESS	RESULT	PAGE
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REASON FOR ERROR
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E-2) BUSY
E-3) NO ANSWER
E-4) NO FACSIMILE CONNECTION

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC HEALTH
OFFICE OF HEALTH CARE ACCESS

FAX SHEET

TO: **Mr. David L. Smith**
Senior Vice President, Strategy

FAX: **(203) 276-5529**

AGENCY: **The Stamford Hospital**

FROM: **Brian A. Carney, OHCA**

DATE: **7/29/2015** **TIME:**

NUMBER OF PAGES: **2**
(including transmittal sheet

Comments: 15-31990–CON
Stamford Hospital acquisition of a CT scanner
Application Deemed Complete

PLEASE PHONE IF THERE ARE ANY TRANSMISSION PROBLEMS.

Phone: (860) 418-7001 ***Fax: (860) 418-7053***

410 Capitol Ave., MS#13HCA
P.O.Box 340308
Hartford, CT 06134

Greer, Leslie

From: Greer, Leslie
Sent: Thursday, October 22, 2015 1:44 PM
To: 'DSmith@stamhealth.org'
Cc: Veyberman, Alla; Carney, Brian
Subject: Notice of Final Decision for Stamford Hospital
Attachments: 31990_201510221325.pdf

Mr. Smith,
Attached is the Notice of Final Decision for The Stamford Hospital's proposal for acquisition of a computed tomography scanner.

Leslie M. Greer
Office of Health Care Access
Connecticut Department of Public Health
410 Capitol Avenue, MS#13HCA, Hartford, CT 06134
Phone: (860) 418-7013 Fax: (860) 418-7053
Website: www.ct.gov/ohca

Department of Public Health
Office of Health Care Access
Certificate of Need Application

Final Decision

Applicant: **The Stamford Hospital**
30 Shelburne Road
Stamford, CT 06907

Docket Number: **15-31990-CON**

Project Title: **Acquisition of a Computed Tomography Scanner**

Project Description: The Stamford Hospital ("Hospital" or "Applicant") is proposing to acquire and operate a new 320-slice computed tomography scanner to be located in the new emergency department on the hospital's main campus at an associated capital cost of $1,366,146.

Procedural History: The Applicant published notice of its intent to file a Certificate of Need ("CON") application in *The Advocate* (Stamford) on January 29, 30 and 31, 2015. On April 13, 2015, the Office of Health Care Access ("OHCA") received the CON application from the Applicant for the above-referenced project and deemed the application complete on July 29, 2015. OHCA received no responses from the public concerning the proposal and no hearing requests were received from the public per Connecticut General Statutes ("Conn. Gen. Stat.") § 19a-639a(e). Deputy Commissioner Brancifort considered the entire record in this matter.

Findings of Fact and Conclusions of Law

To the extent the findings of fact actually represent conclusions of law, they should be so considered, and vice versa. *SAS Inst., Inc., v. S & H Computer Systems, Inc.*, 605 F.Supp. 816 (Md. Tenn. 1985).

1. The Stamford Hospital ("Hospital" or "Applicant") is a 305-bed acute care hospital located in Stamford, Connecticut. Ex. A, p. 13

2. On February 9, 2010, the Applicant received OHCA approval (Docket Number 08-31284-CON) to proceed with its master facility plan that included the construction of a new main hospital building ("Specialty Building") that would be connected to the existing main campus buildings and would house a modernized Emergency Department ("ED"), a replacement surgical suite with 12 operating rooms, a Heart and Vascular Institute with four invasive labs and a five-floor bed tower that would contain 180 replacement beds. Ex. A, p. 13

3. With the projected completion/occupancy date of the new Specialty Building anticipated for summer/fall 2016, the Hospital proposes to acquire a 320-slice computed tomography ("CT") scanner to be located and operated within the new ED. Ex. A, p. 13

4. The Hospital is designated by the Connecticut Department of Public Health and the Joint Commission as a Primary Stroke Center and has been designated by the American College of Surgeons ("ACS") as a Level II Trauma Center since 1993. Ex. A, pp. 15

5. The Hospital's designation as a Level II Trauma Center requires continued verification from the ACS. During the last re-verification review, the Hospital was advised to have a CT scanner located closer to the ED. If not, the Hospital could face receiving a citation from the ACS and the likelihood of losing its Level II Trauma Center designation. Ex. A, p. 17

6. Research has shown that a CT scan is performed in up to 67% of patients presenting to emergency departments. Many EDs are equipped with a dedicated CT scanner to allow fast access for trauma patients and various medical emergencies, according to an article, *Evaluation of a 16-MDCT Scanner in an Emergency Department: Initial Clinical Experience and Workflow Analysis.* Ex. A, p. 131

7. According to an article, *The Impact on Trauma Patient Management of Installing a Computed Tomography Scanner in the Emergency Department,* CT scanners have the ability to quickly and accurately provide diagnostic imaging of serious medical conditions and potentially life threatening illnesses and accidents. CT is fast, accurate and cost effective in providing clinically useful information in a single examination and helps facilitate rapid therapeutic intervention. Ex. A, pp. 16-18, 21

8. Another article entitled, *New Aspects in the Emergency Room Management of Critically Injured Patient,* found that by integrating a CT scan into the trauma room, the time required for CT examination was reduced from 87 to 38 minutes and the mortality rate decreased from almost 15% to 8.6%. Ex. A, p. 16

9. A study on ED patients with blunt trauma, *Emergency Room Management of Patients with Blunt Major Trauma: Evaluation of The Multislice Computed Tomography Protocol Exemplified by an Urban Trauma Center*, concluded that immediate scans for patients with blunt major trauma leads to more accurate and faster diagnosis, and reduction in ER, ER-to-operating room and ER-to-intensive care unit times. The study also observed reduction in ventilation, ICU, hospital days and organ failure rates. Ex. A, pp. 16, 86-93

10. Time is critical for stroke patients who present at the ED. Both the American Heart and Stoke Associations state that the essential best practice is to initiate a CT scan within 25 minutes of arrival and to complete interpretation of the scan within 45 minutes to exclude intracranial hemorrhage. Ex. A, pp. 16-17, 36-43, 95-129

11. Based on the principle of the "golden hour in shock," primary diagnostic procedures must be highly effective and focused, and the primary clinical and radiological survey should be completed within 30 minutes after admission of the patient in the emergency room, according to an article, *The Benefit of Multislice CT in the Emergency Room Management of Polytraumatized Patients.* Ex. A, pp. 15, 36-43

12. A delay in proper surgical care is a major cause of preventable deaths in trauma care, and the earliest possible identification of potential lethal injuries is critical, according to an article, *Whole-body multislice computed Tomography (MSCT) improves trauma care in patients requiring surgery after multiple trauma*. Ex. A, pp. 16, 45-49

13. Currently, patients at the existing ED that require a CT scan are transported to the Hospital's radiology department. Patient transport time can range from three to seven minutes, depending on the transporter, patient, required ancillary equipment (e.g., IV poles, ventilator) and accompanying staff. Ex. A, pp. 13-14

14. The new ED is located farther from the radiology department than the existing ED. While the new ED will have a designated trauma elevator, the elevator from the basement to the existing building will be shared with other departments, making wait-time more variable. As a result, the time it will take to transport a patient from the new ED to the radiology department could surpass 10 minutes. Ex. A, p. 14

15. The 320-slice CT scanner provides high-resolution images in less time and will allow for faster, more accurate diagnoses with less radiation. Ex. A, p. 15

16. The proposed CT scanner would serve as an alternative in the event that the existing CT is offline due to malfunction or maintenance. It will also prevent delays for outpatients who may be forced to reschedule scans if emergency patients require scanning. Ex. A, pp. 17-18

17. The Hospital's primary service area consists of the following towns:

TABLE 1
SERVICE AREA TOWNS

Town	Scans	% Scans
Stamford	22,390	74%
Norwalk	1,138	5%

Ex. A, p. 23

18. The Hospital's ED patients receive approximately 15,000 CT scans each year, approximately half of all CT scans performed at the Hospital in the last three fiscal years. The table below shows the current and projected volume for all CT scanners operated by the Hospital:

TABLE 2
HISTORICAL, CURRENT, AND PROJECTED VOLUME

CT Scanner	Actual Volume			CFY Volume	Projected Volume			
	FY 2012	FY 2013	FY 2014	FY 2015***	FY 2016	FY 2017	FY 2018	FY 2019
Inpatient	9,853	9,414	9,099	9,444	9,099	9,399	9,399	9,399
Outpatient	7,686	6,731	6,111	6,674	6,358	6,485	6,615	6,747
ED*	13,184	15,408	15,060	15,602	15,248	-	-	-
Total	**30,723**	**31,553**	**30,270**	**31,720**	**-**	**15,248**	**16,014**	**16146**
ED**	-	-	-	-	-	15,467	15,467	15,467
Total	**31,353**	**31,553**	**30,270**	**31,720**	**30,705**	**31,351**	**31,481**	**31,613**

Stamford Hospital's Fiscal Year is October 1- September 30
*CT scans performed on ED patients in the Radiology Department
** Proposed new CT
*** May YTD, annualized
Note: Volume decline from FY13 to FY14 is based on: a shift of O/P volume from the Hospital campus to the Hospital's ambulatory imaging sites, contract with a new radiology group that started in January 2013 and the ED's campaign to decrease the number of CT scans to limit radiation exposure.
Ex. A, pp. 20, 22 and Ex. C. pp. 203-205

19. The population to be served by the proposed CT scanner is the same population that is currently served by the existing scanners and therefore, there will be no impact on existing providers or duplication of services. Ex. A, p. 21

20. The Applicant's payor mix will remain unchanged as a result of this proposal.

TABLE 3
APPLICANT'S CURRENT & PROJECTED PAYER MIX

Payor	2014	2015	2016	2017	2018	2019
	%	%	%	%	%	%
Medicare*	27%	27%	27%	27%	27%	27%
Medicaid*	16%	16%	16%	16%	16%	16%
CHAMPUS & TriCare	0%	0%	0%	0%	0%	0%
Total Government	**43%**	**43%**	**43%**	**43%**	**43%**	**43%**
Commercial Insurers	51%	51%	51%	51%	51%	51%
Uninsured	5%	5%	5%	5%	5%	5%
Workers Compensation	1%	1%	1%	1%	1%	1%
Total Non-Government	**57%**	**57%**	**57%**	**57%**	**57%**	**57%**
Total Payer Mix	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

*Includes managed care activity.
Ex. C. p.207

21. The proposed CT scanner will provide services to all patient populations including Medicaid, Medicare, commercially insured and uninsured patients. Ex. A, p. 27

22. The proposed acquisition will be funded from the Applicant's cash from operations. Ex. A, p. 26

23. The proposal's total capital expenditure is shown below:

TABLE 4
TOTAL PROPOSAL CAPITAL EXPENDITURE

Purchase	Cost
Equipment	$1,366,146
Total Project Cost	**$1,366,146**

Ex. A, p. 26

24. The Hospital projects an incremental increase in operating expenses but overall gain from operations in each of the first three years following the proposed equipment acquisition (FY 2017-2019).

TABLE 5
THE HOSPITAL'S PROJECTED INCREMENTAL REVENUES AND EXPENSES

Description	FY 2017	FY 2018	FY 2019
Revenue from Operations	$498,000	$689,000	$894,000
Total Operating Expenses*	$386,000	$407,000	$430,000
Gain/(Loss) from Operations**	**$112,000**	**$282,000**	**$464,000**

*Operating expenses include depreciation expenses and the cost of the new service contract
**Gain from operations based on volume resulting from the additional CT scanner
Ex. A, pp. 28, 198.

25. OHCA is currently in the process of establishing its policies and standards as regulations. Therefore, OHCA has not made any findings as to this proposal's relationship to any regulations not yet adopted by OHCA. (Conn. Gen. Stat. § 19a-639(a)(1))

26. This CON application is consistent with the overall goals of the Statewide Health Care Facilities and Service Plan. (Conn. Gen. Stat. § 19a-639(a)(2))

27. The Applicant has established that there is a clear public need for the proposal. (Conn. Gen. Stat. § 19a-639(a)(3))

28. The Applicant has demonstrated that the proposal is financially feasible. (Conn. Gen. Stat. § 19a-639(a)(4))

29. The Applicant has satisfactorily demonstrated that the proposal will improve quality and the accessibility of health care delivery in the region. (Conn. Gen. Stat.§ 19a-639(a)(5))

30. The Applicant has shown that there would be no adverse change in the provision of health care services to the relevant populations and payer mix, including access to services by Medicaid recipients and indigent persons. (Conn. Gen. Stat. § 19a-639(a)(6))

31. The Applicant has satisfactorily identified the population to be affected by this proposal. (Conn. Gen. Stat. § 19a-639(a)(7))

32. The Applicant's historical provision of treatment in the service area supports this proposal. (Conn. Gen. Stat. § 19a-639(a)(8))

33. The Applicant has satisfactorily demonstrated that this proposal would not result in an unnecessary duplication of existing services in the area. (Conn. Gen. Stat. § 19a-639(a)(9))

34. The Applicant has demonstrated that there will be no reduction in access to services by Medicaid recipients or indigent persons. (Conn. Gen. Stat. § 19a-639(a)(10))

35. The Applicant has demonstrated that the proposal will not negatively impact the diversity of health care providers and patient choice in the region. (Conn. Gen. Stat. § 19a-639(a)(11))

36. The Applicant has satisfactorily demonstrated that the proposal will not result in any consolidation that would affect health care costs or access to care. (Conn. Gen. Stat. § 19a-639(a)(12))

DISCUSSION

CON applications are decided on a case by case basis and do not lend themselves to general applicability due to the uniqueness of the facts in each case. In rendering its decision, OHCA considers the factors set forth in § 19a-639(a) of the Statutes. The Applicants bear the burden of proof in this matter by a preponderance of the evidence. *Jones v. Connecticut Medical Examining Board, 309 Conn. 727 (2013).*

The Applicant, Stamford Hospital, is a 305-bed acute care hospital and a Primary Stroke Center/Level II Trauma Center located in Stamford, CT. *FF1,4* The Applicant is seeking authorization for the acquisition of a 320-slice CT scanner to be located in its new modernized Emergency Department. *FF2,3* Currently, ED patients requiring a CT scan must be transported from the ED to the Radiology Department, regardless of the severity of their illness or injury. *FF13*

Many Emergency Departments are equipped with a dedicated CT scanner to allow fast access for trauma patients and medical emergencies. *FF6* Dedicated ED CT scanners can quickly and accurately provide diagnostic imaging of serious medical conditions and potentially life threatening illnesses and accidents. *FF7* According to one study, integrating a CT scanner into the trauma room reduced the time required for a CT examination from 87 to 38 minutes and the mortality rate declined from almost 15% to 8.6%. *FF8* Research has also shown that immediate scans for patients with blunt major trauma leads to more accurate and faster diagnosis, and reduction in ER, ER-to-operating room and ER-to-intensive care unit times as well as declines in ventilation, ICU, hospital days and organ failure rates. *FF9* Both the American Heart and Stroke Associations best practices stress the need for initiation of a CT scan within 25 minutes of arrival and complete interpretation of the scan within 45 minutes. *FF10* Research also indicates the importance of completing a patient's radiological survey within 30 minutes after ED admission. *FF11* A delay in proper surgical care is a major cause of preventable deaths in trauma care, and the earliest possible identification of potential lethal injuries is critical, particularly those patients suffering from stroke or trauma. *FF12* Without a dedicated ED CT scanner, the Hospital risks loss of certification as a Level II Trauma Center. *FF5*

In addition to benefits to the Hospital's critically ill ED patients, access overall will be improved, as the proposed scanner will serve as a backup in the event that the Radiology Department CT scanner goes offline due to malfunction or maintenance issues. The existence of a backup scanner will prevent delays for outpatients who may otherwise be forced to reschedule if emergency patients require scanning. *FF16* Quality of care will also be improved, as the proposed 320-slice CT scanner provides high-resolution images in less time, allowing for faster and more accurate diagnoses with less radiation. *FF15* Locating a CT scanner in the ED is also supported by the volume of ED patients scanned, as approximately half of the Hospital's CT scans in the last three fiscal years were conducted on ED patients. *FF18*

The proposed acquisition will be funded from the Applicant's cash from operations. *FF22* The Applicant projects incremental gains from operations in each of the first three fiscal years following the proposed equipment acquisition, based on the volume resulting from the additional CT scanner. *FF24* Therefore, OHCA finds the proposal financially feasible.

The scanner will provide service to all patient populations, including Medicaid, Medicare, commercial and uninsured patients. The Applicant anticipates treating the same population and payer mix following implementation of the proposal. *FF19-21*

The Applicant has satisfactorily demonstrated that there is a clear public need for this proposal. Acquiring and locating a CT scanner in the Hospital's ED will enable more timely diagnoses and treatment of patients presenting with stroke, trauma or other life threatening conditions. Moreover, the proposal is consistent with the Statewide Health Care and Facilities Plan as it allows for a backup alternative in the event that the existing imaging equipment is offline due to malfunction or maintenance.

Order

Based upon the foregoing Findings and Discussion, the Certificate of Need application of Stamford Hospital for the acquisition if the CT scanner is hereby **APPROVED**.

All of the foregoing constitutes the final order of the Office of Health Care Access in this matter.

By Order of the
Department of Public Health
Office of Health Care Access

Oct. 20, 2015
Date

Janet M. Brancifort
Janet M. Brancifort, MPH, RRT
Deputy Commissioner

Greer, Leslie

From: Smith, David L (SVP, Administration) <DSmith@stamhealth.org>
Sent: Thursday, October 22, 2015 5:20 PM
To: Greer, Leslie
Cc: Veyberman, Alla
Subject: RE: Notice of Final Decision for Stamford Hospital

Ms. Greer,

Yes I received the attached documents. Thank you very much.

David Smith

David L. Smith
Senior Vice President, Strategy
Chief Strategy and Network Development Officer
Stamford Health System
30 Shelburne Road
Stamford, CT 06904-9317
(203) 276-7510

From: Greer, Leslie [mailto:Leslie.Greer@ct.gov]
Sent: Thursday, October 22, 2015 3:17 PM
To: Smith, David L (SVP, Administration)
Cc: Veyberman, Alla
Subject: Notice of Final Decision for Stamford Hospital

Mr. Smith,
Please confirm that you've received the attached documents.
Thank you,
Leslie Greer

From: Greer, Leslie
Sent: Thursday, October 22, 2015 1:44 PM
To: 'DSmith@stamhealth.org'
Cc: Veyberman, Alla; Carney, Brian
Subject: Notice of Final Decision for Stamford Hospital

Mr. Smith,
Attached is the Notice of Final Decision for The Stamford Hospital's proposal for acquisition of a computed tomography scanner.

Leslie M. Greer
Office of Health Care Access
Connecticut Department of Public Health
410 Capitol Avenue, MS#13HCA, Hartford, CT 06134
Phone: (860) 418-7013 Fax: (860) 418-7053
Website: www.ct.gov/ohca

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DPH
Connecticut Department
of Public Health