

Computed Tomography Professional Curriculum

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Introduction

The professional practice of computed tomography requires specific knowledge and skills generally not obtained in basic education programs in radiography. The curriculum is intended as a guide to establish criteria for educational programs in computed tomography. It provides educational institutions with a structured program containing the necessary elements to produce graduates with superb knowledge and skills in computed tomography. Upon completion of this curriculum, graduates should be able to perform computed tomography with a high level of proficiency. The curriculum complements and adheres to Standard Four - Curriculum and Academic Practices of the “Standards for an Accredited Educational Program in Radiologic Sciences” as established by the Joint Review Committee on Education in Radiologic Technology (JRCERT). Further, the curriculum complies with the mission statements of the American Registry of Radiologic Technologists (ARRT) and the American Society of Radiologic Technologists (ASRT) while preparing students for advanced certification in computed tomography.

The didactic portions of the curriculum cover all topics in the “Content Specifications for the Examination in Computed Tomography” published by the ARRT. The clinical education component of the curriculum is competency based, assuring that all students meet established standards of performance and requirements for advanced-level certification beginning in 2000.

The curriculum recognizes that the components are not static, but representative of current practices and trends in the speciality. It is the responsibility of educators to incorporate new concepts and trends in the curriculum as they occur.

The computed tomography curriculum is based on the premise that students have completed a basic educational program in radiography. With basic radiography program courses as prerequisites, this curriculum is suitable as a certificate program for graduates of certificate and associate degree radiography programs. It also may be incorporated into baccalaureate degree programs after basic radiography courses have been completed. With some modifications, the curriculum is suitable for extended fellowships. The clinical education practicums and associated competencies may be used to assist current CT practitioners in meeting the qualifications for advanced certification.

Course sequencing is suggested. This represents an effort to provide the student with the foundation necessary for the synthesis of subsequent information. However, the proposed sequence is just that, a suggestion. The actual sequence of the courses is ultimately determined by the program faculty, recognizing that it is their responsibility to provide a quality educational experience for their students.

Courses are listed in syllabus format with learning objectives. The course descriptions and objectives are general in nature and not all-inclusive. Instructors may modify the descriptions and objectives to reflect personal knowledge and experience. Course content in outline form is included to provide the general aspects that should be covered in the course while allowing

instructor latitude in choosing specific content areas. Suggested prerequisites are provided in each syllabus where necessary. Program faculty should decide whether to combine courses or divide the information in one course into separate courses. Length of program, whether quarter or semester format, course importance to the faculty, etc. will guide these types of decisions.

A reference resource list is included with the curriculum. It is not a comprehensive list of computed tomography resources and is not an endorsement of publications other than those of the ASRT.

The ASRT acknowledges the dedication and hard work of those individuals who developed the curriculum. Acknowledgement and gratitude also is extended to other technologists, educators and physicians who assisted in the development of this curriculum. Special thanks to Audrey Harris, M.A. Ed., R.T.(R)(CT)(M), radiography program director, Carraway Methodist Medical Center, Birmingham, Ala., for tirelessly reviewing this document and to Maria Carter-Tyson, administrative assistant, for providing excellent word-processing skills and motivational support. Without the effort of all parties, this publication would not be a reality.

Computed Tomography Curriculum Development Team

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Orientation to the Educational Program

Course Description

Content provides the student with an overview of the educational program in computer tomography. A program handbook containing all essential information and distributed to each student is suggested. Prior to the student's first clinical education practicum assignment, it is suggested that they attend a clinical orientation session. A clinical education handbook may be distributed during the orientation and should be reviewed thoroughly. The clinical education preceptor, should be supplied with the forms required for student clinical evaluations (affective and competency), counseling, etc.

I. Admission Requirements

- A. Application process
- B. Important dates
- C. Selection process
- D. Acceptance notification
- E. Registration
- F. Program start date

II. Program Orientation

- A. General information
 - 1. Program policies and procedures
 - a. Attendance
 - b. Dress code
 - c. Disciplinary actions
 - d. Grievance process
 - e. Health
 - f. Student responsibilities
 - g. Student educational rights
 - h. Tuition and fees
 - i. Academic counseling
 - j. Program faculty and staff
 - 2. Curriculum
 - a. General didactic course requirements
 - 1) Course schedule, textbook list
 - 2) Attendance
 - 3) Testing and evaluation
 - 4) Grading criteria
 - b. General clinical course requirements
 - 1) Course schedule

- 2) Attendance
- 3) Rules and regulations
- 4) Supervision
- 5) Testing and evaluation
- c. General laboratory course requirements
 - 1) Course schedule
 - 2) Attendance
 - 3) Rules and regulations
 - 4) Supervision
 - 5) Testing and evaluation
- d. Program completion requirements

B. Other

III. Clinical Education Practicums

- A. General requirements
 - 1. Attendance
 - 2. Dress code
 - 3. Schedules
 - 4. Supervision and preceptors
 - 5. Disciplinary actions
- B. Course requirements
 - 1. Course syllabus
 - 2. Documentation
 - 3. Testing and evaluations
 - 4. Competency requirements
 - 5. Grading criteria

IV. Clinical Education Affiliates

- A. Institutions
- B. Clinical preceptors
- C. Rules and regulations

V. Optional Courses

- A. Current trends in health care providership
- B. Departmental fiscal management
- C. Departmental management skills
- D. Radiology information management systems

Patient Care and Management in Computed Tomography

Patient Care

Course Description

This unit provides a review of the basic elements of patient care including effective communication, patient education and consent for treatment. Patient rights and responsibilities as defined by the American Hospital Association will be examined for clarity.

Objectives

The student will:

1. List and define the elements of patient care.
2. Define communication and list the parameters necessary for effective communication.
3. Understand the use of verbal and nonverbal communication.
4. Explain what is meant by patient education.
5. List and define the types and characteristics of patients.
6. Define consent and list the types.
7. Describe the correct procedure for obtaining patient consent.
8. List the patient's rights and responsibilities.

Content

I. Review of Patient Care Elements

- A. Communication
- B. Education
- C. Evaluation

II. Understanding the Types and Characteristics of Patients

- A. Age-related
- B. Gender-related
- C. Impairment-related
- D. Substance abusers
- E. Seriously ill and traumatized patients
- F. Chronically ill
- G. Terminally ill
- H. Non-English speaking

III. Patient Consent for Treatment

- A. Types of patient consent

- B. Requirements for obtaining consent
 - 1. Ethical
 - 2. Legal

IV. Patient Rights and Responsibilities

- A. "A Patient's Bill of Rights and Responsibilities" – American Hospital Association

- B. Ethical and legal obligations of health care providers

Patient Assessment and Management

Course Description

This unit introduces criteria for obtaining an accurate, thorough and pertinent patient history. Normal patient vital signs are discussed and students are taught to assess each parameter. Medical laboratory tests pertinent to CT will be defined, normal ranges identified and the meaning of abnormal results will be studied. Students also will learn what is meant by "level of consciousness" and how it is determined. Life-threatening situations likely to occur in CT will be discussed and the correct response to each identified.

Objectives

The student will:

1. Describe the correct procedure for a current, accurate and essential patient history.
2. Define vital signs and demonstrate knowledge of how to obtain each parameter.
3. Explain what is meant by normal vital signs and list the normals for each.
4. Define blood urea nitrogen (BUN), creatinine, prothrombin time (PT), partial thromboplastin time (PTT) and platelet count, specify the normal range for each and explain what conditions abnormal values may indicate.
5. Explain why BUN, creatinine, PT, PTT and platelet count values are important in computed tomography.
6. Define level of consciousness and explain how it is determined.
7. List the life-threatening situations that may occur in CT and the correct response to each.

Content

I. Patient History

- A. Elements
 1. Data collection
 2. Patient interview
 3. Questioning skills

II. Patient Vital Signs

- A. Blood pressure
- B. Pulse
- C. Respirations
- D. Temperature
 1. Assessment
 2. Normal ranges

III. Laboratory Tests Pertinent to Computed Tomography

- A. Blood urea nitrogen (BUN)
- B. Creatinine

- C. Prothrombin time (PT)
- D. Partial thromboplastin time (PTT)
- E. Platelet count
 - 1. Normal values
 - 2. Abnormal values
 - a. Indications

IV. Level of Consciousness

- A. Assessment
 - 1. Glasgow Coma Scale

V. Life-Threatening Situations

- A. Cardiac arrest
- B. Contrast media reaction
- C. Cerebrovascular accident (CVA)
- D. Diabetic crises
- E. Deteriorating head injuries
- F. Myocardial infarction
 - 1. Symptoms
 - 2. Response and treatment

Basic Pharmacology

Course Description

This unit introduces the student to drugs commonly used in computed tomography, including contrast media and those used for conscious sedation. The chemical make-up, actions, indications, interactions, dose calculations and administration routes of the drugs will also be studied from both adult and pediatric standpoints. Venipuncture techniques will also be taught. Patient reactions to contrast media will be explored and the medical interventions necessary for treatment provided.

Objectives

The student will:

1. Name the most common types of contrast media used in computed tomography.
2. List indications or contraindications to the use of each type of contrast agent.
3. Describe the chemical make-up of common contrast agents used in CT.
4. List other common drugs used in CT.
5. Explain the indications for administration of other common drugs used in CT.
6. Categorize the common drugs used in CT.
7. Define what is meant by drug interaction.
8. List the routes of administration of common drugs used in CT.
9. Calculate the doseages for both adult and pediatric administration, when provided the names of specific drugs.
10. Categorize patient reactions to contrast media.
11. Describe the medical intervention necessary for each category of contrast media patient reactions.
12. Demonstrate correct venipuncture technique.

Content

I. Common Contrast Media

- A. Intravenous
- B. Oral
- C. Rectal
- D. Other

II. Indications and Contraindications for Contrast Media

- A. Diagnosis
- B. Differentiation
- C. Allergies
- D. Disease processes

III. Chemical Properties of Contrast Media

- A. Intravenous
 - 1. Ionic
 - a. Dimers
 - b. Monomers
 - 2. Nonionic
 - a. Dimers
 - b. Monomers
 - 3. Other
- B. Oral
 - 1. Barium-based
 - 2. Iodine-based
 - 3. Other
- C. Rectal
- D. Other

IV. Common Drugs Other Than Contrast Media

- A. Antianxiety
- B. Sedatives
- C. Pain relief
- D. Antispasmodics
- E. Other

V. Drug Interactions

VI. Routes of Drug Administration

VII. Drug Dose Calculations

- A. Adults
- B. Children

VIII. Contrast Media Reactions

- A. Types
 - 1. Mild
 - 2. Moderate
 - 3. Severe

B. Contrast media reaction treatment

IX. Venipuncture Techniques

Universal Precautions, Aseptic Technique and Radiation Protection

Course Description

This unit covers the application of universal precautions and aseptic technique in computed tomography. Centers for Disease Control and Prevention (CDC) protocols for both these areas will be examined. Sterile technique, handwashing, sterile gloving and gowning will be demonstrated. Proper assisting techniques in sterile situations also are covered. Radiation protection practices governing patients, those who must remain in the CT room during the scanning process and CT technologists are presented. In addition, current CT "spot radiation exposure reduction devices" will be introduced.

Objectives

The student will:

1. Define universal precautions and aseptic technique.
2. List CDC guidelines for the application of universal precautions and aseptic technique.
3. Demonstrate knowledge of aseptic and sterile technique.
4. Demonstrate handwashing techniques.
5. Self-sterile glove and assist another in sterile gloving.
6. Demonstrate proper self-sterile gowning and assisting another to sterile gown.
7. Define radiation protection.
8. List radiation protection practices that reduce radiation exposure to:
 - a. Patient.
 - b. Technologist.
 - c. Other medical personnel.
 - d. Family or friends assisting with procedure.
9. List current "spot radiation protection devices" used in computed tomography.

Content

I. Universal Precautions and Aseptic and Sterile Techniques

- A. CDC guidelines
- B. Aseptic and sterile procedures
 1. Handwashing
 2. Self-gloving
 3. Assisting another in gloving
 4. Self-gowning
 5. Assisting another in gowning

II. Radiation Protection

- A. ALARA concept
- B. Basic radiation protection techniques
 1. Time, distance and shielding
 2. Technical factor selection
 3. Equipment maintenance

- C. Application of basic radiation protection techniques
 - 1. Patient
 - 2. Self
 - 3. Others

III. CT "Spot Radiation Exposure Reduction Devices"

- A. Thyroid
- B. Genitals
- C. Eyes

Computerized Imaging

Course Description

This course provides the student with a basic understanding of computer hardware and software, including terminology and keyboarding skills. Hands-on, in-class computing assignments are used to build the students' skills. Professional aspects of computing such as algorithms, data structure and algorithm complexity will be introduced to assure that all students have the prerequisite knowledge essential to the information presented in CT Physics - Instrumentation and Imaging. The role of computers in computed tomography and digital imaging also will be explained.

Objectives

The student will:

1. Define computer systems and list the fundamental components.
2. Describe the most common types of computers.
3. List and define common terms used in reference to computers and computing applications.
4. Locate and correctly use the alphanumeric and command keys on a personal computer.
5. Demonstrate an understanding of the use and functions of various keyboard-assisting devices such as the track ball, light pen, etc.
6. Define the term algorithm and explain its relationship to data structure (digital imaging).
7. Explain the role of computers in computed tomography.
8. Describe common data storage methods.

Content

I. Computers

- A. General definition
- B. Associated terminology
- C. History
- D. General purpose
- E. Special purpose
- F. Analog
- G. Digital
- H. Hardware
 1. Input devices
 2. Central processing unit (CPU)
 3. Memory
 4. Output devices

I. Software

II. Demonstration and Application

A. Keyboard orientation

B. Peripheral devices orientation

C. Hands-on sessions

III. Applications in Radiology

A. Peripheral devices

B. Analog to digital converter

C. Pixel

D. Matrix

E. Voxel

F. Field size

G. Array processor

H. Laser optics

I. Windowing

IV. The CT Computer

A. Hardware

B. Data acquisition system

C. Software

D. Algorithms

E. Postprocessing techniques

V. Digital Imaging

VI. Laser Imaging

VII. Image Viewing

VIII. Image Archiving

IX. Teleradiology

CT Physics – Instrumentation and Imaging

Prerequisites

Computerized Imaging

Course Description

A thorough understanding of the physical principles involved in computed tomography, as well as instrumentation, is essential to the performance of this continually evolving imaging specialty. As an introduction to the course, the historical development and evolution of computed tomography is reviewed. Physics topics covered include the characteristics of x-radiation, CT beam attenuation, linear attenuation coefficients, tissue characteristics and Hounsfield numbers application. Data acquisition and manipulation techniques, image reconstruction algorithms such as back-projection, filtered back-projection (convolution) and Fourier transform will be explained. Computed tomography systems and operations will be explored with full coverage of radiographic tube configuration, collimator design and function, detector type, characteristics and functions and the CT computer and array processor. CT image processing and display will be examined from data acquisition through postprocessing and archiving system and patient factors related to other elements affecting image quality will be explained, as well as artifact production and reduction.

Objectives

The student will:

1. Describe events leading to the discovery of computed tomography and its evolution.
2. Describe the components of the CT imaging system.
3. List the characteristics of x-radiation.
4. Explain the interaction of x-rays with matter.
5. Explain the configuration of the radiographic tube and its components.
6. Define the heat load capacity of the radiographic tube and explain what it means in both conventional and spiral/helical CT scanning.
7. Explain the functions of collimators in CT.
8. Explain the location and function of detectors used in CT systems.
9. List the types of CT detectors.
10. Explain the most common materials used in CT detectors and how differences in materials affects the way detectors function.
11. Define "attenuation" and list the associated parameters.
12. Define linear attenuation coefficient.
13. Define and describe the functions of the data acquisition system (DAS).
14. List the CT computer data processing steps.
15. Name the functions of the array processor.
16. Define the term "algorithm."
17. Name the current algorithms used in CT.
18. Define the terms "raw data" and "image data."
19. Explain the difference between reconstructing and reformatting an image.

20. Define and explain the correlation between CT and each of the following:
 - a. Pixel
 - b. Matrix
 - c. Voxel
 - d. x, y, z coordinates
 - e. Scan field of view (sfov)
 - f. Display field of view (dfov)
 - g. Linear attenuation coefficient
 - h. CT/Hounsfield number
 - i. Partial volume averaging
 - j. Window width (ww) and window level (wl)
 - k. Spatial resolution
 - l. Contrast resolution
 - m. Noise
 - n. Aliasing
 - o. Digital imaging
 - p. Annotation
 - q. Scanogram
 - r. Region of interest (ROI)
 - s. Standard vs. volumetric data acquisition
 - t. Half-scan, full-scan, overscan
 - u. Interscan delay
 - v. Rays and views
 - w. Sampling (angular and ray)
21. List the selectable scan factors and explain how each affects the CT image.
22. Name the factors affecting image quality in CT.
23. Name the common controls found on CT operator consoles and describe how and why each is used.
24. Describe the steps that may be taken to assure constant high-quality CT images.
25. Define the term "artifact," list the types of artifacts and name and describe the appearance of those most commonly affecting CT images.
26. Explain how artifacts may be eliminated or reduced.
27. Trace the sequence of events in CT scanning from the application of electrical current to the radiographic tube through image display.
28. Name and explain the scanner design that led to the development of spiral/helical CT.
29. Relate differences between conventional and spiral/helical CT scanning.
30. Name and list the characteristics of the two types of "slip-rings" used in spiral/helical CT scanners.
31. Discuss the differences between low-voltage and high-voltage slip-ring CT scanners.
32. Specify the selectable scan factors that affect patient radiation dose and how that dose can be reduced.
33. Name the radiation protection devices that may be used to reduce patient dose in CT and describe the correct application of each.
34. List and describe current data storage techniques used in CT.

Content

I. Historical Development of Computed Tomography

- A. Definition
 - 1. Evolution of terms

- B. Research contributors
 - 1. Radon
 - 2. Hounsfield
 - 3. Ambrose
 - 4. Cormack

- C. Historical events
 - 1. 1917
 - 2. 1967
 - 3. 1970
 - 4. 1971
 - 5. 1973
 - 6. 1974
 - 7. 1989

II. Computed Tomography Generations

- A. First

- B. Second

- C. Third

- D. Fourth

- E. Fifth

III. Characteristics of X-radiation

- A. Sources
 - 1. Natural
 - 2. Artificial

- B. Electromagnetic radiation
 - 1. Ionization
 - 2. Interactions with matter
 - a. Compton effect
 - b. Photoelectric effect
 - 3. Wave particle duality
 - a. Reflection/transmission
 - b. Absorption/attenuation

IV. CT Scanner Components and Operations

- A. Radiographic tube
- B. Filters
- C. Collimators
- D. Detectors
- E. Data acquisition system
- F. Computer and array processor
- G. Consoles
- H. Monitors and archival devices

V. Digital Imaging

- A. Process
 - 1. Scanning
 - 2. Sampling
 - 3. Quantization
- B. Image characteristics
- C. Scan projection radiography
- D. Tube and detector characteristics
- E. Beam configuration
- F. Picture archival and communication systems (PACS)

VI. Computed Tomography Process

- A. Data acquisition
 - 1. Methods
 - a. Slice-by-slice
 - b. Volumetric
 - 2. Elements
 - a. Beam geometry
 - 1) Parallel
 - 2) Fan
 - 3) Spiral
 - 3. Data acquisition system (DAS)
 - a. Components

- 1) Tube
- 2) Detectors
- 3) Filters
- 4) Collimators
- 5) Analog-to-digital converter (ADC)
- b. Functions
 - 1) Measurement of transmitted beam
 - 2) Encoding measurements into binary data
 - 3) Logarithmic conversion of data
 - 4) Transmission of data to computer
4. Data acquisition process
 - a. Scanning/raw data/image data
 - 1) Rays
 - 2) Views
 - 3) Profiles
 - a) Pixels
 - b) Matrices
 - c) Voxels
 - 4) Sampling
 - a) Angular
 - b) Ray
 - b. Attenuation
 - 1) Lambert-Beer law
 - 2) Linear attenuation coefficients
 - 3) CT/Hounsfield numbers
 - c. Selectable scan factors
 - 1) Scan field of view
 - 2) Display field of view
 - 3) Matrix size
 - 4) Slice thickness
 - 5) Window width
 - 6) Window level
 - 7) Algorithm
 - 8) Scan time and rotational arc
 - 9) Radiographic tube output
 - 10) Region of interest (ROI)
 - 11) Magnification
 - 12) Focal spot size and tube geometry

B. Image reconstruction

1. CT computer
 - a. Minicomputer and microprocessors
 - b. Array processors
2. Reconstruction algorithms
 - a. Back-projection

- b. Filtered back-projection (convolution)
 - c. Fourier reconstruction
 - d. 3-D
 - e. Interpolation
- C. Image display, manipulation, recording and archiving
- 1. Display
 - a. Cathode ray tube (CRT)
 - 2. Manipulation
 - a. Image reformation
 - b. Image smoothing
 - c. Edge enhancement
 - d. Gray-scale manipulation
 - e. Three-dimensional processing
 - f. Stereotaxis
 - g. Radiation oncology treatment planning
 - 3. Recording
 - a. Film
 - 1) Multiformat cameras
 - 2) Laser cameras
 - 4. Archiving
 - a. Tapes
 - b. Disks
 - c. Laser and optical

VII. Image Quality in CT

- A. Definition
- B. Determiners
 - 1. Artifacts
 - 2. Contrast resolution
 - 3. Distortion
 - 4. Noise
 - 5. Spatial resolution
- C. Influencing factors
 - 1. Film contrast
 - 2. Focal spot size
 - 3. Geometry
 - 4. Image receptor
 - 5. Motion
 - 6. Subject contrast
 - 7. Viewing conditions

D. Measurements

1. Contrast transfer and response function
2. Line spread function
3. Point spread function
4. Modulation transfer function
5. Full width at half maximum
6. Edge response function

E. Quality control programs in CT

1. Definition of QC
2. Principles
 - a. Regular performance
 - b. Prompt interpretation of results
 - c. Accurate and faithful bookkeeping
3. Common QC tests
 - a. Choosing techniques
 - b. Determining frequency of performance
 - c. Establishing acceptable limits from test results
 - d. Types
 - 1) CT number calibration
 - 2) Standard deviation of CT number in water
 - 3) High-contrast resolution
 - 4) Low-contrast resolution
 - 5) Accuracy of distance measuring device
 - 6) Distortion of video monitor
 - 7) Hard copy output distortion
 - 8) CT number flatness
 - 9) Hard copy output
 - 10) Localization device accuracy
 - 11) CT couch indexing
 - 12) CT couch backlash
 - 13) Light field accuracy
 - 14) Slice width
 - 15) CT number vs. patient position
 - 16) CT number vs. patient size
 - 17) CT number vs. algorithm selection
 - 18) CT number vs. slice width
 - 19) Radiation leakage and scatter
 - 20) Kvp wave form

VIII. Radiation Protection Practices for the CT Patient

- A. Measuring patient radiation dose
 - 1. Methods
 - 2. Procedures

- B. Reducing radiation dose
 - 1. Methods
 - a. Technical factor selection
 - b. Scanner dosimetry survey

IX. Spiral/Helical Computed Tomography

- A. Definition

- B. Historical development

- C. Differences between convention and spiral/helical CT
 - 1. Advantages
 - 2. Disadvantages

- D. Scanner designs
 - 1. High-voltage and low-voltage scanners
 - 2. Slip-ring cylinders and slip-ring disk scanners
 - 3. Composite and wire brush scanners

Sectional Anatomy and Imaging Applications

Course Description

This course begins with a review of gross anatomy of the entire body. Detailed study of gross anatomical structures will be conducted systematically for location, relationship to other structures and function.

Gross anatomical structures are located and identified in axial (transverse), sagittal, coronal and orthogonal (oblique) planes using cadaver cross-section photos. The cadaver photos are subsequently compared with MR, ultrasound and CT images in the same imaging planes and at the same level. The characteristic appearance of each anatomical structure as it appears on CT, MR and ultrasound, when applicable, will be stressed.

Objectives

The student will:

1. Name the anatomical structures located within the head and neck.
2. Describe the relationship of each head and neck anatomical structure to surrounding structures.
3. Describe the function of each anatomical structure in the head and neck.
4. Locate each anatomical structure on CT, MR and ultrasound images in the transverse axial, coronal, sagittal and orthogonal (oblique) cross-sectional imaging planes.
5. Name the anatomical structures located within the thorax.
6. Describe the relationship of each thoracic structure to surrounding structures.
7. Describe the function of each anatomical structure located within the thorax.
8. Locate each anatomical structure of the thorax on CT, MR and ultrasound images in the transverse axial, coronal, sagittal and oblique imaging planes.
9. List and describe the function of each anatomical structure located within the abdomen and pelvis.
10. Describe the relationship of each anatomical structure in the abdomen and pelvis to surrounding structures.
11. Locate each anatomical structure of the abdomen and pelvis on CT, MR and ultrasound images in the transverse axial, coronal, sagittal and oblique planes.
12. Name and describe the function of each anatomical structure located in the upper and lower extremities.
13. Locate each anatomical structure in the upper and lower extremities on CT and MR images in the transverse axial, coronal, sagittal and oblique planes.

Content

I. Head and Brain

- A. Surface anatomy of the brain
 1. Fissures (sulci)
 - a. Longitudinal cerebral
 - b. Lateral (Sylvian)
 - c. Central (of Rolando)

2. Convolutions (gyri)
 - a. Precentral
 - b. Postcentral
- B. Sinuses
1. Frontal
 2. Maxillary
 3. Ethmoidal
 4. Sphenoidal
- C. Facial bones
1. Mandible
 2. Maxillae
 3. Zygomas
 4. Nasal bones
- D. Facial muscles
1. Orbicularis oculi
 2. Orbicularis oris
 3. Masseter
- E. Cranial bones
1. Frontal
 2. Ethmoid
 - a. Nasal conchae (turbinates)
 - b. Nasal septum
 3. Parietal
 4. Sphenoid
 - a. Lesser wings
 - 1) Tuberculum sellae
 - 2) Sella turcica
 - 3) Dorsum sellae
 - 4) Anterior and posterior clinoid process
 - 5) Optic canals
 - b. Greater wings
 - 1) Foramen rotundum
 - 2) Foramen ovale
 - a) Foramen spinosum
 5. Occipital
 - a. Foramen magnum
 - b. Internal and external occipital protuberance
 - c. Jugular foramen
 6. Temporal
 - a. Zygomatic process
 - b. External auditory meatus (EAM)

- c. Mastoid process
 - d. Petrous portion or ridge
- F. Lobes of the brain and midline cerebral hemisphere structures
- 1. Frontal
 - 2. Parietal
 - 3. Occipital
 - 4. Temporal
 - 5. Insula (island of Reil)
 - 6. Cerebellum
 - 7. Corpus callosum (genu, body and splenium)
 - 8. Septum pellucidum
- G. Cranial nerves
- 1. Olfactory
 - 2. Optic
 - 3. Oculomotor
 - 4. Trochlear
 - 5. Trigeminal
 - 6. Abducens
 - 7. Facial
 - 8. Vestibulocochlear
 - 9. Glossopharyngeal
 - 10. Vagus
 - 11. Accessory
 - 12. Hypoglossal
- H. Brainstem
- 1. Diencephalon
 - a. Thalamus
 - b. Hypothalamus
 - c. Optic chiasm
 - d. Optic tracts
 - e. Infundibulum (pituitary stalk)
 - f. Pituitary gland
 - g. Mammillary bodies
 - h. Pineal gland
 - 2. Midbrain
 - 3. Pons
 - 4. Medulla oblongata
 - a. Spinal cord
- I. Arteries (Circle of Willis)
- 1. Vertebral
 - 2. Basilar

3. Internal carotid
4. Anterior and posterior communicating
5. Anterior and posterior cerebral
6. Middle cerebral

J. Veins

1. Venous sinuses
 - a. Superior sagittal sinus
 - b. Vein of Galen
 - c. Straight sinus
 - d. Confluence of sinuses (torcular herophili)
 - e. Transverse sinus
 - f. Sigmoid sinus
2. Internal jugular

K. Ventricular system

1. Lateral ventricles (anterior, body, posterior, inferior or temporal and trigone or atrium)
2. Interventricular foramen (of Monro)
3. Third ventricle
4. Cerebral aqueduct (of Sylvius)
5. Fourth ventricle
6. Foramen of Luschka
7. Foramen of Magendie
8. Choroid plexus

L. Meninges

1. Dura mater
 - a. Extensions of the dura mater
 - 1) Falx cerebri
 - 2) Falx cerebelli
 - 3) Tentorium cerebelli
 - 4) Diaphragma sellae
2. Arachnoid
3. Pia mater
 - a. Epidural
 - b. Subdural

M. Basal ganglia

1. Caudate nucleus
2. Putamen
3. Globus pallidus
4. Claustrum
5. Internal capsule

6. External capsule
7. Extreme capsule

N. Orbit

1. Globe
2. Lens
3. Optic nerve
4. Lateral rectus muscle
5. Medial rectus muscle
6. Superior rectus muscle
7. Inferior rectus muscle
8. Superior oblique muscle
9. Inferior oblique muscle
10. Orbital fat
11. Ophthalmic artery
12. Retinal vein

O. Anatomical structures of brain

1. Vertex
2. Dipole
3. Subcutaneous soft tissue
4. Superior sagittal sinus (anterior and posterior)
5. Central sulcus
6. Interhemispheric fissure
7. Falx cerebri
8. Centrum semiovale
9. Corpus callosum (genu, body and splenium)
10. Septum pellucidum
11. Fornix
12. Sylvian fissure
13. Insula
14. Lentiform nucleus (putamen and globus pallidus)
15. Caudate nucleus (head)
16. Internal capsule (anterior, body and posterior sections)
17. Thalamus
18. External capsule
19. Claustrum
20. Hippocampus
21. Tentorium cerebelli
22. Optic chiasm
23. Optic tract
24. Petrous portion or ridge
25. Cerebellar tonsil
26. Internal auditory canal (IAC)

27. Nasal septum
28. External auditory meatus (EAM)
29. Clivus
30. Mastoid air cells
31. Lines of angulation (imaging baselines)
 - a. Supraorbitomeatal line
 - b. Orbitomeatal line
 - c. Infraorbitomeatal line
32. Anatomical landmarks
 - a. Midsagittal plane
 - b. Glabella
 - c. Nasion
 - d. Acanthion
 - e. Mental point
 - f. Jugular (manubrial) notch

II. Neck

A. Bones

1. Cervical vertebrae

B. Organs

1. Pharynx
2. Larynx
3. Esophagus
4. Trachea
5. Salivary glands
6. Thyroid gland
7. Parathyroid glands
8. Lymph nodes

C. Vasculature and neurovasculature

1. Carotid arteries
2. Vertebral arteries
3. Jugular veins
4. Carotid sheath

D. Musculature

1. Anterior triangle
2. Posterior triangle

III. Chest and mediastinum

A. Bony thorax

1. Thoracic vertebrae
2. Sternum

3. Ribs
4. Costal cartilages
5. Scapulae

B. Pulmonary

1. Apices (lung)
2. Diaphragm
3. Angles
4. Hilum
5. Lobes (lungs)
6. Trachea
7. Carina
8. Primary (mainstem) bronchi
9. Secondary bronchi

C. Mediastinum

1. Thymus gland
2. Heart
3. Aortic arch
4. Branches of the aortic arch
5. Descending (thoracic) aorta
6. Inferior vena cava
7. Esophagus
8. Trachea
9. Thoracic duct
10. Lymph nodes
11. Azygos vein

D. Breasts

E. Musculature

IV. Abdomen

A. Surface landmarks and regions

1. Quadrants
 - a. Upper left
 - b. Upper right
 - c. Lower left
 - d. Lower right

B. Addison's planes (regions)

1. Left hypochondric
2. Epigastric
3. Right hypochondric

4. Left lumbar
5. Umbilical
6. Right lumbar
7. Left iliac
8. Hypogastric
9. Right iliac

C. Branches of the abdominal aorta

1. Anterior visceral branches
 - a. Celiac axis
 - 1) Left gastric
 - 2) Splenic
 - 3) Hepatic
2. Superior mesenteric
 - a. Jejunal and ileal
 - b. Inferior pancreaticoduodenal
 - c. Middle colic
 - d. Right colic
 - e. Ileocolic
3. Inferior mesenteric
 - a. Left colic
 - b. Sigmoid
 - c. Superior rectal
4. Lateral visceral branches
 - a. Suprarenal
 - b. Renal
 - c. Testicular or ovarian
5. Terminal branches
 - a. Common iliacs
 - b. Median sacral

D. Tributaries of the vena cava

1. Anterior visceral
 - a. Hepatic veins
2. Lateral visceral
 - a. Right suprarenal
 - b. Renal veins
 - c. Right testicular or ovarian
3. Tributaries of origin
 - a. Common iliacs
 - b. Median sacral

E. Tributaries of the portal vein

1. Splenic
2. Inferior mesenteric

3. Superior mesenteric
 - a. Left gastric
 - b. Right gastric
 - c. Cystic

F. Abdominal organs and structures

1. Bony structures
 - a. Lumbar vertebrae
2. Abdominal cavity
 - a. Peritoneum
 - b. Peritoneal space
 - c. Retroperitoneum
 - d. Retroperitoneal space
3. Liver
4. Gallbladder and biliary system
5. Pancreas and pancreatic ducts
6. Spleen
7. Adrenal glands
8. Urinary system and tract
 - a. Kidneys
 - b. Ureters
9. Stomach
10. Small intestine
11. Colon
12. Musculature

V. Pelvis

A. Bony structures

1. Proximal femur
2. Ilium
3. Ischium
4. Pubis
5. Sacrum
6. Coccyx

B. Pelvic vasculature

1. Arterial
 - a. Common iliacs
 - b. Internal iliacs
 - c. External iliacs
 - d. Femoral
2. Venous
 - a. Femoral
 - b. External iliacs

- c. Internal iliacs
- d. Common iliacs

C. Pelvic organs

1. Urinary bladder
 - a. Ureter
 - b. Urethra
2. Small intestine
 - a. Terminal ilium and ileocecal valve
3. Colon
 - a. Ascending
 - b. Transverse
 - c. Descending
 - d. Sigmoid
 - e. Rectum
 - f. Veriform appendix
4. Female reproductive organs
 - a. Vagina
 - b. Cervix
 - c. Uterus
 - d. Ovaries
5. Males reproductive organs
 - a. Penis
 - b. Testes
 - c. Prostate gland
 - d. Seminal vesicles

VI. Musculoskeletal

A. Upper extremities

1. Shoulder
 - a. Bony anatomy
 - 1) Clavicle
 - 2) Scapula
 - 3) Humerus
 - 4) Acromioclavicular joint
 - b. Muscles and tendons
 - 1) Deltoid
 - 2) Supraspinatus
 - 3) Infraspinatus
 - 4) Teres minor
 - 5) Subscapularis
 - 6) Supraspinatus tendon
 - 7) Biceps tendon

- c. Labrum and ligaments
 - 1) Glenoid labrum
 - 2) Glenohumeral ligaments
 - 3) Coracoacromial ligament
 - 4) Coracoclavicular ligaments
 - 5) Bursa (subacromial and subdeltoid)
- 2. Elbow
 - a. Bony anatomy
 - 1) Humerus
 - 2) Radius
 - 3) Ulnar
 - b. Muscles and tendons
 - 1) Anterior group
 - 2) Posterior group
 - 3) Lateral group
 - 4) Medial group
 - c. Ligaments
 - 1) Ulnar collateral
 - 2) Radial collateral
 - 3) Annular
 - d. Neurovasculature
 - 1) Brachial artery
 - 2) Radial artery
 - 3) Ulnar artery
 - 4) Basilic vein
 - 5) Cephalic vein
 - 6) Median cubital vein
 - 7) Ulnar nerve
- 3. Hand and wrist
 - a. Bony anatomy
 - 1) Carpal bones
 - 2) Radius
 - 3) Ulnar
 - b. Tendons
 - 1) Palmar tendon group
 - 2) Dorsal tendon group
 - 3) Triangular fibrocartilage complex
 - c. Neurovascular
 - 1) Ulnar artery
 - 2) Ulnar nerve
 - 3) Radial artery
 - 4) Median nerve

B. Lower Extremities

1. Hip

- a. Bony anatomy
- b. Labrum and ligaments
- c. Muscle groups
- d. Neurovasculature

2. Knee

- a. Bony anatomy
- b. Menisci and ligaments
- c. Muscles
- d. Vasculature

3. Foot and Ankle

- a. Bony anatomy
- b. Ligaments
- c. Tendons
- d. Muscles

Professional Ethics and Law

Course Description

Course content helps the student become familiar with the history of ethics, ethical theories and theorists and how personal values shape professional ethical choices. How personal and professional ethics are developed and the role they play in professional conduct and decision-making processes also will be stressed. A detailed discussion of professional codes of ethics provides the opportunity for comparison of codes pertinent to the medical imaging professions. Types of ethical problems common to medical imaging and other health professions will be introduced, defined and discussed and orderly methods for finding solutions will be applied. Ethical and legal issues surrounding patient rights and responsibilities, confidentiality, impaired colleagues, charting and documentation, research, special populations, euthanasia (active and passive) and the allocation of scarce resources will also be studied. The "Practice Standards" and "Scopes of Practice" that govern the medical imaging professions will be examined in detail. Other relevant topics may be included as necessary.

Objectives

The student will:

1. Define
 - a. Ethics and ethical
 - b. Bioethics and biomedical ethics
 - c. Morals and morality
 - d. Values
 - e. Values clarification
 - f. Theory and ethical theory
 - g. Universal ethical principles
 - h. Law, legal and illegal
2. Clarify his or her personal values.
3. Differentiate ethical issues from those of etiquette, common sense, common law and law.
4. List and define the traditional ethical theories and name the theorists who developed them.
5. State the purpose and intent of professional codes of conduct.
6. Compare and contrast codes of ethics pertinent to the medical imaging professions.
7. List and define each of the "universal ethical principles" and relate them to medical imaging codes of ethics and to professional practice.
8. Name and define the types of ethical problems .
9. Construct an ethical case study in which one or more ethical problem exists.
10. Name at least two ethical problem-solving techniques and list the steps in each.
11. Apply an ethical problem-solving technique to examples of each type of ethical problem discussed in class.
12. List the ethical and legal issues surrounding the following:
 - a. Patient rights and responsibilities
 - b. Working with impaired colleagues
 - c. Whistleblowing
 - d. Charting and documentation

- e. Imaging special populations
 - f. Active and passive euthanasia
 - g. Allocation of scarce resources
 - h. Managed care
 - i. Failure to abide by the ARRT Standards of Ethics
 - j. Breach of patient duty
 - k. Medical malpractice
13. Name the most common reasons for litigation against medical imaging professionals and steps that may be taken to avoid litigation for those reasons.
14. List the steps taken in medical malpractice determinations.
15. List and define the legal doctrines that may be applicable in medical malpractice.
16. Define and list the elements of "Practice Standards" and "Scopes of Practice."

Content

I. Terminology

- A. Ethics and ethical

- B. Bioethics and biomedical ethics

- C. Morals and morality

- D. Values

- E. Values clarification

- F. Theory and ethical theory

- G. Universal ethical principles

- H. Law, legal and illegal

- I. Personal values

- J. Sources
 - 1. Culture
 - 2. Education
 - 3. Religion
 - 4. Science

- K. Values clarification

- L. Personal values vs. professional ethics

II. Ethical Theories and Theorists

- A. Deontology
 - 1. Act
 - 2. Rule
 - a. Categorical imperative
 - b. Prima facie duties
 - c. Maximin principle of justice
 - d. Natural law ethics
 - 1) Principles

- B. Teleology
 - 1. Egoism
 - a. Impersonal
 - b. Personal
 - 2. Utilitarianism
 - a. Act
 - b. Rule

- C. Bioethics
 - 1. Macroethics
 - 2. Microethics

III. Professional Codes of Ethics and Conduct

- A. Intent and purpose

- B. ARRT Standards of Ethics

- C. ARRT/ASRT Code of Ethics

- D. Comparison and contrast among medical imaging codes
 - 1. ARRT/ASRT
 - 2. ARDMS
 - 3. SNM-TS

IV. Universal Ethical Principles

- A. Autonomy

- B. Beneficence

- C. Confidentiality

- D. Justice

- E. Nonmaleficence

F. Role fidelity

G. Varacity

V. Ethical Problems

A. Ethical dilemma

B. Ethical dilemma of justice

C. Ethical distress

D. Locus of authority issue

VI. Ethical Problem-Solving Techniques

A. Models

VII. Case Studies

A. Identification of problem types

B. Application of problem-solving techniques

VIII. Concepts of Basic Law

A. Sources of law

B. Judicial system and trial process

C. Civil and criminal liabilities

D. Legal doctrines

IX. Medical Legal Issues

A. Practice Standards

B. Scopes of Practice

C. Malpractice

D. Confidentiality

E. Charting and documentation

X. Ethical and Legal Case Studies

A. Issues

B. Solutions

Pathology Correlation in Computed Tomography

Prerequisites

Patient Care and Management in Computed Tomography
Computerized Imaging
CT Physics – Instrumentation and Imaging
Sectional Anatomy and Imaging Applications

Course Description

This course provides thorough coverage of common diseases and trauma associated with the body systems. Each disease or trauma process is examined from its description, etiology, associated symptoms and diagnosis. Emphasis is placed on the characteristic manifestations of these pathologies on CT images. Common terminology associated with pathology will also be reviewed.

Objectives

The student will:

1. Define common terms used in the study of pathology.
2. Name the common pathological conditions affecting any of the body systems studied in this course.
3. For each common pathological condition identified in the course:
 - a. Describe the disorder.
 - b. List the etiology.
 - c. Name the associated symptoms.
 - d. Name the common means of diagnosis.
 - e. List characteristic CT manifestations of the pathology.
4. Identify each of the pathological conditions studied on CT images.
5. Identify pathology resulting from trauma on CT images.
6. Identify pathology common only in pediatric patients.

Content

I. Autoimmune system

- A. Acquired immune deficiency syndrome
- B. Systemic lupus erythematosus

II. Cardiovascular system

- A. Cardiomegaly
- B. Aortic aneurysm
- C. Aortic dissection

D. Congenital malformations

E. Cardiac transplant

III. Central Nervous System

A. Tumors (benign and malignant)

1. Glioma
2. Lipoma
3. Meningioma
4. Cholesteatoma
5. Acoustic neuroma
6. Pineal
7. Pituitary

B. Arteriovenous malformation (AVM)

C. Transient ischemic attack (TIA)

D. Metastases

E. Hematoma

1. Subdural
2. Epidural

F. Hemorrhage

G. Hydrocephalus

H. Cysts

I. Infarct

J. Infections

1. Encephalitis
2. Meningitis
3. Abscess

K. Trauma

L. Atrophic and degenerative disorders

1. Multiple sclerosis
2. Alzheimer disease
3. Parkinson disease

- M. Spine
 - 1. Tumors
 - 2. Stenosis
 - 3. Disk herniation
 - 4. Spondylitis
 - 5. Astrocytoma
 - 6. Congenital abnormalities
 - 7. Trauma

IV. Circulatory and Lymph System

- A. Leukemia

- B. Lymphoma (Hodgkin and non-Hodgkin)

- C. Lymphosarcoma

V. Respiratory System

- A. Masses (benign and malignant)

- B. Pneumonia

- C. Emphysema

- D. Pulmonary edema

- E. Bronchiectasis

- F. Metastases

- G. Acute respiratory distress syndrome

- H. Pulmonary fibrosis

- I. Hemothorax and pneumothorax

- J. Trauma

VI. Gastrointestinal System

- A. Primary neoplasms

- B. Metastases

- C. Tumors

- D. Abscesses

- E. Cysts
- F. Ascites
- G. Splenomegaly
- H. Splenic infarction
- I. Pancreatic carcinoma
- J. Pancreatic pseudocyst
- K. Small and large bowel obstruction
- L. Gastric carcinoma
- M. Esophageal cancer
- N. Polycystic disease
- O. Congenital abnormalities
- P. Trauma

VII. Genitourinary System

- A. Masses (benign and malignant)
- B. Primary neoplasms
- C. Metastases
- D. Cysts
- E. Infection
- F. Polycystic disease
- G. Bladder cancer
- H. Adenocarcinoma
- I. Ovarian cancer
- J. Endometrial cancer

- K. Prostate cancer
- L. Seminoma
- M. Testicular cancer
- N. Renal transplant
- O. Congenital abnormalities
- P. Trauma

VIII. Hepatobiliary System

- A. Masses (benign and malignant)
- B. Hemangioma
- C. Cirrhosis
- D. Gallbladder carcinoma
- E. Hemochromatosis
- F. Biliary obstruction
- G. Congenital abnormalities
- H. Trauma

IX. Musculoskeletal System

- A. Osteosarcoma
- B. Osteoporosis
- C. Masses (benign and malignant)
- D. Osteogenesis imperfecta
- E. Metastases
- F. Trauma
- G. Arthritis

X. Pediatric Pathologies

A. Congenital abnormalities

B. Seizures

C. Vascular problems

D. Inflammation

E. Tumors

F. Pulmonary diseases

G. Orthopedic

H. Osteogenesis imperfecta

Scientific Inquiry, Presentation and Publication

Course Description

This course explores common methods of conducting scientific research, statistical analysis of research data and oral and written presentation of research findings. Under the direction and supervision of the instructor, each student will select a research topic or project, methodically gather, analyze, format and present data, with audiovisuals, to the class. The data also will be prepared in manuscript form and submitted to a professional journal for publication. The manuscript will be written according to the author guidelines of the journal to which it is submitted. All students must submit a manuscript.

Objectives

Students will:

1. Describe the most common methods of conducting scientific research.
2. Gather data on specific research topics.
3. Perform statistical analysis of research data.
4. Prepare research findings for oral presentation, including audiovisuals such as slides and overhead transparencies.
5. Prepare data in manuscript form for submission to a peer-reviewed journal according to the established guidelines of the selected journal.
6. Submit manuscript to journal.

Content

I. Topic Identification

II. Literature Review

III. Refining the Research Question

IV. Research Methods

V. Data Collection

VI. Data Analysis

VII. Results and Conclusions

VIII. Writing, Publishing and Presentations

CT Procedure Protocols

Procedure Protocols I: Head and Neck

Prerequisites

Patient Care and Management in Computed Tomography
Computerized Imaging
CT Physics – Instrumentation and Imaging
Sectional Anatomy and Imaging Applications
Pathology Correlation in Computed Tomography

Course Description

This course provides thorough coverage of CT procedures for imaging structures located in the head and neck. CT protocols will be taught for differentiation of specific structures, patient symptomology and pathology. Patient history, education and preparation, contrast media type, amount and administration route, patient positioning and orientation, scout image, scan parameters and filming will be covered. CT images from each procedure protocol studied will be reviewed for quality, anatomy and pathology. The course complements CT Clinical Education Practicum I by providing the didactic information for integration into clinical practice and concentrating study on the clinical practicum "focus areas." This affords students the benefit of having the same general CT procedure information with specifics stressed in the clinical arena. CT procedure protocols vary from facility to facility and are normally dependent on the preferences of the radiologists.

Objectives

The student will:

1. List the CT scanner and scan room preparation steps necessary for CT procedures of the head and neck.
2. Name the indicated CT procedure for specific anatomical structures, patient symptoms or pathology associated with the head and neck.
3. Educate the patient on the general aspects of CT and the specifics of the CT procedure.
4. Name the patient preparation required for each protocol.
5. Determine if contrast media is indicated for a specific protocol and if indicated, name the type and specify the dosage and route of administration.
6. Determine from patient medical laboratory results, patient history and charted information if the use of contrast media is contraindicated and explain why.
7. Describe the conditions that require a patient to grant informed consent in writing for a CT procedure.
8. List the range, azimuth, anatomical landmarks, patient orientation and position and technical factors used to produce scout and scan images for a given head or neck protocol.
9. Provide correct information concerning the scan field of view (sfov), display field of view (dfv), mode, algorithm, gantry angle, technical factors, range, table incrementation and slice thickness (z-axis) selection for each procedure protocol.

10. List accurate window width (ww) and window level (wl) selections for each head and neck procedure protocol.
11. Explain why different window width and levels are selected.
12. List the required imaging planes for each procedure.
13. Determine the correct matrix size selection for each head and neck protocol studied.
14. List the information that should be noted on each scout and scan image.
15. Name the routine filming format for each head and neck protocol studied.
16. Perform any nonroutine procedure tasks associated with CT protocols for the head and neck.
17. Adapt routine scanning parameters for CT procedures of the head and neck to spiral/helical mode and explain the differences.

Content

I. CT Equipment Overview

II. Patient Care, Education and Management Review

III. Head and Neck Anatomy Review

- A. Bones
- B. Organs, structures and glands
- C. Musculature
- D. Vasculature
- E. Nerves

IV. Head and Neck Procedure Protocols

- A. Indications for each protocol
- B. Contraindications for each protocol
- C. Indications for contrast media[`]
 1. Types of contrast media
- D. Contraindications for contrast media
- E. Informed consent requirements
- F. Patient preparation and postprocedure instructions
- G. Protocol parameters
 1. Range
 2. Azimuth
 3. Anatomical landmarks

4. Patient orientation
5. Patient position
6. Scout image parameters
7. Scan field of view
8. Display field of view
9. Mode
10. Algorithm
11. Gantry angle
12. Technical factor selection
13. Range
14. Table indexing
15. Z-axis selection
16. Window level
17. Window width
18. Matrix size
19. Image annotation parameters
20. Imaging planes
21. Spiral/helical application
22. Filming format
23. Image archiving
24. Identification of pathology
25. Charting and documentation requirements
26. Other

Protocols studied in this course include, but are not limited to the following:

- CT head (brain, sella turcica, ventricles, etc.) without contrast
- CT head with contrast
- CT head for craniofacial deformities
- CT head for trauma
- CT head for circulus arteriosus cerebri (circle of Willis)
- CT head for seizure
- CT head for thalamus and hypothalamus
- CT head for pituitary gland
- CT head to rule out metastasis
- CT head for multiple sclerosis
- CT head for pineal gland
- CT head for optic nerve
- CT head for ophthalmic artery and retinal vein
- Maxillofacial CT (orbits, nasal bones, facial bones, temporomandibular joints, etc.)
- CT facial bones for trauma
- CT paranasal sinuses
- CT temporal bone (internal auditory canals, posterior fossa, base of skull, etc.)
- Spiral/helical head with or without contrast
- CT neck (nasopharynx, larynx, parotid glands, etc.) with or without contrast

CT neck (spine, submandibular glands, vascular structures, etc.) with contrast
CT neck for thyroid and parathyroid glands
Stereotaxis
Spiral/helical neck
Others as determined by program and clinical faculty

Procedure Protocols II: Thorax, Spine and Musculoskeletal System

Prerequisites

Patient Care and Management
Computerized Imaging
CT Physics – Instrumentation and Imaging
Sectional Anatomy and Imaging Applications
Pathology Correlation in Computed Tomography
CT Protocols I

Course Description

This course provides detailed coverage of CT procedure protocols of the thorax, spine and musculoskeletal system. Protocols include, but are not limited to, indications for the procedure, patient education, preparation, orientation and positioning, patient history and assessment, contrast media usage, scout image, selectable scan parameters, filming and archiving of the images. This course stresses CT Clinical Education Practicum II focus areas and should be taught concurrently.

Objectives

The student will:

1. List the equipment preparation necessary for performing the procedure.
2. List the scan room preparation for each procedure protocol of the thorax, spine and musculoskeletal system presented in this course.
3. Determine the CT procedure indicated for specific anatomical structures, patient symptoms or pathology associated with the thorax, spine or musculoskeletal system.
4. Educate the patient on the general aspects of CT and the specifics of each procedure.
5. List the patient prep required for each procedure protocol.
6. Describe the conditions in which a patient must give informed consent in writing for a CT procedure.
7. Determine if contrast media is indicated for a specific protocol.
8. Determine the type, amount and route of administration if contrast media is indicated.
9. Determine from patient laboratory results, patient history and charted information if contrast media is contraindicated and explain why.
10. List the range, azimuth, anatomical landmarks, patient orientation and position and the technical factors used to produce scout images for each procedure protocol.
11. Provide correct information concerning scan field of view (sfov), display field of view (dfov), mode, algorithm, gantry angle, technical factors, range, table incrementation and slice thickness (z-axis) selection for each procedure protocol.
12. List accurate window width (ww) and window level (wl) settings for each procedure protocol.
13. Explain why different window width and level settings are used.
14. Determine the correct matrix size selection for each protocol.
15. List the information which should be annotated on each scout and scan image.
16. Name the routine filming format for each procedure protocol.
17. List the required imaging planes for each procedure.

18. List the nonroutine procedure tasks associated with procedure protocols of the thorax, spine and musculoskeletal system.
19. Differentiate between scanning parameters for routine CT procedure vs. spiral/helical protocols.
20. Explain current trends in CT image archiving.
21. List postprocedure patient instructions for each procedure protocol.

Content

I. Thorax, Spine and Musculoskeletal System Anatomy Review

- A. Bones
- B. Organs, structures and glands
- C. Musculature
- D. Vasculature
- E. Nerves

II. Procedure Protocols

- A. Indications for each protocol
- B. Contraindications for each protocol
- C. Indications for contrast media
 1. Types of contrast media
- D. Contraindications for contrast media
- E. Informed consent requirements
- F. Patient preparation and postprocedure instructions
- G. Protocol parameters
 1. Range
 2. Azimuth
 3. Anatomical landmarks
 4. Patient orientation
 5. Patient position
 6. Scout image parameters
 7. Scan field of view
 8. Display field of view
 9. Mode
 10. Algorithm
 11. Gantry angle

12. Technical factor selection
13. Range
14. Table indexing
15. Z-axis selection
16. Window level
17. Window width
18. Matrix size
19. Image annotation parameters
20. Imaging planes
21. Spiral/helical application
22. Filming format
23. Image archiving
24. Identification of pathology
25. Charting and documentation requirements
26. Other

Protocols studied in this course include, but are not limited to the following:

- CT thorax without contrast
- CT thorax with contrast
- CT thorax for mediastinal structures (with or without contrast)
- CT thorax (bone windows)
- CT thorax (lung windows)
- CT thorax for aortic dissection
- CT thorax for pulmonary embolism
- CT sternum
- CT thorax for thymus gland
- CT thorax (thoracic lymph nodes) for disease staging
- CT thorax (trauma)
- Spiral/helical CT thorax
- CT cervical spine
- CT thoracic spine
- CT lumbar spine
- CT spine (cervical, thoracic or lumbar) postmyelogram
- CT spine (trauma)
- Spiral/helical CT spine
- CT upper extremity
- CT lower extremity
- CT soft tissue extremity
- CT pelvic girdle
- CT extremity (trauma)

Procedure Protocols III: Abdomen, Pelvis and Special Applications

Prerequisites

Patient Care and Management
Computerized Imaging
CT Physics – Instrumentation and Imaging
Sectional Anatomy and Imaging Applications
Pathology Correlation in Computed Tomography
CT Protocols I & II

Course Description

This course provides detailed knowledge of procedure protocols of the abdomen, pelvis and special applications of CT. Procedure protocols include, but are not limited to, indications for the procedure, patient preparation, education, patient history and assessment, orientation and positioning, contrast media usage, scout and scan factor parameters and filming and archiving of images. The content of this course is the same as the focus areas of CT Clinical Education Practicum III. The two are complementary and should be offered concurrently.

Objectives

The student will:

1. List the required CT scanner and scan room preparations for each procedure protocol presented in this course.
2. Determine the procedure protocol indicated for specific anatomical structures, patient symptoms or pathology associated with the abdomen, pelvis and special applications.
3. Educate the patient on the general aspects of CT and specifics for each protocol.
4. List the patient preparation required for each procedure protocol.
5. Determine if contrast media is indicated for a specific procedure protocol, and if indicated, list the type, amount and route of administration.
6. Describe the conditions that require a patient to give informed consent in writing prior to a CT procedure.
7. List the reasons that contrast media may be contraindicated and explain why.
8. List the range, azimuth, anatomical landmarks, patient orientation and position and technical factors used to produce scout images for each procedure protocol.
9. Provide correct information concerning scan field of view (sfov), display field of view (dfov), mode, algorithm, gantry angle, technical factors, range, table incrementation, slice thickness (z-axis) selection and patient breathing instructions for each procedure protocol.
10. List accurate window width (ww) and window level (wl) settings for each procedure protocol.
11. Determine the correct matrix size selection for each procedure protocol.
12. List the information that should be noted on each CT scan and scout image.
13. Name the routine filming format for each of the procedure protocols discussed in this course.
14. List all nonroutine procedure tasks associated with the procedure protocols in this course.
15. List the required imaging planes for each procedure.

16. Explain the differences between routine CT and spiral/helical procedure protocols.
17. List the postprocedure patient instructions for each procedure.

Content

I. Abdomen, Pelvis and Special Applications Anatomy Review

- A. Bones
- B. Organs, structures and glands
- C. Musculature
- D. Vasculature
- E. Nerves

II. Procedure Protocols

- A. Indications for each protocol
- B. Contraindications for each protocol
- C. Indications for contrast media
 1. Types of contrast media
- D. Contraindications for contrast media
- E. Informed consent requirements
- F. Patient preparation and postprocedure instructions
- G. Protocol parameters
 1. Range
 2. Azimuth
 3. Anatomical landmarks
 4. Patient orientation
 5. Patient position
 6. Scout image parameters
 7. Scan field of view
 8. Display field of view
 9. Mode
 10. Algorithm
 11. Gantry angle
 12. Technical factor selection
 13. Range
 14. Table indexing
 15. Z-axis selection

16. Window level
17. Window width
18. Matrix size
19. Image annotation parameters
20. Imaging planes
21. Spiral/helical application
22. Filming format
23. Image archiving
24. Identification of pathology
25. Charting and documentation requirements
26. Other

Protocols studied in this course include, but are not limited to the following:

- CT abdomen without contrast
- CT abdomen with contrast
- CT abdomen for pancreas
- CT abdomen for liver
- CT abdomen for renal system
- CT abdomen for adrenal glands
- CT abdomen for aortic dissection
- CT abdomen for vascular structures
- CT abdomen for spleen
- CT abdomen for gastrointestinal system
- CT gallbladder
- CT abdomen for suspected appendicitis
- CT abdominal lymph nodes (disease staging)
- CT abdomen to rule out metastasis
- CT abdomen (trauma)
- Spiral/helical abdomen
- CT pelvis without contrast
- CT pelvis for female genitourinary system
- CT pelvis for male genitourinary system
- CT pelvimetry
- CT scrotum
- Spiral/helical pelvis

CT Synthesis Seminar

Prerequisite

CT Curriculum Courses

Course Description

This course is a basic review of all material presented during the preceding terms. Following each course review, students will be tested for retention of course content knowledge. After all instructors have reviewed and tested the students, three comprehensive examinations will be given.

This course allows students to identify areas of poor knowledge retention and remedy the situation. The three comprehensive examinations include the areas listed in the "Content Specifications for the Examination in Computed Tomography" published by the American Registry of Radiologic Technologists (ARRT). This prepares the student for the advanced certification examination by:

1. Reinforcing knowledge.
2. Allowing early identification of areas requiring additional study.
3. Decreasing test anxiety through repetitive testing and format familiarity.

This course is designated pass/fail. Expected student attendance and scores above 75 on the three comprehensive examinations (or continued increasing scores) constitutes a "pass" grade.

Objectives

The student will:

1. Recall content information from each course in the curriculum.
2. Determine areas of knowledge that need strengthening.
3. Systematically strengthen weak areas.
4. Feel comfortable with taking standardized examinations.
5. Use the material presented in this course to assist in preparation for the CT certification examination.

Content

I. Patient Care and Management in Computed Tomography

A. Pretest

B. Post-test

II. Computerized Imaging

A. Pretest

B. Post-test

- III. CT Physics - Instrumentation and Imaging**
 - A. Pretest
 - B. Post-test
- IV. Sectional Anatomy and Imaging Applications**
 - A. Pretest
 - B. Post-test
- V. Professional Ethics and Law**
 - A. Pretest
 - B. Post-test
- VI. Pathology Correlation in Computed Tomography**
 - A. Pretest
 - B. Post-test
- VII. Procedure Protocols I**
 - A. Pretest
 - B. Post-test
- VIII. Procedure Protocols II**
 - A. Pretest
 - B. Post-test
- IX. Procedure Protocols III**
 - A. Pretest
 - B. Post-test
- X. Comprehensive Examination #1**
 - A. Assessment and review
- XI. Comprehensive Examination #2**
 - A. Assessment and review
- XII. Final Comprehensive Examination**

Practicum I: Head and Neck

Suggested Credit Hours

4-5 semester hours (160-210 contact hours)

Prerequisites

Patient Care and Management in Computed Tomography
Computerized Imaging
CT Physics - Instrumentation and Imaging
Sectional Anatomy and Imaging Applications
Pathology Correlation in Computed Tomography

Course Description and Content

This course is taught in the clinical setting and requires application, with moderate to close supervision, of information from previous and concurrent didactic courses. This is the first in a series of three clinical practicums, each corresponding to a didactic CT procedure protocol course and each having specific focus areas. While all three clinical education practicums are designed so that the student will observe, assist with and perform basic patient care and a variety of technological procedures, CT protocols and procedures of the head and neck are the focus areas of this clinical education course. The student will be required to demonstrate competency in numerous CT head and neck procedures. The number of required competency evaluations will be determined by program and clinical affiliate personnel.

Evaluation will occur in the affective, cognitive and psychomotor domains. The affective domain may be evaluated using the Clinical Behavior Characteristics Form. The cognitive and psychomotor domains will be evaluated using the parameters established for the CT clinical procedure competency evaluations. Competency will be assessed in patient care, instrumentation, protocol knowledge and actual scanning procedures of the head and neck. Although no formal mandatory clinical competency requirements presently exist in CT, the ARRT is in the process of establishing competency requirements for the advanced certification examination. Implementation of these requirements is scheduled for 2000. With these requirements in mind, the student should be evaluated for competency in the following head and neck CT procedures (focus areas):

- CT head (brain, sella turcica, ventricles, etc.) without contrast
- CT head with contrast
- CT head for craniofacial deformities
- CT head for trauma
- CT head for circulus arteriosus cerebri (circle of Willis)
- CT head for seizure protocol
- CT head for thalamus and hypothalamus
- CT head for pituitary gland
- CT head to rule out metastasis
- CT head for multiple sclerosis

CT head for pineal gland
CT head for optic nerve
CT head for ophthalmic artery and retinal vein
Maxillofacial CT (orbits, nasal bones, facial bones, tempromandibular joints, etc.)
CT facial bones for trauma
CT paranasal sinuses
CT temporal bone (internal auditory canals, posterior fossa, base of skull, etc.)
Spiral/helical head with or without contrast
CT neck (nasopharynx, larynx, parotid glands, etc.) with or without contrast
CT neck (spine, submandibular glands, vascular structures, etc.) with contrast
CT neck for thyroid and parathyroid glands
Stereotaxis
Spiral/helical CT neck
Others as determined by program and clinical faculty

The number of required competencies is determined by the program faculty.

Objectives

The student will:

1. Perform scanner-on (boot-up) and warm-up, scan abort, emergency equipment shutdown and scanner-off procedures properly.
2. Communicate effectively and efficiently with the CT patient.
3. Provide patient education on the general aspects of CT and patient-specific procedures.
4. Obtain adequate patient history.
5. Locate pertinent information in the patient chart.
6. Analyze patient history, other information and pertinent laboratory procedure results and notify radiologist of findings.
7. Prepare the patient for the CT procedure correctly.
8. Prepare the scan room for the scheduled procedure correctly.
9. Prepare contrast media, if required, for the procedure including correctly loading, defining dose parameters and arming the automatic injector.
10. Identify patient reactions to contrast media and determine the steps necessary to treat reactions when required.
11. Position the patient for performance of the requested procedure.
12. Select the correct scan factors for the requested procedure on the operator's console.
13. Perform the scout image for the CT procedure correctly.
14. Perform a specific CT head and neck procedure accurately and independently.
15. Identify anatomy on CT images of the head and neck, noting normal vs. abnormal anatomy.
16. Film the CT procedure accurately and properly archive the images.
17. Provide postprocedure instructions and discharge the patient.
18. Document required information in the medical record.

Practicum II: Thorax, Spine and Musculoskeletal System

Suggested Credit Hours

4-5 semester hours (160-210 contact hours)

Prerequisites

Patient Care and Management in Computed Tomography
Computerized Imaging
CT Physics – Instrumentation and Imaging
Sectional Anatomy and Imaging Applications
Pathology Correlation in Computed Tomography
CT Procedure Protocols I
CT Clinical Education Practicum I

Course Description and Content

The second in a sequence of three clinical courses, Practicum II further refines skills mastered by the student and introduces additional focus areas: the thorax, spine and musculoskeletal system. Protocols for these areas are taught concurrently in CT Procedure Protocols II. This course integrates knowledge gained in preceding courses with that currently being introduced. Clinical Education Practicum II requires the student to be evaluated for competency in selected CT procedures of the head and neck with the addition of the thorax, spine and musculoskeletal system. This assures that the student continues to demonstrate competency in the preceding clinical practicum focus area while learning and becoming competent in current focus areas. The number of required clinical competency evaluations performed will be determined by program and clinical affiliate personnel.

Students will be evaluated in the affective, cognitive and psychomotor domains. It is suggested that two to three affective domain evaluations be submitted for each student by the clinical instructor. The scores from each should be averaged for the final affective domain grade.

The cognitive and psychomotor domains will be evaluated using clinical procedure competency evaluations. Competency will be assessed in patient care, instrumentation, protocol knowledge and actual scan performance.

Students may be evaluated for competency in the following Clinical Education Practicum II focus areas. For head and neck competency suggestions, refer to the Clinical Education Practicum I focus area.

CT thorax without contrast
CT thorax with contrast
CT thorax for mediastinal structures (with or without contrast)
CT thorax (bone windows)
CT thorax (lung windows)
CT thorax for aortic dissection

CT thorax for pulmonary embolism
CT sternum
CT thorax for thymus gland
CT thorax (thoracic lymph nodes) for disease staging
CT thorax (trauma)
Spiral/helical CT thorax
CT cervical spine
CT thoracic spine
CT lumbar spine
CT spine (cervical, thoracic or lumbar) postmyelogram
CT spine (trauma)
Spiral/helical CT spine
CT upper extremity
CT lower extremity
CT soft tissue extremity
CT pelvic girdle
CT extremity (trauma)

The actual number of competencies is determined by program and clinical faculty.

Objectives

The student will:

1. Perform scanner-on (boot-up), warm-up, scan abort, emergency equipment shutdown and scanner-off procedures.
2. Communicate effectively and efficiently with the CT patient.
3. Provide patient education concerning general aspects of CT and patient-specific procedures.
4. Locate pertinent information in the patient chart.
5. Analyze pertinent laboratory procedure results.
6. Obtain adequate patient history prior to the CT procedure.
7. Notify radiologist of findings from patient history, laboratory tests and the chart.
8. Prepare the patient for the procedure correctly.
9. Prepare the scan room for the procedure, including setting any gantry-controlled scan parameters.
10. Prepare contrast media if required per procedure protocol, including correctly identifying type of contrast, route of administration, dose parameters and loading and arming power injector if necessary.
11. Identify patient reactions to contrast media and steps taken in treating reactions.
12. Position the patient correctly for the procedure.
13. Select the correct scan factors for the requested procedure on the operator's console.
14. Produce the scout image accurately.
15. Perform CT procedure independently after observing and assisting with other procedures.
16. Perform the number of required clinical competencies in the course focus areas for this practicum and those required from the preceding focus areas.
17. Identify normal anatomy and pathology on the CT images accurately.

18. Film the procedure and archive the images correctly.
19. Provide postprocedure instructions and discharge the patient.
20. Document required information in the patient's medical record.

Practicum III: Abdomen, Pelvis and Special Applications

Suggested Credit Hours

5-6 semester hours (210-252 contact hours)

Prerequisites

Patient Care and Management in Computed Tomography
Computerized Imaging
CT Physics – Instrumentation and Imaging
Sectional Anatomy and Imaging Applications
Pathology Correlation in Computed Tomography
CT Procedure Protocols I
CT Clinical Education Practicum I
CT Procedure Protocols II
CT Clinical Education Practicum II

Course Description and Content

The third course in the clinical practicum series, this course builds on the foundational knowledge provided by the preceding two. The clinical procedure focus areas of this unit are the abdomen, pelvis and special applications. Didactic information for these focus areas is taught concurrently in CT Procedure Protocols III. The student should need only indirect supervision in performing procedures from the preceding clinical practicum focus areas. Close to moderate supervision of the student may be required in the current focus areas. Clinical competency evaluations include several from the focus areas of Clinical Education Practicums I and II in addition to a number from Clinical Education Practicum III. The intent is to further refine previously learned skills and knowledge while introducing new concepts and procedures resulting in demonstrated competency and mastery of all CT procedure protocols and patient care skills.

Students will be evaluated in the affective, cognitive and psychomotor domains. As in each of the preceding clinical practicums, two to three affective domain evaluations should be conducted per student during the term. Scores from each should be averaged for the final affective domain grade. Cognitive and psychomotor domains are evaluated by clinical competency. Competency is assessed in patient care and management, instrumentation, procedure protocol knowledge and application, identification of anatomy and pathology and focus areas from Clinical Education Practicums I, II and III. Students may be evaluated for competency in the following Clinical Education Practicum III focus areas.

CT abdomen without contrast
CT abdomen with contrast
CT abdomen for pancreas
CT abdomen for liver
CT abdomen for renal system
CT abdomen for adrenal glands
CT abdomen for aortic dissection

CT abdomen for vascular structures
CT abdomen for spleen
CT abdomen for gastrointestinal system
CT gallbladder
CT abdomen for suspected appendicitis
CT abdominal lymph nodes (disease staging)
CT abdomen to rule out metastasis
CT abdomen (trauma)
Spiral/helical abdomen
CT pelvis without contrast
CT pelvis for female genitourinary system
CT pelvis for male genitourinary system
CT pelvimetry
CT scrotum
Spiral/helical pelvis
CT angiography
CT-guided biopsy
CT-guided aspiration
CT radiation oncology treatment planning
CT cerebral blood flow studies
Pediatric CT procedures
Multiplanar reformation
3-D imaging surface and volumetric reconstruction
CT bone mineral density studies

The actual number of competencies are determined by the program faculty and clinical instructors.

Objectives

The student will:

1. Perform scanner-on (boot-up), warm-up, scan abort, emergency equipment shut-down and scanner-off procedures.
2. Communicate effectively and efficiently with patients.
3. Provide clear and concise patient education.
4. Obtain pertinent patient history.
5. Locate pertinent information in the patient chart.
6. Analyze the results of pertinent medical laboratory tests.
7. Notify radiologist of significant laboratory test results, patient history findings and charted information.
8. Prepare the patient per procedure protocol.
9. Prepare the scan room for requested procedure.
10. Prepare contrast media if required for the procedure, including determining the type of contrast to be administered, mixing oral contrast if indicated, calculating dose parameters for loading hand syringes and loading and arming automatic injectors for intravenous contrast.

11. Identify patient reactions to contrast agents and determine the steps taken in treating reactions.
12. Position the patient correctly for the requested procedure.
13. Select the proper scan factors for the requested procedure on the operator's console and gantry.
14. Produce the scout image accurately.
15. Perform CT procedures from the preceding clinical practicum focus areas independently.
16. Demonstrate knowledge of aseptic technique by preparing for and assisting with CT procedures requiring its use.
17. Observe, assist with and perform a variety of CT procedures with moderate supervision, especially those within the Clinical Practicum III focus areas.
18. Identify normal anatomy and pathology on CT images accurately.
19. Film procedures and archive images according to protocol.
20. Provide postprocedure instructions and discharge the patient.
21. Document required information in the patient's medical records.

**MODEL COMPUTED TOMOGRAPHY (CT) CLINICAL COMPETENCY
EVALUATION FORM**

STUDENT NAME: _____ EVALUATION DATE: _____

TYPE OF PROCEDURE: _____ EVALUATOR'S SIGNATURE: _____

PATIENT NAME _____ MEDICAL/RADIOLOGY RECORD # _____

The point scale for this evaluation is as follows:

- 3-Above average knowledge and performance**
- 2-Average knowledge and performance**
- 1-Below average knowledge and performance**
- 0-Unacceptable level of knowledge and performance**
- N/A-Not applicable**

Section I: Patient Care	3	2	1	0	N/A
A. Prepares examination room for the patient					
B. Identifies the patient properly					
C. Introduces himself or herself to the patient					
D. Educates patient on general aspects of CT and procedure specifics, including obtaining pertinent information concerning allergies if contrast media is to be administered					
E. Screens patient's medical record for information necessary for the performance of the procedure (consent form, lab values, etc.), documents and reports findings					
F. Obtains and records patient history and procedure information					
G. Transports patient to the examination room					
H. Transfers patient to CT couch					
I. Answers patient questions and addresses concerns					

Section II: Procedure Performance

3 2 1 0 N/A

- A. Evaluates procedure request form
- B. Prepares examination room properly
- C. Prepares contrast media if necessary, including identification of type, dosage and administration route.
- D. Loads power injector if required
- E. Properly administers contrast media if allowed
- F. Identifies contrast media reactions and responds accordingly
- G. Transfers patient to CT couch
- H. Positions patient for procedure
- I. Enters the proper patient identification information into the CT computer
- J. Identifies and uses proper protocol for procedure
- K. Selects and uses proper equipment controls to obtain the best technical image (window width, window level, fields-of-view, matrix size, algorithm, etc.)
- L. Performs procedure properly (proper patient instructions, etc.)
- M. Identifies pathology in relation to normal anatomy
- N. Demonstrates knowledge of necessary adjustments to be made if pathology is discovered
- O. Demonstrates knowledge of aseptic and sterile technique when required

- P. Applies radiation protection devices correctly to the patient and others who must remain in the radiographic room
- Q. Follows correct filming format for procedure
- R. Archives images and records pertinent information on the medical record
- S. Dismisses the patient with proper postprocedure instructions

SCORE: _____

CT DAILY LOG OF EXPERIENCES

NAME OF STUDENT		INSTITUTION/DIVISION	SPECIALTY SUPERVISOR
DATE	CASE#	PROCEDURE	COMMENTS
1			
2			
3			
4			
5			
6			
7			

Keep one sheet for each date in clinical education.

MODEL COMPUTED TOMOGRAPHY CLINICAL EDUCATION BEHAVIOR EVALUATION

NAME OF STUDENT _____ DATE _____

NAME OF CLINICAL EDUCATION CENTER _____

Using the following scale, place the number which best describes the performance of the student in each of the areas identified:

- 3** = Outstanding performance (consistently performs in a superior manner, needs no improvement in this area)
- 2** = Above average performance (performs well, requires minimal improvement)
- 1** = Average performance (basically acceptable with necessary improvement)
- 0** = Inadequate performance (needs major improvement)

- ___A. **Application of technical knowledge:** understands and applies knowledge of procedure
- ___B. **Attitude towards patients:** always polite and empathetic; demonstrates good disposition
- ___C. **Attitude towards work:** enthusiastic; considerate; helpful; follows instructions
- ___D. **Communication skills:** transmits pertinent information to patients and staff in a professional and cheerful manner
- ___E. **Confidence:** confident of ability to adequately perform procedures and interact with patients
- ___F. **Compassion:** assists patients willingly without regard for ethnicity, socioeconomic status, disease process, etc.
- ___G. **Efficiency of work:** completes tasks in a timely manner; does not impede patient flow
- ___H. **Initiative and motivation:** volunteers for assignments; thorough with all assignments; exhibits desire to learn
- ___I. **Judgment:** exhibits good judgement, asks when in doubt

- ___ J. **Personal appearance:** exemplary; very professional with good personal hygiene
- ___ K. **Quality of work:** accurate; most work completed at expected level or higher
- ___ L. **Reaction to criticism:** readily accepts constructive criticism and adapts behavior to reflect improvement
- ___ M. **Tact and diplomacy:** exercises discretion in dealing with sensitive issues regarding patients; is courteous to patients, staff and visitors
- ___ N. **Technical knowledge:** performs procedures accurately and efficiently; knows when adjustments are necessary and responds accordingly

COMMENTS: Please list relevant comments including the area(s) in which the student is above average and those which require improvement

TOTAL POINTS RECEIVED BY STUDENT: _____

TOTAL SCORE ON 100% SCALE: _____

LETTER GRADE PER SCORE: _____

Student's Signature _____ Date _____

CT Technologist's Signature _____ Date _____

Signature of Clinical Preceptor _____ Date _____

Signature of Clinical Coordinator (faculty) _____ Date _____

Introduction to Computed Tomography Practice Standards

The complex nature of disease processes involves multiple imaging modalities. Although an interdisciplinary team of radiologists, computed tomography technologists and support staff plays a critical role in the delivery of health services, it is the computed tomography technologist who performs the computed tomography examination that creates the images needed for diagnosis. Computed tomography technologists integrate scientific knowledge and technical skills with effective patient interaction to provide quality patient care and useful diagnostic information.

Computed Tomography Technologist

The computed tomography technologist must demonstrate an understanding of human cross-sectional anatomy, physiology, pathology, pharmacology and medical terminology.

Computed tomography technologists must maintain a high degree of accuracy in positioning and exposure technique. He or she must maintain knowledge about radiation protection and safety. Computed tomography technologists prepare for and assist the radiologist in the completion of intricate computed tomography examinations including a range of tissue biopsies and fluid drainages. They prepare and administer contrast media and medications in accordance with state and federal regulations.

Computed tomography technologists are the primary liaison between patients and radiologists and other members of the support team. They must remain sensitive to the physical and emotional needs of the patient through good communication, patient assessment, patient monitoring and patient care skills.

Computed tomography technologists use professional and ethical judgment and critical thinking when performing their duties. Computed tomography quality improvement programs allow the computed tomography technologist to be a responsible member of the health care team by continually assessing professional performance. Computed tomography technologists embrace continuing education for optimal patient care, public education and enhanced knowledge and technical competence.

Education and Certification

Computed tomography technologists prepare for their role on the interdisciplinary team by satisfactorily completing an accredited educational program in radiologic technology or radiation therapy. Two-year certificate, associate degree and four-year baccalaureate degree programs exist throughout the United States.

Accredited programs must meet specific curricular and educational standards. The Joint Review Committee on Education in Radiologic Technology (JRCERT) is the accrediting agency for radiologic technology and radiation therapy programs recognized by the U.S. Department of Education.

Upon completion of a course of study in radiologic technology or radiation therapy, individuals may apply to take the national certification examination. The American Registry of Radiologic Technologists (ARRT) is the recognized certifying agency for radiographers and radiation therapists and offers examinations three times per year. Those who successfully complete the certification examination in radiologic technology may use the credential R.T.(R) following their name; the R.T. signifies registered technologist and the (R) indicates radiography. Those who successfully complete the certification examination in radiation therapy may use the credential R.T.(T) following their name; R.T. signifies registered technologist and the (T) indicates radiation therapy.

Eligibility to take the advanced-level examination in computed tomography requires certification as a registered technologist in radiography or radiation therapy for a minimum of one year. After successfully completing the computed tomography advanced-level exam, the credentials R.T.(R)(CT) or R.T.(T)(CT) may be used.

To maintain ARRT certification, a level of expertise and awareness of changes and advances in practice, computed tomography technologists must complete 24 hours of appropriate continuing education every two years.

Practice Standards

The practice standards define the practice and establish general criteria to determine compliance. Practice standards are authoritative statements enunciated and promulgated by the profession for judging the quality of practice, service and education. They include desired and achievable levels of performance against which actual performance can be measured.

Professional practice constantly changes and actual practice varies from state to state as determined by local law and community custom. Recognizing this, the profession has adopted standards that are general in nature. The general format was favored over a “cookbook” style or “step-by-step” approach that would be difficult to maintain in a changing environment and confining for those practitioners with an expanded practice.

The standards focus on the dynamic nature of the health care delivery system. The standards are adaptable not only to the area of practice but also the locality of practice and institutional needs. While a minimum standard of acceptable performance is appropriate and should be followed by all practitioners in a specific area, it is unrealistic and highly inappropriate to assume that professional practice is the same in all regions of the United States.¹ State statute or regulation may dictate practice parameters. To conduct an appropriate review of the standards, one must look to the professional standard as well as local or state law that may impact the nature and scope of practice.

¹ The term “practitioner” is used in all areas of the standards in place of the various names used in medical imaging and radiation therapy, such as radiologic technologist, sonographer or radiation therapist. Practitioner is defined as any individual practicing in a specific area or discipline. The profession believes that any individual practicing in one of the defined disciplines or specialties should be held to a minimum standard of performance to protect the patients who receive professional services.

Format

The cohesive nature and inherent differences of medical imaging and radiation therapy are recognized in the general format of the standards. The standards are divided into three sections: clinical performance, quality performance and professional performance.

Clinical Performance Standards. The clinical performance standards define the activities of the practitioner in the care of patients and delivery of diagnostic or therapeutic procedures and treatments. The section incorporates patient assessment and management with procedural analysis, performance and evaluation.

Quality Performance Standards. The quality performance standards define the activities of the practitioner in the technical areas of performance including equipment and material assessment, safety standards and total quality management.

Professional Performance Standards. The professional performance standards define the activities of the practitioner in the areas of education, interpersonal relationships, personal and professional self-assessment and ethical behavior.

Each section of the standards is subdivided into individual standards. The standards are numbered and followed by a term or set of terms that identify the standards, such as “assessment” or “analysis/determination.” The next statement is the expected performance of the practitioner when performing the procedure or treatment. A rationale statement follows and explains why a practitioner should adhere to the particular standard of performance.

Criteria. Criteria are used in evaluating a practitioner’s performance. Each set of criteria is divided into two parts, the general criteria and the specific criteria. Both the measurement and specific criteria should be used when evaluating performance.

General Criteria. General criteria are written in a general style that applies to either medical imaging or radiation therapy practitioners. These criteria are the same in all sections of the standards and should be used for the appropriate area of practice. For example, a radiographer should use good professional judgment to make decisions concerning the adaptation of equipment and technical variables for a diagnostic procedure. Under these circumstances, the evaluation of the decision-making process concerning radiation therapy procedures would not be appropriate and should not be applied unless the procedure is diagnostic in nature, such as simulation.

Specific Criteria. While many areas of performance within medical imaging and radiation therapy are similar, others are not. The specific criteria are drafted with these differences in mind. For example, a criterion that calls for daily review of patient treatment records and doses to ensure that treatment does not exceed prescribed dose or normal tissue tolerance is imperative for those who practice in radiation therapy yet is not applicable to those who practice in the imaging professions.

A profession's practice standards serve as a guide for appropriate practice. Standards provide role definition for practitioners that can be used by individual facilities to develop job descriptions and practice parameters. Those outside the medical imaging and radiation therapy community can use the standards as an overview of the role and responsibilities of the practitioner as defined by the profession.

Computed Tomography Clinical Performance Standards

Standard One – Assessment

The practitioner collects pertinent data about the patient and the procedure.

Rationale

Information about the patient's health status is essential in providing appropriate imaging and therapeutic services.

General Criteria

The practitioner:

1. Uses consistent and appropriate techniques to gather relevant information from the medical record, significant others and health care providers. The collection of information is determined by the patient's needs or condition.
2. Reconfirms patient identification and verifies the procedure requested or prescribed.
3. Verifies the patient's pregnancy status when appropriate.
4. Determines whether the patient has been appropriately prepared for the procedure.
5. Assesses factors that may contraindicate the procedure, such as medications, insufficient patient preparation or artifacts.

Specific Criteria

The practitioner:

1. Identifies any artifact-producing objects, such as dentures, chest leads, jewelry or hearing aids.

Standard Two – Analysis/Determination

The practitioner analyzes the information obtained during the assessment phase and develops an action plan for completing the procedure.

Rationale

Determining the most appropriate action plan enhances patient safety and comfort, optimizes diagnostic and therapeutic quality and improves cost effectiveness.

General Criteria

The practitioner:

1. Selects the most appropriate and cost-effective action plan after reviewing all pertinent data and assessing the patient's abilities and condition.
2. Uses his or her professional judgment to adapt imaging and therapeutic procedures to improve diagnostic quality and therapeutic outcome.
3. Consults appropriate medical personnel to determine a modified action plan when necessary.
4. Determines the need for accessory equipment.

Specific Criteria

The practitioner:

1. Selects various power-up techniques as appropriate, including routine, nonroutine and fast activation.
2. Evaluates lab values prior to administering contrast media and beginning interventional procedures.
3. Selects appropriate shielding devices.
4. Selects appropriate patient immobilization devices.
5. Reviews the patient's chart and the physician's request to determine optimal scanning parameters for suspected pathology.
6. Determines the appropriate type and dose of contrast agent to be administered, based on the patient's age, weight and medical/physical status.

Standard Three – Patient Education

The practitioner provides information about the procedure to the patient, significant others and health care providers.

Rationale

Communication and education are necessary to establish a positive relationship with the patient, significant others and health care providers.

General Criteria

The practitioner:

1. Verifies that the patient has consented to the procedure and fully understands its risks, benefits, alternatives and follow-up. When appropriate, the practitioner verifies that written consent has been obtained.
2. Provides accurate explanations and instructions at an appropriate time and at a level the patient can understand. Addresses and documents patient questions and concerns regarding the procedure when appropriate.
3. Refers questions about diagnosis, treatment or prognosis to the patient's physician.
4. Provides appropriate information to any individual involved in the patient's care.

Specific Criteria

The practitioner:

1. Consults with other departments, such as patient transportation and anesthesia, for patient services.
2. Instructs patients regarding preparation prior to imaging procedures, including providing information about oral or bowel preparation and allergy preparation.
3. Ensures that all procedural requirements are in place to achieve a quality diagnostic examination.
4. Explains precautions regarding administration of contrast agents to nursing mothers.

Standard Four – Implementation

The practitioner implements the action plan.

Rationale

Quality patient services are provided through the safe and accurate implementation of a deliberate plan of action.

General Criteria

The practitioner:

1. Implements an action plan that falls within established protocols and guidelines.
2. Elicits the cooperation of the patient to carry out the action plan.
3. Uses an integrated team approach as needed.
4. Modifies the action plan according to changes in the clinical situation.
5. Administers first aid or provides life support in emergency situations.
6. Uses accessory equipment when appropriate.
7. Assesses and monitors the patient's physical and mental status.

Specific Criteria

The practitioner:

1. Performs venipuncture, IV patency and maintenance procedures according to established guidelines.
2. Administers contrast agents according to established guidelines.
3. Monitors the patient for reactions to contrast agent.
4. Uses appropriate radiation safety devices.
5. Monitors the patient's physical condition during the procedure.
6. Applies appropriate patient immobilization devices when necessary.
7. Completes routine camera operations – switches from manual to automatic, changes formats, ensures an adequate film supply for the procedure and verifies image location.

Standard Five – Evaluation

The practitioner determines whether the goals of the action plan have been achieved.

Rationale

Careful examination of the procedure is important to determine that all goals have been met.

General Criteria

The practitioner:

1. Evaluates the patient and the procedure to identify variances that may affect patient outcome. The evaluation process should be timely, accurate and comprehensive.
2. Measures the procedure against established protocols and guidelines.
3. Identifies any exceptions to the expected outcome.
4. Documents any exceptions clearly and completely.
5. Develops a revised action plan to achieve the intended outcome if necessary.
6. Disseminates reasons for revisions to all team members.

Specific Criteria

The practitioner:

1. Reviews images to determine if additional scans will enhance the diagnostic value of the procedure.

Standard Six – Implementation

The practitioner implements the revised action plan.

Rationale

It may be necessary to make changes to the action plan to achieve the intended outcome.

General Criteria

The practitioner:

1. Bases the revised plan on the patient's condition and the most appropriate means of achieving the intended outcome.
2. Takes action based on patient and procedural variances.
3. Measures and evaluates the results of the revised action plan.
4. Notifies appropriate health provider when immediate clinical response is necessary based on procedural findings and patient condition.

Specific Criteria

The practitioner:

1. Performs retrospective reconstruction on raw data.
2. Reformats images.
3. Revises scanning parameters to better visualize the pathology in accordance with established guidelines.
4. Implements special filming or computer-generated information to improve the outcome of the procedure.
5. Changes the position of the patient or alters scanning parameters to improve the quality of the procedure.

Standard Seven – Outcomes Measurement

The practitioner reviews and evaluates the outcome of the procedure.

Rationale

To evaluate the quality of care, the practitioner compares the actual outcome with the intended outcome.

General Criteria

The practitioner:

1. Reviews all diagnostic or therapeutic data for completeness and accuracy.
2. Determines whether the actual outcome is within established criteria.
3. Evaluates the process and recognizes opportunities for future changes.
4. Assesses the patient's physical and mental status prior to discharge from the practitioner's care.

Specific Criteria

None added.

Standard Eight – Documentation

The practitioner documents information about patient care, the procedure and the final outcome.

Rationale

Clear and precise documentation is essential for continuity of care, accuracy of care and quality assurance.

General Criteria

The practitioner:

1. Documents diagnostic, treatment and patient data in the appropriate record. Documentation must be timely, accurate, concise and complete.
2. Documents any exceptions from the established criteria or procedures.
3. Records diagnostic or treatment data.

Specific Criteria

The practitioner:

1. Archives images to data storage devices according to established guidelines.

Quality Performance Standards

Standard One - Assessment

The practitioner collects pertinent information regarding equipment, the procedures and the work environment.

Rationale

The planning and provision of safe and effective medical services relies on the collection of pertinent information about equipment, procedures and the work environment.

General Criteria

The practitioner:

1. Ensures that services are performed in a safe environment in accordance with established guidelines.
2. Ensures that equipment maintenance and operation comply with established guidelines.
3. Assesses equipment to determine acceptable performance based on established guidelines.
4. Ensures that protocol and procedure manuals include recommended criteria and are reviewed and revised on a regular basis.

Specific Criteria

The practitioner:

1. Maintains controlled access to restricted area during radiation exposure to ensure safety of patients, visitors and hospital personnel.

Standard Two - Analysis/Determination

The practitioner analyzes information collected during the assessment phase and determines whether changes need to be made to equipment, procedures or the work environment.

Rationale

Determination of acceptable performance is necessary for the provision of safe and effective services.

General Criteria

The practitioner:

1. Assesses whether services, procedures and environment meet or exceed established guidelines. If not, the practitioner develops an action plan.
2. Evaluates equipment to determine if it meets or exceeds established standards. If not, the practitioner develops an action plan.
3. Analyzes information collected during the assessment phase to determine whether optimal services are being provided. If not, the practitioner develops an action plan.

Specific Criteria

None added.

Standard Three - Education

The practitioner informs the patient, public and other health care providers about procedures, equipment and facilities.

Rationale

Open communication promotes safe practices.

General Criteria

The practitioner:

1. Elicits confidence and cooperation from the patient, the public and other health care providers by providing timely communication and effective instruction.
2. Presents explanations and instructions at the learner's level of understanding and learning style.

Specific Criteria

The practitioner:

1. Instructs health care providers and students regarding CT procedures and radiation safety.
2. Educates the public about CT procedures and radiation safety.

Standard Four – Performance

The practitioner performs quality assurance activities or acquires information on equipment and materials.

Rationale

Quality assurance activities provide valid and reliable information regarding the performance of materials and equipment.

General Criteria

The practitioner:

1. Performs quality assurance activities based on established protocols.
2. Provides evidence of ongoing quality assurance activities.

Specific Criteria

The practitioner:

1. Monitors image production to determine variance from established quality standards.

Standard Five – Evaluation

The practitioner evaluates quality assurance results and establishes an appropriate action plan.

Rationale

Materials, equipment and procedure safety depend on ongoing quality assurance activities that evaluate performance based on established guidelines.

General Criteria

The practitioner:

1. Compares quality assurance results to established acceptable values.
2. Verifies quality assurance testing conditions and results.
3. Formulates an action plan following verification of testing.

Specific Criteria

The practitioner:

1. Performs routine archiving status checks and deletes data according to established guidelines.

Standard Six – Implementation

The practitioner implements the quality assurance action plan.

Rationale

Implementation of a quality assurance action plan is imperative for quality diagnostic and therapeutic procedures and patient care.

General Criteria

The practitioner:

1. Obtains assistance from appropriate personnel to implement the quality assurance action plan.
2. Implements the quality assurance action plan.

Specific Criteria

None needed.

Standard Seven – Outcomes Measurement

The practitioner assesses the outcome of the quality assurance action plan in accordance with established guidelines.

Rationale

Outcome assessment is an integral part of the ongoing quality assurance plan to enhance diagnostic and therapeutic services.

General Criteria

The practitioner:

1. Reviews the implementation process for accuracy and validity.
2. Determines whether the performance of equipment and materials is safe for practice based on outcome assessment.
3. Develops and implements a modified action plan when testing results are not in compliance with guidelines.

Specific Criteria

None added.

Standard Eight – Documentation

The practitioner documents quality assurance activities and results.

Rationale

Documentation provides evidence of quality assurance activities designed to enhance the safety of patients, the public and health care providers during diagnostic and therapeutic services.

General Criteria

The practitioner:

1. Maintains documentation of quality assurance activities, procedures and results in accordance with established guidelines.
2. Provides timely, concise, accurate and complete documentation.
3. Provides documentation that adheres to current protocol, policy and procedures.

Specific Criteria

None added.

Professional Performance Standards

Standard One – Quality

The practitioner strives to provide optimal care of all patients.

Rationale

All patients expect and deserve optimal care during diagnosis and treatment.

General Criteria

The practitioner:

1. Works with others to elevate the quality of care.
2. Participates in quality assurance programs.
3. Adheres to the accepted standards, policies and procedures adopted by the profession and regulated by law.
4. Provides the best possible diagnostic study or therapeutic treatment for each patient by applying professional judgement and discretion.
5. Anticipates and responds to the needs of the patient.

Specific Criteria

None added.

Standard Two – Self-Assessment

The practitioner evaluates personal performance, knowledge and skills.

Rationale

Self-assessment is an important tool in professional growth and development.

General Criteria

The practitioner:

1. Monitors personal work ethics, behaviors and attitudes.
2. Monitors and evaluates orientation guidelines and recommends improvements or changes as needed.
3. Evaluates performance and recognizes opportunities for improvement.
4. Recognizes his or her strengths and uses them to benefit patients, coworkers and the profession.
5. Performs procedures only after receiving appropriate education and training.
6. Recognizes and takes advantage of opportunities for educational growth and improvement in technical and problem-solving skills.
7. Actively participates in professional societies and organizations.

Specific Criteria

None added.

Standard Three – Education

The practitioner acquires and maintains current knowledge in clinical practice.

Rationale

Advancements in medical science require enhancement of knowledge and skills through education.

General Criteria

The practitioner:

1. Demonstrates completion of the appropriate education related to clinical practice.
2. Maintains appropriate credentials and certification related to clinical practice.
3. Participates in educational activities to enhance knowledge, skills and performance.
4. Shares knowledge and expertise with others.

Specific Criteria

None added.

Standard Four – Collaboration and Collegiality

The practitioner promotes a positive, collaborative practice atmosphere with other members of the health care team.

Rationale

To provide quality patient care, all members of the health care team must communicate effectively and work together efficiently.

General Criteria

The practitioner:

1. Shares knowledge and expertise with colleagues, peers, students and all members of the health care team.
2. Develops collaborative partnerships with other health care providers in the interest of diagnostic and therapeutic quality and cost effectiveness and safety.

Specific Criteria

None added.

Standard Five – Ethics

The practitioner adheres to the profession's accepted Code of Ethics.

Rationale

All decisions and actions made on behalf of the patient are based on a sound ethical foundation.

General Criteria

The practitioner:

1. Provides health care services with respect for the patient's dignity and age-specific needs.
2. Acts as a patient advocate to support patients' rights.

3. Takes responsibility for professional decisions.
4. Delivers patient care and service without bias based on personal attributes, nature of the disease, sex, race, creed, religion or socioeconomic status.
5. Respects the patient's right to privacy and confidentiality.
6. Adheres to the established practice standards of the profession.

Specific Criteria

None added.

Standard Six – Exploration and Investigation

The practitioner participates in the acquisition, dissemination and advancement of the professional knowledge base.

Rationale

Scholarly activities such as research, scientific investigation, presentation and publication advance the profession and thereby improve the quality and efficiency of patient services.

General Criteria

The practitioner:

1. Reads and critically evaluates research in diagnostic and therapeutic services.
2. Investigates new, innovative methods and applies them in practice.
3. Shares information with colleagues through publication, presentation and collaboration.
4. Pursues lifelong learning.
5. Participates in data collection.

Specific Criteria

None added.

Glossary

Artifacts – False features in the image produced by patient instability or equipment deficiencies.

Archiving – The storage of image data for future retrieval.

Assess – To determine the significance, importance or value.

Clinical – Pertaining to or founded on actual observation and treatment of patients.

Competency – Having the ability to perform a specific task.

Contrast media – Substance administered to subject being imaged to alter selectively the image intensity of a particular anatomical or functional region.

Contraindicate – To make the indicated or expected treatment or drug inadvisable.

Disease – A disorder or abnormal condition having a characteristic train of symptoms that may affect the whole body or any of its parts. Its etiology, pathology and prognosis may be known or unknown.

Data storage device – Data may be archived on either magnetic tape or optical disk.

ECG – Electrocardiogram.

Ethical – Conforming to the standards of conduct of a given profession or group.

Interpret – To understand and explain an image for the purposes of providing a diagnostic report.

Intervention procedures – Percutaneous catheterization for diagnostic and therapeutic purposes.

Quality assurance – A comprehensive set of policies and procedures designed to optimize the performance of personnel and equipment.

Radiation protection – Procedures followed to prevent inappropriate or accidental irradiation of patient, public and health care professionals.

Raw data – The values of x-ray detector response from all views and rays within a scan. These data are then convolved with the convolution filter function and back-projected to produce a CT image.

Reformat – The process of recreating images in various body planes using a series of original slices.

Venipuncture – The puncture of a vein.

Reference Resources

Adler A, Carlton R. *Introduction to Radiography and Patient Care*. Philadelphia, Pa: WB Saunders Company; 1994.
ISBN 0-721-63465-6

Apfel PA, Tortorici M, Apfel PJ. *Advanced Radiographic and Angiographic Procedures With an Introduction to Specialized Imaging*. Philadelphia, Pa: FA Davis Company; 1995.
ISBN 0-8036-8571-8

Applegate E. *The Sectional Anatomy Learning System*. Philadelphia, Pa: WB Saunders Company; 1991.
ISBN 0-721-63269-6

Applegate E. *The Anatomy and Physiology Learning System*. Philadelphia, Pa: WB Saunders Company; 1995.
ISBN 0-721-6663-53

Barrett CP. *Primer of Sectional Anatomy With MRI and CT Correlation*. Baltimore, Md: Williams & Wilkins; 1994.
ISBN 0-6873-00472-7

Bushong S. *Radiologic Science for Technologists: Physics, Biology, and Protection*. 6th ed. St. Louis, Mo: CV Mosby Company; 1997.
ISBN 0-815-11579-2

Carpenter MB. *Core Text of Neuroanatomy*. 4th ed. Baltimore, Md: Williams & Wilkins; 1991.
ISBN 0-683-01457-9

Chisin R. *MRI/CT and Pathology in Head and Neck Tumors*. Boston, Mass: Kluwer Academic Publishing; 1989.
ISBN 0-792-30227-3

Code of Ethics. Albuquerque, NM: American Society of Radiologic Technologists; 1998.

Computed Tomography Competency Requirements. St. Paul, Minn: American Registry of Radiologic Technologists.

Content Specifications for the Examination in Computed Tomography. St. Paul, Minn: American Registry of Radiologic Technologists; 1994.

Demayo D. *Registry Review in Computed Tomography*. Philadelphia, Pa: WB Saunders Company; 1996.
ISBN 0-7216-62854

- Durham, D. *Atlas of CT Pathology*. Philadelphia, Pa: WB Saunders Company; 1997.
ISBN 0-7216-6415-6
- El-Khoury GY, Bergman RA, Montgomery W. *Sectional Anatomy by MRI/CT*. New York, NY: Churchill Livingstone Inc; 1994.
ISBN 0-443-08890-X
- Firooznia H, Golimbu CN, Rafii M. *MRI and CT of the Musculoskeletal System*. St. Louis, Mo: Mosby-Year Book Inc; 1992.
ISBN 0-815-13247-6
- Fishman E, Jeffrey R Jr. *Spiral CT: Principles, Techniques, and Clinical Applications*. 2nd ed. New York, NY: Raven Press; 1998.
ISBN 0-781712513
- Goldman M. *CT and MRI Genitourinary Tract*. New York, NY: Churchill Livingstone; 1990.
ISBN 0-443-08657-5
- Hayman LA, Hinck VC. *Clinical Brain Imaging: Normal Structure and Functional Anatomy*. St. Louis, Mo: Mosby-Year Book Inc; 1992.
ISBN 0-815-14180-7
- Kelley LL, Peterson CM. *Sectional Anatomy for Imaging Professionals*. St. Louis, Mo: Mosby-Year Book Inc; 1997.
ISBN 0-815-18665-7
- Krause D. *CT and MRI of Disk Herniations*. New York, NY: Springer-Verlag; 1990.
ISBN 0-387-19163-1
- Kricun R, Kricun ME. *MRI Imaging and CT of the Spine: Case Study Approach*. Philadelphia, Pa: Lippincott-Raven Publishers; 1993.
ISBN 0-781-7002-64
- Lane A, Sharfai H. *Modern Sectional Anatomy*. Philadelphia, Pa: WB Saunders Co; 1992.
ISBN 0-721-6321-73
- Lee JKT, Sagel SS, Stanley RJ, Theiken. *Computed Body Tomography with MRI Correlation*. 3rd ed. Philadelphia, Pa: Lippincott-Raven Publishers; 1997.
ISBN 0781702917
- Lee H. *Cranial MRI and CT*. New York, NY: McGraw-Hill; 1995.
ISBN 0-070-37508-9
- Linn-Watson T. *Radiographic Pathology*. Philadelphia, Pa: WB Saunders Co; 1996.
ISBN 0-721-64129-6

Mathers LH Jr. *Clinical Anatomy Principles (Clinical Anatomy Study System)*. St. Louis, Mo: Mosby-Year Book Inc; 1995.
ISBN 0-801-66356-3

McMinn RMH. *Color Atlas of Human Anatomy*. 3rd ed. St. Louis, Mo: Mosby-Year Book Inc; 1988.
ISBN 0-815-15823-8

McPhee SJ, Lingappa VR, Ganong WF, Lange JD. *Pathophysiology Of Disease: An Introduction To Clinical Medicine*. 2nd ed. Norfolk, Conn: Appleton and Lange; 1997.
ISBN 0-8385-7678-8

Miller BF, Miller-Keane. *Encyclopedia and Dictionary of Medicine, Nursing and Allied Health*. 6th ed. Philadelphia, Pa: WB Saunders Co; 1997.
ISBN 0-7216-6278-1

Model Clinical Behavior and Competency Evaluation Forms. Albuquerque, NM: American Society of Radiologic Technologists; 1997.

Moller TB. *Pocket Atlas of Cross-Sectional Anatomy: CT and MRI: Thorax, Abdomen and Pelvis*. New York, NY: Thieme Medical Publishers Inc; 1994.
ISBN 0-865-77510-9

Moss AA, Gamsu G, Genant HK. *Computed Tomography of the Body With Magnetic Resonance Imaging*. 2nd ed. Vols. 1-3. Philadelphia, Pa: WB Saunders Co; 1992.
ISBN 0-7216-2415-4

Murphy GP, Lawrence W, Lenhard RE. *American Cancer Society Textbook of Clinical Oncology*. 3rd ed. Atlanta, Ga: American Cancer Society; 1995.

Obergfell A. *Law and Ethics in Diagnostic Imaging and Therapeutic Radiology*. Philadelphia, Pa: WB Saunders Co; 1995.
ISBN 0-7216-5062-7

Orrison WW Jr. *Atlas of Brain Function*. New York, NY: Thieme Medical Publishers, Inc; 1995.
ISBN 0-865-77528-1

Professional Curriculum for Computed Tomography. Albuquerque, NM: American Society of Radiologic Technologists; 1998.

Radiation Therapist Code of Ethics. Albuquerque, NM: American Society of Radiologic Technologists; 1998.

Romans L. *Introduction to Computed Tomography*. Baltimore, Md: Williams & Wilkins Company; 1995.
ISBN 0-683-007353-2

Romans L. *Review Questions and Explanations in Computed Tomography*. Philadelphia, Pa: Williams & Wilkins; 1996.
ISBN 0-683-07353-2

Rules and Regulations. St. Paul, Minn: American Registry of Radiologic Technologists.

Seeram E. *Computed Tomography: Physical Principles, Clinical Applications and Quality Control*. Philadelphia, Pa: WB Saunders Co; 1994.
ISBN 0-721-66710-4

Standards for an Accredited Education Program in the Radiologic Sciences. Chicago, Ill: Joint Review Committee on Educational Programs in Radiologic Technology.

Stedman's Concise Medical Dictionary for the Health Professions. 3rd ed. Philadelphia, Pa: Williams & Wilkins; 1997.
ISBN 0-683-40019-3

Taber's Cyclopedic Medical Dictionary. 18th ed. Philadelphia, Pa: FA Davis Company; 1997.
ISSN 1065-1357

Teplick JG. *Lumbar Spine CT and MRI*. Philadelphia, Pa: Lippincott-Raven Publishers; 1992.
ISBN 0-397-50891-3

Tortorici M. *Administration of Imaging Pharmaceuticals*. Philadelphia, Pa: WB Saunders Co; 1996.
ISBN 0-721-64813-4

Wagner M, Lawson TL. *Atlas of Chest Imaging: Correlated Anatomy with MRI and CT*. Philadelphia, Pa: Lippincott-Raven Publishers; 1992.
ISBN 0-881-67888-0

Warden-Tamparo C, Lewis MA. *Diseases of the Human Body*. Philadelphia, Pa: FA Davis Company; 1989.
ISBN 0-803-69054-1

Webb WR, Brant WE, Helms CA. *Fundamentals of Body CT*. 2nd ed. Philadelphia, Pa: WB Saunders Co; 1998.
ISBN 0-721-66862-3

Wilson B. *Ethics and Basic Law for Medical Imaging Professionals*. Philadelphia, Pa: FA Davis Company; 1997.
ISBN 0-803-60152-2

Wimmer B. *Trauma of the Spine: CT and MRI*. New York, NY: Springer-Verlag; 1990.
ISBN 0-387-50977-1

Wladyslaw G, Rankin S. *Practical CT Techniques*. New York, NY: Springer-Verlag; 1992.
ISBN 0-387197265

Zirinsky K. *Cross-Sectional Abdominal Anatomy: CT, MRI and Ultrasound: A Programmed Atlas*. New York, NY: Igaku-Shoin; 1992.
ISBN 0-896-40215-0

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800-782-4479
www.wbsaunders.com

Journals

Journal of Computer Assisted Tomography. 6 issues/year. Philadelphia, Pa: Lippincott-Raven Publishers.

Journal of Neuroimaging. 4 issues/year

Seminars in Ultrasound, CT and MRI. 6 issues/year. Philadelphia, Pa: WB Saunders Publishing Co.

Neuroradiology. New York, NY: Springer-Verlag.

Radiation Therapist. 2 issues/year. Albuquerque, NM: American Society of Radiologic Technologists.

Radiologic Technology. 6 issues/year. Albuquerque, NM: American Society of Radiologic Technologists.

Radiology. 12 issues/year. Oakbrook, Ill: Radiological Society of North America.

RadioGraphics. 6 issues/year. Oakbrook, Ill: Radiological Society of North America.