

Computed Tomography Curriculum

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Introduction

The goal of this curriculum is to provide the professional community with a cognitive base of entry-level education in the practice of computed tomography (CT). The curriculum is suitable for all programs in this specialty, including limited fellowships, short-term certificate programs and collegiate-based education programs. The curriculum recognizes that the educational components are not static, but are representative of current practice and trends in the field. It is the responsibility of educators to incorporate new concepts and trends in the curriculum as they occur.

The curriculum is divided into specific content areas representing essential components of a computed tomography educational program. No particular sequence is suggested. The content and objectives should be organized to meet the mission, goals and needs of each program. Faculty members are encouraged to expand and broaden these fundamental objectives as they incorporate them into their curricula. Specific instructional methods are intentionally omitted to allow for programmatic prerogative as well as creativity in instructional delivery.

The curriculum document consists of three sections: foundations, core content and clinical experience requirements. The foundations section represents an inventory of pre-existing knowledge and skills gained through an entry-level radiography educational experience and reinforced through professional practice. The content in the foundations section is intended to aid technologists in career planning and program managers in the development of preassessment tools for candidate selection.

The professional practice of computed tomography requires specific knowledge and skills generally not obtained in basic educational programs in radiography. The core content section represents curriculum elements that are considered essential in educating technologists in the postprimary practice of computed tomography.

The clinical experience requirements section is intended as a guide to developing a well-rounded clinical experience and to aid in meeting the eligibility requirements for a postprimary certification examination in computed tomography.

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Foundations

This foundations section represents an inventory of pre-existing knowledge and skills gained through an entry-level radiography educational experience and reinforced through professional practice. The content in this section is intended to aid technologists in career planning and program managers in the development of preassessment tools for candidate selection.

Basic Principles of Computed Tomography

Content is designed to provide entry-level radiography students with principles related to computed tomography (CT) imaging.

Clinical Practice

Content and clinical practice experiences should be designed to sequentially develop, apply, critically analyze, integrate, synthesize and evaluate concepts and theories in the performance of radiologic procedures. Through structured, sequential, competency-based clinical assignments, concepts of team practice, patient-centered clinical practice and professional development are discussed, examined and evaluated.

Clinical practice experiences should be designed to provide patient care and assessment, competent performance of radiologic imaging and total quality management. Levels of competency and outcomes measurement ensure the well-being of the patient preparatory to, during and following the radiologic procedure.

Ethics and Law in the Radiologic Sciences

Content is designed to provide a fundamental background in ethics. The historical and philosophical bases of ethics, as well as the elements of ethical behavior, are discussed. The student will examine a variety of ethical issues and dilemmas found in clinical practice.

An introduction to legal terminology, concepts and principles also will be presented. Topics include misconduct, malpractice, legal and professional standards and the ASRT scope of practice. The importance of proper documentation and informed consent is emphasized.

Human Structure and Function

Content is designed to establish a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and systems will be described and discussed.

Patient Care in Radiologic Science

Content is designed to provide the basic concepts of patient care, including consideration for the physical and psychological needs of the patient and family. Routine and emergency patient care procedures are described, as well as infection control procedures using standard precautions. The role of the radiographer in patient education is identified.

Pharmacology and Drug Administration

Content is designed to provide basic concepts of pharmacology. The theory and practice of basic techniques of venipuncture and administration of diagnostic contrast agents and/or intravenous

medications is included. The appropriate delivery of patient care during these procedures is emphasized.

Radiation Protection

Content is designed to present an overview of the principles of radiation protection including the responsibilities of the radiographer for patients, personnel and the public. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated.

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Refer to Appendix A for a detailed list of objectives for each content area.

Core Content

The professional practice of computed tomography requires specific knowledge and skills generally not obtained in basic educational programs in radiography. The core content section represents curriculum elements that are considered essential in educating technologists in the postprimary practice of computed tomography.

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Pathology Correlation in Computed Tomography

Description

Content provides thorough coverage of common diseases diagnosable via CT. Each disease or trauma process is examined from its description, etiology, associated symptoms and diagnosis with appearance on CT. Terms associated with these pathologies will be included.

Objectives

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:
 - Describe the disorder.
 - List the etiology.
 - Name the associated symptoms.
 - Name the common means of diagnosis.
 - 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 immunodeficiency syndrome
- B. Systemic lupus erythematosus

II. Cardiovascular System

- A. Cardiomegaly
- B. Aortic aneurysm
- C. Aortic dissection
- D. Congenital malformations
- E. Cardiac transplant
- F. Congestive heart failure (CHF)/pleural fluid
- G. Coronary artery disease
- H. Pericardial effusion
- I. Tumors (myxomas)

III. Central Nervous System

- A. Tumors (benign and malignant)
 - 1. Glioma
 - 2. Lipoma
 - 3. Meningioma
 - 4. Cholesteatoma (inner ear)
 - 5. Acoustic neuroma (inner ear)
 - 6. Pineal gland disorders
 - 7. Pituitary adenoma
 - 8. Astrocytoma
 - 9. Medulloblastoma
- B. Arteriovenous malformation (AVM)
- C. Aneurysm
- D. Congenital abnormalities
- E. Metastases
- F. Hematoma

G. Hydrocephalus

H. Cysts

I. Cerebrovascular accident (CVA)

1. Infarct
2. Hemorrhage
 - a. Subdural
 - b. Epidural
 - c. Subarachnoid
 - d. Intracerebral

J. Infections

1. Encephalitis
2. Meningitis
3. Abscess

K. Trauma

L. Atrophic and degenerative disorders

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

M. Spine

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

N. Cerebral hemorrhage

O. CNS lymphoma

P. Toxoplasmosis

IV. Circulatory and Lymph System

A. Leukemia

B. Lymphoma (Hodgkin and non-Hodgkin)

C. Lymphosarcoma

D. Lymphadenopathy

V. Endocrine System

VI. Respiratory System

A. Benign and malignant masses

B. Pneumonia

C. Emphysema

D. Pulmonary edema

E. Bronchiectasis

F. Metastases

G. Acute respiratory distress syndrome

H. Pulmonary fibrosis

I. Hemothorax and pneumothorax

J. Sarcoidosis

K. Tuberculosis

L. Trauma

M. Pleural effusion

N. Atelectasis

O. Other

VII. Gastrointestinal System

A. Primary neoplasms

B. Metastases

C. Tumors

D. Abscesses

E. Autoimmune (i.e., Crohn's, Colitis)

- F. Cysts
- G. Ascites
- H. Small and large bowel obstruction
- I. Appendicitis
- J. Gastric carcinoma
- K. Esophageal cancer
- L. Polycystic disease
- M. Congenital abnormalities
- N. Trauma

VIII. Genitourinary System

- A. Masses (benign and malignant)
 - 1. Renal cell carcinoma
 - 2. Wilms tumor
 - 3. Cystic mass
- B. Metastases
- C. Infection
- D. Renal calculi
- E. Polycystic disease
- F. Bladder cancer
- G. Adenocarcinoma
- H. Ovarian cancer
- I. Endometrial cancer
- J. Prostate cancer
- K. Prostate hypertrophy
- L. Seminoma

- M. Testicular cancer
- N. Renal transplant
- O. Hydronephrosis
- P. Pheochromocytoma
- Q. Congenital abnormalities
- R. Trauma

IX. Hepatobiliary System

- A. Masses (benign and malignant)
- B. Cirrhosis
- C. Gallbladder carcinoma
- D. Cholecystitis
- E. Cholelithiasis
- F. Hemochromatosis
- G. Biliary obstruction
- H. Congenital abnormalities
- I. Trauma
- J. Infection
- K. Hepatomegaly
- L. Hepatic carcinoma
- M. Hemangioma
- N. Liver metastases
- O. Splenomegaly
- P. Splenic infarction
- Q. Pancreatic carcinoma

R. Pancreatic pseudocyst

X. Musculoskeletal System

A. Bone tumors

1. Osteosarcoma

B. Cartilaginous tumors

C. Soft tissue tumors

1. Liposarcoma

2. Synovial sarcoma

D. Osteoporosis

E. Skeletal dysplasias

F. Joint disorders

G. Fractures

H. Metastases

I. Trauma

J. Arthritis

XI. Pediatric Pathologies

A. Congenital abnormalities

B. Seizures

C. Vascular problems

D. Inflammation

E. Tumors

F. Pulmonary diseases

G. Orthopedic

H. Osteogenesis imperfecta (skeletal dysplasias)

I. Infection

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Physics – Instrumentation and Imaging

Description

Content is designed to impart an understanding of the physical principles and instrumentation involved in computed tomography. 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 filtered back-projection 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 and patient factors related to other elements affecting image quality will be explained, as well as artifact production and reduction and image communication.

Objectives

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 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 affect 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 terms algorithm and filter.
17. Identify common filters, algorithms and kernel settings.
18. Define the terms "raw data," "image data" and "scan data."
19. Explain the difference between reconstructing and reformatting an image.
20. Describe postprocessing techniques.
21. Explain the components of the CT computer system.

22. Define and explain the correlation between CT and each of the following:
 - Pixel.
 - Matrix.
 - Voxel.
 - Pitch.
 - X, y, z coordinates.
 - Scan field of view (sfov).
 - Display field of view (dfov).
 - CT/Hounsfield number.
 - Partial volume averaging.
 - Window width (ww), window level (wl).
 - Spatial resolution.
 - Contrast resolution.
 - Noise.
 - Aliasing.
 - Digital imaging.
 - Annotation.
 - Scanogram/scout/pilot/topogram/survey.
 - Region of interest (ROI).
 - Conventional (slice-by-slice) vs. volumetric data acquisition.
 - Half-scan, full-scan, overscan.
 - Interscan delay.
 - Rays and views.
 - Sampling (angular and ray).
23. List the selectable scan factors and explain how each affects the CT image.
24. Name the factors affecting image quality in CT.
25. Name the common controls found on CT operator consoles and describe how and why each is used.
26. Describe the steps that may be taken to assure constant high-quality CT images.
27. Define the term "artifact," list the types of artifacts and name and describe the appearance of those most commonly affecting CT images.
28. Explain how artifacts may be eliminated or reduced.
29. Trace the sequence of events in CT scanning from the application of electrical current to the radiographic tube through image display.
30. Name and explain the scanner design that led to the development of spiral CT.
31. Name and list the characteristics of the two types of "slip-rings" used in spiral CT scanners.
32. Discuss the differences between low-voltage and high-voltage slip-ring CT scanners.
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.

Content

I. Historical Development of Computed Tomography

A. Definition

1. Evolution of terms
 - a. Computerized transaxial tomography
 - b. Computerized axial tomography
 - c. Computed tomography

B. Research contributors

1. Johann Radon
2. Dr. Godfrey Hounsfield
3. James Ambrose and Robert S. Ledley
4. Allen MacLeod Cormack

C. Historical events

1. 1917 – Radon proved that it was possible to reconstruct an object from the infinite sets of its parts; i.e., an object can be reconstructed from its parts
2. 1967 – Working for Electrical and Musical Industries (EMI), Hounsfield develops first CT scanner
3. 1970 – Construction of CT units that could be used to examine the head of patients begins
4. 1971 – First clinical machine is installed – Atkinson Morley Hospital, Wilmington, England
5. 1973 – EMI commercial head scanners become available
6. 1974 – Whole body scanners become available
7. 1989 – Spiral CT units become available
8. 1998 – Multidetector row CT scanners become available

II. Computed Tomography Generations

A. First: Pencil beam geometry

B. Second: Fan beam, multiple detector bank

C. Third: Fan beam, rotating detectors – 360° of detectors

D. Fourth: Fan beam, fixed detectors

E. Fifth: Scanning electron beam

III. Characteristics of X-radiation

A. Sources

1. Natural
2. Artificial

B. Electromagnetic radiation

1. Ionization

2. Interactions with matter
 - a. Attenuation
 - 1) Compton effect
 - 2) Photoelectric effect

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. Beam configuration
- E. Picture archiving 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) Pencil
 - 2) Fan
 - 3) Cone

3. Data acquisition system (DAS)
 - a. Components
 - 1) Tube
 - 2) Detectors
 - 3) Filters
 - 4) Collimators
 - 5) Analog-to-digital converter (ADC)
 - 6) Digital-to-analog converter
 - 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) mAs and kVp
 - 8) Algorithm
 - 9) Scan time and rotational arc
 - 10) Radiographic tube output
 - 11) Region of interest (ROI)
 - 12) Magnification
 - 13) Focal spot size and tube geometry

B. Image reconstruction

1. CT computer
 - a. Minicomputer and microprocessors

- b. Array processors
- 2. Reconstruction algorithms
 - a. Conventional CT
 - 1) Back projection (historical only)
 - 2) Filtered back projection
 - b. Single detector row spiral
 - 1) Linear interpolation
 - c. Multidetector row spiral
 - 1) Longitudinal interpolation with Z-axis filtering
 - 2) Interlaced sampling
 - 3) Fan-beam
 - d. 3-D
- C. Image display, manipulation, recording and archiving
 - 1. Display
 - a. Cathode ray tube (CRT)
 - 2. Basic tools use
 - a. Pan
 - b. Zoom
 - c. Axial image scrolling
 - d. Swivel
 - e. Roll
 - f. Rotate
 - 3. Manipulation
 - a. Image reformation
 - b. Image smoothing
 - c. Edge enhancement
 - d. Gray-scale manipulation
 - e. 3-D processing
 - f. Multiplanar reformation
 - g. Shaded surface rendering
 - h. Maximum intensity projection (MIP)
 - i. Volume rendering
 - j. Stereotaxis
 - k. Radiation oncology treatment planning
 - l. Fusion
 - m. Curved multiplanar reconstruction (cMPR)
 - n. Virtual endoscopy/colonoscopy (VE)
 - o. Vessel analysis (VA)
 - p. Vessel tracking (VT)
 - 4. Viewing modes
 - a. 2-D
 - b. Slab
 - c. Planar
 - 5. Basic use of the workstation –
 - a. Directory

- b. Film
- c. Report
- d. Delete
- e. Archive
- f. Copy
- g. Online help
- 6. Workstation applications
 - a. Cardiac
 - b. Neurology
 - c. Vascular
 - d. Gastrointestinal
 - e. Pulmonary
 - f. Dental
 - g. Orthopedics
- 7. Recording
 - a. Film
 - 1) Laser cameras
- 8. Archiving
 - a. Laser, DVD and optical disks
- 9. PACS
- 10. Image communication

VII. Image Quality in CT

- A. Definition
- B. Determiners
 - 1. Artifacts
 - 2. Contrast resolution
 - 3. Linearity
 - 4. Noise
 - 5. Spatial resolution
- C. Influencing factors
 - 1. Focal spot size
 - 2. Beam geometry
 - 3. Image receptor
 - 4. Motion
 - 5. Subject contrast
 - 6. Viewing conditions
 - 7. Selectable factors
 - a. mA
 - b. Scan time
 - c. Scan field of view (SFOV)
 - d. Displayed field of view (DFOV)
 - e. Slice thickness and spacing
 - f. Filter

- g. kV
- h. Presets
 - 1) Organ mode

D. Measurements by physicists

- 1. Contrast transfer and response function
- 2. Line spread function
- 3. Point spread function
- 4. Modulation transfer function
- 5. 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) Radiation leakage and scatter
 - 16) kVp wave form

VIII. Radiation Protection Practices for the CT Patient

A. Measuring patient radiation dose

- 1. Methods
- 2. Procedures
- 3. CT dose index (CTDI)
- 4. Multiple scan average dose (MSAD)
- 5. Dose length product (DLP)

6. Millisievert (mSv)
7. Grays (gy)

- B. Reducing radiation dose
 1. Methods
 - a. Technical factor selection
 - b. Scanner dosimetry survey
 - c. Operator dependent
 - 1) Shielding
 - 2) Positioning
- C. Pediatric patients
- D. Ethical considerations
 1. Overuse
 2. Pediatrics

IX. Spiral Computed Tomography

- A. Definition
- B. Historical development
- C. Differences between conventional and spiral CT
 1. Operation
 2. Advantages
 3. Disadvantages
- D. Multidetector Row Computed Tomography (MDCT)
- E. Scanner designs
 1. High-voltage and low-voltage scanners
 2. Slip-ring cylinders and slip-ring disk

X. Computed Tomography Angiography (CTA)

XI. Positron Emission Tomography/Computed Tomography (PET/CT)

XII. Virtual CT

XIII. CT colonography

XIV. Cystography

XV. Endography

CT Procedures

Description

Content provides detailed coverage of procedures for CT imaging. Procedures 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. CT procedures will be taught for differentiation of specific structures, patient symptomology and pathology. CT images studied will be reviewed for quality, anatomy and pathology. CT procedures vary from facility to facility and normally are dependent on the preferences of the radiologists.

Objectives

1. List the CT scanner and scan room preparation steps necessary for CT procedures.
2. Name the indicated CT procedure for specific anatomical structures, patient symptoms or pathology.
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 procedure.
5. Determine if contrast media is indicated for a specific procedure 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 procedure.
9. Provide correct information concerning the 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.
10. List accurate window width (WW) and window level (WL) selections for each 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 procedure studied.
14. List the information that should be noted on each scout and scan image.
15. Name the routine filming format for each procedure studied.
16. Perform any nonroutine procedure tasks associated with CT procedures.
17. Adapt routine scanning parameters for CT procedures of the head and neck to spiral mode and explain the differences.
18. Differentiate between scanning parameters for conventional vs. spiral procedures.
19. Explain current trends in CT image archiving.
20. List postprocedure patient instructions for each procedure.
21. Describe proper procedures for patient screening.

Content

- I. CT Equipment Overview**
- II. Patient Care, Education and Management Review**
- III. Anatomy Review**
 - A. Bones
 - B. Organs
 - C. Musculature
 - D. Vasculature
 - E. Nerves
- IV. Procedure Elements**
 - A. Indications for each protocol
 - B. Contraindications for each procedure
 - C. Venipuncture
 - D. Power ports
 - E. Power pics
 - F. Indications for contrast media
 - 1. Pharmacology
 - 2. Types of contrast media
 - 3. Route of administration and venipuncture
 - 4. Contraindications for contrast media
 - G. Power injectors
 - 1. Single head injectors
 - 2. Dual head injectors
 - H. Informed consent requirements and charting
 - I. Patient preparation and postprocedure instructions
 - J. ECG
 - 1. Parts of wave
 - 2. Patient preparation
 - 3. Lead placement
 - 4. Artifacts

- K. Procedure 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
 - a. Conventional
 - b. Spiral
 - 10. Algorithm
 - 11. Pitch
 - a. Single detector row
 - b. Multidetector row spiral
 - 12. Gantry angle
 - 13. Technical factor selection
 - 14. Table indexing
 - 15. Slice thickness
 - 16. Window level
 - 17. Window width
 - 18. Matrix size
 - 19. Image annotation parameters
 - 20. Imaging planes
 - 21. Spiral application
 - 22. Image archiving
 - 23. Identification of pathology
 - 24. Charting and documentation requirements
 - 25. Bolus parameters and timing
 - 26. Workstation
 - 27. Other

V. Procedures of the Head and Neck:

- A. CT head (brain, sella turcica, ventricles, etc.) without contrast
- B. CT head with contrast
- C. CT head for craniofacial deformities
- D. CT head for trauma
- E. CT head for circulus arteriosus cerebri (circle of Willis)
- F. CT head for seizure

- G. CT head for thalamus and hypothalamus
- H. CT head for pituitary gland
- I. CT head to rule out metastasis
- J. CT head for multiple sclerosis
- K. CT head for pineal gland
- L. CT head for optic nerve
- M. CT head for ophthalmic artery and retinal vein
- N. Maxillofacial CT (orbits, nasal bones, facial bones, tempromandibular joints, etc.)
- O. CT facial bones for trauma
- P. CT paranasal sinuses
- Q. CT temporal bone (internal auditory canals, posterior fossa, base of skull, etc.)
- R. CT neck (nasopharynx, oropharynx, larynx, parotid glands, etc.) with or without contrast
- S. CT neck (submandibular glands, vascular structures, etc.) with contrast
- T. CT neck for thyroid and parathyroid glands
- U. Stereotaxis
- V. CTA carotid
- W. Others as determined by program and clinical faculty

VI. Procedures for the Thorax, Spine and Musculoskeletal System

- A. CT coronaries
- B. CT calcium score
- C. Gated cardiac studies
- D. CT thorax with and without contrast
- E. CT thorax with or without contrast for mediastinal structures

- F. CT thorax (bone windows)
- G. CT thorax (lung windows)
- H. CT thorax for aortic dissection
- I. CT thorax for pulmonary embolism
- J. CT sternum
- K. CT thorax for thymus gland (not visible in adults unless autoimmune disorder is present)
- L. CT thorax (thoracic lymph nodes) for disease staging
- M. CT thorax (trauma)
- N. CT cervical spine
- O. CT thoracic spine
- P. CT lumbar spine
- Q. CT spine (cervical, thoracic or lumbar) postmyelogram
- R. CT spine (trauma)
- S. CT upper extremity
- T. CT lower extremity
- U. CT soft tissue extremity
- V. CT pelvic girdle
- W. CT extremity (trauma, mass, prosthesis loosening)
- X. CTA runoff

VII. Procedures for the Abdomen, Pelvis and Special Applications

- A. CT abdomen without and with contrast
- B. CT abdomen for pancreas
- C. CT abdomen for liver

- D. CT abdomen for renal system
- E. CT abdomen for adrenal glands
- F. CT abdomen for aortic dissection
- G. CTA of the abdomen
- H. CT abdomen for spleen
- I. CT abdomen for gastrointestinal system
- J. CT gallbladder
- K. CT abdomen for suspected appendicitis
- L. CT abdominal lymph nodes (disease staging)
- M. CT abdomen to rule out metastasis
- N. CT enterography
- O. CT virtual colonoscopy
- P. CT guided needle biopsies
- Q. CT guided abscess drains
- R. CT abdomen (trauma)
- S. CT pelvis without contrast
- T. CT pelvis for female genitourinary system
- U. CT pelvis for male genitourinary system
- V. Brain perfusion
- W. CT of transplanted organs

Sectional Anatomy

Description

Content 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. Illustrations and anatomy images will be compared with MR and CT images in the same imaging planes and at the same level when applicable. The characteristic appearance of each anatomical structure as it appears on CT, MR and ultrasound, when applicable, will be stressed.

Objectives

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, PET and ultrasound images in the 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

- 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. Internal auditory canal
 - d. Mastoid process
 - e. 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, rostrum, body and splenium)
 8. Septum pellucidum
 9. Sella turcica
 10. Pineal gland
 11. Falx cerebri
 12. 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 and adjoining structures
 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
- 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. Lacrimal gland
5. Lateral rectus muscle
6. Medial rectus muscle
7. Superior rectus muscle
8. Inferior rectus muscle
9. Superior oblique muscle
10. Inferior oblique muscle
11. Orbital fat
12. Ophthalmic artery
13. Retinal vein

O. Anatomical structures of brain

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

25. Nasal septum
26. External auditory canal (EAC)
27. Clivus
28. Mastoid air cells

P. Lines of angulation (imaging baselines)

1. Supraorbitomeatal line
2. Orbitomeatal line
3. Infraorbitomeatal line

Q. Anatomical landmarks

1. Glabella
2. Nasion
3. Acanthion
4. Mental point
5. External auditory meatus (EAM)

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
6. Clavicles

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
 - a. Arteries
 - b. Veins
 - c. Chamber
 - d. Valves
3. Pulmonary vessels
4. Coronary vessels
5. Ascending aorta
6. Aortic arch
7. Branches of the aortic arch
8. Descending (thoracic) aorta
9. Inferior vena cava
10. Esophagus
11. Trachea
12. Thoracic duct
13. Lymph nodes
14. Azygos vein
15. Hemiazygos vein

D. Breasts

E. Musculature

IV. Abdomen

A. Diaphragm and openings

1. Aortic hiatus
2. Caval hiatus
3. Esophageal hiatus

B. Surface landmarks and regions

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

C. 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

D. 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. Parietal branches
 - a. Inferior phrenics
 - b. Lumbar
 - c. Middle sacral
6. Terminal branches
 - a. Common iliacs

E. 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
- F. Tributaries of the portal vein
1. Splenic
 2. Inferior mesenteric
 3. Superior mesenteric
 - a. Left gastric
 - b. Right gastric
 - c. Cystic
- G. 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
 - a. Hepatic arteries
 - b. Portal venous system
 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. Ovarian/testicular
2. Venous
 - a. External iliacs
 - b. Internal iliacs
 - c. Common iliacs
 - d. Ovarian/testicular

C. Pelvic organs

1. Urinary bladder
 - a. Ureter
 - b. Urethra
2. Small intestine
 - a. Terminal ilium and ileocecal valve
3. Colon
 - a. Ascending
 - b. Descending
 - c. Sigmoid
 - d. Rectum
 - e. Vermiform appendix
4. Female reproductive organs
 - a. Vagina
 - b. Cervix
 - c. Uterus
 - d. Fallopian tubes
 - e. Ovaries
5. Male reproductive organs
 - a. Testes/scrotum
 - b. Prostate gland
 - c. Seminal vesicles
 - d. External to pelvis
 - 1) Penis

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)
 - d. Vascularity
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
 - b. Phalanges
 - c. Metacarpals
 - 1) Carpal bones
 - 2) Radius

- 3) Ulnar
- d. Tendons
 - 1) Palmar tendon group
 - 2) Dorsal tendon group
 - 3) Triangular fibrocartilage complex
- e. 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

Appendix A

This section represents an inventory of pre-existing knowledge and skills gained through an entry-level radiography educational experience and reinforced through professional practice. The content in this section is intended to aid technologists in career planning and program managers in the development of preassessment tools for candidate selection.

ASRT

Basic Principles of Computed Tomography

Description

Content is designed to provide entry-level radiography students with principles related to computed tomography (CT) imaging.

Objectives

- Describe the components of the CT imaging system.
- Differentiate between conventional and spiral/helical CT scanning.
- Explain the functions of collimators in CT.
- List the CT computer data processing steps.
- Name the functions of the array processor used for image reconstruction.
- Define the term "algorithm" and explain its impact on image scan factors and reconstruction.
- Define the terms "raw data" and "image data."
- Explain the difference between reconstructing and reformatting an image.
- Describe the application of the following terms to CT:
 - Pixel.
 - Matrix.
 - Voxel.
 - Linear attenuation coefficient.
 - CT/Hounsfield number.
 - Partial volume averaging.
 - Window width (ww) and window level (wl).
 - Spatial resolution.
 - Contrast resolution.
 - Noise.
 - Annotation.
 - Region of interest (ROI).
 - Standard vs. volumetric data acquisition.
- Name the common controls found on CT operator consoles and describe how and why each is used.
- Identify the types and appearance of artifacts most commonly affecting CT images.
- Explain how artifacts can be reduced or eliminated.
- List and describe current data storage techniques used in CT.
- Name the radiation protection devices that can be used to reduce patient dose in CT and describe the correct application of each.

Clinical Practice

Description

Content and clinical practice experiences should be designed to sequentially develop, apply, critically analyze, integrate, synthesize and evaluate concepts and theories in the performance of radiologic procedures. Through structured, sequential, competency-based clinical assignments, concepts of team practice, patient-centered clinical practice and professional development are discussed, examined and evaluated.

Clinical practice experiences should be designed to provide patient care and assessment, competent performance of radiologic imaging and total quality management. Levels of competency and outcomes measurement ensure the well-being of the patient preparatory to, during and following the radiologic procedure.

Objectives

- Exercise the priorities required in daily clinical practice.
- Execute medical imaging procedures under the appropriate level of supervision.
- Adhere to team practice concepts that focus on organizational theories, roles of team members and conflict resolution.
- Adapt to changes and varying clinical situations.
- Describe the role of health care team members in responding/reacting to a local or national emergency.
- Provide patient-centered clinically effective care for all patients regardless of age, gender, disability, special needs, ethnicity or culture.
- Integrate the use of appropriate and effective written, oral and nonverbal communication with patients, the public and members of the health care team in the clinical setting.
- Integrate appropriate personal and professional values into clinical practice.
- Recognize the influence of professional values on patient care.
- Explain how a person's cultural beliefs toward illness and health affect his or her health status.
- Use patient and family education strategies appropriate to the comprehension level of the patient/family.
- Provide desired psychosocial support to the patient and family.
- Demonstrate competent assessment skills through effective management of the patient's physical and mental status.
- Respond appropriately to medical emergencies.
- Examine demographic factors that influence patient compliance with medical care.
- Adapt procedures to meet age-specific, disease-specific and cultural needs of patients.
- Assess the patient and record clinical history.
- Demonstrate basic life support procedures.
- Use appropriate charting methods.
- Recognize life-threatening ECG tracing.
- Apply standard and transmission-based precautions.
- Apply the appropriate medical asepsis and sterile technique.

- Demonstrate competency in the principles of radiation protection standards.
- Apply the principles of total quality management.
- Report equipment malfunctions.
- Examine procedure orders for accuracy and make corrective actions when applicable.
- Demonstrate safe, ethical and legal practices.
- Integrate the radiographer's practice standards into clinical practice setting.
- Maintain patient confidentiality standards and meet Health Insurance Portability and Accountability Act (HIPAA) requirements.
- Demonstrate the principles of transferring, positioning and immobilizing patients.
- Comply with departmental and institutional response to emergencies, disasters and accidents.
- Differentiate between emergency and nonemergency procedures.
- Adhere to national, institutional and departmental standards, policies and procedures regarding care of patients, providing radiologic procedures and reducing medical errors.
- Select technical factors to produce quality diagnostic images with the lowest radiation exposure possible.
- Critique images for appropriate anatomy, image quality and patient identification.
- Determine corrective measures to improve inadequate images.

Digital Image Acquisition and Display

Description

Content is designed to impart an understanding of the components, principles and operation of digital imaging systems found in diagnostic radiology. Factors that impact image acquisition, display, archiving and retrieval are discussed. Guidelines for selecting exposure factors and evaluating images within a digital system assist students to bridge between film-based and digital imaging systems. Principles of digital system quality assurance and maintenance are presented.

Objectives

- Define terminology associated with digital imaging systems.
- Describe the various types of digital receptors.
- Discuss the fundamentals of digital radiography, distinguishing between cassette-based systems and cassette-less systems.
- Compare the image acquisition and extraction of cassette-based vs. cassette-less systems, including detector mechanism, initial image processing, histogram analysis, automatic rescaling and exposure index determination.
- Describe the evaluative criteria for digital radiography detectors.
- Describe the response of digital detectors to exposure variations.
- Compare the advantages and limits of each system.
- Given the performance criteria for a digital radiography detector, evaluate the spatial resolution and dose effectiveness.
- Compare dynamic range to latitude of a film-screen receptor system to that of a digital radiography system.
- Describe the histogram and the process or histogram analysis as it relates to automatic rescaling and determining an exposure indicator.
- Describe or identify the exposure indices used by each photostimulable phosphor (PSP)-based system.
- Describe the difference between dose area product (DAP) measured with a flat panel system vs. the exposure index for a PSP-based system.
- Relate the receptor exposure indicator values to technical factors, system calibration, part/beam/plate alignment and patient exposure.
- Describe image acquisition precautions necessary for CR imaging.
- Describe the response of PSP systems to background and scatter radiation.
- Utilize appropriate means of scatter control.
- Avoid grid use errors associated with grid cutoff and Moiré effect.
- Identify common limitations and technical problems encountered when using PSP systems.
- Employ appropriate beam/part/receptor alignment to avoid histogram analysis errors.
- Describe the various image processing employed for digital images.
- Associate impact of image processing parameters to the image appearance.
- Associate effects of inappropriate processing on image clarity or conspicuity.
- Describe the fundamental physical principles of exposure for digital detectors.
- Apply the fundamental principles to digital detectors.

- Describe the selection of technical factors and technical factor systems to assure appropriate receptor exposure levels for digital detectors.
- Evaluate the effect of a given exposure change on histogram shape, data width and image appearance.
- Describe the conditions that cause quantum mottle in a digital image.
- Formulate a procedure or process to minimize histogram analysis and rescaling errors.
- Describe the exposure precautions and limitations associated with PSP-based systems.
- Avoid poor quality images by observing acquisition precautions.
- Examine the potential impact of digital radiographic systems on patient exposure and methods of practicing the as low as reasonably achievable (ALARA) concept with digital systems.
- Describe PACS and its function.
- Identify components of a PACS system.
- Describe patient benefits gained through the use of teleradiology.
- Identify modality types that may be incorporated into a PACS.
- Define accession number.
- Describe worklist and correct usage.
- Define digital imaging and communications in medicine (DICOM).
- Describe how an image is associated with a radiology order to create a DICOM image.
- Describe data flow for a DICOM image from an imaging modality to a PACS.
- Describe HIPPA concerns with electronic information.
- Identify common problems associated with retrieving/viewing images within a PACS.
- Identify the primary uses of the diagnostic display workstation and clinical display workstation.

Ethics and Law in the Radiologic Sciences

Description

Content is designed to provide a fundamental background in ethics. The historical and philosophical bases of ethics, as well as the elements of ethical behavior, are discussed. The student will examine a variety of ethical issues and dilemmas found in clinical practice.

An introduction to legal terminology, concepts and principles also will be presented. Topics include misconduct, malpractice, legal and professional standards and the ASRT scope of practice. The importance of proper documentation and informed consent is emphasized.

Objectives

- Discuss the origins of medical ethics.
- Apply medical/professional ethics in the context of a broader societal ethic.
- Explain the role of ethical behavior in health care delivery.
- Differentiate between empathetic rapport and sympathetic involvement in relationships with patients and relate these to ethical conduct.
- Explain concepts of personal honesty, integrity, accountability, competence and compassion as ethical imperatives in health care.
- Identify legal and professional standards and relate each to practice in health professions.
- Identify specific situations and conditions that give rise to ethical dilemmas in health care.
- Explain select concepts embodied in the principles of patients' rights, the doctrine of informed (patient) consent and other issues related to patients' rights.
- Explain the legal implications of professional liability, malpractice, professional negligence and other legal doctrines applicable to professional practice.
- Describe the importance of accurate, complete, correct methods of documentation as a legal/ethical imperative.
- Explore theoretical situations and questions relating to the ethics of care and health care delivery.
- Explain legal terms, principles, doctrines and laws specific to the radiologic sciences.
- Outline the conditions necessary for a valid malpractice claim.
- Describe institutional and professional liability protection typically available to the radiographer.
- Describe the components and implications of informed consent.
- Identify standards for disclosure relative to informed consent.
- Describe how consent forms are used relative to specific radiographic procedures.
- Identify the four sources of law to include statutory, administrative, common and constitutional.
- Differentiate between civil and criminal liability.
- Define tort and explain the differences between intentional and unintentional torts.
- Exhibit critical data research retrieval and analysis skills composing an evidence-based narrative that addresses an ethical dilemma found in the patient care setting.

Human Structure and Function

Description

Content is designed to establish a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and systems are described and discussed.

Objectives

- Discuss the basics of anatomical nomenclature.
- Describe the chemical composition of the human body.
- Identify cell structure and elements of genetic control.
- Explain the essentials of human metabolism.
- Describe the types and functions of human tissues.
- Classify tissue types, describe the functional characteristics of each and give examples of their location within the human body.
- Describe the composition and characteristics of bone.
- Identify and locate the bones of the human skeleton.
- Identify bony processes and depressions found on the human skeleton.
- Describe articulations of the axial and appendicular skeleton.
- Differentiate the primary and secondary curves of the spine.
- Summarize the functions of the skeletal system.
- Label different types of articulations.
- Compare the types, locations and movements permitted by the different types of articulations.
- Examine how muscle is organized at the gross and microscopic levels.
- Differentiate between the structures of each type of muscle tissue.
- State the function of each type of muscle tissue.
- Name and locate the major muscles of the skeleton.
- Differentiate between the structure and function of different types of nerve cells.
- State the structure of the brain and the relationship of its component parts.
- Describe brain functions.
- List the meninges and describe the function of each.
- Outline how cerebrospinal fluid forms, circulates and functions.
- Describe the structure and function of the spinal cord.
- Determine the distribution and function of cranial and spinal nerves.
- Summarize the structure and function of components that comprise the autonomic nervous system.
- Describe the structures and functions of the components that comprise the human eye and ear.
- List the component body parts involved in the senses of smell and taste.
- List the somatic senses.
- Define endocrine.
- Describe the characteristics and functions of the components that comprise the endocrine system.
- Describe the hard and soft palates.

- Describe the structure and function of the tongue.
- Identify the structure, function and locations of the salivary glands.
- Describe the composition and characteristics of the primary organs of the digestive system.
- Describe the function(s) of each primary organ of the digestive system.
- Differentiate between the layers of tissue that comprise the esophagus, stomach, small intestine, large intestine and rectum.
- Differentiate between peritoneum, omentum and mesentery.
- List and label the accessory organs of the digestive system and describe their function.
- Identify the secretions and function of each accessory organ of the digestive system.
- Explain the purpose of digestion.
- List the digestive processes that occur in the body.
- Describe the composition and characteristics of blood.
- List the types of blood cells and state their functions.
- Differentiate between blood plasma and serum.
- Outline the clotting mechanism.
- List the blood types.
- Explain the term Rh factor.
- Explain the antigen/antibody relationship and its use in blood typing.
- Label the parts of the human heart.
- Describe the flow of blood through the body and identify the main vessels.
- Describe the structure and function of arteries, veins and capillaries.
- Differentiate between arterial blood in systemic circulation and arterial blood in pulmonary circulation.
- Outline the major pathways of lymphatic circulation.
- Correlate cardiac electrophysiology to a normal ECG tracing.
- Differentiate between nonspecific defenses and specific immunity.
- Explain antibody production and function.
- List the different types and functions of T- and B-cells and explain their functions.
- Label the components of the respiratory system.
- Describe the physiology and regulation of respiration.
- Label the parts of the kidneys, ureters, bladder and urethra.
- Describe the function of each organ of the urinary system.
- Describe the composition and formation of urine.
- Explain micturition.
- Label the anatomy of the male and female reproductive organs.
- Analyze the function of each of the male and female reproductive organs.
- Identify major anatomical structures found within sectional images.

Patient Care in Radiologic Sciences

Description

Content is designed to provide the basic concepts of patient care, including consideration for the physical and psychological needs of the patient and family. Routine and emergency patient care procedures are described, as well as infection control procedures using standard precautions. The role of the radiographer in patient education is identified.

Objectives

- Identify the responsibilities of the health care facility and members of the health care team.
- List the general responsibilities of the radiographer.
- Describe the practice standards for the radiographer as defined by the ASRT and state licensure.
- Discuss the interrelationship between personal, community and societal values.
- Explain the influence a person's value system has on his or her behavior.
- Discuss the development of personal and professional values.
- Describe how professional values influence patient care.
- Differentiate between culture and ethnicity.
- Explain how a person's cultural beliefs toward illness and health affect his or her health status.
- Explain perceptions of death and dying from the viewpoint of both patient and radiographer.
- Describe ethical, emotional, personal and physical aspects of death.
- List the stages of dying and describe the characteristics of each stage.
- Identify the support mechanisms available to the terminally ill.
- Identify methods for determining the correct patient for a given procedure.
- Explain the use of various communication devices and systems.
- Explain specific aspects of a radiographic procedure to the patient.
- Demonstrate correct principles of body mechanics applicable to patient care.
- Demonstrate techniques for specific types of patient transfer.
- Demonstrate select procedures to turn patients with various health conditions.
- Describe select immobilization techniques for various types of procedures and patient conditions.
- Describe specific patient safety measures and concerns.
- Explain the purpose, legal considerations and procedures for reporting an accident or incident.
- Describe methods to evaluate patient physical status.
- List the information to be collected prior to a patient examination.
- Describe vital signs used to assess patient condition that include sites for assessment and normal values.
- Recognize and describe abnormal respiratory patterns.
- State the terms used to describe respiratory rates that are above and below normal values.
- Identify terms used to describe above and below normal pulse rates.
- Assess patient vital signs.

- List the normal ranges for specific laboratory studies.
- Define terms related to infection control.
- Describe the importance of standard precautions and isolation procedures that includes sources and modes of transmission of infection and disease and institutional control procedures.
- Identify symptoms related to specific emergency situations.
- Describe the emergency medical code system for the institution and the role of the student during a medical emergency.
- Explain the special considerations necessary when performing radiographic procedures on an infant or child.
- Explain the special considerations necessary when performing radiographic procedures on a geriatric patient.
- Describe the symptoms and precautions taken for a patient with a head injury.
- Describe three areas that are assessed by the Glasgow Coma Scale and the numbers associated with each area.
- Explain the types, immobilization devices and positioning for upper and lower extremity fractures.
- Describe the symptoms and precautions taken for a patient with traumatic injury.
- Describe the symptoms and medical interventions for a patient with a contrast agent reaction.
- Explain the role of the radiographer in patient education.
- Discuss family dynamics, culture, social, ethnic and lifestyle considerations and their impact on health status.
- Describe the patient preparation for barium studies.
- Identify specific types of tubes, lines, catheters and collection devices.
- Outline the steps in the operation and maintenance of suction and oxygen equipment and demonstrate their use.
- Demonstrate competency in basic life support (BLS).
- Demonstrate the use of specific medical emergency equipment and supplies.
- Describe the monitoring, preprocedure and postprocedure care, drug administration and special precautions for a patient undergoing invasive procedures.
- Demonstrate the appropriate procedure for gathering information prior to performing a mobile radiographic examination.
- Describe the initial steps in performing a mobile procedure.
- Explain the procedure for placing an image receptor under a patient in an orthopedic bed frame.
- Describe the special problems faced in performing procedures on a patient with a tracheotomy and specific tubes, drains and catheters.
- Describe the procedure for producing diagnostic images in the surgical suite.
- Explain the appropriate radiation protection required when performing mobile/surgical radiography.

Pharmacology and Drug Administration

Description

Content is designed to provide basic concepts of pharmacology. The theory and practice of basic techniques of venipuncture and administration of diagnostic contrast agents and/or intravenous medications is included. The appropriate delivery of patient care during these procedures is emphasized.

Objectives

- Distinguish between the chemical, generic and trade names for select drugs.
- Describe pharmacokinetic and pharmacodynamic principles of drugs.
- Classify drugs according to specific categories.
- Explain the actions, uses and side effects for select drugs.
- Explain the effects of select drugs on medical imaging procedures.
- Define the categories of contrast agents and give specific examples for each category.
- Explain the pharmacology of barium and iodine compounds.
- Describe methods and techniques for administering various types of contrast agents.
- Identify and describe the routes of drug administration.
- Discuss the purposes and advantages of intravenous drug administration over other routes.
- Demonstrate appropriate venipuncture technique.
- Differentiate between the two major sites of intravenous drug administration.
- Identify, describe and document complications associated with intravenous drug therapy and appropriate actions to resolve these complications.
- Discuss the various elements of initiating and discontinuing intravenous drug therapy.
- Differentiate and document dose calculations for adult and pediatric patients.
- Prepare for injection of contrast agents/intravenous medications using aseptic technique.
- Explain the current legal and ethical status of the radiographer's role in drug administration.
- Explain a radiographer's professional liability concerning drug administration.

Radiation Protection

Description

Content is designed to present an overview of the principles of radiation protection, including the responsibilities of the radiographer for patients, personnel and the public. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated.

Objectives

- Identify and justify the need to minimize unnecessary radiation exposure of humans.
- Distinguish between somatic and genetic radiation effects.
- Differentiate between the stochastic (probabilistic) and nonstochastic (deterministic) effects of radiation exposure.
- Explain the objectives of a radiation protection program.
- Define radiation and radioactivity units of measurement.
- Identify effective dose limits (EDL) for occupational and nonoccupational radiation exposure.
- Describe the ALARA concept.
- Identify the basis for occupational exposure limits.
- Distinguish between perceived risk and comparable risk.
- Describe the concept of the negligible individual dose (NID).
- Identify ionizing radiation sources from natural and man-made sources.
- Comply with legal and ethical radiation protection responsibilities of radiation workers.
- Describe the relationship between irradiated area and effective dose.
- Describe the theory and operation of radiation detection devices.
- Identify appropriate applications and limitations for each radiation detection device.
- Describe how isoexposure curves are used for radiation protection.
- Identify performance standards for beam-limiting devices.
- Describe procedures used to verify performance standards for equipment and indicate the potential consequences if the performance standards fail.
- Describe the operation of various interlocking systems for equipment and indicate potential consequences of interlock system failure.
- Identify conditions and locations evaluated in an area survey for radiation protection.
- Distinguish between controlled and noncontrolled areas and list acceptable exposure levels.
- Describe “Radiation Area” signs and identify appropriate placement sites.
- Describe the function of federal, state and local regulations governing radiation protection practices.
- Describe the requirements for and responsibilities of a radiation safety officer.
- Express the need and importance of personnel monitoring for radiation workers.
- Describe personnel monitoring devices, including applications, advantages and limitations for each device.
- Interpret personnel monitoring reports.
- Compare values for individual effective dose limits for occupational radiation exposures (annual and lifetime).

- Identify anatomical structures that are considered critical for potential late effects of whole body irradiation exposure.
- Identify dose equivalent limits for the embryo and fetus in occupationally exposed women.
- Distinguish between primary and secondary radiation barriers.
- Demonstrate how the operation of various x-ray and ancillary equipment influences radiation safety and describe the potential consequences of equipment failure.
- Perform calculations of exposure with varying time, distance and shielding.
- Discuss the relationship between workload, energy, half-value layer (HVL), tenth-value layer (TVL), use factor and shielding design.
- Identify emergency procedures to be followed during failures of x-ray equipment.
- Demonstrate how time, distance and shielding can be manipulated to keep radiation exposures to a minimum.
- Explain the relationship of beam-limiting devices to patient radiation protection.
- Discuss added and inherent filtration in terms of the effect on patient dosage.
- Explain the purpose and importance of patient shielding.
- Identify various types of patient shielding and state the advantages and disadvantages of each type.
- Use the appropriate method of shielding for a given radiographic procedure.
- Explain the relationship of exposure factors to patient dosage.
- Explain how patient position affects dose to radiosensitive organs.
- Identify the appropriate image receptor that will result in an optimum diagnostic image with the minimum radiation exposure to the patient.
- Select the immobilization techniques used to eliminate voluntary motion.
- Describe the minimum source-to-tabletop distances for fixed and mobile fluoroscopic devices.
- Apply safety factors for the patient (and others) in the room during mobile radiographic procedures.

Appendix B

The clinical experience requirements section is intended to provide information regarding the development of a well-rounded clinical experience. Information regarding the eligibility requirements for a postprimary certification examination in computed tomography is provided in this section.

ASRT

Clinical Experience Requirements

The most current information regarding the eligibility requirements for a postprimary certification examination in computed tomography can be found at the link below.

The ARRT Clinical Experience Requirements document is located at http://arrt.org/education/ct_cx_2003.pdf.

ARRT

Reference Resources

Adler A, Carlton R. *Introduction to Radiography and Patient Care*. Philadelphia, PA: WB Saunders Company; 1999.

ISBN 0721676626

Aehlert B, *ECGs Made Easy, Pocket Reference*. 2nd ed. St. Louis, MO, Mosby; 2002.

ISBN 0-323-01433-X

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; 2001.

ISBN 0-721-68443-2

Applegate E. *The Anatomy and Physiology Learning System*. Philadelphia, PA: WB Saunders Company; 1995.

ISBN 0-721-6663-53

ARRT Examination in Computed Tomography. New York, NY: National Learning Corporation; 1997.

ISBN 0837358167

Barrett CP. *Primer of Sectional Anatomy With MRI and CT Correlation*. Baltimore, MD: Williams & Wilkins; 1994.

ISBN 0-6873-00472-7

Bushong S. *Computed Tomography*. New York, NY: McGraw-Hill; 2000.

ISBN 0-07-134354-7

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, MA: Kluwer Academic Publishing; 1989.

ISBN 0-792-30227-3

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

Computed Tomography Certification Handbook and Application Materials. St. Paul, MN: American Registry of Radiologic Technologists; 2004.

Computed Tomography Clinical Experience Requirements. St. Paul, MN: American Registry of Radiologic Technologists.

Content Specifications for the Examination in Computed Tomography. St. Paul, MN: American Registry of Radiologic Technologists; 2004.

De Feyter, *Computed Tomography of the Coronary Arteries*, Boca Raton, FL, Taylor & Francis; 2005.
ISBN 1-84184-439-X

Demaio 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

Gillespie JE. *Magnetic Resonance Imaging and Computed Tomography of the Head and Neck.* Philadelphia, PA: Lippincott Williams & Wilkins; 1994.
ISBN 0412452006

Goldman M. *CT and MRI Genitourinary Tract.* New York, NY: Churchill Livingstone; 1990.
ISBN 0-443-08657-5

Grey ML, Ailinani JM. *CT and MRI Pathology: A Pocket Atlas.* New York, NY: McGraw Hill; 2003.
ISBN 0-07-138040-X

Haaga JR. *Computed Tomography and Magnetic Resonance Imaging of the Whole Body.* 4th ed. St. Louis, MO: Mosby-Year Book Inc; 2002.
ISBN 0323011330

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

Hofer, Matthias. *CT Teaching Manual; A Systematic Approach to CT Reading*. 2nd ed. New York, NY: Thieme Medical Publishers Inc; 2007.
ISBN 1588902773

Jensen SC, Peppers MP. *Pharmacology and Drug Administration for Imaging Technologists*. 2nd ed. St. Louis, MO: Mosby Publishers; 2005.
ISBN 0323030750

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 H. *Cranial MRI and CT*. New York, NY: McGraw-Hill; 1995.
ISBN 0-070-37508-9

Lee JKT, Sagel SS, Stanley RJ, Theiken. *Computed Body Tomography with MRI Correlation*. 3rd ed. Philadelphia, PA: Lippincott-Raven Publishers; 1997.
ISBN 0-781-70291-7

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, CN: Appleton and Lange; 1997. ISBN 0-8385-7678-8

Miller BF, Miller-Keane. *Encyclopedia and Dictionary of Medicine, Nursing and Allied Health*. 7th ed. Philadelphia, PA: WB Saunders Co; 2003. ISBN 0-7216-9791-7

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*. 2nd ed. New York, NY: Thieme Medical Publishers Inc; 2001. ISBN 0-865-77872-8

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

Ohnesorge et al. *Multi-slice CT in Cardiac Imaging*. Berlin: Springer-Verlag; 2002. ISBN 3-540-42966-2

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

Philpot-Scroggins D. *Lippincotts Computed Tomography*. Philadelphia, PA: Lippincott Williams and Wilkins; 1995. ISBN 0-397-5515-76

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, MN: American Registry of Radiologic Technologists.

Seeram E. *Computed Tomography: Physical Principles, Clinical Applications and Quality Control*. Philadelphia, PA: WB Saunders Co; 2001.
ISBN 0-721-8173-5

Silverman PM, ed. *Multidetector Computed Tomography: A Practical Approach to Clinical Protocols*. Philadelphia, PA: Lippincott Williams & Wilkins; 2002.
ISBN 0-781-73312X

Silverman PM, ed. *Multislice Computed Tomography: Principles, Practice and Clinical Protocols*. Philadelphia, PA: Lippincott Williams & Wilkins; 2002.
ISBN 0-781-73312X

Standards for an Accredited Education Program in the Radiologic Sciences. Chicago, IL: 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. 20th ed. Philadelphia, PA: FA Davis Company; 2005.
ISBN 0803612079

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*. 4th ed. Philadelphia, PA: FA Davis Company; 2005.
ISBN 0-803-61245-1

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

Publishers

American Cancer Society
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www.cancer.org

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www.lww.com

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www.thieme.com

WB Saunders Publishing Company
The Curtis Center
Independence Square West
Philadelphia, PA 19106-3399
800-782-4479
www.wbsaunders.com

Journals

American Journal of Roentgenology. 12 issues/year. Leesburg, VA: American Roentgen Ray Society.

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

Journal of Invasive Cardiology. 12 issues/year. San Francisco, CA: HPM Communications

Journal of Neuroimaging. 4 issues/year. Malen, MA: Blackwell Publishing.

Neuroradiology. New York, NY: Springer-Verlag.

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

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

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

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

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