Computed Tomography Curriculum

Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE, Albuquerque, NM 87123-3917.

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 as well as 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.

Contents

Foundations 1

Core Content 3
- Pathology Correlation in Computed Tomography 4
- Physics – Instrumentation and Imaging 11
- Procedure Protocols 19
- Sectional Anatomy and Imaging Applications 25

Appendix A 37
- Computers in Radiologic Sciences 38
- Ethics and Law in the Radiologic Sciences 39
- Human Diversity 41
- Human Structure and Function 42
- Imaging and Processing 45
- Patient Assessment, Management and Education 47
- Patient Care in Radiologic Sciences 48
- Patient Information Management 50
- Pharmacology 51
- Quality Management 52
- Radiation Protection 53
- Sectional Anatomy 55

Appendix B 56
- Clinical Experience Requirements 57
- Reference Resources 64

Foundations

Computers in Radiologic Sciences
Content is designed to introduce knowledge in computing and information processing. Computer applications in the radiologic sciences related to image capture, display, storage and distribution are presented.

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 will be described, as well as infection control procedures utilizing standard precautions. The role of the radiographer in patient education will be identified.

Patient Assessment, Management and Education
Content introduces a model for clinical thinking to aid in patient assessment. Content includes a focus on the application of normal anatomy and physiological phenomena to ill and injured individuals. Interviewing skills and assessment techniques with clinical focus will be discussed. An emphasis on the analysis and interpretation of physiological data to assist in patient assessment and management will be introduced.

Patient Information Management
Content is designed to provide the basic concepts of patient information management. Medical records management including privacy and regulatory issues will be examined. The role of the technologist in managing patient information will be identified and discussed.

Pharmacology
Content is designed to broaden the technologist's knowledge of pharmacology. Topics include consumer safety and drug regulation, sources and bodily effects of drugs and safe dose preparation. Types of drug preparations, principles of responsible drug administration including routes and techniques are included. An introduction to clinical drug trials and a classification of drugs related to body systems are included as topics for presentation.

Quality Management
Content is designed to impart an understanding of the tasks and protocols making up the quality management activities of a typical radiology department. The roles and responsibilities of all parties contributing to the quality management effort will be presented. Tools, procedures and evaluation criteria used in the performance assessment of imaging modalities and image processing will be discussed.

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.

Radiographic Pathology
Content is designed to introduce theories of disease causation and the pathophysiologic disorders that compromise healthy systems. Etiology, pathophysiologic responses, clinical manifestations, radiographic appearance and management of alterations in body systems will be presented.

Sectional Anatomy
Content is designed to study normal sectional anatomy via diagrams and radiologic images.

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

Core Content

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. Calcium scoring in coronary arteries

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
   7. Pituitary
   8. Astrocytoma
   9. Medulloblastoma

B. Arteriovenous malformation (AVM)

C. Aneurysm

D. Metastases

E. Hematoma

F. Hydrocephalus

G. Cysts

H. Cerebrovascular attack (CVA)
   1. Infarct
   2. Hemorrhage
      a. Subdural
      b. Epidural
      c. Subarachnoid
      d. Intracerebral

I. Infections
   1. Encephalitis
   2. Meningitis
   3. Abscess

J. Trauma

K. Atrophic and degenerative disorders
   1. Multiple sclerosis
   2. Alzheimer's disease
   3. Parkinson's disease

L. 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. 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. Other

VII. Gastrointestinal System

A. Primary neoplasms

B. Metastases

C. Tumors

D. Abscesses

E. Cysts

F. Ascites

G. Hepatomegaly

H. Hepatic carcinoma

I. Liver metastases

J. Splenomegaly

K. Splenic infarction

L. Pancreatic carcinoma

M. Pancreatic pseudocyst

N. Small and large bowel obstruction

O. Appendicitis

P. Gastric carcinoma

Q. Esophageal cancer

R. Polycystic disease

S. Congenital abnormalities

T. 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. Seminoma

L. Testicular cancer

M. Renal transplant

N. Hydronephrosis

O. Pheochromocytoma

P. Congenital abnormalities

Q. 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

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. Metastases

H. Trauma

I. 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

J. Fractures

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 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 and patient factors related to other elements affecting image quality will be explained, as well as artifact production and reduction.

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 kernel.
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. Postprocessing techniques.

21. 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) and window level (wl).
    - Spatial resolution.
    - Contrast resolution.
    - Noise.
    - Aliasing.
    - Digital imaging.
    - Annotation.
    - Scanogram/scout/pilot/topogram.
    - Region of interest (ROI).
    - Axial single slice vs. volumetric data acquisition.
    - Half-scan, full-scan, overscan.
    - Interscan delay.
    - Rays and views.
    - Sampling (angular and ray).
22. List the selectable scan factors and explain how each affects the CT image.
23. Name the factors affecting image quality in CT.
24. Name the common controls found on CT operator consoles and describe how and why each is used.
25. Describe the steps that may be taken to assure constant high-quality CT images.
26. Define the term "artifact," list the types of artifacts and name and describe the appearance of those most commonly affecting CT images.
27. Explain how artifacts may be eliminated or reduced.
28. Trace the sequence of events in CT scanning from the application of electrical current to the radiographic tube through image display.
29. Name and explain the scanner design that led to the development of spiral CT.
30. Relate differences between conventional and spiral CT scanning.
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. Specify the selectable scan factors that affect patient radiation dose and how dose can be reduced.
34. Name the radiation protection devices that may be used to reduce patient dose in CT and describe the correct application of each.
35. 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 Louis Kreel
   4. Allen MacLeod Cormack

C. Historical events
   1. 1917 – Radon proved 2-D or 3-D images reconstruction was possible
   2. 1967 – Working for EMI, Hounsfield develops first CT scanner
   3. 1970 – Construction of CT units that could be used to examine 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

II. Computed Tomography Generations

A. First: Pencil beam geometry

B. Second: Narrow fan beam; multiple detector bank

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

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 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) Pencil
         2) Fan
         3) Cone
         4) Slip rings vs. cables
   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) 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. Back-projection (historical only)
b. Filtered back-projection

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. Multiplanar reformation
g. Shaded surface rendering
h. Stereotaxis
i. Radiation oncology treatment planning
j. Fusion
3. Recording
a. Film
1) Laser cameras
4. Archiving
a. Laser and optical disks
5. PACS
a. Jukebox

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. Beam geometry
4. Image receptor
5. Motion
6. Subject contrast
7. Viewing conditions
8. Selectable factors
a. mA

b. Scan time
c. Slice width
d. Kernal
e. KV
f. 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) 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
   3. CT dose index (CTDI)
   4. Multislice average dose (MSAD)

B. Reducing radiation dose
   1. Methods
      a. Technical factor selection
      b. Scanner dosimetry survey
      c. Operator dependent
         1) Shielding
         2) Positioning

IX. Spiral Computed Tomography

A. Definition

B. Historical development

C. Differences between conventional and spiral CT
   1. Operation
   2. Advantages
   3. Disadvantages

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

X. Computed Tomography Angiography (CTA)

XI. Multidetector Row Computed Tomography (MDCT)

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

XIII. Multislice CT

XIV. Virtual CT

Procedure Protocols

Description

Content provides detailed coverage of procedure protocols for CT imaging. 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. CT protocols will be taught for differentiation of specific structures, patient symptomology and pathology. CT images studied will be reviewed for quality, anatomy and pathology. CT procedure protocols 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 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 protocol.
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 protocol.
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 protocol studied.
14. List the information that should be noted on each scout and scan image.
15. Name the routine filming format for each protocol studied.
16. Perform any nonroutine procedure tasks associated with CT protocols.
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 routine CT procedure vs. spiral protocols.
19. Explain current trends in CT image archiving.
20. List postprocedure patient instructions for each procedure protocol.

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 Protocol Elements

A. Indications for each protocol

B. Contraindications for each protocol

C. Indications for contrast media`
   1. Types of contrast media
   2. Route of administration and venipuncture

D. Contraindications for contrast media

E. Informed consent requirements and charting

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
      a. Conventional
      b. Spiral
   10. Algorithm
   11. Pitch
   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. Filming format
23. Image archiving
24. Identification of pathology
25. Charting and documentation requirements
26. Other

V. Protocols 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 arteriosis 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. Spiral head with or without contrast

S. CT neck (nasopharynx, larynx, parotid glands, etc.) with or without contrast

T. CT neck (spine, submandibular glands, vascular structures, etc.) with contrast

U. CT neck for thyroid and parathyroid glands

V. Stereotaxis

W. Spiral neck

X. Others as determined by program and clinical faculty

VI. Protocols for the Thorax, Spine and Musculoskeletal System

A. CT thorax with and without contrast

B. CT thorax with or without contrast for mediastinal structures

C. CT thorax (bone windows)

D. CT thorax (lung windows)

E. CT thorax for aortic dissection

F. CT thorax for pulmonary embolism

G. CT sternum

H. CT thorax for thymus gland

I. CT thorax (thoracic lymph nodes) for disease staging

J. CT thorax (trauma)

K. Spiral CT thorax

L. CT cervical spine

M. CT thoracic spine

N. CT lumbar spine

O. CT spine (cervical, thoracic or lumbar) postmyelogram

P. CT spine (trauma)

Q. Spiral CT spine

R. CT upper extremity

S. CT lower extremity

T. CT soft tissue extremity

U. CT pelvic girdle

V. CT extremity (trauma)

VII. Protocols for the Abdomen, Pelvis and Special Applications

A. CT abdomen without contrast

B. CT abdomen with contrast

C. CT abdomen for pancreas

D. CT abdomen for liver

E. CT abdomen for renal system

F. CT abdomen for adrenal glands

G. CT abdomen for aortic dissection

H. CT abdomen for vascular structures

I. CT abdomen for spleen

J. CT abdomen for gastrointestinal system

K. CT gallbladder

L. CT abdomen for suspected appendicitis

M. CT abdominal lymph nodes (disease staging)

N. CT abdomen to rule out metastasis

O. CT abdomen (trauma)

P. Spiral abdomen

Q. CT pelvis without contrast

R. CT pelvis for female genitourinary system

S. CT pelvis for male genitourinary system

T. Spiral pelvis

Sectional Anatomy and Imaging Applications

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, ultrasound 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 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. 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

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 antrium)
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. 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. Tentorium cerebelli
20. Petrous portion or ridge
21. Cerebellar tonsil
22. Internal auditory canal (IAC)
23. Nasal septum

24. External auditory meatus (EAM)
25. Clivus
26. 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
3. Ascending aorta
4. Aortic arch
5. Branches of the aortic arch
6. Descending (thoracic) aorta
7. Inferior vena cava
8. Esophagus
9. Trachea
10. Thoracic duct
11. Lymph nodes
12. Azygos vein
13. Hemiazygos vein

D. Breasts

E. Musculature

IV. Abdomen

A. Diaphragm and openings

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 hypochrondric
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. Lumbars
      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
    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
      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

Appendix A

Computers in Radiologic Sciences

Description
Content is designed to introduce knowledge in computing and information processing. Computer applications in the radiologic sciences related to image capture, display, storage and distribution are presented.

Objectives
1. Identify various types of computers.
2. Define analog to digital conversion and digital signal processor.
3. Identify various terms related to computer fundamentals and components.
4. Describe major functions of the central processing unit (CPU).
5. Differentiate the various input and output devices.
6. Give examples of various types of memory.
7. Describe computer care and preventive maintenance.
8. Explain computer operation.
9. Distinguish between analog computers and digital computers.
10. Discuss application of various types of software.
11. Explain the following computing applications as they relate to radiology: radiology information system (RIS), hospital information systems (HIS) and picture archiving communication system (PACS).
12. Define digital imaging and communications in medicine (DICOM).
13. Discuss the impact the Internet has on the distribution of health information.

Ethics and Law in the Radiologic Sciences

Description
Content is designed to provide a fundamental background in ethics. The historical and philosophical basis of ethics, as well as the elements of ethical behavior, will be 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
1. Describe specialized standards of behavior for the healing arts as a continuum, with historical and philosophical roots in the earliest periods of human history.
2. List the major milestones in the development of codes of behavior and ethical standards in the healing arts.
3. Explain ethics as a branch of philosophy and the moral, social and cultural basis of the development of an ethic.
4. Describe the moral, social and cultural basis of ethics.
5. Apply medical/professional ethics in the context of a broader societal ethic.
6. Explain the role of ethical behavior in health care delivery.
7. Differentiate between empathetic rapport and sympathetic involvement in relationships with patients and relate these to ethical conduct.
8. Explain concepts of personal honesty, integrity, accountability, competence and compassion as ethical imperatives in health care.
9. List legal/professional standards and their relationship to practice in health professions.
10. Identify specific situations and conditions that give rise to ethical dilemmas in health care.
11. Discuss the *US Genome Project* relative to the cause of genetically induced disease.
12. Explore the ethical issues of genetic screening.
13. Explain the genetic counseling responsibility of health care providers.
14. Employ a basic system of examination, clarification, determination of alternatives and decision-making in addressing ethical questions.
15. Explain select concepts embodied in principles of patients' rights, the doctrine of informed (patient) consent and other issues related to patients' rights.
16. Explain the legal implications of professional liability, malpractice, professional negligence/carelessness and other legal doctrines applicable to professional practice.
17. Describe the importance of accurate, complete, correct methods of documentation as a legal/ethical imperative.
18. Explore theoretical situations and questions relating to the ethics of care and health care delivery.
19. Explain specific legal terms, principles and laws.
20. Outline the elements necessary for a valid malpractice claim.
21. Define specific legal doctrines to include vicarious liability, respondeat superior, and res ipsa loquitur.

22. Describe the scope of practice for radiography, the elements that comprise it and responsibilities of the radiographer.
23. Differentiate between professional and legal standards and describe how each relates to the radiography profession.
24. Describe institutional and professional liability protection typically available to the radiographer.
25. Describe the elements and implications of informed consent.
26. Identify standards for disclosure relative to informed consent.
27. Describe how consent forms are utilized relative to specific radiographic procedures.

Human Diversity

Description

Content is designed to promote better understanding of patients, the patients' families and professional peers through comparison of diverse populations based on their value systems, cultural and ethnic influences, communication styles, socioeconomic influences, health risks and life stages. Content will include the study of factors that influence relationships with patients and professional peers. Understanding human diversity assists the student in providing better patient care.

Objectives

1. Explain the development of a personal value system.
2. Discuss the interrelationship between personal, community and societal values.
3. Explain the influence a person's value system has on his or her behavior.
4. Discuss the development of personal and professional values.
5. Describe how professional values influence patient care.
6. Examine Kohlberg's theory on how an individual's morality influences his or her behavior.
7. Differentiate between culture and ethnicity.
8. Explain how a person's cultural beliefs towards illness affect his or her recovery.
9. Explain the origins of medical ethnocentrism.
10. Discuss the societal factors that influence the quality of health care.
11. Compare alternative/complementary medicine to the traditional Western model.
12. Describe the culture of poverty and its effect on health care.
13. Discuss family dynamics in a cultural, social, ethnic and lifestyle context.

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 will be described and discussed.

Objectives
1. Identify the location of structures using directional and orientation terms.
2. Indicate where various planes lie in relation to the body.
3. Identify the structural limits, functions and contents of each of the body cavities.
4. Explain the terms atom, ion, atomic number and atomic weight.
5. Describe the nature of chemical bonds and compare the different types of chemical bonds.
6. Apply the pH scale to differentiate between acid and base substances.
7. Differentiate between polar and nonpolar compounds, and relate these to water solubility.
8. List different types of carbohydrates and give examples of each type.
9. Differentiate between the different types of lipids and determine common characteristics.
10. Describe the structure and functions of proteins.
11. Describe the structure of deoxyribonucleic acid (DNA) and the law of complementary base pairing.
12. Describe the structure of ribonucleic acid (RNA) and name the different types of RNA.
13. Characterize the structure of the cell membrane and the cytoskeleton.
14. Compare endocytosis and exocytosis.
15. Identify the structure and function of cilia and flagella.
16. Diagram the replication of DNA.
17. Diagram the phases of the cell cycle.
18. Describe genetic transcription and the post-transcriptional modifications that change pre-mRNA into mRNA.
19. List the functions of mRNA, tRNA and rRNA.
20. List the functions of the rough endoplasmic reticulum and Golgi apparatus in post-transitional modifications of secretory proteins.
21. Outline the sequence of events that occur in the synthesis packaging and exocytosis of secretory proteins.
22. Differentiate between the stages of meiosis and mitosis and identify the stages of each reproductive process.
23. Define the following: anabolism, catabolism and metabolism.
24. Characterize the role of enzymes in metabolism.
25. Describe carbohydrate metabolism.
26. Describe lipid metabolism.
27. Describe the Krebs cycle in general terms and its functional significance.
28. Express the significance of ketone.
29. List the factors that affect the basal metabolic rate.
30. Diagram the germinal layers of the embryo.
31. Classify tissue types, describe the functional characteristics of each and give examples of their location within the human body.
32. Identify and locate the bones of the human skeleton.

33. Identify bony processes and depressions found on the human skeleton.
34. Describe articulations of the axial and appendicular skeleton.
35. Differentiate the primary and secondary curves of the spine.
36. Describe sesamoid bones and locate examples on radiographs.
37. Summarize the functions of the skeletal system.
38. Label different types of articulations.
39. Compare the types, locations and movements permitted by the different types of articulations.
40. Examine the organization of muscle at the gross and microscopic levels.
41. Differentiate between the structures of each type of muscle tissue.
42. State the function of each type of muscle tissue.
43. Name and locate the major muscles of the skeleton.
44. Differentiate between the structure and function of different types of nerve cells.
45. State the structure of the brain and the relationship of its component parts.
46. Describe the brain functions.
47. List the meninges and describe the function of each.
48. Outline the formation, circulation and function of cerebrospinal fluid.
49. Describe the structure and function of the spinal cord.
50. Determine the distribution and function of cranial and spinal nerves.
51. Summarize the structure and function of components making up the autonomic nervous system.
52. Describe the structures and functions of the components making up the human eye and ear.
53. List the component body parts involved in the senses of smell and taste.
54. List the somatic senses.
55. Define endocrine.
56. Describe the characteristics and functions of the components making up the endocrine system.
57. Identify the location and describe the structure of each component of the endocrine system.
58. Identify the major hormone(s) secreted by each component of the endocrine system.
59. Describe the hard and soft palates.
60. Differentiate between deciduous and permanent teeth in terms of age for eruption and number.
61. Differentiate between the types of teeth in terms of number, location within the jaws and their function.
62. Label the component parts of a tooth.
63. Describe the structure and function of the tongue.
64. Identify the structure, function and locations of the salivary glands.
65. Recite and label the primary organs of the digestive system.
66. Describe the function(s) of each primary organ of the digestive system.
67. Differentiate between the layers of tissue that comprise the esophagus, stomach, small intestine, large intestine and rectum.
68. Differentiate between peritoneum, omentum and mesentery.
69. List and label the accessory organs of the digestive system, and describe their function.
70. Identify the secretions of accessory organs of the digestive system and the function of each.
71. Explain the purpose of digestion.
72. List the digestive processes that occur in the body.

73. Describe the composition and characteristics of blood.
74. List the types of blood cells and state their functions.
75. Differentiate between blood plasma and serum.
76. Outline the clotting mechanism.
77. List the blood types.
78. Explain the term Rh factor.
79. Explain the antigen/antibody relationship and its use in blood typing.
80. Label the parts of the human heart.
81. Describe the flow of blood through the body and identify the main vessels.
82. Describe the structure and function of arteries, veins and capillaries.
83. Differentiate between arterial blood in systemic circulation and arterial blood in pulmonary circulation.
84. Differentiate between normal and common abnormal electrocardiogram (ECG) tracings.
85. Summarize the structure, distribution and function of lymphatic vessels.
86. Outline the major pathways of lymphatic circulation.
87. Identify the location of major lymph node clusters.
88. Differentiate between nonspecific defenses and specific immunity.
89. Explain antibody production and function.
90. List the different types and functions of T- and B-cells and explain their functions.
91. Label the components of the respiratory system.
92. Describe the physiology and regulation of respiration.
93. Label the parts of the kidneys, ureters, bladder and urethra.
94. Describe the function of each organ of the urinary system.
95. Describe the composition and formation of urine.
96. Explain micturition.
97. Label the anatomy of the male and female reproductive organs.
98. Analyze the function of each of the male and female reproductive organs.
99. Demonstrate the use of topographical landmarks to locate internal structures.
100. Identify major anatomical structures found within sectional images.

Imaging and Processing

Description
Content is designed to establish a knowledge base in factors that govern and influence the production and recording of radiologic images. Film and electronic imaging with related accessories will be emphasized. Class demonstrations/labs are used to demonstrate application of theory.

Objectives
1. Discuss practical considerations in setting standards for acceptable image quality.
2. Assess radiographic density on radiographic images.
3. Distinguish between acceptable and unacceptable image densities.
4. Analyze the relationships of factors that control and affect image density.
5. Critique the radiographic contrast within various radiographic images.
6. Differentiate between subject contrast and image receptor contrast.
7. Distinguish between acceptable and unacceptable contrast scales.
8. Compare long-scale and short-scale contrast images.
9. Analyze the relationships of factors that control and affect radiographic contrast.
10. Critique recorded detail on various radiographic images.
11. Differentiate between umbra and focal spot blur.
12. Analyze the relationships of factors affecting recorded detail.
13. Define distortion.
14. Differentiate between shape and size distortion.
15. Perform calculations to determine image magnification and percent magnification.
16. Differentiate between magnification as distortion and macro-radiography.
17. Summarize the relationships of factors affecting distortion.
18. Formulate a plan of action to decrease image distortion.
19. Summarize the relationships of factors affecting exposure latitude.
20. Describe the operation and applications for different types of beam-limiting devices.
21. Evaluate beam-limiting devices.
22. Select the most appropriate beam-limiting device to be used for a given clinical situation.
23. Explain beam filtration.
24. Describe the change in the half-value layer (HVL) when additional filtration is added to the beam.
25. Summarize the relationships of factors affecting scattered and secondary radiation.
26. Evaluate the effects of scattered radiation on the image.
27. Compare types of grid.
28. Articulate the advantages and disadvantages of grid use.
29. Describe grid maintenance.
30. Select the most appropriate grid for a given clinical situation.
31. Interpret grid efficiency in terms of grid ratio and frequency.
32. Define grid cut-off.
33. Summarize the factors influencing grid cut-off.
34. Evaluate grid artifacts.
35. Formulate a set of rules for grid use to prevent grid cut-off and artifacts.

36. Explain the use of standardized radiographic technique charts.
37. Explain exposure factor considerations involved in technique selection.
38. Compare fixed kilovolt peak (kVp) and variable kVp systems.
39. Formulate a technique chart using either a fixed kVp or variable kVp system.
40. Calculate the photographic effect when exposure factors are given.
41. Apply mAs reciprocity to clinical simulations.
42. Describe the function of each component of radiographic film.
43. Explain latent image formation.
44. Discuss photostimulable phosphor plates as image receptors.
45. Discuss how an image is retrieved from a photostimulable phosphor.
46. Describe the features of the characteristic curve and explain its purpose.
47. Compare the characteristic curve for differing types of image receptors, both film and photostimulable phosphor plates.
48. Select the most appropriate image receptor to be used for given clinical situations.
49. Describe various types of image receptor holder.
50. Describe the function of each component of an intensifying screen.
51. Select the most appropriate intensifying screen for given clinical situations.
52. Explain the classifications of intensifying screens and the applications of each.
53. Identify procedures that ensure a long screen life devoid of artifacts and distortion.
54. Employ a quality control program for intensifying screens.
55. Differentiate between traditional intensifying screens and photostimulable phosphors.
56. Discuss darkroom-related OSHA standards for health and safety.
57. Discuss safelight illumination appropriate for specific image receptor systems.
58. Discuss the possible causes and health implications of "darkroom chemical sensitivity."
59. Describe the effects of storage on image quality.
60. List image archiving options.
61. Describe the operation and utilization of wet and dry processing.
62. Analyze the effects of processing on image quality.
63. Identify key components of an automatic film processor.
64. Demonstrate how various film sizes are fed into the film processor.
65. Analyze the steps of the processing cycle providing the specific action and duration of time for each step.
66. Identify the purpose of a daily quality control program for processors.
67. Discuss digital image processing and postprocessing.
68. Identify types of image artifacts and analyze the artifacts to determine the cause.
69. Compare methods of silver recovery.
70. Evaluate silver recovery security in terms of control, theft and misappropriation.

Patient Assessment, Management and Education

Description
Content is designed to introduce a model for clinical thinking to aid in patient assessment. Content includes a focus on the application of normal anatomy and physiological phenomena to ill and injured individuals. Interviewing skills and assessment techniques with clinical focus will be discussed. An emphasis on the analysis and interpretation of physiological data to assist in patient assessment and management will be introduced.

Objectives
1. Develop clinical thinking skills applied to the patient care setting.
2. Develop skills in conducting patient interviews to document a patient's medical history.
3. Apply the techniques and procedures for conducting a patient physical assessment and procedures to document findings.
4. Obtain and critically analyze a patient's vital signs.
5. Compose a plan for managing the patient based upon patient needs.
6. Participate in patient education.
7. Foster relationship-centered patient care.
8. Adapt communication techniques to address patient needs.

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 will be described, as well as infection control procedures utilizing standard precautions. The role of the radiographer in patient education will be identified.

Objectives
1. Identify the responsibilities of the health care facility and members of the health care team.
2. List the general responsibilities of the radiographer.
3. Describe the scope of practice for the radiographer as defined by the ASRT and state licensure.
4. Explain select perceptions of death and dying from patient and technologist viewpoints.
5. Describe ethical, emotional, personal and physical aspects of death.
6. List the stages of dying and describe the characteristics of each stage.
7. Identify the support mechanisms available to the terminally ill.
8. Identify methods for determining the correct patient for a given procedure.
9. Explain the use of various communication devices and systems.
10. Explain specific aspects of a radiographic procedure to the patient.
11. Demonstrate correct principles of body mechanics applicable to patient care.
12. Demonstrate techniques for specific types of patient transfer.
13. Demonstrate select procedures for turning patients with various health conditions.
14. Describe select immobilization techniques for various types of procedures and patient conditions.
15. Describe specific patient safety measures and concerns.
16. Explain the purpose, legal considerations and procedures for reporting an accident or incident.
17. Describe methods for evaluation of patient status.
18. List the information to be collected prior to patient examination.
19. Describe vital signs used to assess patient condition.
20. Convert a Fahrenheit measurement to the Celsius equivalent.
21. State the normal temperature values for the oral and rectal routes of measurement.
22. Describe the method of monitoring respiration and state the normal values expected.
23. Identify the normal values for blood pressure for males and females.
24. Identify the seven major sites for monitoring the pulse and indicate the normal values.
25. Assess patient vital signs.
26. List the normal ranges for specific laboratory studies.
27. Define terms related to infection control.
28. Describe the importance of Standard Precautions and Isolation Procedures.
29. Explain sources and modes of transmission of infection and disease.
30. List institutional/departmental procedures for infection control.
31. Describe methods for the prevention of infection to the health worker and patient.
32. Identify symptoms related to specific emergency situations.

33. Describe the emergency medical code system for the institution and the role of the student during a medical emergency.
34. Explain the special considerations necessary when performing radiographic procedures on an infant or a child.
35. Explain the special considerations necessary when performing radiographic procedures on a geriatric patient.
36. Describe the symptoms and precautions taken for a patient with a head injury.
37. Describe the symptoms and precautions taken for a patient with a spinal injury.
38. Explain the types, immobilization devices and positioning for upper and lower extremity fractures.
39. Describe the symptoms and precautions taken for a patient with massive wounds.
40. Describe the classifications and medical interventions for burns.
41. Describe the symptoms and medical interventions for a patient having a contrast agent reaction.
42. Explain the role of the technologist in patient education.
43. Describe the patient preparation for various barium studies.
44. Describe the procedure to properly prepare a patient for a barium study.
45. Identify specific types of tubes, lines, catheters and collection devices.
46. Explain the purpose, precautions and care of tubes, lines, catheters and collection devices.
47. Outline the steps in the operation and maintenance of suction and oxygen equipment and demonstrate their use.
48. Demonstrate competency in cardiopulmonary resuscitation (CPR).
49. Demonstrate the use of specific medical emergency equipment and supplies.
50. Demonstrate select first aid techniques.
51. Describe the monitoring, preprocedure and postprocedure care, drug administration and special precautions for a patient undergoing myelography and urography.
52. Demonstrate the appropriate procedure for gathering information prior to performing a mobile radiographic examination.
53. Describe the initial steps in performing a mobile procedure.
54. Explain the procedure for placing an image receptor under a patient in an orthopedic bed frame.
55. Describe the special problems faced in performing procedures on a patient with tracheotomy and specific tubes, drains and catheters.
56. Describe the procedure for producing diagnostic images in the surgical suite.
57. Explain the appropriate radiation protection required when performing mobile/surgical radiography.

Patient Information Management

Description
Content is designed to provide the basic concepts of patient information management. Medical records management including privacy and regulatory issues will be examined. The role of the technologist will be identified and discussed.

Objectives
1. Discuss the JCAHO standards regarding the accountability and protection of patient information.
2. List the requirements of a patient consent document.
3. Identify challenges to the protection of patient information.
4. Distinguish between various types of patient records.
5. Explain the contents of the medical record.
6. Demonstrate proper protocols for charting patient information.
7. Explain the procedures for document administration.
8. Discuss privacy and regulatory issues related to patient information.
9. Assess the application of the Health Insurance Portability and Accountability Act (HIPAA) to patient information systems.
10. Define medical informatics and describe examples of informatics systems found in today's patient care setting.
11. Identify potential abuses of the use of confidential patient information.

Pharmacology

Description
Content is designed to broaden the technologist's knowledge of pharmacology. Topics include consumer safety and drug regulation, sources and bodily effects of drugs and safe dose preparation. Types of drug preparations and principles of responsible drug administration, including routes and techniques, are included. An introduction to clinical drug trials and a classification of drugs related to body systems are included as topics for presentation.

Objectives
1. Identify key drug laws impacting consumer safety.
2. Identify the five schedules of controlled substances and cite a drug example of each.
3. Identify the role of the Food and Drug Administration (FDA) and Drug Enforcement Administration (DEA) in the regulation and control of consumer drugs.
4. Implement strategies for health care workers involved in dispensing medications to comply with the restrictions of drug laws.
5. Interpret common abbreviations and symbols used for medication orders.
6. Translate drug measurements across measurement systems.
7. Differentiate among drug names (generic, chemical, trade, official).
8. Explain the restrictions of drug sales implied by the designation of: over the counter, legend drug and controlled substance.
9. List common material sources from which drugs are developed.
10. Describe the biological processing of drugs in the body.
11. List common variables affecting drug action within the body.
12. Describe common unexpected responses to drugs.
13. Accurately perform calculations for drug dose delivery.
14. Describe dose modifiers for pediatric and geriatric patients.
15. Describe various forms of drug preparations and supplies.
16. Incorporate the principles of responsible drug administration in the patient care setting to prevent medication error.
17. Describe administration routes and techniques for select medications.
18. Describe the principles associated with a controlled clinical drug trial.
19. Distinguish between single-blind and double-blind drug trials.
20. Organize drugs according to body system.

Quality Management

Description
Content is designed to impart an understanding of the tasks and protocols making up the quality management activities of a typical radiology department. The roles and responsibilities of all parties contributing to the quality management effort will be presented. Tools, procedures and evaluation criteria used in the performance assessment of imaging modalities and image processing will be discussed.

Objectives
1. Discuss practical considerations in setting standards for acceptable image quality.
2. Employ a quality control program for intensifying screens.
3. Describe the effects of storage on image quality.
4. Analyze the effects of processing on image quality.
5. Identify the purpose of a daily quality control program for processors.
6. Differentiate between quality improvement/management, quality assurance and quality control.
7. List the benefits of a quality management program to the patient and to the department.
8. List elements of a quality management program and discuss how each is related to the quality management program.
9. Identify common equipment malfunctions that affect image quality.
10. Apply the principles of total quality management.
11. Ensure that performance reflects professional competence in the selection of technical factors to produce quality diagnostic images with lowest radiation exposure possible.
12. Critique images for appropriate clinical information, image quality and patient documentation.

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
1. Identify and justify the need to minimize unproductive radiation exposure of humans.
2. Distinguish between somatic and genetic radiation effects.
3. Differentiate between the stochastic and nonstochastic (deterministic) effects of radiation exposure.
4. Explain the objectives of a radiation protection program.
5. Define radiation and radioactivity units of measurement.
6. Identify dose equivalent limits (DEL) for occupational and nonoccupational radiation exposure.
7. Describe the as low as reasonably achievable (ALARA) concept.
8. Identify the basis for occupational exposure limits.
9. Distinguish between perceived risk and comparable risk.
10. Describe the concept of negligible individual risk level (NIRL).
11. Identify ionizing radiation sources from natural and man-made sources.
12. Comply with legal and ethical radiation protection responsibilities of radiation workers.
13. Calculate dose equivalent limits (DEL) with reference to the latest National Council on Radiation Protection and Measurements (NCRP) reports.
14. Describe the theory and operation of radiation detection devices.
15. Identify appropriate applications and limitations for each radiation detection device.
16. Describe how isoexposure curves are used for radiation protection.
17. Identify performance standards for beam-directing, -defining and -limiting devices.
18. Describe procedures used to verify performance standards for equipment and indicate potential consequences of performance standards failure.
19. Describe the operation of various interlocking systems for equipment and indicate potential consequences of interlock system failure.
20. Identify conditions and locations evaluated in an area survey for radiation protection.
21. Distinguish between controlled and noncontrolled areas and list acceptable exposure levels.
22. Describe “Radiation Area” signs and identify appropriate placement sites.
23. Describe the function of federal, state and local regulations governing radiation protection practices.
24. Describe the requirements for and responsibilities of a radiation safety officer.
25. Express the need and importance of personnel monitoring for radiation workers.
26. Describe personnel monitoring devices, including applications, advantages and limitations for each device.
27. Interpret personnel monitoring reports.
28. Compare values for dose equivalent limits for occupational radiation exposures (annual and lifetime).

29. Identify anatomical structures that are considered critical for potential late effects of whole body irradiation exposure.
30. Identify dose equivalent limits for the embryo and fetus in occupationally exposed women.
31. Distinguish between primary and secondary radiation barriers.
32. Demonstrate how the operation of various x-ray and ancillary equipment influences radiation safety and describe the potential consequences of equipment failure.
33. Perform calculations of exposure with varying time, distance and shielding.
34. Discuss the relationship between HVL and shielding design.
35. Identify emergency procedures to be followed during failures of x-ray equipment.
36. Demonstrate how time, distance and shielding can be manipulated to keep radiation exposures to a minimum.
37. Explain the relationship of beam-limiting devices to patient radiation protection.
38. Discuss added and inherent filtration in terms of the effect on patient dosage.
39. Explain the purpose and importance of patient shielding.
40. Use the appropriate method of shielding for a given radiographic procedure.
41. Explain the relationship of exposure factors to patient dosage.
42. Identify the appropriate image receptor that will result in an optimum diagnostic image with the minimum radiation exposure to the patient.
43. Select the immobilization techniques used to eliminate voluntary motion.
44. Describe the minimum source-to-tabletop distances for fixed and mobile fluoroscopic devices.
45. Apply safety factors for the patient (and others) in the room during mobile radiographic procedures.

Sectional Anatomy

Description
Content is designed to study normal sectional anatomy via diagrams and radiologic images.

Objectives
1. Differentiate between sagittal, coronal and axial planes of the body.
2. Review the principles of imaging for imaging modalities using relevant terminology.
3. Compare the imaging modalities for application to radiation therapy.
4. Identify normal anatomical structures on sectional images.
5. Identify topographic anatomy used to locate underlying internal structures.

Appendix B

Clinical Experience Requirements

The ARRT Clinical Experience Requirements is reprinted by the permission of the ARRT. The ARRT Clinical Experience Requirements and all parts thereof are copyrighted by the ARRT.

COMPUTED TOMOGRAPHY
CLINICAL EXPERIENCE REQUIREMENTS
Eligibility Requirements Effective
for Examinations Beginning January 2003

All applicants for the Examination in Computed Tomography are required to perform certain clinical procedures to establish eligibility for certification. This document identifies the minimum core clinical experience requirements for certification. The ARRT encourages individuals to obtain education and experience beyond these minimum requirements.

Directions

1. ***Perform the Procedure***s: Applicants are required to perform a minimum total of 125 repetitions for the clinical procedures selected from this document. Repetitions must be performed within the 24 month period immediately before submitting the application for examination. Repetitions may be completed in less than 24 months.

2. ***Document Performance:*** Applicants must use the attached Clinical Experience Documentation Form to record the performance of each repetition of the procedures. The procedures should be organized according to the categories and the same procedures should be grouped together (e.g., all repetitions of "Routine Head" should be listed together under "Head"). The documentation must include: name of procedure, date performed, time of day completed, facility where performed, and the initials of person verifying performance. The "Verified By" column on the form must be initialed by a Registered Technologist or a licensed physician. The name and address corresponding to each set of initials must also be provided on the form.

3. ***Apply for the Examination:*** When applying for the examination, applicants must complete the verification section of the exam application to attest to the completion of the experience requirements. Mail only the application for examination to the ARRT; do not send the Clinical Experience Document Form to ARRT with the application. Submitting false documentation to ARRT as part of the application process is a violation of the ARRT Standards of Ethics and may result in sanctions up to and including revocation.

4. ***Maintain Your Records:*** Applicants must keep the Clinical Experience Documentation Form for at least 24 months after the application for examination is submitted. The ARRT conducts audits of some applications for examination. Applicants who are audited will be required to send the Clinical Experience Documentation Form to ARRT. Additional documentation may be required from individuals who are audited**.**

** These clinical experience requirements are to be used for applications submitted after January 1, 2003. The ARRT periodically updates the clinical experience requirements, and future requirements may be different from those specified in this document. Candidates are responsible for meeting the requirements in force at the time of application.*

Clinical Experience Requirements

Specific Procedural Requirements

The Clinical Experience Requirements for CT consist of 53 procedures in 9 different categories. The 9 categories include:

A. Head
B. Neck
C. Spine and Musculoskeletal
D. Chest
E. Abdomen
F. Pelvis
G. Special Procedures
H. Image Display and Post Processing
I. Quality Assurance

Applicants must complete and document the performance of a subset of these 53 procedures according to the following rules:

1. Choose a minimum of 25 different procedures out of the 53 procedures.
2. Complete a minimum of 3 and a maximum of 5 repetitions on any chosen procedure.
3. Complete a minimum total of 125 repetitions across all procedures.

Examples

An applicant who works in a specialized setting wanted to complete the minimum number of procedures. This person chose 25 procedures from any of the 9 categories. To complete 125 repetitions, each of the 25 procedures was performed 5 times each. This applicant satisfied all 3 rules.

Another applicant works in a facility that does most types of CT scans, so completing a wide variety of procedures was quite feasible. This applicant completed a total of 30 procedures from all 9 categories. Although most of these procedures were performed 3 times (the minimum), several of them were performed 4 or 5 times each until the applicant reached 125 procedures. This applicant satisfied all 3 rules.

General Guidelines

When performing the CT imaging procedures, the applicant must demonstrate appropriate:

- evaluation of requisition and/or medical record
- preparation of examination room
- identification of patient
- patient assessment and education concerning the procedure
- documentation of patient history including allergies
- patient positioning
- protocol selection
- parameter selection
- image display, filming, and archiving
- documentation of procedure, treatment and patient data in appropriate record
- patient discharge with post-procedure instructions
- universal precautions
- radiation protection
- preparation and/or administration of contrast media

and evaluate the resulting images for:

- image quality (e.g., motion, artifacts, noise)
- optimal demonstration of anatomic region (e.g., delayed imaging, reconstruction spacing, algorithm, slice thickness)
- exam completeness

Computed Tomography
Clinical Experience Requirement Procedures

A. Head

1. routine head
2. sinuses
3. facial / orbit
4. temporal bones
5. trauma head
6. vascular head

B. Neck

1. soft tissue neck
2. larynx and vocal cords
3. vascular neck

C. Spine and Musculoskeletal

1. lumbar
2. cervical
3. thoracic
4. spinal trauma
5. upper extremity
6. lower extremity
7. pelvic girdle; hips
8. musculoskeletal trauma
9. CT arthrography

D. Chest

1. routine chest
2. HRCT
3. vascular chest
   (i.e., PE, AAA)
4. chest trauma
5. airway (trachea, bronchus)
6. heart (e.g., cardiac scoring, angiography)

E. Abdomen

1. routine abdomen
2. liver (multi-phase)
3. kidneys (with contrast)
4. pancreas
5. adrenals
6. GI tract
7. renal stone
8. abdominal trauma
9. vascular abdomen
10. CT intravenous pyelogram

F. Pelvis

1. routine pelvis
2. bladder
3. pelvic trauma
4. vascular pelvis
5. colorectal studies

G. Special Procedures

1. biopsies
2. drainage / aspirations
3. radiation therapy planning

H. Image Display and Postprocessing

1. geometric measurements
   (e.g., stent graft, distance)
2. ROI
3. retrospective reconstruction
4. multiplanar reconstruction
5. 3-D rendering (MIP, SSD, VR)

I. Quality Assurance

1. calibration checks
2. CT number
3. standard deviation
4. linearity
5. spatial resolution
6. contrast resolution

Clinical Experience Documentation Form – Computed Tomography

Procedures should be organized as presented in this Clinical Experience Requirements Document.
Like procedures must be grouped together.

Applicant Name: _____

Category and Procedure	Date Performed	Time of Day	Facility Name	Verified By (Initials)
Example: Head				
Routine head	**7/9/02**	**10:15 a.m.**	**General Hospital**	**BTL**
Routine head	**7/12/02**	**3:00 p.m.**	**General Hospital**	**BTL**
Routine head	**7/30/02**	**8:00 a.m.**	**General Hospital**	**BTL**

This form may be duplicated

DIRECTIONS

The *Computed Tomography Clinical Experience Documentation Form* requires only that the initials of the person verifying performance of a procedure be listed. The full name and mailing address must be supplied below to completely identify each person whose initials appear on the form.

			Mailing Address			
Verified By (Initials)	Printed Name	ARRT ID#	Street	City	State	Zip

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

ARRT Examination in Computed Tomography. 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. 6*th 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 Clinical Experience Requirements. St. Paul, Minn: American Registry of Radiologic Technologists.

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

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

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

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 0-781-70291-7

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*. 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

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, 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

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, 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: Spinger-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
Atlanta, GA 30368-2454
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www.cancer.org

American Society of Radiologic Technologists
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www.lww.com

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www.mcgraw-hill.com

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www.mosby.com

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800-777-4643
www.springer-ny.com

Thieme
333 Seventh Avenue
New York, NY 10001
800-782-3488
www.thieme.com

WB Saunders Publishing Company
The Curtis Center
Independence Square West
Philadelphia, PA 19106-3399
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.