Radiography Curriculum 2012 Revision Transitional Guide

Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE, Albuquerque, NM 87123-3909.

Introduction

The first ASRT Radiography Curriculum was written in 1952. Throughout its history, the goal of this document has been to outline a common body of knowledge that is essential for entry-level radiographers. However, rapid technological changes have made it increasingly difficult to define a "common" body of knowledge for the profession. Some clinical settings have incorporated state-of-the-art equipment and cutting-edge technology, while others have not. The curriculum must meet the needs of students in both types of environments. As a result, this version of the curriculum is in many ways an incremental or transitional document. While it maintains elements based on film-screen capture and processing, it also incorporates topics such as basic digital image acquisition, picture archiving and informatics. As the radiography workplace evolves, the curriculum must evolve with it.

The challenge in any curriculum is to give students a solid foundation of traditional core knowledge while also providing opportunities to develop skills that will serve them beyond entry to the profession. In particular, students must develop skills in areas such as information literacy, scientific inquiry, self-reflection, collaboration, peer counseling and mentoring.

To assist students in acquiring these types of skills, postsecondary general education content is included as a "required" element of this radiography curriculum instead of as a "recommended" element. General education provides an opportunity for personal enrichment and exploration outside the confines of the technical professional curriculum. The general education content objectives in this curriculum were purposely labeled "global content objectives" to give program officials flexibility in determining specific credit-bearing course work that will satisfy these objectives.

Also new to this curriculum is an emphasis on critical thinking. Advances in technology and employer expectations demand more independent judgment by radiographers. Consequently, critical-thinking skills must be developed and assessed in the educational process. Critical thinking is incorporated in multiple content areas throughout the curriculum, including clinical practice and the recommended postsecondary general education. It is expected that the faculty will continue to develop and implement critical thinking throughout the educational program.

This version of the curriculum also incorporates emerging technologies that traditionally have not been part of the radiography curriculum. For example, computed tomography (CT) exams have replaced many of the x-ray procedures that once were core to traditional radiography. Although this may not be seen in the American Registry of Radiologic Technologists (ARRT) mandatory or elective radiography clinical competencies, a basic understanding of computed tomography is increasingly expected of new program graduates. In planning student clinical experiences, radiography programs with sufficient local resources are encouraged to provide students with clinical exposure to computed tomography.

The document itself is divided into specific content areas. A compendium of learning objectives and appendices indexed by content area has been incorporated into this document to serve as a resource for program planners and course managers. Radiography programs are encouraged to organize the content and objectives to meet their individual goals and needs. Faculty members also are encouraged to expand and broaden these fundamental objectives as they incorporate them into their curricula. Specific instructional methods were intentionally omitted to allow for programmatic prerogative as well as creativity in instructional delivery.

New content and objectives in this curriculum include human diversity, clinical competency, ethical considerations of genetics and a required general education component. Clinical and didactic competencies have been correlated. Content related to advanced modalities (e.g., quality management, computed tomography, magnetic resonance imaging and mammography) has been modified. Some content areas have been retitled or reorganized, and outdated content has been eliminated.

In addition to skill development in specific content areas, this curriculum is designed to ensure that entry-level radiographers possess the following basic traits upon graduation from an educational program in the radiologic sciences:

- The technical competence to perform diagnostic imaging procedures.
- Prudent judgment in administering ionizing radiation to produce diagnostic images.
- A focus on providing optimum patient care in a society that is becoming increasingly diverse and experiencing generational, cultural and ethnic shifts.
- The ability to work with others in a team relationship.
- An understanding of the intricacies associated with providing direct patient care in today's health care setting.
- The skill to use modern technologies to research and retrieve information, weigh and discriminate between good and poor sources of information, and take action based upon the acquisition of new information and knowledge.
- Stewardship over the security and confidentiality associated with patient medical information.
- Skills that promote career-long learning, where the radiographer assumes the role of student and that of teacher.
- An eagerness to collaborate with others within the medical imaging community to promote standards of excellence in the medical imaging sciences.
- A willingness to contribute to the education and clinical skills development of radiologic science students.

The ASRT Radiography Curriculum serves as a blueprint for educators to follow in designing their programs and in ensuring that their programs match the profession's standards. In the radiologic sciences, educators not only must teach the essential clinical skills that employers expect of graduates, but also must ensure that students will be prepared to take certification examinations offered by the ARRT. This curriculum allows

for faculty flexibility to meet the needs of the local community, yet satisfy the requirements for accreditation standards and the ARRT examination. It also offers a foundation for a transition to baccalaureate studies and, more importantly, for individual lifelong learning.

Radiography Curriculum

Table of Contents

Basic Principles of Computed Tomography

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

Note: Although this may not be seen in the ARRT mandatory or elective radiography clinical competencies, a basic understanding of computed tomography is increasingly expected of new program graduates. In planning student clinical experiences, radiography programs with sufficient local resources are encouraged to provide students with clinical exposure to computed tomography.

Content

I. Computed Tomography Generations
- A. Capabilities and limitations
  1. First
  2. Second
  3. Third
  4. Fourth
  5. Fifth
  6. Spiral

II. Components, Operations and Processes
- A. Data acquisition
  1. Methods
     - a. Slice-by-slice
     - b. Volumetric
  2. Elements
     - a. Beam geometry
       1) Parallel
       2) Fan
       3) Spiral
  3. Data acquisition system (DAS)
     - a. Components
       1) Tube
       2) Detectors
       3) Filters
       4) Collimators
       5) Analog-to-digital converter (ADC)
     - b. Functions
       1) Measurement of transmitted beam
       2) Encoding measurements into binary data
       3) Logarithmic conversion of data
       4) Data transmission to computer

4. Data acquisition process
    a. Scanning/raw data/image data
        1) Rays
        2) Views
        3) Profiles
            a) Pixels
            b) Matrices
            c) Voxels
    b. Attenuation
        1) Linear attenuation coefficients
        2) CT/Hounsfield numbers
            a) Baseline reference numbers
                i) Water equal to 0
                ii) Bone (white) equal to 400 – 1000
                iii) Air (black) equal to – 1000
    c. Selectable scan factors
        1) Scan field of view
        2) Display field of view
        3) Matrix size
        4) Slice thickness
        5) Algorithm
        6) Scan time and rotational arc
        7) Radiographic tube output
        8) Region of interest (ROI)
        9) Magnification
        10) Focal spot size and tube geometry
    d. Power injectors

Comment [RH1]: This item was moved to the Pharmacology section, not optional.

B. Factors controlling image appearance

C. Anatomical structures
    1. Artifacts
    2. Contrast resolution
        a. Window width
    3. Grayscale manipulation
        a. Window level
    4. Distortion
    5. Noise
    6. Spatial resolution

D. Postprocessing
    1. Image reformation
    2. Image smoothing
    3. Edge enhancement
    4. Grayscale manipulation

III. Radiation Protection

A. Methods for reducing radiation dose to the patient
   1. Technical factor selection
   2. Technical adjustments for children
   3. Scatter radiation reduction

B. Reducing the radiographer's exposure to scatter radiation

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.

Content

I. Clinical Practice

A. Code of ethics/professional behavior
   1. Practice standards
   2. Consistency, Accuracy, Responsibility and Excellence in Medical Imaging and Radiation Therapy (CARE) bill
   3. Incident reporting mechanisms
   4. Standards for supervision
      a. Direct
      b. Indirect
   5. Patient Bill of Rights

B. Professional communication
   1. Patients
   2. Patient's family
   3. Health care team
   4. Confidentiality of patient records (Health Insurance Portability and Accountability Act, or HIPAA, compliance)

C. Role of radiographer
   1. Technical
   2. Professional
   3. Equipment operation
   4. Ability to adapt to varying clinical situations
   5. Emergency response
   6. Total quality management

D. Values
   1. Personal
      a. Values development
      b. Effect on medical care

c. Impact on patient care
d. Values clarification

2. Societal
   a. Rights and privileges
   b. Community values
   c. Impact on patient care
3. Professional
   a. Values development
   b. Values conflict
   c. Impact on patient care

E. Culture, ethnicity and diversity
1. Societal and individual factors
2. Socioeconomic
3. Gender
4. Age
   a. Infant
   b. Child
   c. Adolescent
   d. Adult
   e. Middle aged
   f. Elder
5. Family structure and dynamics
6. Geographical factors
7. Religion
8. Lifestyle choices and behaviors
9. Sexual orientation
10. Disability

II. Procedural Performance

A. Scheduling and sequencing of exams

B. Order/requisition evaluation and corrective measures

C. Facilities setup

D. Patient assessment, clinical history, education and care
1. Patient monitoring – emergency and nonemergency
   a. Vital signs
   b. Assessment and clinical history
   c. Equipment
   d. Patient emergencies
2. Patient privacy and confidentiality
3. Documentation and charting
4. Infection control
5. Patient education

a. Communication style
b. Age specific
c. Cultural and socioeconomic sensitivity
d. Patient focused care

6. Medical error reduction

E. Imaging
1. Positioning considerations
2. Technical considerations
3. Image processing (automatic/digital)
4. Image analysis

F. Radiation protection (patient and personnel)
1. Principles
2. Equipment and accessories

III. Clinical Competency

A. ARRT Competency Requirements (refer to the document located at http://www.arrt.org/education/CompReqs/RAD_CX_2005.pdf)*

B. Optional basic computed tomography
1. Head
2. Thorax
3. Abdomen

Note: Although this may not be seen in the ARRT mandatory or elective radiography clinical competencies, a basic understanding of computed tomography is increasingly expected of new program graduates. In planning student clinical experiences, radiography programs with sufficient local resources are encouraged to provide students with clinical exposure to computed tomography.

*Refer to ARRT Competency Requirements for mandatory and elective requirements.

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.

Content

I. Basic Principles of Digital Radiography

A. Digital image characteristics
   1. Picture elements – pixels
   2. Pixel size
   3. Matrix size
   4. Spatial resolution
   5. Bit depth
   6. Information content – megabytes/image

B. Digital receptors
   1. Cassette-less systems
      a. Thin film transistor (TFT) arrays
      b. Charged coupled device (CCD) and complementary metal oxide semiconductor (CMOS) systems
         1) Linear scanning arrays
            a) Fixed photostimulable phosphor (PSP) plates
         2) Optically coupled cameras
            a) Phosphor structure
            b) Detector characteristics
   2. Cassette-based systems
      a. PSP plates
         1) Turbid phosphors
         2) Structured phosphors

C. Comparison of detector properties and evaluative criteria
   1. Detective quantum efficiency (DQE) predicts dose efficiency
   2. System speed vs. “speed class” operation
   3. Spatial resolution
      a. Cassette-based systems
         1) Sampling frequency – pixel pitch
         2) Receptor size vs. sampling frequency
         3) Light spread – phosphor layer thickness
      b. Cassette-less systems – detector element size
   4. Advantages over film-screen
      a. Increased dynamic range

b. More contrast resolution
5. Limitation relative to film-screen
a. Lower spatial resolution
b. Strong dependence of image quality on
1) Image processing
2) Display characteristics

D. Dynamic range vs. latitude
1. Dynamic range of the detector
a. Acquisition data width
b. Greater than film-screen
2. Latitude – allowable error for optimal image acquisition
a. Actual exposure latitude is approximately double that of film-screen
1) 50% below ideal causes mottle
2) Greater than 200% above ideal results in loss of contrast
b. Beam-part-receptor alignment latitude less than film-screen

II. Image Acquisition

A. Raw data acquisition – "latent image"
1. Positioning
2. Exposure field alignment and collimation
a. Cassette-less system
b. Cassette-based system
3. Exposure – technique selection

B. Image extraction – cassette-less system
1. Rows and columns read line by line
2. Data transferred to external electronics
3. Digitized by analog to digital converter (ADC)
4. Histogram created and analyzed by software
5. Initial image processing
a. Exposure field recognition
b. Histogram analysis
c. Automatic rescaling – risk of failure

C. Image extraction – cassette-based system
1. Plate scanned by laser
2. Signal data digitized by ADC
3. Exposure field(s) identified
4. Histogram created and analyzed by software
5. Initial image processing
a. Exposure field recognition
b. Histogram analysis
1) Exposure index determination – risk of inappropriate value
2) Automatic rescaling – risk of failure

D. Exposure indicators
1. Cassette-less systems
a. Dose area product (DAP)
1) Actual patient dose of calibrated
2) No established DAP standard
3) Receptor exposure not indicated
b. Relationship to patient exposure
1) Exposure indicator – "speed class"
2) Reached exposure index (REX)
2. Cassette-based systems
a. Vendor specific values
1) Sensitivity ("S")
2) Exposure index (EI)
3) Log mean exposure (LgM)
b. Relationship to patient exposure
c. Reader calibration
d. Centering and beam collimation
e. Optimal value ranges

III. Image Acquisition Errors

A. Exposure field recognition
1. Single field patterns – collimation margins and alignment
2. Multiple exposure fields – optimal patterns

B. Histogram analysis error
1. Incorrect anatomic menu selection
2. Exposure field not detected
a. Collimation border recognition
b. Exposure field distribution – multiple fields/plate
3. Unexpected material in data set, i.e., metal
4. Large exposure error – plate saturation
5. Inappropriate rescaling – dark or light image

C. Low intensity radiation response
1. Background
a. Cassette-less system constantly refreshed
b. Cassette-based system plate is storage phosphor
1) Stores background exposure
2) Plate responds to an exposure as low as 60 µR
3) Background is 40 µR/day to 80 µR/day
4) Plates unused for more than 48 hours should be erased
2. Scatter
a. More intense than background
b. Scatter control becomes critical

D. Scatter control

1. Beam limiting
2. Optimal exposure - overexposure produces more scatter
3. Grid use
    a. Kilovoltage (kVp) conversion preferred
    b. Grid cutoff produces low contrast
    c. Compare short dimension (SD) grid and long dimension (LD) grid
    d. Moiré effect
        1) Grid frequency approximately equal to Nyquist
        2) Reduce risk – unmatched frequencies
            a) Grid frequency less than Nyquist (178 lpi)
            b) Grid frequency greater than Nyquist (103 lpi)

IV. Software (Default) Image Processing

A. Automatic rescaling

B. Final image processing
    1. Gradient processing
        a. Brightness
        b. Contrast
    2. Frequency processing
        a. Smoothing
        b. Edge enhancement
    3. Equalization

C. Effects of excessive processing

D. Recognition of image processing errors that affect image clarity

V. Fundamental Principles of Exposure

A. Optimal receptor exposure
    1. Receptor exposure variables
    2. Receptor exposure control

B. Receptor response - DQE

C. Selection of exposure factors
    1. Same principles as film-screen
        a. Maintain consistent specific receptor exposure
        b. Control scatter
        c. Adjust for differences in:
            1) Structure composition
            2) Source-to-image receptor distance (SID)
            3) Grid utilization

D. Exposure myths associated with digital systems
    1. Milliampere-seconds (mAs)

2. kVp
3. Collimation
4. Grid
5. SID
6. Speed class
7. Fog

E. Control patient exposure
1. Higher kVp levels
2. Additional filtration
3. Interfacing with automatic exposure control (AEC) systems
4. As low as reasonably achievable (ALARA) principles

F. Monitor patient exposure
1. Part of quality assurance (QA) program
2. Vendor supplied software
3. Logbook

VI. Image Evaluation

A. Evidence of appropriate exposure level
1. Exposure indicator
a. Low contrast due to overexposure
b. Noise due to underexposure
2. Evidence of exposure recognition failure or histogram analysis error
a. Image brightness
b. Low contrast
c. Off focus/scatter outside exposure field

B. Contrast
1. Appropriate for exam
2. Evidence of processing error

C. Recorded detail
1. Image blur
2. Spatial resolution
3. Distortion
4. Mottle

D. Artifacts

VII. Quality Assurance and Maintenance Issues

A. Initial acceptance testing

B. Cassette-based system reader preventive maintenance (PM)

C. Plate maintenance

1. Cleaning and inspecting plates
2. Erasing plates

D. Uniformity of default processing codes

E. Reject analysis

VIII. Display

A. Monitor
1. Liquid crystal display (LCD)
2. Cathode ray tube (CRT)

B. Film
1. Lose dynamic range
2. Thermal film degradation
3. Film storage

C. Picture archiving and communication system (PACS)
1. Terminology
2. System components and function
3. PACS
   a. Image manipulation
   b. Access to report information
   c. Access from multiple locations
   d. Image retrieval
   e. PACS issues – contingency plans
4. Digital imaging and communication in medicine (DICOM)

D. Teleradiology

E. Radiographer's responsibilities
1. Access order (worklist)
2. Image acquisition
3. Postprocessing – image manipulation
4. Annotation issues
5. Transmitting image(s) to PACS
6. HIPAA and patient confidentiality

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.

Content

I. Ethics and Ethical Behavior

A. Origins and history of medical ethics

B. Moral reasoning

C. Personal behavior standards

D. Competence

E. Professional attributes

F. Standards of practice

G. Self-assessment and self-governance

H. Code of professional ethics

I. Ethical concepts
   1. Ethical principles
   2. Violation process

J. Systematic analysis of ethical problems

K. Ethical patient care data research/data discovery

II. Ethical Issues in Health Care

A. Individual and societal rights

B. Cultural considerations

C. Economical considerations

D. Technology and scarce resources

E. Access to quality health care

F. Human experimentation and research

G. Medical/health care research

H. End-of-life issues

III. Legal Issues

A. Parameters of legal responsibility

B. Patient personal information
   1. HIPAA
   2. Confidentiality of patient information

C. Intentional torts

D. Negligence and malpractice
   1. Definitions
   2. Components of malpractice
   3. Legal doctrines
   4. Legal and professional standards
   5. Medical liability
   6. Sources of law
   7. Civil and criminal liability

E. Legal risk reduction

IV. Patient Consent

A. Definition

B. Types

C. Condition for valid consent

D. Documentation of consent

Fundamentals of Radiologic Science and Health Care

Description
Content is designed to provide an overview of the foundations in radiography and the practitioner's role in the health care delivery system. Principles, practices and policies of the health care organization(s) are examined and discussed in addition to the professional responsibilities of the radiographer.

Content

I. The Health Science Professions

A. Radiologic technology
1. Radiography disciplines
a. Diagnostic radiography
b. Computed tomography
c. Mammography
d. Cardiac-interventional radiography
e. Vascular-interventional radiography
f. Bone densitometry
g. Quality management
h. Radiologist assistant
i. Multiskilled (fusion technology)
2. Radiation therapy
3. Nuclear medicine technology
4. Diagnostic medical sonography
5. Magnetic resonance imaging
6. PACS administration
7. Education
8. Management

B. Health care professions
1. Health information management
2. Medical laboratory sciences
3. Occupational therapy
4. Pharmacy
5. Physical therapy
6. Respiratory therapy
7. Social services
8. Nursing
9. Other

II. The Health Care Environment

A. Health care systems
1. Hospitals
a. Veterans Administration/military
b. Not-for-profit

c. For-profit
d. System/network

2. Clinics
3. Independent facilities
4. Mental health facilities
5. Long-term/residential facilities
6. Hospice

B. Health care delivery settings

1. Outpatient/ambulatory care
2. Inpatient
3. Long-term care
4. Preventive care
5. Home health care
6. Telehealth/telemedicine

C. Payment/reimbursement systems

1. Self-pay
2. Indemnity insurance
3. Entitlement/governmental programs
   a. Medicare
   b. Medicaid
4. Managed care

III. Hospital Organization

Comment [RH2]: Note: Added Quality Management as III. Hospital Organization is now IV.

A. Philosophy

B. Mission

1. Role within the community
2. Commitment to education within the profession and community health

C. Administrative services

1. Governing board
2. Hospital administration
3. Admissions
4. Information systems
5. Procurement
6. Accounting
7. Support services
   a. Facilities management
   b. Environmental services (housekeeping)
   c. Security
8. Personnel

D. Medical services

1. Personnel

a. Medical director
b. Medical staff
c. House staff
1) Medical residents
2) Interns
3) Medical students

2. Nursing services
3. Clinical services
a. Internal medicine
b. Surgery
c. Mental health
d. Geriatrics
e. Pediatrics

4. Clinical support services
a. Dietary
b. Medical laboratories
c. Oncology
d. Pastoral care
e. Rehabilitation
f. Social services
g. Risk management

IV. Radiology Organization

A. Professional personnel

1. Radiology director/chairman
2. Radiologists
a. Attending
b. Fellow
c. Resident
d. Intern

3. Radiation physicists
4. Radiographer
a. Administrative director
b. Chief/senior technologist
c. Staff technologist
d. Quality control/assurance officer/technologist

5. Radiologist assistant
6. Radiology nurses

B. Support services

1. Clerical staff
a. Administrative assistant
b. Receptionist
c. Medical secretary

2. Financing/accounting
3. Patient transportation services

4. File room/image management
5. Information systems manager
   a. Radiology information systems (RIS)
   b. PACS

C. Patient services

D. Educational personnel
   1. Educational/program director
   2. Clinical coordinator
   3. Didactic instructor
   4. Clinical instructor
   5. Clinical staff
   6. Students

V. Accreditation

A. Definition

B. Programmatic accreditation
   1. Joint Review Committee on Education in Radiologic Technology (JRCERT)

C. Institutional accreditation
   1. Degree granting regional (college/proprietary)
   2. Health care organization(s)
      a. Joint Commission on Accreditation of Healthcare Organizations (JCAHO)
      b. American Osteopathic Association
      c. American College of Radiology (ACR)

VI. Regulatory Agencies

A. Federal

B. Reimbursement

C. State

VII. Professional Credentialing

A. Definition
   1. Certification
   2. Registration
   3. Licensure

B. Agencies
   1. National
      a. American Registry of Radiologic Technologists (ARRT)
      b. Nuclear Medicine Technology Certification Board (NMTCB)
      c. American Registry of Diagnostic Medical Sonographers (ARDMS)

d. Other

2. State – licensure

VIII. Professional Organizations

A. Purpose, function, activities

B. Local organizations

C. State organizations

D. National

1. American Society of Radiologic Technologists (ASRT)
2. American Healthcare Radiology Administrators (AHRA)
3. Association of Collegiate Educators in Radiologic Technology (ACERT)
4. Association of Educators in Imaging and Radiologic Sciences Inc. (AEIRS)

E. International

International Society of Radiographers and Radiological Technologists (ISRRT)

F. Related associations organizations

1. American Board of Radiology (ABR)
2. American College of Radiology (ACR)
3. Radiological Society of North America (RSNA)

IX. Professional Development and Advancement

A. Continuing education and competency requirements

1. Definition
2. Rationale/benefits
3. Requirements
   a. ARRT
   b. State
   c. Institutional

B. Continuing education opportunities

1. Postprimary certification
2. Collegiate/educational programs
3. Self-learning activities
4. Professional conferences

C. Employment considerations

1. Geographic mobility
2. Economic factors
3. Manpower issues

D. Advancement opportunities

1. Education

a. Administration
b. Faculty
    1) Didactic
    2) Clinical

2. Administration
3. Physics
4. Research
5. Industrial
6. Medical informatics
7. Sales/applications

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.

Content

I. Anatomical Nomenclature

A. Terms of direction
1. Anterior/posterior
2. Ventral/dorsal
3. Medial/lateral
4. Superior/inferior
5. Proximal/distal
6. Cephalad/caudad

B. Body planes
1. Median/mid-sagittal
2. Sagittal
3. Coronal
4. Transverse
5. Longitudinal

C. Body cavities – structural limits, function, contents
1. Cranial
2. Thoracic
3. Abdominal/pelvic

II. Chemical Composition

A. Atoms

B. Chemical bonds

C. Inorganic compounds
1. Acids
2. Bases
3. Salts
4. Acid-base balance
5. pH maintenance

D. Organic compounds
1. Carbohydrates
2. Lipids
3. Proteins
4. Nucleic acids

5. DNA
6. RNA
7. Adenosine triphosphate (ATP)
8. Cyclic AMP (adenosine 3', 5'-monophosphate)

III. Cell Structure and Genetic Control

A. Cell membrane
1. Chemistry
2. Structure
3. Physiology
4. Types of transport processes
   a. Diffusion
   b. Osmosis
   c. Filtration
   d. Active transport/physiological pumps
   e. Phagocytosis and pinocytosis

B. Cytoplasm

C. Organelles
1. Nucleus
2. Ribosomes
3. Endoplasmic reticulum
4. Golgi complex
5. Mitochondria
6. Lysosomes
7. Peroxisomes
8. Cytoskeleton
9. Centrosome and centrioles
10. Flagella and cilia

D. Gene action
1. Protein synthesis
2. Nucleic acid (RNA/DNA) synthesis
3. Transcription
4. Translation

E. Cell reproduction
1. Mitosis
2. Meiosis

F. Aberration/abnormal cell division

IV. Metabolism

A. Anabolism

B. Catabolism

C. Enzymes and metabolism

D. Carbohydrate metabolism

E. Lipid metabolism

F. Protein metabolism

G. Regulation and homeostasis

V. Tissues

A. Types of tissue
1. Epithelial
2. Connective
3. Muscle
4. Nerve

B. Tissue repair

VI. Skeletal System

A. Osseous tissue
1. Structural organization
   a. Medullary cavity/marrow
   b. Compact bone
   c. Cancellous bone
   d. Periosteum
   e. Cartilage
2. Development and growth
   a. Physis
   b. Diaphysis
   c. Diaphysis/epiphyseal line
   d. Metaphysis
3. Classification and markings
   a. Long
   b. Short
   c. Flat
   d. Irregular
   e. Processes and bony projections
   f. Depressions/openings

B. Divisions
1. Axial
   a. Skull
   b. Hyoid bone

c. Vertebral column
d. Thorax

2. Appendicular
   a. Pectoral girdle
   b. Upper extremities
   c. Pelvic girdle
   d. Lower extremities
3. Sesamoids
4. Functions

C. Articulations
1. Types
   a. Synarthroses, fibrosis
   b. Amphiarthroses, cartilaginous
   c. Diarthroses, synovial
2. Movement

VII. Muscular System

A. Types and characteristics
1. Smooth
2. Cardiac
3. Skeletal

B. Functions

VIII. Nervous System

A. Neural tissue – structure and function
1. Neurons
2. Neuroglia

B. Central nervous system – structure and function
1. Brain and cranial nerves
2. Spinal cord

C. Peripheral nervous system – structure and function
1. Sympathetic nerves
2. Parasympathetic nerves

IX. Sensory System

A. General senses
1. Nociperception
2. Chemoreception
3. Thermoreception
4. Mechanoreception

B. Special senses – structure, function

1. Vision
2. Hearing and equilibrium
3. Olfaction
4. Gustation
5. Tactile

X. Endocrine System

A. Primary organs - structure, function and location

B. Homeostatic control

C. Endocrine tissue and related hormones
1. Pituitary (hypophysis) gland
2. Pineal gland
3. Thyroid gland
4. Parathyroid gland
5. Adrenal (suprarenal) glands
6. Heart and kidneys
7. Digestive system
8. Pancreas
9. Testes
10. Ovaries
11. Thymus
12. Placenta

XI. Digestive System

A. Primary organs – structure, function and location
1. Oral cavity
2. Esophagus
3. Stomach
4. Small intestine
5. Large intestine
6. Rectum

B. Accessory organs – structure, function and location
1. Salivary glands
2. Pancreas
3. Liver
4. Gallbladder

C. Digestive processes
1. Ingestion
2. Peristalsis
3. Digestion
4. Absorption
5. Defecation

XII. Cardiovascular System

A. Blood
   1. Composition
   2. Clotting system
   3. Hemopoiesis
   4. Function

B. Heart and vessels
   1. Anatomy
   2. Function

C. Electrocardiogram (ECG) tracings correlated to normal cardiac rhythm

XIII. Lymphatic System and Immunity

A. Lymphatic system
   1. Lymph vessels
   2. Lymphatic organs
      a. Thymus
      b. Lymph nodes
      c. Spleen
   3. Lymphatic tissue
      a. Tonsils
      b. Peyer's patches

B. Immune system
   1. Nonspecific defenses
      a. Physical barriers
      b. Leukocytes
      c. Immunological surveillance
   2. B-cell response
      a. Production
      b. Types of immunoglobulins
      c. Function
      d. Regulation of B-cell response
   3. T-cell response
      a. Production
      b. Types
      c. Function
      d. Regulation of T-cell response
   4. Passive and active immunity

XIV. Respiratory System

A. Components, structure and function
   1. Nose and sinus cavities
   2. Pharynx

3. Larynx
4. Trachea
5. Bronchi
6. Lungs
7. Thorax

B. Physiology
1. Pulmonary ventilation
2. Alveolar gas exchange
3. Transport of blood gases
4. Tissue gas exchange
5. Control and regulation of respiration

XV. Urinary System

A. Components, structure and function
1. Kidneys
2. Ureters
3. Bladder
4. Urethra

B. Urine
1. Physical characteristics
2. Chemical composition

C. Micturition

XVI. Reproductive System

A. Male – structure, function and location
1. External organs
2. Internal organs

B. Female – structure, function and location
1. External organs
2. Internal organs
3. Mammary glands

C. Reproductive physiology
1. Ovarian cycle
2. Menstrual cycle
3. Aging and menopause

XVII. Sectional Anatomy

A. Structures and locations
1. Head and neck
   a. Brain
   b. Cranium

c. Major vessels

2. Thorax
   a. Mediastinum
   b. Lung
   c. Heart
   d. Airway
   e. Major vessels
3. Abdomen
   a. Liver
   b. Biliary
   c. Spleen
   d. Pancreas
   e. Kidneys/ureters
   f. Peritoneum
   g. Retroperitoneum
   h. Gastrointestinal (GI) tract
   i. Major vessels

Image Analysis

Comment [RH3]: Note: Section enhanced with components from Film-Screen Image Acquisition and Processing.

Description

Content is designed to provide a basis for analyzing radiographic images. Included are the importance of minimum imaging standards, discussion of a problem-solving technique for image evaluation and the factors that can affect image quality. Actual images will be included for analysis.

Content

I. Imaging Standards

A. Purpose

B. Problem-solving process

C. Role of the radiographer
   1. Determining cause of problems
   2. Recommending corrective action

D. Establishing acceptable limits

II. Image Appearance Characteristics

A. Density/brightness
   1. Film-screen equal to density
   2. Digital/PACS equal to brightness

B. Contrast

C. Recorded detail/spatial resolution

D. Distortion

III. Procedural Factors

A. Image identification
   1. Patient information
   2. Date of examination
   3. Proper use of identification markers
   4. Institutional data

B. Documentation of ordered exam
   1. Prescription
   2. Patient chart
   3. Telephone orders
   4. Faxed orders

C. Positioning
   1. Anatomical considerations
      a. Anatomy of interest
      b. Plane/baseline reference
      c. Central ray angulation
      d. Anatomical variations
      e. Body habitus
      f. Pathology
   2. Positioning aids
   3. Special concerns
      a. Age
      b. Patient condition
      c. Mobile radiography

D. Centering
   1. Central ray location
   2. Area of interest
   3. Beam alignment and angulation

E. Exposure index
   1. Interpretation
   2. Modifiers

F. Radiation protection
   1. Collimation/beam limitation
   2. Shielding
   3. Repeats
   4. Image receptor
      a. Size
      b. Speed

G. Patient preparation
   1. Contrast agent
   2. Pre-examination preparation

H. Artifacts

IV. Corrective Action

A. Equipment
   1. Radiographic system
      a. Film-screen
      b. Digital
   2. Fluoroscopic unit

B. Technical factors

C. Procedural factors

D. Artifacts

Imaging Equipment

Description

Content is designed to establish a knowledge base in radiographic, fluoroscopic, mobile and tomographic equipment requirements and design. The content also provides a basic knowledge of quality control.

Content

I. X-ray Circuit

A. Electricity
   1. Potential difference
   2. Current
      a. Direct
      b. Alternating
   3. Resistance

B. Protective devices
   1. Ground
   2. Circuit breaker

C. Transformers
   1. Step-up
   2. Step-down
   3. Auto transformer

D. Components and functions
   1. Filament circuit
   2. Tube circuit

E. Rectification
   1. Purpose
   2. Mechanisms

F. Generator types
   1. Single phase
   2. High frequency
      a. Constant load – constant mA
      b. Falling load – decreasing mA with time

II. Radiographic Equipment

A. Permanent installation
   1. Tubes
   2. Collimators
   3. Tables
   4. Control panels

5. Tube stands
6. Wall units
7. Equipment manipulation

B. Mobile units
1. Types
   a. Battery
   b. Capacitor discharge
2. Components
3. Purpose
4. Applications

C. Automatic exposure control (AEC) devices
1. Ionization chambers
2. Solid-state detector
3. Minimum response time
4. Back-up time
5. Alignment/positioning considerations
   a. Cell locations
   b. Cell size
   c. Cell sensitivity/balance
6. Compensation issues
   a. Patient size
   b. Pathology/metal
   c. Beam size
   d. Image receptor variations

III. Diagnostic X-Ray Tubes

A. Construction
1. Design
2. Function

B. Extending tube life
1. Warm-up procedures
2. Rotor considerations
3. Filament considerations
4. Single exposure limits
5. Multiple exposure limits
6. Anode thermal capacity
7. Tube movement

IV. Image Intensified Fluoroscopy

A. Construction
1. Design
2. Function

B. Intensification principles/characteristics
   1. Brightness gain
   2. Flux gain
   3. Minification gain
   4. Conversion factor
      a. Conversion factor and brightness gain
   5. Automatic brightness control
   6. Multi-field intensifiers
      a. Magnification
      b. Dose
   7. Spatial resolution
   8. Distortion
   9. Noise

C. Viewing and recording systems
   1. Video camera tube
   2. Charged coupled device (CCD)
   3. Television monitor
   4. Cassette spot film
   5. Film cameras
   6. Videorecorders

D. Digital fluoroscopy
   1. Types of acquisition
      a. Video analog to digital
      b. Charge coupled device – CCD
      c. Flat panel detector
   2. Operations and technique

V. Linear Tomography

A. Purpose

B. Principles

C. Equipment

D. Applications

VI. Quality Management

A. Definitions
   1. Quality improvement/management
   2. Quality assurance
   3. Quality control

B. Benefits
   1. Patient safety

2. Reduction in radiation exposure
3. Efficacy of patient care
4. Departmental efficiency
5. Consistent image quality
6. Cost-effectiveness

C. Elements
   1. Standards for quality – agencies
   2. Communications
   3. Quality management manual
   4. Responsibility and administration
   5. Test equipment, procedures and training
   6. Record-keeping
   7. Test review
   8. Evaluation
   9. Continuing education

D. Equipment
   1. kVp/half-value layer (HVL)
   2. Milliampere
      a. mAs reciprocity
      b. mA linearity
   3. Timer accuracy
   4. Image receptors
   5. Beam alignment
   6. Illuminator brightness/consistency
   7. Video monitor calibration

Medical Terminology

Description
Content is designed to provide an introduction to the origins of medical terminology. A word-building system is introduced and abbreviations and symbols are discussed. Also introduced is an orientation to understanding radiographic orders and diagnostic report interpretation. Related terminology is addressed.

Content

I. The Word-Building Process
- A. Basic elements
  1. Root words
  2. Prefixes
  3. Suffixes
  4. Combination forms
- B. Parts of speech
  1. Nouns
  2. Verbs
  3. Adjectives
  4. Adverbs
- C. Translation of terms into common language
- D. Correct pronunciation of medical terms

II. Medical Abbreviations and Symbols
- A. Role in communications
- B. Abbreviations
  1. Examples
  2. Interpretations
- C. Pharmaceutical symbols and terms

III. Radiologic Technology Procedures and Terminology
- A. Radiography
- B. Radiation oncology
- C. Nuclear medicine
- D. Sonography

IV. Understanding Orders, Requests and Diagnostic Reports
- A. Radiographic orders and requisitions – components
  1. Procedures ordered
  2. Patient history

3. Clinical information

B. Diagnostic reports
   1. Content
   2. Interpretation

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.

Content

I. Radiographer and Health Care Team

A. Responsibilities of the health care facility
   1. Caring for all patients regardless of condition
   2. Caring for the trauma patient
   3. Caring for the pediatric patient
   4. Caring for the geriatric patient
   5. Promoting health
   6. Preventing illness
   7. Education
   8. Research

B. Health care team
   1. Make-up of health care team
   2. Responsibilities

C. Responsibilities of the radiographer
   1. Performing radiographic examination
   2. Assisting the radiologist
   3. Providing patient care
   4. Practice Standards
      a. ASRT
      b. State licensure

II. Attitudes and Communication in Patient Care

A. Health and illness continuum

B. Developing professional attitudes
   1. Health role model
   2. Sympathy
   3. Empathy
   4. Assertiveness

C. Communication across the age continuum
   1. Neonatal
   2. Pediatric
   3. Adolescence

4. Young adulthood
5. Elderly

D. Communication
1. Verbal
   a. Presentation of material
   b. Attitudes
   c. Voice tone and volume
   d. Effective listening
2. Nonverbal communication
   a. Facial expression
   b. Physical appearance
   c. Touch
   d. Meta communication
   e. Eye contact
3. Cultural variations
4. Challenges of communication
   a. Non-English-speaking patients
   b. Hearing, vision and speech impairments
   c. Impaired mental function
   d. Altered states of consciousness
   e. Children and adolescents
   f. Geriatric patients
   g. Stress
   h. Human diversity
   i. Artificial speech
      1) Transesophageal puncture (TEP)
      2) Esophageal speech
      3) Electrolarynx devices
5. Other factors that impede communication
   a. Colloquialism/slang
   b. Medical jargon
6. Feedback
7. Patient interactions
   a. Establishing communication guidelines
   b. Reducing distance
   c. Listening
   d. Using therapeutic silence
   e. Responding to the feeling and the meaning of the patient's statement
   f. Restating the main idea
   g. Reflecting the main idea
   h. Making observations
8. Communication with families
9. Communication with other health care professionals

E. Psychological considerations
1. Dying and death
a. Understanding the process
b. Aspects of death
1) Emotional
2) Personal
3) Physical
a) Pain
b) Suffering
c) Disability
d) Deterioration
c. Stages of dying
1) Denial
2) Anger
3) Bargaining
4) Depression
5) Acceptance
d. Patient support services
1) Family/friends
2) Pastoral care
3) Patient-to-patient support groups
4) Psychological support groups
5) Hospice
6) Home care
2. Patient's emotional responses
a. General behavior
b. Influencing factors
1) Age
2) Sex
3) Marital/family status
4) Socioeconomic factors
5) Cultural/religious variations
6) Physical condition
7) Self-image
8) Past health care experiences
9) Beliefs
10) Attitudes
11) Prejudices
12) Self-awareness

III. Patient/Radiographer Interactions

A. Patient identification methods
1. Interview/questioning
2. Chart/requisition
3. Wrist band

B. Procedure questions and explanations
   1. Positioning
   2. Length of procedure
   3. Audio and visual intercommunication systems
   4. Room noises
   5. Immobilization devices
   6. Machine type
   7. Machine movement
   8. Machine and patient contact
   9. Application of auxiliary equipment

C. Interaction with patient family members and friends

IV. Safety and Transfer Positioning

A. Environmental safety
   1. Fire
   2. Electrical
   3. Hazardous materials
   4. Radioactive materials
   5. Personal belongings
   6. Occupational Safety and Health Administration (OSHA)
   7. Environmental Protection Agency (EPA)

B. Body mechanics
   1. Proper body alignment
   2. Proper movement
   3. Proper balance
   4. Center of balance in the body
   5. Practicum

C. Patient transfer and movement
   1. Assess the patient's mobility
   2. Rules for safe patient transfer
   3. Wheelchair transfers
   4. Stretcher transfers
      a. Sheet transfer
      b. Three-carrier lift
      c. Log roll
      d. Positioning for safety, comfort and/or exams
   5. Disabled patients
   6. Geriatric patients
   7. Pediatric patients
   8. Patients with intravenous infusions
   9. Patients with tubes or catheters
   10. Metastatic disease
   11. Practice

D. Positioning for safety and comfort

Comment [RH4]: Note: Fall prevention was added as D. This is now E.

1. Positions
    a. Supine
    b. Fowler's
    c. Semi-Fowler's
    d. Sims'
    e. Trendelenburg
    f. Lithotomy
    g. Knee-chest
2. Safety straps and rails

E. Immobilization techniques

1. Purpose
2. Adult
    a. Types
    b. Applications
    c. Devices
3. Pediatric
    a. Types
    b. Applications
    c. Devices

F. Accident and incident reporting

1. Purpose
2. Legal considerations
3. Documentation
4. Procedures

V. Evaluating Physical Needs

A. Assess patient status

1. Evaluation methodology
2. Clinical information

B. Vital signs – ranges and values

1. Temperature
2. Pulse
3. Respiration
4. Blood pressure
5. Normal values
6. Interfering factors
7. Terminology
8. Adult vs. pediatric
9. Documentation
10. Pain assessment
11. Body type

C. Acquiring and recording vital signs
   1. Procedures
   2. Demonstration

D. Review of laboratory data
   Normal ranges for:
      a. Blood urea nitrogen (BUN)
      b. Creatinine
      c. Hemoglobin
      d. Red blood cells (RBCs)
      e. Platelets
      f. Oxygen (O_2) saturation
      g. Prothrombin
      h. Part thromboplastin time

E. Patient chart
   1. Aspects of patient chart
   2. Retrieval of specific information
   3. Proper documentation in the chart

VI. Infection Control

A. Terminology
   1. Nosocomial
   2. Communicable
   3. Infectious pathogens
   4. Human immunodeficiency virus (HIV)
   5. Hepatitis
   6. Other

B. Centers for Disease Control and Prevention (CDC)
   1. Purpose
   2. Publications and bulletins

C. Cycle of infection
   1. Infectious pathogens – bloodborne and airborne
   2. Reservoir of infection
   3. Susceptible host
   4. Transmission of disease
      a. Direct
      b. Indirect

D. Prevent disease transmission
   1. Transmission-based precautions
   2. Health care worker
      a. Immunization

b. Booster
c. Postexposure protocols

E. Asepsis
1. Medical
a. Definition
b. Procedures
1) Hand washing
2) Chemical disinfectants
2. Surgical
a. Definition
b. Growth requirements for microorganisms
c. Methods used to control microorganisms
1) Moist heat
a) Boiling
b) Steam under pressure
2) Dry heat
a) Incineration
b) Dry heat
3) Gas
4) Chemicals
d. Procedures – demonstrate
1) Opening packs
2) Gowning/gloving
3) Skin preparation
4) Draping
5) Dressing changes
e. Packing
f. Storage
g. Rules for surgical asepsis

F. Environmental asepsis
1. Linen handling
2. Wound care
a. Cleansing
b. Dressing
3. Techniques
a. Dress
b. Hair
c. Hand washing
d. Gloves
e. Eye protection
f. Cleaning and proper disposal of contaminated waste
4. Practice

G. Isolation techniques and communicable diseases

1. Category-specific
2. Disease-specific
3. Standard precautions

H. Isolation patient in radiology department
1. Procedure
   a. Gowning
   b. Gloving
   c. Masking
2. Patient transfer
3. Cleaning and proper disposal of contaminated waste
4. Cleaning cassettes and imaging equipment

I. Precautions for the compromised patient (reverse isolation)
1. Purpose
2. Procedure

J. Psychological considerations

VII. Medical Emergencies

A. Terminology

B. Emergency equipment

C. Latex reactions

D. Shock
1. Signs and symptoms
2. Types
   a. Hypovolemic
      1) Hemorrhage
      2) Plasma loss
      3) Drugs
   b. Disruptive
      1) Anaphylactic
      2) Neurogenic
      3) Septic
   c. Cardiogenic
3. Medical intervention

E. Diabetic emergencies – signs, symptoms and interventions
1. Hypoglycemia
2. Ketoacidosis
3. Hyperosmolar coma

F. Respiratory and cardiac failure – signs, symptoms and interventions
1. Adult vs. pediatric

2. Equipment

G. Airway obstruction – signs, symptoms and interventions

H. Cerebral vascular accident (stroke) – signs, symptoms and interventions

I. Fainting and convulsive seizures, signs, symptoms and interventions
   1. Types
      a. Nonconvulsive (petit mal)
      b. Convulsive (grand mal)
   2. Reasons for fainting

J. Other medical conditions
   1. Epistaxis
   2. Nausea
   3. Postural hypotension
   4. Vertigo
   5. Asthma

VIII. Unique Situations and Trauma

A. Head injuries
   1. Four levels of consciousness
   2. Symptoms
   3. Medical intervention
   4. Adult vs. pediatric

B. Spinal injuries
   1. Assessment
   2. Symptoms
   3. Medical intervention
   4. Transportation

C. Extremity fractures
   1. Types
   2. Symptoms
   3. Splints
   4. Casts
   5. Positioning
   6. Adult vs. pediatric

D. Wounds
   1. Symptoms
   2. Medical intervention

E. Burns
   1. Burn classifications

2. Medical intervention

F. Reactions to contrast agents
   1. Signs and symptoms of mild, moderate and severe contrast reactions
   2. Medical interventions for each type of reaction
   3. Vasovagal reactions

IX. Contrast Studies

A. Patient education
   1. Radiographer's responsibility
   2. Standard procedure

B. Patient preparation and care per procedure

C. Follow-up care

X. Tubes, Catheters, Lines and Collection Devices

Comment [RH5]: Note: Reactions to Contrast Agents was added as X. This is now XI.

A. Terminology

B. Function of devices

C. Nasogastric/nasointestinal

D. Suction
   1. Adult vs. pediatric
   2. Special precautions

E. Tracheostomy
   1. Suction techniques
   2. Cardiopulmonary resuscitation (CPR) with tracheostomy

F. Chest (thoracostomy) tube
   1. Purpose
   2. Location

G. Central venous lines
   1. Purpose
   2. Types

H. Tissue drains

I. Oxygen administration
   1. Values
   2. Oxygen therapy
   3. Oxygen delivery systems
      a. Low-flow systems

b. High-flow systems
4. Documentation
5. Special precautions

J. Urinary collection
1. Procedure
a. Male
b. Female
2. Alternative methods of urinary drainage
3. Documentation

K. Other ostomies
1. Ileostomy
2. Ureteroileostomy

L. Myelography

XI. Mobile and Surgical Radiography

A. Prior to bedside procedure:
1. Exam order
2. Chart
3. Right patient – right procedure

B. Steps followed during bedside procedure

C. Bedside procedure for neonate

D. Bedside procedure for the orthopedic patient

E. Special situations

F. Radiography in surgery
1. Surgical clothing
2. Equipment preparation
3. Sterile fields
4. Communication skills

G. Radiation protection

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.

Considerations
Students should successfully complete patient care objectives (including CPR/BLS certification), as well as objectives related to anatomy and physiology of the circulatory and excretory systems, prior to introducing this educational content.

Though regulations regarding the administration of contrast media and intravenous medications vary in different states and institutions, the official position of the American Society of Radiologic Technologists is that venipuncture falls within the profession's general scope of practice and practice standards. Therefore, it should be included in the didactic and clinical curriculum with demonstrated competencies of all appropriate disciplines regardless of the state or institution where the curriculum is taught.

In states or institutions where students are permitted to perform intravenous injections, the program has specific ethical and legal responsibilities to the patient and the student. The student shall be assured that:

- Legal statutes allow student radiographers to perform this procedure.
- Professional liability coverage is adequate.
- Adequate supervision is provided.
- Appropriate, structured, laboratory objectives are identified.
- Evaluation and demonstration of competency occur before this task is performed unsupervised.

Content

I. Drug Nomenclature
- A. Chemical name
- B. Generic name
- C. Trade name

II. Methods of Drug Classification
- A. Chemical group
- B. Mechanism/site of action
- C. Primary effect

III. General Pharmacologic Principles

A. Pharmacokinetics

B. Pharmacodynamics

IV. Five Rights of Drug Safety

A. The right medication

B. The right dose

C. The right patient

D. The right time

E. The right location

V. Drug Categories of Relevance to Radiography (Side Effects, Uses and Impacts on Medical Imaging)

A. Analgesics

B. Antiemetic drugs

C. Antianxiety drugs

D. Antidepressants

E. Anti-inflammatory drugs

F. Antiarrhythmic drugs

G. Vasodilators and vasoconstrictors

H. Diuretics

I. Antihypertensive drugs

J. Anticoagulant and coagulant drugs

K. Antiallergic and antihistamine drugs

L. Bronchodilators

M. Antibacterial drugs

N. Antiseptic and disinfectant agents

O. Sedative and hypotonic drugs

P. Anesthetic agents

Q. Cathartic and antidiarrheal drugs

R. Diagnostic contrast agents

VI. Classification of Contrast Agents

A. Types of compound
   1. Metallic salts
   2. Organic iodides
      a. Ionic contrast agents
      b. Nonionic contrast agents
   3. Iodized oils
   4. Gaseous

B. Beam attenuation characteristics
   1. Radiolucent (negative)
   2. Radiopaque (positive)
   3. Impact of atomic number

C. Pharmacologic profile of contrast agents
   1. Chemical composition
   2. Absorption characteristics
   3. Distribution characteristics
   4. Metabolic characteristics
   5. Elimination characteristics
   6. Indications, actions and effects
   7. Interactions and contraindications
   8. Patient reactions

D. Dosage

E. Preparation

VII. Routes of Drug Administration

A. Systemic
   1. Oral
   2. Rectal
   3. Tube/catheter
   4. Inhalation

B. Parenteral
   1. Intravenous

2. Intra-arterial
3. Intrathecal

VIII. Intravenous Drug Therapy

A. Purpose

B. Advantages

C. Methods
1. Continuous infusion
2. Intermittent infusion
3. Direct injection

D. Sites of administration
1. Peripheral
2. Central

E. Complications
1. Infiltration
2. Extravasation
3. Phlebitis
4. Air embolism
5. Drug incompatibility
6. Low fluid level in container

F. Initiation of intravenous therapy
1. Intravenous infusion/venipuncture equipment
2. Patient identification, assessment and instructions
3. Dosage, dose calculations and dose-response
   a. Adults
   b. Pediatric patients
4. Patient preparation
5. Application of standard precautions
6. Procedure for intravenous infusion/direct puncture
7. Site observation
8. Emergency medical treatment procedure
   a. Appropriate codes
   b. Emergency cart (crash cart)
   c. Emergency medications
   d. Accessory equipment
      1) Oxygen
      2) Suction
   e. Emergency medical treatment follow-up tasks
9. Discontinuation of intravenous therapy
   a. Equipment/supplies for withdrawal
   b. Patient preparation

c. Application of standard precautions
d. Withdrawal procedure
e. Site observation
f. Patient observation
g. Postprocedural tasks

10. Documentation of administration
11. Documentation of complication/reaction

IX. Current Practice Status

A. Professional standards
1. Scope of Practice
2. Practice Standards
3. Professional liability and negligence

B. State statutes

C. Employer prerogative

X. Informed Consent

Radiation Biology

Comment [RH6]: Note: Alpha ordered - Principles of Imaging is now located here.

Description
Content is designed to provide an overview of the principles of the interaction of radiation with living systems. Radiation effects on molecules, cells, tissues and the body as a whole are presented. Factors affecting biological response are presented, including acute and chronic effects of radiation.

Content

I. Introduction

A. Molecule
1. Ionic bond
2. Covalent bond

B. Review of cell biology
1. Basic unit of life
2. Cell constituents
   a. Protoplasm and metabolism
   b. Organic and inorganic compounds
   c. Basic cell chemistry
3. Cell structure
   a. Cell membrane
   b. Cytoplasm
   c. Organelles
   d. Nucleus
4. Cell growth
   a. Mitosis
   b. Meiosis
   c. Cell cycle
   d. Differentiation

C. Types of ionizing radiations
1. Electromagnetic radiations
   a. X-rays
   b. Gamma rays
2. Particulate radiations
   a. Alpha
   b. Beta
      1) Negatron
      2) Positron
   c. Fast neutrons
   d. Protons
3. Absorption and ionization
   a. Direct
   b. Indirect

D. Sources of medical radiation exposure
   1. Diagnostic radiology
   2. Dental radiology
   3. Interventional radiology
   4. Nuclear medicine
   5. Radiation oncology

II. Biophysical Events

A. Molecular effects of radiation
   1. Direct mechanism
      a. Target theory
         1) Target molecules
         2) Cell death
   2. Indirect mechanism
      a. Radiolysis of water

B. The deposition of radiant energy
   1. Linear energy transfer (LET)
   2. Relative biological effectiveness (RBE)
   3. Factors influencing RBE
      a. Linear energy transfer (LET)
      b. Oxygen

III. Radiation Effects

A. Subcellular radiation effects
   1. Radiation effects on DNA
      a. Types of damage
      b. Implications for humans
   2. Radiation effects of chromosomes
      a. Types of damage
      b. Implications for humans

B. Cellular radiation effects
   1. Types of cell death
      a. Interphase death
      b. Mitotic (genetic) death
   2. Other effects
      a. Mitotic delay
      b. Reproductive failure
      c. Interference of function

C. Individual radiation effects
   1. Somatic effects
      a. Short term
      b. Long term

c. Stochastic (probabilistic) effects
2. Genetic effects
a. Mutagenesis
3. Embryo and fetal effects

D. Factors influencing radiation response

IV. Radiosensitivity and Response

A. Law of Bergonié and Tribondeau
1. Differentiation
2. Mitotic rate
3. Metabolic rate

B. Cell survival and recovery
1. Factors influencing survival
a. LET
b. Oxygen enhancement ratio (OER)
c. Fractionation
d. Protraction
2. Lethal dose (LD) 50/30 and LD 30

C. Systemic response to radiation
1. Hemopoietic
2. Integumentary
3. Digestive
4. Urinary
5. Respiratory
6. Reproductive
7. Nervous
8. Other

D. Radiation dose-response curves
1. Linear, nonthreshold
2. Nonlinear, nonthreshold
3. Linear, threshold
4. Nonlinear, threshold

E. Total body irradiation
1. Acute radiation syndrome
a. Hemopoietic
b. Gastrointestinal
c. Central nervous system
2. Stages of response and dose levels
3. Factors that influence response
4. Medical interventions of response

F. Late effects of radiation
    1. Somatic responses
        a. Mutagenesis
        b. Carcinogenesis
    2. Stochastic (probabilistic) effects
    3. Non-stochastic (deterministic) effects
    4. Genetic effects
    5. Occupational risks for radiation workers

G. Risk estimates

Radiation Production and Characteristics

Description
Content is designed to establish a basic knowledge of atomic structure and terminology. Also presented are the nature and characteristics of radiation, x-ray production and the fundamentals of photon interactions with matter.

Content

I. Structure of the Atom
- A. Composition
  1. Nucleus
  2. Structure – proton and electron balance
  3. Electron shells
     a. Binding energy
     b. Valence shell
     c. Ionization
     d. Excitation

- B. Nomenclature
  1. Atomic number
  2. Mass number

II. Nature of Radiation
- A. Radiation
  1. Electromagnetic
     a. Spectrum
     b. Wave-particle duality
     c. Properties
  2. Particulate
     a. Types
     b. Characteristics
  3. Nonionizing (excitation) vs. ionization
     a. Energy
     b. Probability

- B. Radioactivity
  1. Radioactive decay
     a. Alpha emission
     b. Beta emission
     c. Gamma emission
  2. Half-life ($T_{½}$)

III. X-Ray Production
- A. Historical introduction

B. Types
   1. Bremsstrahlung
   2. Characteristic
   3. Percentage relationship with energy

C. Common terms related to the x-ray beam
   1. Primary beam
   2. Exit/remnant beam
   3. Leakage radiation
   4. Off-focus radiation

D. Conditions necessary for production
   1. Source of electrons
   2. Acceleration of electrons
   3. Focusing the electron stream
   4. Deceleration of electrons

E. X-ray emission spectra
   1. Continuous spectrum
   2. Discrete spectrum
   3. Minimum wavelength

F. Factors that affect emission spectra
   1. kVp
   2. mA
   3. Time
   4. Atomic number of target
   5. Distance
   6. Filtration
   7. Voltage waveform

G. Efficiency in production
   1. Description
   2. Frequency and wavelength

IV. Interaction of Photons with Matter

A. Transmission of photons
   1. Attenuated radiation
   2. Exit/remnant radiation

B. Unmodified scattering (coherent)
   1. Description of interaction
   2. Relation to atomic number
   3. Energy of incident photon and resulting product
   4. Probability of occurrence
   5. Application

C. Photoelectric effect
    1. Description of interaction
    2. Relation to atomic number
    3. Energy of incident photon and resulting product
    4. Probability of occurrence
        a. Atomic number
        b. Photon energy
        c. Part density
    5. Application

D. Modified scattering (Compton)
    1. Description of interaction
    2. Relation to electron density
    3. Energy
    4. Probability of occurrence

E. Pair production

F. Photodisintegration

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.

Content

I. Introduction

A. Justification for radiation protection
   1. Somatic effects
   2. Genetic effects

B. Potential biologic damage of ionizing radiation
   1. Stochastic (probabilistic) effects
   2. Nonstochastic (deterministic) effects

C. Objectives of a radiation protection program
   1. Documentation
   2. Occupational and nonoccupational dose limits
   3. ALARA concept (optimization)
   4. Comparable risk
   5. Negligible individual dose (NID)

D. Sources of radiation
   1. Natural
   2. Man-made (artificial)

E. Legal and ethical responsibilities

II. Units, Detection and Measurement

A. Radiation units
   1. Exposure
      a. Coulomb/kilogram (C/kg)
      b. Roentgen (R)
   2. Absorbed dose
      a. Gray (Gy)
      b. Rad
   3. Dose equivalent
      a. Sievert (Sv)
      b. Rem
   4. Radioactivity
      a. Becquerel (Bq)
      b. Curie (Ci)

B. Dose reporting
   1. Code of federal regulations (CFR)
   2. National Council on Radiation Protection and Measurements (NCRP) Guidelines

III. Surveys, Regulatory/Advisory Agencies and Regulations

A. General survey procedures
   1. Qualified expert
   2. Records

B. Equipment survey
   1. Conditions
   2. Radiographic and fluoroscopic equipment

C. Area survey
   1. Controlled/uncontrolled areas
   2. Conditions
   3. Recommendations
   4. "Radiation Area" sign posting
   5. Monitors

D. Regulatory
   1. Nuclear Regulatory Commission (NRC)
   2. Food and Drug Administration (FDA)
   3. State agencies

E. Advisory agencies
   1. International Council on Radiation Protection and Measurements (ICRP)
   2. National Council on Radiation Protection and Measurements (NCRP)
   3. Biological Effects of Ionizing Radiation (BEIR)

F. Radiation safety officer
   1. Requirements
   2. Responsibilities

IV. Personnel Monitoring

A. Historical perspective
   1. Evolution of standards
   2. 10 Code of Federal Regulations (CFR) part 20
   3. NCRP recommendations
   4. ICRP recommendations

B. Requirements for personnel monitoring
   1. Deep dose equivalent (DDE)
   2. Shallow dose equivalent (SDE)
   3. Eye dose equivalent (EDE)
   4. Total effective dose equivalent (TEDE)

C. Methods and types of personnel monitors
   1. Film badge
   2. Thermoluminescent dosimeter (TLD)
      a. Body badge
      b. Ring badge
   3. Optically stimulated luminescent dosimeter (OSLD)

D. Records of accumulated dose
   1. Purpose
   2. Content
   3. Length of record-keeping
   4. Retrieval from previous employers

E. Dose limits – 10 CFR part 20
   1. Occupational
   2. Nonoccupational limits
   3. Critical organ sites
   4. Embryo and fetus

F. Responsibilities for radiation protection
   1. Radiographer
   2. Radiation safety officer (RSO)
   3. Facility

V. Application

A. Design
   1. Materials
   2. Primary barrier
   3. Secondary (scatter and leakage) barrier
   4. HVL and tenth-value layer (TVL)
   5. Factors
      a. Use (U) controlled and uncontrolled
      b. Workload (W)
      c. Occupancy (T)
      d. Distance (D)
   6. X-ray and ancillary equipment
      a. Beam limiting devices
      b. Exposure control devices
      c. On and off switches
      d. Interlocks
      e. Visual/audio monitors
      f. Emergency controls
      g. Quality control
         1) Calibration
         2) Standards

B. Regulations and recommendations
   1. Current NRC recommendations and/or regulations
   2. Current NCRP recommendations and/or regulations
   3. Applicable state regulations
   4. Public Law 97-35 (The Patient Consumer Radiation Health and Safety Act of 1981)
   5. CARE Bill
   6. Public awareness

C. Cardinal principles in protection
   1. Time
   2. Distance
   3. Shielding

D. Emergency procedures

VI. Patient Protection

A. Beam-limiting devices

B. Filtration

C. Shielding

D. Exposure factors

E. Positioning

F. Image receptor system

G. Immobilization

H. Fluoroscopic procedures

I. Mobile radiography

J. Special considerations
   1. Pediatric patients
   2. Pregnant patients

Radiographic Pathology

Description
Content is designed to introduce concepts related to disease and etiological considerations with emphasis on radiographic appearance of disease and impact on exposure factor selection.

Content

I. Definitions/Terminology
- A. Pathology
- B. Disease
  1. Acute
  2. Chronic
- C. Pathogenesis
- D. Etiology
- E. Diagnosis
  1. Signs (objective)
  2. Symptoms (subjective)
- F. Prognosis
- G. Indications for procedure
- H. Manifestations of pathology
- I. Relevance to radiographic procedures
  1. Technical considerations
  2. Patient considerations

II. Classifications (Definition, Examples, Sites, Complications, Prognosis)
- A. Mechanics
- B. Chemicals
- C. Thermals
- D. Radiation

III. Causes of Disease (Process, Examples)
- A. Pathological
- B. Traumatic

C. Surgical

D. Healing process

E. Complications

F. Genetics (caused by or contributed to by genetic factors) vs. heredity

IV. Radiologic Pathology (Definitions, Etiology, Examples, Sites, Complications, Prognosis, Radiographic Appearance, Procedural and Technique Considerations, Appropriate Imaging Modality)

A. Skeletal and articular

B. Digestive

C. Respiratory

D. Urinary

E. Reproductive

F. Circulatory

G. Endocrine

H. Nervous

Radiographic Procedures

Description

Content is designed to provide the knowledge base necessary to perform standard imaging procedures, including basic computed tomography (CT) and special studies. Consideration is given to the evaluation of optimal diagnostic images.

Content

I. Standard Terminology for Positioning and Projection

A. Standard terms
1. Radiographic position
2. Radiographic projection
3. Radiographic view

B. Positioning terminology
1. Recumbent
2. Supine
3. Prone
4. Trendelenburg
5. Decubitus
6. Erect and upright
7. Anterior position
8. Posterior position
9. Oblique position

C. General planes
1. Sagittal or mid-sagittal
2. Coronal or mid-coronal
3. Transverse
4. Longitudinal

D. Skull lines
1. Glabellomeatal line
2. Interpupillary line
3. Orbitomeatal line
4. Infraorbitomeatal line
5. Acanthiomeatal line
6. Mentomeatal line

E. Skull landmarks
1. Auricular point
2. Gonion (angle)
3. Mental point
4. Acanthion
5. Nasion

6. Glabella
7. Inner canthus
8. Outer canthus
9. Infraorbital margin
10. Occlusal plane
11. External auditory meatus
12. Mastoid tip

F. Terminology of movement and direction
1. Cephalad/caudad
2. Inferior/superior
3. Proximal/distal
4. Plantar/palmar
5. Pronate/supinate
6. Flexion/extension
7. Abduction/adduction
8. Inversion/eversion
9. Medial/lateral

G. Positioning aids
1. Sponges
2. Sandbags
3. Compression bands
4. Immobilization devices
5. CT immobilization devices
   a. Straps
   b. Head holders
   c. IV arm boards

H. Accessory equipment
1. Calipers
2. Lead strips
3. Lead shields or shadow shields
4. Lead markers
5. Image receptor holders
6. Power injectors

II. General Considerations

A. Evaluation of radiographic orders
1. Patient identification
2. Verification of procedure(s) ordered
3. Review of clinical history
4. Clinical history and patient assessment
   a. Role of the radiographer
   b. Questioning skills
   c. Chief complaint

d. Allergy history
e. Localization
f. Chronology
g. Severity
h. Onset
i. Aggravating or alleviating factors
j. Associated manifestations
k. Special considerations
1) Age
2) Disability
3) Cultural
a) Gender
b) Age
c) Value systems

B. Room preparation
1. Cleanliness, organization and appearance
2. Necessary supplies and accessory equipment available

III. Patient Considerations

A. Establishment of rapport with patient
1. Patient education
a. Communication
1) Types
2) Barriers
b. Cultural awareness
c. Clinical situations
d. Common radiation safety issues and concerns
2. Determination of pregnancy

B. Patient preparation
1. Verification of appropriate dietary preparation
2. Verification of appropriate medication preparation
3. Appropriate disrobing and gowning
4. Removal of items that may cause artifacts

C. Patient assistance

D. Patient monitoring

E. Patient dismissal

IV. Positioning Considerations for Routine Radiographic Procedures

A. Patient instructions

B. Image evaluation

1. Patient positioning
2. Part placement
3. Image receptor selection and placement
4. Beam-part-receptor alignment
5. Beam restriction and shielding

C. Special considerations
1. Atypical conditions
2. Mobile procedures
3. Surgical unit procedures
4. Age specific
5. Special needs patients
6. Trauma
7. Obesity
8. Cultural awareness
9. Claustrophobia

D. Positioning for the following studies:
1. Skeletal system
   a. Upper extremity
      1) Fingers
      2) Hand
      3) Wrist
      4) Forearm
      5) Elbow
      6) Humerus
   b. Shoulder
      1) Shoulder joint
      2) Scapula
      3) Clavicle
      4) Acromioclavicular articulations
   c. Lower extremity
      1) Toes
      2) Foot
      3) Ankle
      4) Calcaneus
      5) Tibia/fibula
      6) Knee
      7) Patella
      8) Femur
   d. Pelvic girdle
      1) Pelvis
      2) Hip
   e. Vertebral column
      1) Cervical
      2) Thoracic

3) Lumbar
4) Sacrum
5) Coccyx
6) Sacroiliac articulations
7) Scoliosis survey

f. Bony thorax
1) Ribs
2) Sternum
3) Sternoclavicular articulations

g. Cranium
1) Skull
2) Facial bones
3) Nasal bones
4) Orbits/optic foramina
5) Zygomatic arches
6) Mandible
7) Temporomandibular articulations
8) Paranasal sinuses

2. Respiratory system
a. Upper airway
b. Lungs

3. Abdominal viscera
a. Abdomen and GI series
b. Urological studies

V. Procedural Considerations for Contrast Studies

A. Equipment and materials needed

B. Contrast media
1. Purpose
2. Types
a. Negative agents
1) Carbon dioxide
2) Air
3) Nitrous oxide
b. Positive agents
1) Barium sulfate
2) Iodinated

C. General procedure

D. Patient and body part positioning

E. Structures and functions demonstrated

F. Positioning for GI and genitourinary (GU) procedures

1. Digestive system
    a. Single and double contrast examinations
        1) Upper gastrointestinal system
        2) Lower gastrointestinal system
        3) Follow-up care
    b. Swallowing dysfunction study
    c. Small bowel
2. Biliary system
    a. Endoscopic retrograde cholangiographic pancreatography (ERCP)
    b. Surgical cholangiography
3. Genitourinary system
    a. Intravenous urography
    b. Retrograde urography
    c. Cystography and cystourethrography
    d. Hysterosalpingography

G. Basic CT exams with and without contrast
    1. Head
    2. Thorax
    3. Abdomen

H. Procedural considerations for the following special studies:
    1. Arthrography
    2. Myelography
    3. Venography
    4. Other

Required General Education

General education is an integral part of the development of a professional radiographer. The content is designed to assist in developing skills in communication, human diversity, scientific inquiry, critical thinking and judgment that are required to perform the responsibilities of an entry-level radiographer. Knowledge gained from general education serves to enhance the content and application of the radiography curriculum.

An additional goal of general education is to assist students in acquiring these types of skills. Postsecondary general education content is included as a "required" element of this radiography curriculum instead of as a "recommended" element. General education provides personal enrichment and exploration outside the confines of the technical professional curriculum. The general education content objectives in this curriculum were purposely labeled "global content objectives" to give program officials flexibility in determining specific college-level credit-bearing course work that will satisfy these objectives. There must be a minimum of 15 credit hours of general education course work. Written/oral communications and mathematics/analytical studies are required to satisfy a portion of the 15 credit-hour requirement. For the balance of general education credits, institutions are encouraged to draw upon varying areas of study to ensure a diversified educational experience (e.g. social/behavioral sciences, natural sciences, computing or humanities/fine arts).

Postsecondary general education is to be gained through college credit bearing courses that meet the global content objectives listed below:

- Mathematical/logical reasoning (required)
  - Develop skills in analysis, quantification and synthesis.
  - Apply problem-solving or modeling strategies.

- Written/oral communications (required).
  - Write and read critically.
  - Speak and listen critically.
  - Develop the ability to perceive, gather, organize and present information.
  - Locate, evaluate and synthesize material from diverse sources and points of view.

- Arts and humanities.
  - Develop knowledge and understanding of the human condition.
  - Demonstrate respect for diverse populations.
  - Develop an understanding of ethics and the role they play in personal and professional lives.
  - Recognize and critically examine attitudes and values.

- Information systems.
  - Develop the knowledge base to use computerized systems.
  - Use technology to retrieve, evaluate and apply information.

- Social/behavioral sciences.
  - Assist in adapting interactions to meet cultural/psychological needs of people.
  - Develop an understanding of individual and collective behavior.
  - Promote the development of leadership skills.
  - Develop the capacity to exercise responsible and productive citizenship.
  - Function as a public-minded individual.

- Natural sciences.
  - Develop an understanding of the scientific method.
  - Make informed judgments about science-related topics.
  - Develop a scientific vocabulary.

Film-Screen Image Acquisition and Processing

Comment [RH7]: Note: Title changed to Principles of Imaging and moved to alpha order before Radiation Biology. Many items deleted from this section have been moved toother areas in the revised curriculum.

Description

Content is designed to establish a knowledge base in factors that govern the image production process. Film imaging with related accessories is emphasized.

Content

I. **Image Appearance Standards**
- A. Establishing appearance standards
  1. Exam demands
  2. Visual acuity/perception
  3. Image viewing conditions
  4. Radiologist preferences and demands
- B. Maintaining appearance standards
  1. QA program

Comment [RH8]: Note: Exposure Factors is now I.

II. **Optical Density**
- A. Film – image density (optical density)
- B. Screen film factors
  1. Receptor exposure
  2. Receptor response

III. **Contrast**
- A. Definition
- B. Description
  1. High/short grayscale
  2. Low/long grayscale
- C. Components
  1. Subject contrast – variation in receptor exposure
     a. Structural distribution – anatomical contrast
        1) Contrast media
        2) Pathology
     b. kVp
        1) Filtration
        2) Scatter control
           a) Irradiated water volume – beam limiting
           b) Grid
           c) Air gap
  2. Receptor contrast - variation in receptor exposure
     a. Film average gradient
     b. Film-screen spectral match

c. Processing

3. Display contrast
   a. Viewbox brightness
   b. Ambient light in view area

IV. Recorded Detail/Spatial Resolution

A. Definition

B. Types
   1. Motion
      a. Part
      b. Equipment
         1) Exposure time
         2) Immobilization
   2. Geometric
      a. Blur width, geometric unsharpness, edge gradient
         1) Focal spot size
         2) SID
         3) Object-to-image distance (OID)
   3. Receptor
      a. Spatial resolution
         1) Line pair/mm
      b. Light diffusion
         1) Phosphor layer thickness
         2) Phosphor layer dye
         3) Reflective layer
   4. Noise
      a. Structure mottle
         1) Phosphor coating uniformity
      b. Quantum mottle
         1) Receptor speed or speed class

V. Distortion

A. Definition

B. Types
   1. Shape
      a. Foreshortening
      b. Elongation
   2. Size – geometric magnification
   3. Factors
      a. Distance
      b. Tube/part/image receptor relationships

VI. Exposure Latitude

A. Definition

B. Factors
   1. kVp
   2. Image receptor
   3. Spectral matching
   4. Average gradient

VII. Beam-limiting Devices

A. Definition

B. Function/Purpose
   1. Reduce irradiated tissue volume
   2. Reduce patient effective dose
   3. Improve contrast
      a. Reduce scatter
      b. Reduce optical density (OD)

C. Types – applications
   1. Apertures/diaphragms/cylinder
   2. Collimator
      a. Manual
      b. Automatic
   3. Lead masks
   4. Alignment
      a. Light field/x-ray beam
      b. Central ray/Bucky tray
   5. Positive beam limitation (PBL)
      a. Definition

VIII. Beam Filtration

A. Tube filtration
   1. Definition
      a. Inherent
      b. Added
      c. Flat
      d. Stack
   2. Function/mechanism

B. Compensating filtration
   1. Function
   2. Types

C. Impact of filtration on image characteristics
   1. Contrast
   2. OD/screen/film

D. Filtration vs. HVL

IX. Scattered and Secondary Radiation

A. Definitions

B. Factors
1. kVp
2. Irradiated water volume
   a. Anatomical structure
   b. Beam size
3. Contrast agent
4. Patient
5. Beam limitation
6. Grids
7. OID – air gap technique

C. Effects
1. Effective patient dose
2. Subject contrast
3. Image quality
4. Occupational exposure

X. Control of Remnant Beam/Exit Beam

A. Grids
1. Function/mechanism
2. Construction
3. Types
   a. Focused
   b. Parallel
   c. Linear
   d. Crossed
   e. Moving
   f. Stationary
   g. Short dimension
4. Grid characteristics
   a. Focal distance/radius
   b. Focal range
   c. Ratio
   d. Frequency
   e. Lead content
   f. Grid/Bucky factor
   g. Contrast improvement factor
   h. Selectivity
5. Selection
   a. kVp
   b. Patient/exam

c. Beam limiting
d. Alignment latitude

6. Primary cutoff
   a. Definition
   b. Types

XI. Exposure Factor Formulation

A. Purpose
   1. Receptor exposure standardization
   2. Image consistency

B. Considerations
   1. Choice of technique system
   2. Patient thickness
   3. Image processing

C. Types
   1. Optimum kVp/variable mAs
   2. Variable kVp/fixed mAs
   3. Automated exposure

XII. Exposure Factors

A. Distance

B. mAs

C. kVp

D. Grids

E. Receptor speed or speed class

F. Calculations for receptor exposure maintenance
   1. mAs reciprocity
   2. mAs/kVp – 15 percent rule
   3. Grid factor/Bucky factor
   4. Receptor speed or speed class
   5. SID

G. Distortion calculations
   1. Magnification factor
   2. Percent magnification

XIII. Darkroom/Storage Environment

A. Processing considerations

1. Location/construction/function
    a. Centralized/distributed
    b. Access
    c. Entry/warning lights

B. Darkroom environment
1. Temperature
2. Humidity
3. Ventilation
4. Lighting
    a. Safelight
        1) Filter colors – spectral emission vs. film sensitivity
        2) Mounting distance and direction
        3) Bulb size/wattage
        4) Safelight testing
    b. Overhead light
5. Radiation shielding
6. Film handling considerations

C. Film storage considerations
1. Temperature
2. Humidity
3. Light
4. Radiation
5. Gases/fumes
6. Pressure
7. Inventory control
    a. Consumables purchasing
    b. Expiration date
    c. Maximum storage time

D. Safety
1. Occupational Safety & Health Administration (OSHA)
2. Material safety data sheet (MSDS)
3. Darkroom chemical sensitivity

XIV. Characteristics of Image Receptors

A. Properties
1. Contrast
2. Exposure response – speed sensitivity
3. Recorded detail – spatial resolution

B. Latent image formation
1. Sensitivity specks
    a. Definition
    b. Process

c. Latent image fade

C. Response curves
a. D-LogE, Hurter and Driffield (H&D) or characteristic
1) Comparisons
a) Speed
b) Control contrast – average gradient
c) Exposure latitude

XV. Image Receptor Holders and Intensifying Screens

A. Image receptor holders
1. Cassettes
a. Purpose
b. Construction
1) Anti-backscatter foil
2) Front attenuation
c. Loading/unloading
d. Maintenance

B. Intensifying screens
1. Purpose
2. Construction/composition
3. Principles of function
a. Fluorescence
b. Phosphorescence
c. Structure mottle
d. Film-screen contact
e. Technical influences
4. Classification
a. Phosphor spectral emission
b. Absorption efficiency
c. Speed class
1) Technical consideration
2) Patient exposure
5. Maintenance
a. Handling
b. Cleaning
c. Evaluating

XVI. Automatic Processing

A. Purpose

B. Components
1. Developer
a. Function
b. Time and temperature
2. Fixer

a. Function
b. Time and temperature

3. Wash
   a. Function
   b. Time and temperature
   c. Water flow rate
4. Dryer
   a. Function
   b. Time and temperature
   c. Humidity

C. Systems
1. Transport
2. Replenishment
3. Recirculation
4. Temperature control
5. Dryer

D. Image receptor feed

E. Maintenance/cleaning
1. Shut-down procedure
2. Start-up procedure

F. Quality control

G. Documentation

XVII. Artifacts

A. Definition

B. Types

C. Causes

D. Effects

E. Preventive/corrective maintenance

XVIII. Silver Recovery

A. Definition

B. Rationale
1. Environmental Protection Agency (EPA) guidelines

C. Methods

1. Electrolytic
2. Metallic replacement/ion exchange
3. Discarded film

D. Security

Appendix

Compendium of Learning Objectives

This compendium of learning objectives, indexed by content area, serves as a resource for program planners and course managers.

Basic Principles of Computed Tomography

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

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 HIPAA requirements.
- Demonstrate the principles of transferring, positioning and immobilizing patients.
- Comply with departmental and institutional response to emergencies, disasters and accidents.

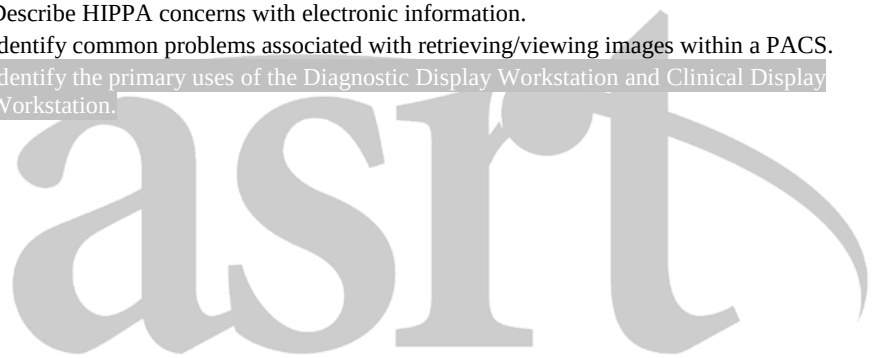
- Differentiate between emergency and non-emergency procedures.
- Adhere to national, institutional and departmental standards, policies and procedures regarding care of patients, providing radiologic procedures and reducing medical errors.
- Select technical factors to produce quality diagnostic images 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

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 screen/film 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 cut off 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 Picture Archival and Communications System (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

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.

Fundamentals of Radiologic Science and Health Care

Objectives

- Identify other health science professions that participate in the patient's total health care.
- Identify various settings involved in the delivery of health care.
- Discuss the reimbursement/payment options for health care services.
- Discuss the role and value of a mission statement to the operation of an institution.
- Discuss the relationship between institutional administrative personnel and radiology services.
- Describe relationships and interdependencies of departments within a health care institution.
- Discuss the responsibilities and relationships of all personnel in the radiology department.
- Explain patient services available in the radiology department.
- Differentiate between programmatic and institutional accreditation.
- Define accreditation, credentialing, certification, registration, licensure and regulations.
- Explain the purposes of accreditation and certification and identify the agencies involved.
- Discuss the general employment outlook for the graduate radiographer.
- Discuss career advancement and opportunities for the radiographer.
- Identify the benefits of continuing education as related to improved patient care and professional enhancement.

Human Structure and Function

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.

Image Analysis

Objectives

- Discuss the elements of a radiographic image.
- Identify anatomy on radiographic images.
- Apply the problem-solving process used for image analysis.
- Describe an effective image analysis method.
- Describe the role of the radiographer in image analysis.
- Apply the process for evaluating images for adequate density/brightness, contrast, recorded detail/spatial resolution and acceptable limits of distortion.
- Explain how the radiographer determines that an adequate level of penetration has been applied to produce the desired level of contrast.
- Summarize the importance of proper positioning.
- Discuss the impact of patient preparation on the resulting radiographic image.
- Analyze images to determine the appropriate use of beam restriction.
- Identify common equipment malfunctions that affect image quality, and corrective action.
- Differentiate between technical factor problems, procedural factor problems and equipment malfunctions.
- Critique images for appropriate technical, procedural and pathologic factors, and employ corrective actions if necessary.

Imaging Equipment

Objectives

- Define potential difference, current and resistance.
- Describe electrical protective devices.
- Identify the general components and functions of the tube and filament circuits.
- Identify the function of solid-state rectification.
- Compare generators in terms of radiation produced and efficiency.
- Discuss permanent installation of radiographic equipment in terms of purpose, components, types and applications.
- Demonstrate operation of various types of permanently installed and mobile radiographic equipment.
- Discuss mobile units in terms of purpose, components, types and applications.
- Describe functions of components of automatic exposure control (AEC) devices.
- Demonstrate proper use of AEC devices.
- Identify the components of diagnostic x-ray tubes.
- Explain protocols used to extend x-ray tube life.
- Explain image-intensified and digital fluoroscopy.
- Discuss gain and conversion factors as they relate to image intensification.
- Discuss conventional and digital fluoroscopic image formation.
- Indicate the purpose, construction and application of video camera tubes, TV monitors and video recorders.
- Identify fluoroscopic recording equipment.
- Explain the purpose, principles and application of linear tomography.
- Differentiate between quality improvement/management, quality assurance and quality control.
- List the benefits of a quality management program to the patient and to the department.
- List elements of a quality management program and discuss how each is related to the quality management program.
- Discuss the proper test equipment/procedures for evaluating the operation of an x-ray generator.
- Evaluate the results of basic QC tests.

Comment [RH9]: Note: This was moved tothe Introduction to Radiologic Science and Health Care section.

Medical Terminology

Objectives

- Apply the word-building process.
- Interpret medical abbreviations and symbols.
- Critique orders, requests and diagnostic reports.
- Define radiation science terms.
- Translate medical terms, abbreviations and symbols into common language from a medical report.

Patient Care in Radiologic Sciences

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 Glascow 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

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 Biology

Objectives

- Differentiate between ionic and covalent molecular bonds.
- Describe principles of cellular biology.
- Identify sources of electromagnetic and particulate ionizing radiations.
- Discriminate between direct and indirect ionizing radiation.
- Discriminate between the direct and indirect mechanisms of radiobiological effects.
- Discuss the direct and indirect effects of ionizing radiation.
- Identify sources of radiation exposure.
- Describe radiation-induced chemical reactions and potential biologic damage.
- Evaluate factors influencing radiobiologic/biophysical events at the cellular and subcellular level.
- Identify methods to measure radiation response.
- Describe physical, chemical and biologic factors influencing radiation response of cells and tissues.
- Explain factors influencing radiosensitivity.
- Recognize the clinical significance of LD50/30 and LD30.
- Identify specific cells from most radiosensitive to least radiosensitive.
- Employ dose response curves to study the relationship between radiation dose levels and the degree of biologic response.
- Examine effects of limited vs. total body exposure.
- Relate short-term and long-term effects as a consequence of high and low radiation doses.
- Differentiate between somatic and genetic radiation effects as well as discuss specific diseases or syndromes associated with them.
- Discuss use of and information to be gained from various dose/response curves.
- Discuss stochastic (probabilistic) and nonstochastic (deterministic) effects.
- Discuss embryo and fetal effects of radiation exposure.
- Discuss risk estimates for radiation-induced malignancies.
- Discuss acute radiation syndromes.

Radiation Production and Characteristics

Objectives

- Describe fundamental atomic structure.
- Explain the processes of ionization and excitation.
- Describe the electromagnetic spectrum.
- Describe wavelength and frequency and how they are related to velocity.
- Explain the relationship of energy, wavelength and frequency.
- Explain the wave-particle duality phenomena.
- Identify the properties of x-rays.
- Describe the processes of ionization and excitation.
- Describe charged and uncharged forms of particulate radiation.
- Differentiate between ionizing and nonionizing radiation.
- Describe radioactivity and radioactive decay in terms of alpha, beta and gamma emission.
- Compare the production of bremsstrahlung and characteristic radiations.
- Describe the conditions necessary to produce x-radiation.
- Describe the x-ray emission spectra.
- Identify the factors that affect the x-ray emission spectra.
- Discuss various photon interactions with matter by describing the interaction, relation to atomic number, photon energy and part density, and their applications in diagnostic radiology.
- Discuss relationships of wavelength and frequency to beam characteristics.
- Discuss the clinical significance of the photoelectric and modified scattering interactions in diagnostic imaging.

Radiation Protection

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 non-controlled 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, HVL, 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.

Radiographic Pathology

Objectives

- Define basic terms related to pathology.
- Describe the basic manifestations of pathological conditions and their relevance to radiologic procedures.
- Discuss the classifications of trauma.
- Describe imaging procedures used in diagnosing disease.
- List the causes of tissue disruption.
- Describe the healing process.
- Identify complications connected with the repair and replacement of tissue.
- Describe the various systemic classifications of disease in terms of etiology, types, common sites, complications and prognosis.
- Describe the radiographic appearance of diseases.
- Identify imaging procedures and interventional techniques appropriate for diseases common to each body system.
- Identify diseases caused by or contributed to by genetic factors.

Radiographic Procedures

Objectives

- Describe standard positioning terms.
- Demonstrate proper use of positioning aids.
- Discuss general procedural considerations for radiographic exams.
- Identify methods and barriers of communication and describe how each may be used or overcome effectively during patient education.
- Explain radiographic procedures to patients/family members.
- Modify directions to patients with various communication problems.
- Develop an awareness of cultural factors that necessitate adapting standard exam protocols.
- Adapt general procedural considerations to specific clinical settings.
- Cite the structures demonstrated on routine radiographic, fluoroscopic and basic CT images.
- Adapt radiographic, fluoroscopic and basic CT procedures based on special considerations.
- Simulate radiographic, fluoroscopic and basic CT procedures on a person or phantom in a laboratory setting.
- Evaluate images for positioning, centering, appropriate anatomy and overall image quality.
- Discuss equipment and supplies necessary to complete radiographic, fluoroscopic and basic CT procedures.
- Explain the patient preparation necessary for various contrast, basic CT and special studies.
- Explain the routine and special positions/projections for all radiographic/fluoroscopic procedures.
- Explain the basic CT acquisition protocol for the head, thorax and abdomen.
- Explain the purpose for using contrast media.
- Name the type, dosage and route of administration of contrast media commonly used to perform radiographic contrast, basic CT and special studies.
- Describe the general purpose of radiographic, fluoroscopic and basic CT studies.
- Apply general radiation safety and protection practices associated with radiologic examinations and basic CT.

Film-Screen Image Acquisition and Processing

Objectives

- Discuss practical considerations in setting standards for acceptable image quality.
- Assess radiographic density on radiographic images.
- Distinguish between acceptable and unacceptable image densities.
- Analyze the relationships of factors that control and affect image density.
- Critique the radiographic contrast within various radiographic images.
- Analyze the relationship of factors that control and affect radiographic contrast.
- Critique recorded detail on various radiographic images.
- Analyze the relationships of factors that control and affect recorded detail.
- Differentiate between size and shape distortion.
- Perform calculations to determine image magnification and percent magnification.
- Summarize the relationship of factors that control and affect distortion.
- Summarize the relationship of factors affecting exposure latitude.
- Explain the rationale for using beam limiting devices.
- Describe the operation and applications for different types of beam-limiting devices.
- Explain the impact beam filtration has on x-ray beam intensity, beam quality and resultant patient exposure.
- Describe the change in the half value layer (HVL) when filtration is added or removed in the beam.
- Summarize the relationship of factors affecting scattered and secondary radiation.
- Evaluate the effects of scattered radiation on the image.
- Compare grid types.
- Select the most appropriate grid for a given clinical situation.
- Interpret grid efficiency in terms of grid ratio and frequency.
- Define grid cutoff.
- Summarize the factors that influence grid cutoff.
- Evaluate grid artifacts.
- Explain the use of standardized radiographic technique charts.
- Explain exposure factor considerations involved in selecting techniques.
- Compare fixed kilovolt peak (kVp) and variable kVp systems.
- Apply mAs reciprocity to clinical simulations.
- Describe the effects of storage on image quality.
- Discuss safelight illumination appropriate for specific image receptor systems.
- Apply conversion factors for changes in the following areas: distance, grid, image receptors, mAs reciprocity and 15 percent rule.
- Discuss darkroom-related OSHA standards for health and safety.
- Discuss the possible causes and health implications of “darkroom chemical sensitivity.”
- Describe the function of each component of radiographic film.

- Explain latent image formation.
- Describe the features of the characteristic curve and explain its purpose.
- Select the most appropriate image receptor to be used for given clinical situations.
- Describe various types of image receptor holders.
- Describe the function of each component of an intensifying screen.
- Select the most appropriate intensifying screen for given clinical situations.
- Identify procedures that ensure a long screen life devoid of artifacts and distortion.
- Analyze the effects of processing on image quality.
- Identify key components of an automatic film processor.
- Demonstrate how various film sizes are fed into the film processor.
- Analyze the steps of the processing cycle by providing the specific action and duration of time for each step.
- Identify the purpose of a daily quality control program for processors.
- Identify types of image artifacts and analyze them to determine the cause.
- Identify common silver recovery methods.

2005-2007 Radiography Curriculum Revision Project Group

Laura Aaron, Ph.D., R.T.(R)(M)(QM)

Angela D. Anderson, M.A., R.T.(R)(CT)(QM)

Anne C. Brittain, Ph.D., R.T.(R)(M)

C. Barry Burns, M.S., R.T.(R), DABR – Content Expert

Diedre Costic, M.P.S., R.T.(R)(M)

Parsha Hobson, M.P.A., R.T.(R)

James Johnston, Ph.D., R.T.(R)(CV)

Bradley Jones, B.S., R.T.(N) – Content Expert

Bill H. May, M.Ed., R.T.(R), FASRT

Jeffrey Meyer, R.T.(R) – Content Expert

Darcie J. Nethery, Ph.D., R.T.(R)

Barbara Smith, M.S., R.T.(R)(QM), FASRT

Deborah Gay Utz, M.Ed., R.T.(R)

Ester L. Verhovsek, Ed.D., R.T.(R)(T)

Robert J. Walker, Ph.D., R.T.(R)(CT)(MR)(QM), FASRT

Organization Representation

ARRT: Eileen Maloney, M.Ed., R.T.(R)(M), FASRT and Ginny Haselhuhn, B.S., R.T.(R)

ASRT BOD Liaison: Cindy Daniels, M.S., R.T.(R) and Connie L. Mitchell, M.A., R.T.(R)(CT)

JRCERT: Denise Moore, M.S., R.T.(R), Joanne Greathouse, Ed.S., R.T.(R), FASRT, FAEIRS, and Leslie Winter, M.S., R.T.(R)

Facilitator: Kevin J. Powers, Ed.S., R.T.(R)(M)

Radiologic Science Resources

Comment [RH10]: This section has been updated.

This list of radiologic science resources will assist educators in sampling the pool of references and study materials that pertain to medical radiography. The resources list should be viewed as a snapshot of available materials. Omission of any one title is not intentional. Because the creation of literature and media related to the field is dynamic, educators are encouraged to search additional sources for recent updates, revisions and additions to this collection of titles.

Textbooks

Acello B. *Patient Care: Basic Skills for the Health Care Provider*. Albany, NY: Delmar Thomson Learning; 2000.
ISBN 0766801829

Adler A, Carlton R. *Introduction to Radiography and Patient Care*. 2nd ed. Philadelphia, Pa: WB Saunders; 1999.
ISBN 0721676626

Adler A, Carlton R, Poelhuis DJ, Kowalczyk NK. *Workbook W/Lab Exercises for Principles of Radiographic Imaging*. 4th ed. Albany, NY: Delmar Thomson Learning; 2006.
ISBN 140187195X

Adolina VF, Lille SL, William KM. *Mammographic Imaging: A Practical Guide.* 2nd ed. Philadelphia, Pa: JB Lippincott; 2001.
ISBN 0781716969

American College of Radiology Committee on Quality Assurance in Mammography. *Mammography Quality Control Manual*. Reston, Va: American College of Radiology; 1999. Product code P-QAM99.

Ball JE, Price T, eds. *Chesneys' Radiographic Imaging.* 6th ed. Cambridge, Mass: Blackwell Scientific Publishers Inc; 1995.
ISBN 0632039019

Biedrzycki, A., *The Radiography Procedure and Competency Manual.* 1st ed. Philadelphia, Pa: F.A. Davis; 2000.
ISBN 0803606729

Blickman H. *Pediatric Radiology.* 2nd ed. St. Louis, Mo: Mosby-Year Book Inc; 1998.
ISBN 0815109938

Bonnick SL. *Bone Densitometry in Clinical Practice: Application & Interpretation.* Totowa, NJ: Humana Press; 1998.
ISBN 0896035131

Bontrager K. *Pocket Atlas-Handbook of Radiographic Positioning and Techniques*. 4th ed.

St. Louis, Mo: Elsevier Mosby; 2002.
ISBN 0964172348

Bontrager K. *Radiographic Positioning and Related Anatomy*. 6th ed. St. Louis, Mo: Elsevier Mosby; 2005.
ISBN 0323025072

Bontrager K, Lampignano J. *Workbook and Laboratory Manual*, 6th ed. Volumes I and II. St. Louis, Mo: Elsevier Mosby; 2005.
Volume I – ISBN 0323025048; Volume II – ISBN 0323025056

Bracco Diagnostics Inc. *Life-Saving Lessons in Myelography*. Bracco Diagnostics Inc; 1999.

Brennan P, Seeram E. *Digital Radiography*. Blackwell Publishing Professional, 2007
ISBN 0632064714

Browne MN. *Asking the Right Questions: A Guide to Critical Thinking*. 7th ed. Upper Saddle Rivers, NJ: Prentice Hall; 2004.
ISBN 0131829939

Burke M, Giesa M, Seager KR, et al. *Orthopaedist's Guide to Plain Film Imaging*. New York: Thieme Medical Publishers Inc; 1999.
ISBN 0865777179

Burton EM. *Essentials of Pediatric Radiology*. New York: Thieme Medical Publishers; 1999.
ISBN 0865778027

Bush Jr, William, King BF Jr, Krecke KN. *Radiology Life Support (RAD-LS).* New York, NY: Oxford University Press; 1999.
ISBN 0340741589

Bushberg JT, et al. *The Essential Physics of Medical Imaging*. 2nd ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2002.
ISBN 0683301187

Bushong S. *Magnetic Resonance Imaging: Physical and Biological Principles.* 2nd ed. St. Louis, Mo: Mosby; 1996.
ISBN 0323014852

Bushong, S. *Mosby's Radiography Online: Radiobiology and Radiation Protection.* 8th ed. St. Louis, Mo: Mosby; 2004.
ISBN-10: 0323032583 and ISBN-13: 978-0323032582

Bushong S. *Mosby's Radiography Online: Radiographic Imaging.* 8th ed. St. Louis, Mo: Mosby; 2004.
ISBN-10: 0323032613

ISBN-13: 978-0323032612

Bushong S. *Mosby's Radiography Online: Radiologic Physics.* 8th ed. St. Louis, Mo: Mosby; 2004.
ISBN-10: 0323032591
ISBN-13: 978-0323032599

Bushong S. *Radiologic Science for Technologists: Physics, Biology, and Protection.* 8th ed. St. Louis, Mo: Mosby; 2001.
ISBN 0323013376

Bushong S. *Radiologic Science for Technologists - Workbook and Laboratory Manual*. 8th ed. St. Louis, Mo: Mosby; 2004.
ISBN 0323025552

Bushong S, Williams EK. *Patient Care: Essentials of Medical Imaging Series*. New York: McGraw-Hill; 1998.
ISBN: 0070706328

Butler J, Lewis R, Shier D. *Hole's Human Anatomy & Physiology*. 10th ed. Boston, Mass: McGraw-Hill Higher Education; 2004.
ISBN 0072438908

Callaway W. *Mosby's Comprehensive Review of Radiography.* 3rd ed. St. Louis, Mo: CV Mosby; 2002.
ISBN 0323011918

Callaway W, Gurley LT. *Introduction to Radiologic Technology.* 5th ed. St. Louis, Mo: Mosby; 2002.
ISBN 0323014488

Campeau FE. *Radiography: Technology, Environment, Professionalism.* Philadelphia, Pa: Lippincott Williams & Wilkins; 1999.
ISBN 0397551967

Campeau F, Fleitz J. *Limited Radiography.* Albany, NY: Delmar Publishers, Inc; 1999.
ISBN 0827333358

Carlton R, Adler A. *Principles of Radiographic Imaging: An Art and a Science.* 4th ed. Albany, NY: Delmar Publishers; 2006.
ISBN 1401871941

Carlton RR, Greathouse JS. *Delmar's Principles of Radiographic Positioning & Procedures Pocket Guide*. Albany, NY: Delmar Publishers; 2005.
ISBN 0766862461

Carroll Q. *Fuch's Radiographic Exposure, Processing, and Quality Control*. 7th ed. Springfield, IL: Charles C. Thomas; 2003.
ISBN 0398073732

Chabner DE. *The Language of Medicine.* 7th ed. Philadelphia, Pa: WB Saunders; 2004.
ISBN 1416001271

Chiu LC, Lipcamon JD, Yiu-Chiu VS. *Clinical Computed Tomography for the Technologist*. 2nd ed. New York: Raven Press; 1995.
ISBN 0781702356

Clinical Governance [pamphlet]. London, England: College of Radiographers; 1999.

Cornuelle AG. *Competency Manual for Radiographic Anatomy & Positioning.* New York: McGraw-Hill Inc; 1998.
ISBN 0838582397

Cornuelle AG, Gronefeld DH. *Radiographic Anatomy Positioning*. Stamford, Conn: Appleton & Lange; 1998.
ISBN 0838582389

Cowling C. *Delmar's Radiographic Positioning & Procedures Volume II: Advanced Positioning and Procedures*. Albany, NY: Delmar Publishers; 1998.
ISBN 0827363176

Cummings GR, Meizner E. *Corectec's Comprehensive Set of Review Questions for Radiography.* 5th ed. Athens, Ga: Corectec; 2005.
ISBN 1880890135

Dahnert W. *Radiology Review Manual.* 3rd ed. Philadelphia, Pa: Williams & Wilkins; 1996.
ISBN 0683023381

Davidhizar RE, Newman Giger J. (editors). *Transcultural Nursing: Assessment & Intervention.* 4th ed. St. Louis, Mo: Mosby; 2004.
ISBN 0323022952

DeVos DC. *Basic Principles of Radiographic Exposure.* 2nd ed. Baltimore, Md: Williams & Wilkins; 1995.
ISBN 0683024582

Diestler S. *Becoming a Critical Thinker: A User Friendly Manual*. 4th ed. Upper Saddle River, NJ: Prentice Hall; 2005.
ISBN 0131779982

Diller JV. *Cultural Diversity: A Primer for the Human Services*. 2nd ed. Cambridge, Mass: Wadsworth Publishing Co; 2004.

ISBN 0534522211

Dowd SB, Wilson BG. *Encyclopedia of Radiographic Positioning.* Philadelphia, Pa: WB Saunders; 1995.
ISBN 0721642020

Dowd S, Tilson E. *Practical Radiation Protection and Applied Radiobiology*. 2nd ed. Philadelphia, Pa: WB Saunders; 1999.
ISBN 0721675239

Dowsett DJ, Kenny PA, Johnston RE. *The Physics of Diagnostic Imaging*. New York: Chapman & Hall Medical; 1998.
ISBN 0412401703

Drafke MW, Nakayama H. *Trauma and Mobile Radiography*. 2nd ed. Philadelphia, Pa: FA Davis; 2001.
ISBN 080360694X

Dreyer KJ, Mehta A, Thrall JH. *PACS – A Guide to the Digital Revolution*. New York: Springer; 2002.
ISBN 0387952918

Durand KS. *Critical Thinking: Developing Skills in Radiography.* Philadelphia, Pa: FA Davis Co; 1999.
ISBN 0803603436

Eisenberg RL, Dennis CA, May CR. *Radiographic Positioning*. 2nd ed. Boston, Mass: Little, Brown and Company; 1995.
ISBN 0316224995

Eisenberg RL, Johnson NM. *Comprehensive Radiographic Pathology*. 4th ed. St. Louis, Mo: Mosby; 2007.
ISBN: 0323036244

Eisenberg RL, Johnson NM., *Workbook for Comprehensive Radiographic Pathology*. 4th ed. St. Louis, Mo: Mosby; 2007.
ISBN: 0323042198

Erlich R, McClosky E, Daly J. *Patient Care in Radiography: With an Introduction to Medical Imaging*. 6th ed. St. Louis, Mo: Mosby; 2004.
ISBN: 0323019374

English PT. *MRI for Radiographers.* New York: Springer Publishing Company; 1995.
ISBN 0387197508

Erkonen WE, Smith WL. *Radiology 101: The Basics and Fundamentals of Imaging.* 2nd ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2005.
ISBN 0781781985

Fauber TL. *Radiographic Imaging & Exposure*. 2nd ed. St. Louis, Mo: Mosby; 2004.
ISBN-10: 0323025579
ISBN-13: 978-0323025577

Finney WF III, Carlton RC, Adler AM. *Workbook W/Lab Exercises for Principles of Radiographic Imaging.* 3rd ed. Albany, NY: Delmar Publishers; 2001.
ISBN 0766813010

Forshier S. *Essentials of Radiation: Biology and Protection.* Albany, NY: Delmar Publishers; 2002.
ISBN 0766813304

Frank ED., Long, BW, Smith, BJ. *Merrill's Atlas of Radiographic Positions & Radiologic Procedures.* 11th ed. St. Louis, Mo: Mosby; 2007.
ISBN 032304210-4

Frank ED., Long, BW, Smith, BJ. *Merrill's Pocket Guide to Radiography.* 6th ed. St. Louis, Mo: Mosby; 2007.
ISBN: 0323042090

Frank ED, Long, BW, Smith, BJ. *Mosby's Radiography Online: Anatomy and Positioning for Merrill's Atlas of Radiographic Positioning & Procedures.* 11th ed. St. Louis, Mo: Mosby; 2007.
ISBN-10: 0323044921 and ISBN-13: 978-0323044929

Frank ED, Long, BW, Smith, BJ, Hall Rollins, J. *Workbook for Merrill's Atlas of Radiographic Positions & Radiologic Procedures.* 11th ed. St. Louis, Mo: Mosby; 2007.
ISBN: 0323042163

Frey GD, Sprawls P, eds. *The Expanding Role of Medical Physics in Diagnostic Imaging*. College Park, Md: AAPM Medical Physics Publishing; 1997.
ISBN 1888340096

Godderidge C. *Pediatric Imaging.* Philadelphia, Pa: WB Saunders; 1995.
ISBN 0721645348

Gollnick DA. *Basic Radiation Protection.* 4th ed. Altadena, Calif: Pacific Radiation Corp; 2000.
ISBN 0916339084

Graham D, Cloke P, Vosper M. *Principles of Radiological Physics*. 5th ed. New York: Churchill Livingstone; 2006.
ISBN: 0443101043

Grainger RG. *Grainger & Allison's Diagnostic Radiology: A Textbook of Medical Imaging*. 3rd ed. New York, NY: Churchill Livingstone; 1997.
ISBN 0443051674

Greathouse JS. *Delmar's Radiographic Positioning & Procedures Volume I: Basic Positioning and Procedures.* Albany, NY: Delmar Publishers; 1998.
ISBN 0827367821

Gronefeld DH, Madigan ML. *Applications Manual for Radiographic Anatomy Positioning.* Stamford, Conn: Appleton & Lange; 1998.
ISBN 0838582478

Gurley LT, Callaway WJ. *Introduction to Radiologic Technology*. 5th ed. St. Louis, Mo**:** CV Mosby; 2002.
ISBN 0323014488

Guy JF. *Learning Human Anatomy: a Laboratory Text and Workbook.* 3rd ed. Norwalk, Conn: Appleton & Lange; 2005.
ISBN 0131433202

Gylys BA, Masters RM. *Medical Terminology Simplified*. 2nd ed. Philadelphia, Pa: FA Davis Co; 2005.
ISBN 0803612540

Halpern B. *Imaging in Musculoskeletal & Sports Medicine*. St. Louis, Mo: Blackwell Science; 1997.
ISBN 0865424187

Harris EL. *The Shadowmakers, A History of Radiologic Technology.* Albuquerque, NM: The American Society of Radiologic Technologists; 1995.
ISBN 1886800006

Harvey CP, Allard MJ. *Understanding and Managing Diversity: Readings, Cases, and Exercises.* 3rd ed. Upper Saddle River, NJ: Prentice Hall; 2005.
ISBN 013144154X

Harvey CP, Allard MJ. *Understanding Diversity: Readings, Cases, and Exercises*. 2nd ed. New York: Addison-Wesley Pub Co; 1995.
ISBN 0673469964

Haus AG, Jaskulski SM. *The Basics of Film Processing in Medical Imaging*. Madison, Wis: Medical Physics Pub; 1997.
ISBN 0944838782

Haus AG. *Advances in Film Processing Systems Technology and Quality Control in Medical Imaging*. Madison, Wis: Medical Physics Pub Corp; 2001.

ISBN 1930524013

Hayes S. *Radiographic Anatomy, Positioning Procedures Workbook Set.* 3rd ed. St. Louis, Mo: Mosby; 2002.
ISBN 0323014801/032301481X

Hendee WR, Ritenour ER. *Medical Imaging Physics*. 4th ed. Hoboken, NJ: Wiley-Liss; 2002.
ISBN 0471382264

Hiss S. *Introduction to Health Care Delivery and Radiology Administration*. Philadelphia, Pa: WB Saunders Company; 1997.
ISBN 0721653146

Hodge JC. *Musculoskeletal Imaging: Diagnostic & Therapeutic Procedures.* Basel, Switzerland: Karger Landes Systems; 1997.
ISBN 1570594171

Huang, HK. *PACS and Imaging Informatics*. 2nd ed. Hoboken, NJ: Wiley-Liss; 2004.
ISBN 0471251232

Huda W, Slone RM. *Review of Radiologic Physics*. Philadelphia, Pa: Lippincott Williams & Wilkins; 1995.
ISBN 0683042300

Hughes W. *Critical Thinking: An Introduction to the Basic Skills*. 3rd ed. Peterborough, Ontario: Broadview Press; 2000.
ISBN 1551112515

Jensen S, Peppers M. *Pharmacology and Drug Administration for Imaging Technologists.* 2nd ed. St. Louis, Mo: CV Mosby; 2006.
ISBN-13 978-0-323-03075-5 and ISBN 0-323-03075-0

Juhl JH. *Paul & Juhl's Essentials of Radiologic Imaging.* 7th ed. Philadelphia, Pa: JB Lippincott Company; 1998.
ISBN 0397584210

Jensen SC. *Pharmacology and Drug Administration for Imaging Technologists.* St. Louis, Mo: Mosby-Year Book; 1998.
ISBN 0815148941

Kelley LL, Peterson CM. *Sectional Anatomy for Imaging Professionals* 2nd ed. St. Louis, Mo: Mosby; 2007
ISBN -13 978-0-323-02003-9 and ISBN 0-323-02003-8

Kelley LL, Peterson CM. *Workbook for Sectional Anatomy for Imaging Professionals.* 2nd ed. St. Louis, Mo: Mosby; 2007.

ISBN: 0323020046

Kent TH, Hart MN. *Introduction to Human Disease.* 4th ed. Norwalk, Conn: Appleton & Lange; 1998.
ISBN 0838540708

Kowalczyk N, Donnett K. *Integrated Patient Care for the Imaging Professional*. St. Louis, Mo: Mosby; 1996.
ISBN 0815125453

LaGuardia D, Guth HP. *American Voices: Culture and Community*. 6th ed. Mountain View, Calif: Mayfield Publishing Co; 2006.
ISBN 0072982640

Langlais RP. *Dental Diagnostic Imaging.* Springfield, Ill: Charles C Thomas Publishing; 1997.
ISBN 0398067848

Lazo DL. *Fundamentals of Sectional Anatomy*. Clifton Park, NJ: Thomson Delmar Learning; 2005.
ISBN 0766861724

Leondes CT. *Medical Imaging Systems Techniques & Applications.* London, England: Gordon & Breach Science Publishers; 1997.
ISBN 9056995979

Leonard WL. *Self-Study Exercises in Radiography.* Upper Saddle River, NJ: Prentice Hall; 1995.
ISBN 0130116513

Linn-Watson T. *Radiographic Pathology*. Philadelphia, Pa: WB Saunders; 1996.
ISBN 0721641296

Linn-Watson T. *Radiographic Pathology: Workbook.* St. Louis, Mo: WB Saunders Co; 1996.
ISBN 0721641695

Long BW, Rafert JA. *Orthopaedic Radiology.* St. Louis, Mo: WB Saunders Co; 1995.
ISBN 0721666493

Lufkin R. *Teaching Atlas of Head & Neck Imaging.* New York, NY: Thieme Medical Publishers; 2002.
ISBN 0865776911

McCance KL, Huether SE. *Pathophysiology: The Biologic Basis for Disease in Adults and Children*. 5th ed. St. Louis, Mo: CV Mosby; 2005.
ISBN 0323035078

McQuillen-Martensen K. *Exercises in Radiographic Critique*. Philadelphia, Pa: WB Saunders Co; 1996.
ISBN 0721649815

Mace JD, Kowalczyk N. *Radiographic Pathology for Technologists*. 3rd ed. St. Louis, Mo: Mosby; 1997.
ISBN 0815145683

Madden ME. I*ntroduction to Sectional Anatomy*. Philadelphia, Pa.: Lippincott Williams & Wilkins; 2001.
ISBN 0781721059

Madden ME. *Sectional Anatomy Review*. Philadelphia, Pa: Lippincott, Williams &Wilkins; 2001.
ISBN 0781721067

Madigan ML. *Pocket Manual for Radiographic Anatomy & Positioning: An Integrated Approach*. New York: McGraw-Hill Co; 1998.
ISBN 0838582370

Manaster B.J. *Handbook of Skeletal Radiology*. 2nd ed. St. Louis, Mo: Year Book Medical Publishers Inc; 1997.
ISBN 0815170327

Marieb EN. *Human Anatomy & Physiology*. 6th ed. New York, NY: Pearson Education; 2004
ISBN 0805354638

Martin JE. *Physics for Radiation Protection*. New York, NY: Wiley InterScience; 2000.
ISBN 0471353736

McQuillen-Martensen K. *Radiographic Critique*. Philadelphia, Pa.: Saunders; 1996.
ISBN 0721649785

Meistrich ML. *Radiation Protection Guidance*. Bethesda, Md: National Council on Radiation Protection and Measurements; 2000.
ISBN 0929600657

Mettler FA. *Medical Effects of Ionizing Radiation.* 2nd ed. Philadelphia, Pa: WB Saunders; 1995.
ISBN 0721666469

Mulvihill ML, et al. *Human Disease: A Systemic Approach.* 6th ed. Norwalk, Conn: Appleton & Lange; 2005.
ISBN 0131527495

NCRP Reports. Bethesda, Md: National Council on Radiation Protection and Measurements.

Nias AH. *An Introduction to Radiobiology*. 2nd ed. Chichester, NY: Wiley; 1998.
ISBN 0471975907

Nosich GM. *Learning to Think Through: A Guide to Critical Thinking Across the Curriculum*. Upper Saddle River, NJ: Prentice Hall; 2001.
ISBN 0130304867

Oakley J. *Digital Imaging: A Primer for Radiographers, Radiologists and Health Care Professionals.* NY: Cambridge University Press; 2003.
ISBN 9780521866194

Obergfell AM. *Law and Ethics in Diagnostic Imaging and Therapeutic Radiology: With Risk Management and Safety Applications*. Philadelphia, Pa: WB Saunders; 1995.
LC Control Number 95010278

O'Neil, SL. *Your Attitude is Showing: A Primer of Human Relations*. 10th ed. Upper Saddle River, NJ: Prentice Hall; 2002.
ISBN 013022507X

Ott DJ. *Manual of Gastrointestinal Fluoroscopy: Performance of Procedures*. Springfield, Ill: Charles C Thomas Publishing; 1996.
ISBN 0398065551

Papp J. *Quality Management in the Imaging Sciences*. 3rd ed. St. Louis, Mo: CV Mosby; 2006.
ISBN 0323035671

Parelli RJ. *Principles of Fluoroscopic Image Intensification and Television Systems Workbook and Laboratory Manual*. Boca Raton, Fla: CRC Press; 1996.
ISBN 1574440829

Parelli RJ. *Medicolegal Issues for Radiographers.* 3rd ed. Boca Raton, Fla: CRC Press; 1997.
ISBN 1574440810

Paterson A, Price R. *Current Topics in Radiography.* Philadelphia, Pa: WB Saunders; 1995.
ISBN 0702019712

Purtilo RB. *Ethical Dimensions in the Health Professions.* 4th ed. Philadelphia, Pa: Saunders; 2005.
ISBN 0721602436

Ramsey RG. *Teaching Atlas of Spine Imaging.* New York: Thieme Medical Publishers Inc; 1999.
ISBN 0865777780

Reiner BI, Siegel EL, Carrino JA. *Quality Assurance: Meeting the Challenge in the Digital Medical Enterprise.* Society for Computer Applications in Radiology (SCAR); 2002,
ISBN 0970669321

Ruggiero VR. *Becoming a Critical Thinker*. 5th ed. Boston, Mass: Houghton Mifflin; 2005.
ISBN 0618527834

Saia DA. *Appleton & Lange's Review for the Radiography Examination*. 4th ed. New York: Appleton & Lange; 2000.
ISBN 0838503896

Saia DA. *Radiography Prep: Program Review & Exam Preparation.* Stamford, Conn: Appleton & Lange; 1996.
ISBN 0838582443

Samei E, Flynn MJ, eds. *2003 Syllabus, Advances in Digital Radiography: Categorical Course in Diagnostic Radiology Physics*. Oak Brook, Ill: Radiological Society of North America; 2003.
LC Control Number 2004275095

Savader S. *Venous Interventional Radiology with Clinical Perspectives*. New York: Thieme Medical Publishers Inc; 1996.
ISBN 0865775990

Scheffer KJ. *Better X-Ray Interpretation.* Springhouse, Pa: Springhouse Corp; 1997.
ISBN 0874348684

Schwartz, SE, Conley C. *Human Diversity: A Guide for Understanding*. 4th ed. New York: McGraw-Hill; 2000.
ISBN 0072428317

Seeram E. *Rad Tech's Guide to Radiation Protection.* Malden, Mass: Blackwell Science; 2001.
ISBN 0865425809

Seeram E. *Radiation Protection.* Philadelphia, Pa: Lippincott; 1997.
ISBN 0397550324

Seibert JA, Filipow L, Andriole K, eds. *Practical Digital Imaging and PACS.* College Park, Md: AAPM, Medical Physics Publishing; 1999.
ISBN 0944838200

Shephard C. *Radiographic image production and manipulation*. New York: McGraw-Hill; 2002.
ISBN 0071375775

Sickles Corbett NA. *Student Study Guide to Accompany Hole's Human Anatomy & Physiology*. 10th ed. Boston, Mass: McGraw-Hill Higher Education; 2003.
ISBN 0072438932

Siegel EL, Kolodner RM, eds. *Filmless Radiology*. New York: Springer; 1999.
ISBN 0387985158

Simmers L. *Diversified Health Occupations.* 4th ed. Albany, NY: Delmar Publishers; 1998.
ISBN 0827378173

Silverman PM. *Imaging Handbook for House Officers.* New York: John Wiley & Sons Inc; 1997.
ISBN 0471137677

Snopek AM. *Fundamentals of Special Radiographic Procedures.* 5th ed. Philadelphia, Pa: WB Saunders; 2006.
ISBN 0721606326

Spector RE. *Cultural diversity in health & illness*. 6th ed. Upper Saddle River, NJ: Pearson Prentice Hall; 2004.
ISBN 0130493791

Squire LF, Novelline RA. *Fundamentals of Radiology.* 6th ed. Cambridge, Mass: Harvard University Press; 2004.
ISBN-10: 0674012798
ISBN-13: 978-0674012790

Statkiewicz-Sherer MA. *Workbook for Radiation Protection in Medical Radiography.* 5th ed. St. Louis, Mo: Mosby; 2006.
ISBN-10: 032304476X
ISBN-13: 978-0323044769

Statkiewicz-Sherer MA, Visconti PJ, Ritenour ER. *Radiation Protection in Medical Radiography*. 5th ed. St. Louis, Mo: Mosby; 2006.
ISBN-10: 0323036007
ISBN-13: 978-0323036009

Swartz JD. *Imaging of the Temporal Bone.* 3rd ed. New York: Thieme Medical Publishers Inc; 1998.
ISBN 0865777004

Thomas J. *FA Davis's Practice Guide for the Radiography Examination.* Philadelphia, Pa: FA Davis Co; 2000.
ISBN 0803604602

Thurmond AS. *Atlas of Infertility: Diagnostic & Therapeutic Radiology.* Malden, Mass: Blackwell Science; 1997.
ISBN 0632043059

Torres LS, Dutton AG, Linn-Watson Norcutt TA. *Basic Medical Techniques & Patient Care in Imaging Technology.* 6th ed. Philadelphia, PA: Lippincott-Raven; 2003.
ISBN 0781731917

Tortorici M. *Administration of Imaging Pharmaceuticals.* Philadelphia Pa.: Saunders; 1996.
ISBN 0721648134

Tortorici M, Apfel P. *Advanced Radiographic and Angiographic Procedures.* Philadelphia, Pa: FA Davis; 1995.
ISBN 0803685718

Towsley-Cook DM, Young TA. *Ethical and Legal Issues for Imaging Professionals.* 2nd ed. St. Louis, Mo: Mosby; 2007
ISBN: 0323045995

Venes D. *Taber's Cyclopedic Medical Dictionary*. 20th ed. Philadelphia, Pa: FA Davis Co; 2005.
ISBN-10: 0803612079
ISBN-13: 978-0803612075

Wallace JE. *Radiographic Exposure: Principles & Practice.* Philadelphia, Pa: FA Davis Co; 1995.
ISBN 0803600518

Weill FS, Manco-Johnson ML. *Imaging of Abdominal and Pelvic Anatomy.* New York, NY: Churchill Livingstone; 1997.
ISBN 0443052387

White L. *Critical Thinking in Practical/Vocational Nursing*. Albany, NY: Delmar/Thomson Learning; 2002.
ISBN 0766834581

Wicke L. *Atlas of Radiologic Anatomy*. 7th ed. Teterboro, NJ: Icon Learning Systems; 2004
ISBN 1929007469

Willis MC. *Medical Terminology: A Programmed Learning Approach to the Language of Health Care*. 2nd ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2007.
ISBN: 9780781792837

Wilson BG. *Ethics and Basic Law for Medical Imaging Professionals*. Philadelphia, Pa: FA Davis Co; 1997.
ISBN 0803602154

Wilson RL. *Chiropractic Radiography & Quality Assurance Handbook.* Boca Raton, Fla: CRC Press; 2000.
ISBN 0849307856

Wojtowycz M. *Handbook of Interventional Radiology and Angiography.* 2nd ed. St. Louis, Mo: Mosby Year-Book; 1995.

ISBN 0815194404

Wolbarst AB. *Physics of Radiology*. 2nd ed. Madison, Wis: Medical Physics Pub; 2005.
ISBN 1930524226

Daly A. *Workplace Diversity: Issues and Perspectives*. Washington, DC: NASW Press; 1998.
ISBN 0871012812

Yochum TR, Rowe LJ. *Essentials of Skeletal Radiology.* 2nd ed. Baltimore, Md: Williams & Wilkins; 1996.
ISBN 0683099116

Journals

Applied Radiology. Anderson Publishing Ltd, Ocean, NJ.

Canadian Journal of Medical Radiation Technology. Canadian Association of Medical Radiation Technologists, Ottawa, Ontario.

Diagnostic Imaging. United Business Media, San Francisco, Calif.

Journal of Vascular Technology. Society of Vascular Technology, Lanham, Md.

Radiologic Science and Education. Association of Educators in Imaging and Radiological Sciences, Albuquerque, NM.

Radiologic Technology. American Society of Radiologic Technologists, Albuquerque, NM.

Radiology. Radiological Society of North America, Oak Brook, Ill.

Videotapes

Bruening BJ. *Deep Venous Thrombosis.* Austin, Tex: Texas Tech University Health Sciences Center.

Conceptual Physics Alive with Paul Hewitt. New York, NY: Addison-Wesley Publishing Co; 2002.

Life-Saving Lessons in Myelography. Princeton, NJ: Bracco Diagnostics Inc; 1999.

Mosby's Radiographic Instructional Series: Radiologic Physics [slides and audiotape]. St. Louis, Mo: Mosby Year-Book; 1997.

Naked to the Bone. San Francisco, Calif: Quest Productions; 1997.

Nuclear Medicine Technology: The Career of the Future. New York, NY: Summit USA Studios.

Software

Radiography Pro: Radiologic School Management Software. Mooresville, NC: America's Software Corporation.

CD-ROMs

Abrahams PH, Marks SC, Amadio PC. *Interactive Skeleton*. London, England: Primal Pictures; 1998.

Ahrendsen & Winders. *Radiographic Anatomy and Positioning Multimedia Kit*. D & J Productions; 1999-2000.

Bontrager K, Lampignano JP. *Mosby's Electronic Image Collection to Accompany Textbook of Radiographic Positioning and Related Anatomy*. St. Louis, Mo: Mosby; 2001.

Bouvier M , Bushyhead AL, Benson AN. *Cross-Sectional Anatomy Tour*. Sudbury, Mass: Exeter Multimedia Publishing, Jones and Bartlett; 1998.

CD-Roentgen: Interactive Radiology Teaching File. New York, NY: Insight Media; 1996.

Coleman S, Griffith C, Wells J, Wilcox A. *Radiography in a Flash!* Albany, NY: Delmar Publishers; 2002.

Daniels C, Cupido, eds. *Fundamentals of Diagnostic Radiology*. Halifax, Nova Scotia: Dalhousie University; 1996.

Greathouse JS. *Delmar's Radiographic Positioning and Procedures* [book on CD-ROM]. Albany, NY: Delmar Publishers, 1999.

Lanier LR, Rathe, Seymour J. *Radiologic Anatomy*. Gainesville, Fla: Gold Standard Multimedia; 1995.

Mosby's Medical Encyclopedia for Health Professionals [book on CD-ROM]. St. Louis, Mo: Mosby; 1996.

Mosby's Radiographic Instructional Series: Radiologic Physics. St. Louis, Mo: Mosby Year-Book Inc; 1998.

Mosby Year-Book's Radiographic Anatomy and Positioning [book on CD-ROM]. St. Louis, Mo: Mosby; 1996.

Physics. Los Gatos, Calif: Knowledge Books & Software; 1999.

Radiographic Positioning and Procedures Image Library, Diagnostic Imaging Expert. New York, NY: Insight Media; 1998.

Scott J, Nieder G, Anderson, M. *The Lost Files of Vesalius*. Dayton, Ohio: Wright State University School of Medicine, 1998.

Sim X-ray. Upper Montclair, NJ: Rems Software; 2001.

Walsh R, Raskin S. *Cross-Sectional Anatomy: A Gallery of Images*. Scholar Educational Systems; 1997.

Web sites

American Registry of Radiologic Technologists
http://www.arrt.org

American Society of Radiologic Technologists
https://www.asrt.org/asrt.htm

Aunt Minnie: Radiology Daily Case Studies
http://www.auntminnie.com

Australian Institute of Radiography
http://www.air.asn.au

Cerebral Angiography
http://user.shikoku.ne.jp/tobrains/exam/Angio/Angio-e.html

Chorus: Collaborative Hypertext of Radiology
http://chorus.rad.mcw.edu/

Department of Radiology at Emory
http://www.emory.edu/X-RAYS/Sprawls/

Diagnostic Imaging.Com News Service
http://www.dimag.com/

Digital Radiography Home Page
http://homepage.mac.com/kieranmaher/digrad/index.html

EduMed Corporation
http://www.edumed.com

Educating Teachers for Diversity
http://www.ncrel.org/sdrs/areas/issues/educatrs/presrvce/pe300.htm

Joint Review Committee on Education in Radiologic Technology
http://www.jrcert.org

MedWeb at Emory University Search Site
http://www.medweb.emory.edu/

Medical Imaging References
http://www.medtechcon.com/imaginglinks.html

National Council on Radiation Protection and Measurements (NCRP), NCRP Reports
http://www.ncrp.com

Radiation and Health Physics
http://www.umich.edu/~radinfo/

Radiography Discussion Forum
http://www.radiography.com/

Radiology Info: Terminology Glossary
http://www.radiologyinfo.org/glossary/

Research Center for Excellence in the Radiologic Sciences
http://www.radsciresearch.org

General Information and Radiology Search Sites
Altavista
http://www.altavista.com/

Dogpile
http://dogpile.com

Google
http://google.com

Hotbot
http://hotbot.lycos.com/

Metacrawler
http://www.cs.washington.edu/research/projects/WebWare1/www/metacrawler/

Webcrawler
http://web.webcrawler.com/d/search/p/webcrawler/

Yahoo Directory
http://dir.yahoo.com/Health/Medicine/Radiology/

Resources for Instructional Design and Media
Cognitive Approaches to Instructional Design
http://carbon.cudenver.edu/~bwilson/training.html

Association of Educators in Imaging and Radiological Sciences Instructional Resources

http://www.aeirs.org/resources.html

List of Tutorials for Educators
Learning Styles Tutorials
http://7-12educators.about.com/cs/learningstyles/index.htm

PowerPoint Tutorials
http://www.actden.com/pp/
http://www.electricteacher.com/tutorial3.htm
http://www.powerpointbackgrounds.com/powerpointtutorials.htm