

# Radiography Curriculum

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

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# 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. 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 radiologic science profession. In particular, students must develop skills in areas such as information literacy, scientific inquiry, self-reflection, collaboration and mentoring.

The guidance provided by this curriculum document will span the time period prior to and after the projected Jan. 1, 2015 start date of the American Registry of Radiologic Technology's minimum associate degree requirement for candidates seeking professional certification. The focus of this document is on the pre-professional core instructional content that will be expanded with institution-specific course content to fulfill metrics for receipt of an academic degree. It is beyond the scope of this document to outline administrative strategies for programs that are unable to award graduates an academic degree to comply with the ARRT 2015 degree requirement.

Postsecondary general education content is included as a "required" element of this radiography curriculum. 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. Following 2015, it is expected that this component of the entry-level curriculum will be satisfied with general education courses needed to fulfill institution-specific degree requirements.

This curriculum is designed to ensure that entry-level radiographers possess the technical skills outlined in the ASRT Radiography Practice Standards. In addition, the graduate will exhibit the following professional characteristics:

- 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 in 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 document itself is divided into specific content areas: pre-professional core and optional content.

- Pre-professional core content: This content makes up the body of the document and reflects educational content the professional community supports as essential for preparation to enter the radiography field. Specific instructional methods were intentionally omitted to allow for programmatic prerogative as well as creativity in instructional delivery.
- Optional content: This section is intended to decrease the hardship imposed on programs by requiring instructional content that is representative of technologies and technical principles that have been replaced with newer technical systems. It is recognized that traditional technologies are still part of the fabric of many communities. Content in this section will assist program planners wishing to enhance the curriculum with select topics of instruction intended to satisfy the mission of a given program or local employment market.

A list 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. Faculty members also are encouraged to expand and broaden these fundamental objectives as they incorporate them into their curricula.

Radiography programs are encouraged to organize the content and objectives to meet their individual goals and needs. In particular, students must develop skills in areas such as information literacy, scientific inquiry, self-reflection, collaboration and mentoring. Advances in technology and employer expectations require more independent judgment by radiographers.

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.

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# 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. Consistency, Accuracy, Responsibility and Excellence (CARE) in Medical Imaging and Radiation Therapy
  - 2. Incident reporting mechanisms
  - 3. Standards for supervision
    - a. Direct
    - b. Indirect
  - 4. The Patient Care Partnership: Understanding expectations, rights and responsibilities
- 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. Radiographer Practice Standards
  - 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. Geriatric
  - 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 acquisition
- 4. Image analysis

F. Radiation protection

- 1. Principles
- 2. Equipment and accessories

**III. Clinical Competency**

ARRT Competency Requirements (refer to the document located at [www.arrt.org/pdfs/Disciplines/Competency-Requirements/RAD-Competency-Requirements-2012.pdf](http://www.arrt.org/pdfs/Disciplines/Competency-Requirements/RAD-Competency-Requirements-2012.pdf)) \*

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



# Digital Image Acquisition and Display

## Description

Content imparts 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. Principles of digital system quality assurance and maintenance are presented.

**Special Note:** Digital imaging is a rapidly evolving technology. Every effort has been made to provide a curriculum outline that reflects, as accurately as possible, the state of the art of this discipline as of publication. Educators are encouraged to modify this outline with up-to-date information as it becomes available from vendors, clinical sites, textbooks, and technical representatives.

## 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. Contrast resolution
  
- B. Digital receptors
  - 1. Amorphous selenium/Thin film transistor (TFT) arrays
  - 2. Cesium iodide/amorphous silicon thin film transistor (TFT) arrays
  - 3. Charged coupled device (CCD) and complementary metal oxide semiconductor (CMOS) systems
  - 4. Photostimulable phosphor (PSP) plates
  
- C. Comparison of detector properties and evaluative criteria
  - 1. Detective quantum efficiency (DQE)
  - 2. Exposure index
  - 3. Spatial resolution
    - a. PSP
      - 1) Sampling frequency – pixel pitch
      - 2) Receptor size
      - 3) Light spread – phosphor layer thickness
    - b. TFT detector element (DEL) size
  
- D. Dynamic range and latitude
  - 1. Dynamic range of the detector
  - 2. Latitude – allowable error for optimal image acquisition
    - a. Exposure latitude

- b. Beam-part-receptor alignment latitude

## **II. Image Acquisition**

- A. Raw data acquisition
  - 1. Positioning
  - 2. Exposure field alignment and collimation
  - 3. Exposure – technique selection
  
- B. Image formation
  - 1. Image extraction
    - a. TFT, CMOS, CCD
    - b. PSP plate scanned by laser
  - 2. Digitized by analog-to-digital converter (ADC)
  - 3. Exposure field recognition
  - 4. Histogram created and analyzed by software
  - 5. Initial image processing
    - a. Exposure indicator determination
    - b. Automatic rescaling
    - c. Look-up table (LUT)
  - 6. Image enhancement processing
    - a. Gradient processing
      - 1) Brightness
      - 2) Contrast
    - b. Frequency processing
      - 1) Smoothing
      - 2) Edge enhancement
    - c. Equalization
  
- C. Exposure indicators
  - 1. Dose area product (DAP)
  - 2. Vendor-specific values
    - a. Relationship to patient exposure
    - b. Reader calibration
    - c. Centering and beam collimation
    - d. Optimal value ranges
  - 3. Exposure indicators

## **III. Image Acquisition Errors**

- A. Histogram analysis error
  - 1. Incorrect anatomic menu selection
  - 2. Exposure field recognition errors
    - a. Collimation border recognition
    - b. Exposure field distribution – multiple fields/plate
  - 3. Unexpected material in data set, e.g., metal
  - 4. Large overexposure error
  - 5. Inappropriate rescaling – dark or light image

- B. Low intensity radiation response – PSP only
  - 1. Background
    - a. Stores background exposure
      - 1) Plate responds to an exposure as low as 60  $\mu$ R
      - 2) Background is 40  $\mu$ R/day to 80  $\mu$ R/day
    - b. Plates unused for more than 48 hours should be erased
  - 2. Scatter no PSP storage in exam room
- C. Scatter control
  - 1. Beam limitation
  - 2. Optimal exposure
  - 3. Grid use
    - a. Kilovoltage peak (kVp)
    - b. Grid cutoff
    - c. Compare short dimension (SD) grid and long dimension (LD) grid
    - d. Storage

#### **IV. Fundamental Principles of Exposure**

- A. Optimal receptor exposure
  - 1. Milliampere-seconds (mAs)
  - 2. kVp
  - 3. Collimation
  - 4. Grid
  - 5. Source-to-image distance (SID)
  - 6. Speed class
  - 7. Fog
- B. Exposure myths and misconceptions associated with digital systems
- C. 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
- D. Monitor patient exposure
  - 1. Part of quality assurance (QA) program
  - 2. Vendor-supplied software

#### **V. Image Evaluation**

- A. Evidence of appropriate exposure level (exposure indicator range)
  - 1. Exposure indicator range
  - 2. Noise
    - a. Computer noise
    - b. Electronic noise

- c. Material mottle
- d. Quantum mottle

B. Contrast

C. Recorded detail

D. Artifacts

- 1. Patient
- 2. Equipment
- 3. Exposure
- 4. Processing
- 5. Moiré effect

**VI. Quality Assurance and Maintenance Issues**

A. Technologist responsibilities

- 1. Image quality control
  - a. Exposure indicator appropriateness
  - b. Image accuracy
- 2. Plate maintenance
  - a. Cleaning and inspection
  - b. Erasure
- 3. Reject analysis

B. Service engineer or medical physicist responsibilities

**VII. Display**

A. Monitor

- 1. Plasma
- 2. Liquid crystal display (LCD)
- 3. Cathode ray tube (CRT)

B. Laser film

**VIII. Data Management**

A. Network

B. Hospital information system (HIS)

C. Radiology information system (RIS)

D. Picture archiving and communication system (PACS)

- 1. System components and functions
- 2. Emergency contingency plan
- 3. Digital imaging and communication in medicine (DICOM)
- 4. Teleradiography

5. Radiographer responsibilities
  - a. Access work order (worklist)
  - b. Postprocessing – image manipulation
  - c. Annotation issues
  - d. Transmitting images to PACS
  - e. HIPAA
  - f. Workflow

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# Ethics and Law in the Radiologic Sciences

## Description

Content provides a foundation in ethics and law related to the practice of medical imaging. An introduction to terminology, concepts and principles will be presented. Students will examine a variety of ethical and legal issues found in clinical practice.

## 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

### 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. End-of-life issues

- H. Ethical research
  - 1. Institutional review board approval
  - 2. Data collection
  - 3. Data reporting
- I. Radiology-specific
  - 1. Dose creep
  - 2. ALARA

### **III. Legal Issues**

- A. Parameters of legal responsibility
- B. HIPAA
  - 1. Confidentiality of patient medical records (written and electronic)
  - 2. Electronic communication (e.g., cell phones, social networking sites, e-mail, photography)
- C. Torts
  - 1. Intentional
  - 2. Unintentional

### **IV. Legal doctrines**

- A. Legal and professional standards
- B. Medical records
  - 1. Accuracy of documentation
  - 2. Radiographic images as legal documents
- C. Legal risk reduction/risk management

### **V. Patient Consent**

- A. Definition
- B. Types
- C. Condition for valid consent
- D. Documentation of consent
- E. Right of refusal

# Human Structure and Function

## Description

Content establishes a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and systems are described and discussed. The fundamentals of sectional anatomy relative to routine radiography are addressed.

## 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/midsagittal
  - 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 adenosine 3', 5'-monophosphate (cyclic AMP)

### **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. Introduction to Sectional Anatomy**

**A. Structures and locations**

1. Head/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

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# Image Analysis

## Description

Content provides a basis for analyzing radiographic images. Included are the importance of optimal 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. 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-QA program

### II. 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

### III. Image Appearance Characteristics

- A. Brightness/density (film)
  - 1. Exposure to image receptor
  - 2. Brightness on display monitor
- B. Contrast
  - 1. Subject
  - 2. Image
- C. Recorded detail/spatial resolution
  - 1. Motion
  - 2. Geometric
  - 3. Receptor
  - 4. Noise
- D. Distortion
  - 1. Shape



2. Size
3. Spatial

#### **IV. 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. Order types
    - a. Written orders
    - b. Verbal orders
    - c. Electronic orders
  2. Order appropriateness
  
- 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 indicator appropriateness
  
- F. Radiation protection
  1. Collimation/beam limitation
  2. Shielding
  3. Repeats
  
- G. Patient preparation
  1. Contrast agents
  2. Pre-examination preparation

H. Artifacts

**V. Corrective Action**

A. Equipment

B. Technical factors

C. Procedural factors

D. Artifacts

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# Imaging Equipment

## Description

Content establishes a knowledge base in radiographic, fluoroscopic and mobile 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 (single and three phase)
    - 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. Components
2. Purpose
3. Applications

**C. Automatic exposure control (AEC) devices**

1. Ionization chambers
2. Solid state detector
3. Minimum response time
4. Backup 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. Field size
  - d. Image receptor variations

**III. Diagnostic X-Ray Tubes**

**A. Construction**

**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**

**B. Intensification principles/characteristics**

1. Brightness gain
2. Flux gain
3. Minification gain
4. Automatic brightness control (ABC)
5. Multi-field intensifiers
  - a. Magnification
  - b. Dose

6. Spatial resolution
  7. Contrast
  8. Distortion
  9. Noise
- C. Viewing systems
1. Video camera tube
  2. CCD
  3. CRT/LCD/flat screen monitor
- D. Digital fluoroscopy
1. Types of acquisition
  2. Operations and technique

## **V. Quality Control**

- A. 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
- B. 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. Collimator accuracy
  7. Illuminator brightness/consistency
  8. Monitor calibration

## **VI. Modality Exploration and Radiation Therapy**

- A. Magnetic resonance (MR) imaging, nuclear medicine, ultrasonography, mammography, bone densitometry, interventional radiography
1. Basic principles of operation
  2. Image data presentation/appearance
  3. Education and certification
- B. Radiation therapy

1. Basic principles of treatment delivery (external beam, brachytherapy)
2. Image data presentation/appearance
3. Education and certification

ASRT

# Introduction to Computed Tomography

## Description

Content is designed to provide entry-level radiography students with an introduction to and basic understanding of the operation of a computed tomography (CT) device. Content is not intended to result in clinical competency.

## Content

### I. 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) ADC
    - b. Functions
      - 1) Measurement of transmitted beam
      - 2) 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 numbers (Hounsfield numbers)
        - a) Baseline reference numbers
          - i) Water equal to 0
          - ii) Bone (white) equal to 400 to 1000 HU
          - iii) Air (black) equal to -1000 HU
    - 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

B. Factors controlling image appearance

C. Anatomical structures

1. Artifacts
2. Contrast resolution (window width)
3. Grayscale manipulation (window level)
4. Distortion
5. Noise
6. Spatial resolution

**II. 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

C. Measurement units in CT

1. CT dose index (CTDI)
2. Multiple scan average dose (MSAD)
3. Dose length product (DLP)

D. CT immobilization devices

1. Straps
2. Head holders
4. IV arm boards



# Introduction to Radiologic Science and Health Care

## Description

Content provides an overview of the foundations of radiography and the practitioner's role in the health care delivery system. Principles, practices and policies of health care organizations 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
  - 2. Radiation therapy
  - 3. Nuclear medicine technology
  - 4. Multiskilled (fusion technology)
  - 5. Diagnostic medical sonography
  - 6. MR imaging
  - 7. PACS administration/informatics
  - 8. Education
  - 9. Management
- B. Other health care professions

### II. The Health Care Environment

- A. Health care settings
  - 1. Hospitals
  - 2. Clinics
  - 3. Mental health facilities
  - 4. Long-term/residential facilities
  - 5. Hospice
  - 6. Outpatient/ambulatory care
  - 7. Preventive care
  - 8. Home health care
  - 9. Telemedicine
- B. Payment/reimbursement systems
  - 1. Self-pay
  - 2. Insurance

3. Government programs

### **III. Quality Management**

- A. Quality improvement/management
- B. Quality assurance
- C. Quality control
- D. Benefits within radiology
  1. Patient safety
  2. Reduction in radiation exposure
  3. Efficacy of patient care
  4. Departmental efficiency
  5. Consistent image quality
  6. Cost-effectiveness

### **IV. Hospital Organization**

- A. Philosophy
- B. Mission
- C. Administrative services
  1. Governing board
  2. Hospital administration
  3. Admissions
  4. Information systems
  5. Procurement
  6. Accounting
  7. Support services
  8. Human resources
- D. Medical services
  1. Physicians
  2. Clinical services
  3. Clinical support services

### **V. Radiology Organization**

- A. Professional personnel
  1. Administrators/managers
  2. Radiologists
  3. Radiographers
  4. Radiologist assistants
  5. Radiology nurses
  6. Radiation physicists

- B. Support personnel
  - 1. Information systems staff
  - 2. Clerical staff
- C. Educational personnel
  - 1. Program director
  - 2. Clinical coordinator
  - 3. Didactic instructor
  - 4. Clinical instructor
  - 5. Clinical staff

**VI. Accreditation**

- A. Health care institutions
- B. Modalities
- C. Educational
  - 1. Programmatic accreditation (e.g., Joint Review Committee on Education in Radiologic Technology [JRCERT])
  - 2. Regional
  - 3. Other

**VII. Regulatory Agencies**

- A. Federal
- B. State

**VIII. Professional Credentialing**

- A. Certification
- B. Registration
- C. Licensure
- D. Agencies
  - 1. National
  - 2. State

**IX. Professional Organizations**

- A. Purpose, function, activities
- B. Types
  - 1. Local
  - 2. State
  - 3. National
  - 4. International

5. Other

**X. Professional Development and Advancement**

- A. Continuing education
- B. Clinical experience requirements
- C. Continued qualifications
- D. Continuing education opportunities
  - 1. Postprimary certification
  - 2. Collegiate/educational programs
  - 3. Self-learning activities
  - 4. Professional conferences
- E. Employment considerations
  - 1. Geographic mobility
  - 2. Economic factors
  - 3. Workforce needs
- F. Advancement opportunities
  - 1. Education
  - 2. Administration
  - 3. Advanced practice
  - 4. Physics
  - 5. Research
  - 6. Industrial
  - 7. Medical informatics
  - 8. Sales/applications

# Medical Terminology

## Description

Content provides 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 and other imaging modalities
- B. Radiation oncology

### 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

ASRT

# Patient Care in Radiologic Sciences

## Description

Content provides the concepts of optimal 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. Health Care Team

- A. Responsibilities of the health care facility
  - 1. Caring for all patients regardless of condition
  - 2. Promoting health
  - 3. Preventing illness
  - 4. Education
  - 5. Research
- B. Members and responsibilities
- C. Responsibilities of the radiographer
  - 1. Performing radiographic examination
  - 2. Performing patient care and assessment
  - 3. Adhering to radiation protection guidelines
  - 4. Following practice standards
  - 5. Assisting the radiologist

### II. Professionalism and Communication in Patient Care

- A. Health and illness continuum
- B. Developing professional attitudes
  - 1. Teamwork
  - 2. Work ethic
  - 3. Health role model
  - 4. Sympathy
  - 5. Empathy
  - 6. Assertiveness
- C. Age- and generation-specific communication
  - 1. Neonatal
  - 2. Pediatric
  - 3. Adolescence
  - 4. Young adulthood
  - 5. Middle adulthood
  - 6. Geriatric

- D. Communication
  - 1. Verbal
  - 2. Nonverbal communication
  - 3. Language/cultural variations
    - a. Challenges
    - b. Hearing, vision and speech impairments
    - c. Impaired mental function
    - d. Altered states of consciousness
    - e. Human diversity
    - f. Artificial speech
  - 4. Other factors that impede communication
    - a. Colloquialism/slang
    - b. Medical terminology
  - 5. Patient interactions
    - a. Eye contact
    - b. Volume and speed of speech
    - c. Effective listening
    - d. Feedback
  - 6. Communication with families
  - 7. 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
    - c. Stages of grief
      - 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. Factors affecting patient's emotional responses
    - a. Age
    - b. Gender
    - c. Marital/family status
    - d. Socioeconomic factors



- e. Cultural/religious variations
- f. Physical condition
- g. Self-image
- h. Past health care experiences
- i. Beliefs
- j. Attitudes
- k. Prejudices
- l. Self-awareness

### **III. Patient/Radiographer Interactions**

- A. Patient identification methods
  - 1. Interviewing/questioning
  - 2. Chart/requisition
  - 3. Wrist band
  - 4. Institution-specific
- B. Procedure questions and explanations
  - 1. Positioning
  - 2. Length of procedure
  - 3. Immobilization devices
  - 4. Machine movement/sounds
- C. Interaction with patient's 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
- 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 or exams
- e. Transfer devices

D. Fall prevention

E. Patient Positions

- 1. Supine
- 2. Prone
- 3. Decubitus
- 4. Oblique
- 5. Fowler's
- 6. Semi-Fowler's
- 7. Sims'
- 8. Trendelenburg
- 9. Lithotomy

F. Safety and immobilization

- 1. Types
- 2. Applications
- 3. Devices
  - a. Adult
  - b. Pediatric

G. MR Safety

- 1. Pacemakers and other implanted devices
- 2. Aneurysm clips
- 3. O<sub>2</sub> containers

H. Incident reporting

- 1. Legal considerations
- 2. Documentation
- 3. 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. Normal ranges of laboratory data

1. Blood urea nitrogen (BUN)
2. Creatinine
3. Glomerular filtration rate (GFR)
4. Hemoglobin
5. Red blood cells (RBCs)
6. Platelets
7. Oxygen (O<sub>2</sub>) saturation
8. Prothrombin
9. Partial thromboplastin time

E. Patient chart (paper and electronic)

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

## VI. Infection Control

A. Terminology

1. Hospital acquired
2. Communicable
3. Infectious pathogens
4. Human immunodeficiency virus (HIV)
5. Hepatitis
6. Multidrug-resistant organisms (MDRO)
7. 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. Post-exposure protocols
  
- E. Asepsis
  - 1. Medical
    - a. Hand washing
    - b. Chemical disinfectants
  - 2. Surgical
    - a. Growth requirements for microorganisms
    - b. Methods used to control microorganisms
      - 1) Moist heat
      - 2) Dry heat
      - 3) Gas
      - 4) Chemicals
    - c. Procedures
      - 1) Opening packs
      - 2) Gowning/gloving
      - 3) Skin preparation
      - 4) Draping
      - 5) Dressing changes
    - d. Packing
    - e. Storage
    - f. Linen
  
- F. Isolation techniques and communicable diseases
  - 1. Category-specific
  - 2. Disease-specific
  - 3. Standard precautions
  
- G. 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 image receptors and imaging equipment
  
- H. Precautions for the compromised patient (reverse isolation)
  - 1. Purpose
  - 2. Procedure

I. 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. Trauma**

- A. Head injuries
  1. Four levels of consciousness
  2. Symptoms
  3. Medical intervention
  
- B. Spinal injuries
  1. Assessment
  2. Symptoms
  3. Medical intervention
  4. Transportation
  
- C. Extremity fractures
  1. Types
  2. Symptoms
  3. Orthopedic devices
  4. Positioning
  
- D. Wounds
  1. Symptoms
  2. Medical intervention
  
- E. Burns
  1. Classifications
  2. Medical intervention

### **IX. Contrast Studies**

- A. Patient education
  1. Radiographer's responsibility
  2. Standard procedure
  
- B. Patient preparation and care per procedure
  
- C. Follow-up care
  1. Post exam
  2. Infiltrate

### **X. Reactions to Contrast Agents**

- A. Signs and symptoms
  
- B. Medical intervention
  
- C. Vasovagal reactions

## **XI. Tubes, Catheters, Lines and Other Devices**

- 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. Implanted devices (pacemakers)
  - 1. Purpose
  - 2. Location
- H. Greenfield filter (IVL filter)
  - 1. Purpose
  - 2. Location
- I. Peripheral venous lines
  - 1. Purpose
  - 2. Location
- J. Central venous lines
  - 1. Purpose
  - 2. Types
  - 3. Access
- K. Tissue drains
- L. Oxygen administration
  - 1. Values
  - 2. Oxygen therapy
  - 3. Oxygen delivery systems
    - a. Low-flow systems
    - b. High-flow systems
  - 4. Documentation

- 5. Special precautions
- M. Urinary collection
  - 1. Procedure
    - a. Male
    - b. Female
  - 2. Alternative methods of urinary drainage
  - 3. Documentation
- N. Ostomies
  - 1. Ileostomy
  - 2. Ureteroileostomy

## **XII. Mobile and Surgical Radiography**

- A. Prior to bedside procedure:
  - 1. Verify order
  - 2. 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
  - 1. Patient
  - 2. Radiographer
  - 3. Other



# Pharmacology and Venipuncture

## Description

Content provides basic concepts of pharmacology, venipuncture and administration of diagnostic contrast agents and intravenous medications. The appropriate delivery of patient care during these procedures is emphasized.

## Considerations

Students should successfully complete patient care objectives (including CPR and basic life support (BLS) certification), as well as objectives related to the 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 between states and institutions, the official position of the American Society of Radiologic Technologists is that venipuncture falls within the radiologic technology profession's general scope of practice and practice standards. Therefore, it should be included in the didactic and clinical curriculum included with demonstrated competencies in 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 venipuncture.
- Professional liability coverage is adequate.
- Adequate supervision is provided.
- Appropriate, structured laboratory objectives are identified.
- Evaluation and demonstration of competency occur before venipuncture 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. Six Rights of Drug Safety**

- A. The right medication
- B. The right dose
- C. The right patient
- D. The right time
- E. The right location
- F. The right documentation

### **V. Drug Categories of Relevance to Radiography (Uses and Impacts on Patient)**

- A. Analgesics
- B. Anesthetic agents
- C. Antiallergic and antihistamine drugs
- D. Antianxiety drugs
- E. Antiarrhythmic drugs
- F. Antibacterial drugs
- G. Anticoagulant and coagulant drugs
- H. Antidepressants
- I. Antiemetic drugs
- J. Antihypertensive drugs
- K. Anti-inflammatory drugs
- L. Antiseptic and disinfectant agents
- M. Bronchodilators
- N. Cathartic and antidiarrheal drugs

- O. Diuretics
- P. Sedative and hypotonic drugs
- Q. Vasodilators and vasoconstrictors

## **VI. Contrast Agents**

- A. Types of compound
  - 1. Metallic salts
  - 2. Organic iodides
    - a. Ionic contrast agents
    - b. Nonionic contrast agents
  - 3. 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. Venipuncture**

### **A. Methods**

1. Continuous infusion
2. Intermittent infusion
3. Direct injection
  - a. Hand injection
  - b. Mechanical pressure injector

### **B. Sites of administration**

1. Peripheral
2. Central

### **C. Complications**

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

### **D. Venipuncture procedures**

1. Equipment
2. Patient identification, assessment and instructions
3. Informed consent
4. Dosage, dose calculations and dose-response
  - a. Adults
  - b. Pediatric patients
5. Patient preparation
6. Application of standard precautions
7. Procedure
  - a. Injection through an existing line
  - b. Venipuncture
8. Site observation
9. 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
10. Discontinuation
  - 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
- 11. Documentation of administration
- 12. 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

ASRT

# Principles of Imaging

## Description

Content establishes a knowledge base in factors that govern the image production process.

## Content

### I. Exposure Factors

- A. Distance
- B. mAs
- C. kVp
- D. Grids
- E. Receptor speed

### II. Brightness Digital Display/Density (Film)

- A. Exposure to image receptor
- B. Calculations for receptor exposure maintenance
  - 1. Reciprocity law
  - 2. 15 percent rule
  - 3. Grid factor/Bucky factor
  - 4. Speed class
  - 5. SID

### III. Contrast

- A. Description
  - 1. High/short gray scale
  - 2. Low/long gray scale
- B. Components
  - 1. Subject contrast – variation in receptor exposure
    - a. Structural distribution – anatomical contrast
      - 1) Contrast media
      - 2) Pathology
    - b. Beam quality
      - 1) kVp
      - 2) Filtration
    - c. Scatter control
      - 1) Beam limitation
      - 2) Grid
      - 3) Air gap
  - 2. Image receptor contrast

3. Display contrast
  - a. Brightness
  - b. Ambient light in view area
  - c. Window width and level

#### **IV. Recorded Detail/Spatial Resolution**

- A. Factors affecting recorded detail/spatial resolution
  1. Motion
    - a. Part
    - b. Equipment
  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
    - b. Light diffusion
  4. Noise/mottle

#### **V. Distortion**

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

#### **VI. Exposure Latitude**

- A. Factors affecting exposure latitude
  1. kVp
  2. Image receptor

#### **VII. Beam-limiting Devices**

- A. Function/Purpose
  1. Reduce irradiated tissue volume
  2. Reduce patient effective dose
  3. Improve contrast
- B. Types – applications
  1. Cylinders
  2. Collimator
  3. Lead masks

4. Alignment

### **VIII. Beam Filtration**

- A. Types
  1. Inherent
  2. Added
  3. Flat
  4. Compound
- B. Function/mechanism
- C. Compensating filtration
- D. Impact of filtration on image characteristics
- E. Filtration vs. HVL

### **IX. Scattered and Secondary Radiation**

- A. Factors
  1. kVp
  2. Contrast agent
  3. Patient
  4. Beam limitation
  5. Grids
  6. OID – air gap technique
- B. Effects
  1. Effective patient dose
  2. Subject contrast
  3. Image quality
  4. Occupational exposure

### **X. Grids**

- A. Function/mechanism
- B. Construction
- C. Types
  1. Focused
  2. Parallel
  3. Linear
  4. Crossed
  5. Moving
  6. Stationary
  7. Short dimension
  8. Long dimension



- D. Characteristics
  - 1. Focal distance/radius
  - 2. Focal range
  - 3. Ratio
  - 4. Frequency
  - 5. Lead content
  - 6. Grid/Bucky factor
  - 7. Contrast improvement factor
  - 8. Selectivity

- E. Selection
  - 1. kVp
  - 2. Patient/exam
  - 3. Beam limiting
  - 4. Alignment latitude

- F. Primary cutoff

## **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
  - 4. Anatomically programmed radiography

# Radiation Biology

## Description

Content provides 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. Basic cellular biology
  - 1. Cellular structure
    - a. Cell membrane
    - b. Cytoplasm
    - c. Protoplasm
    - d. Organelles
    - e. Nucleus
  - 2. Cellular function
    - a. Basic cell chemistry
    - b. Metabolism
    - c. Organic and inorganic compounds
  - 3. Cell proliferation
    - a. Cell cycle
    - b. Mitosis
    - c. Meiosis
    - d. Differentiation
  
- C. Types of ionizing radiation
  - 1. Electromagnetic radiation
    - a. X-rays
    - b. Gamma rays
  - 2. Particulate radiations
    - a. Alpha
    - b. Beta
      - 1) Negatron
      - 2) Positron
    - c. Neutrons
    - d. Protons
  
- D. Sources of medical radiation exposure
  - 1. Diagnostic radiology

2. Dental radiology
3. Cardiovascular-interventional radiology
4. Nuclear medicine
5. Radiation oncology

E. Other sources of radiation exposure

## **II. Radiation Energy Transfer**

A. Molecular effects of radiation

1. Direct effect
  - a. Target theory
    - 1) Target molecules
    - 2) Cell death
2. Indirect effect
  - a. Radiolysis of water

B. Factors effecting energy transfer

1. Linear energy transfer (LET)
2. Relative biological effectiveness (RBE)
3. Factors influencing RBE
  - a. LET
  - b. Oxygen effect

## **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

- d. Nonstochastic (deterministic) effects
- 2. Genetic effects
  - a. Mutagenesis
  - b. Genetically significant dose (GSD)
- 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)
- C. Systemic response to radiation
  - 1. Hemopoietic
  - 2. Integumentary
  - 3. Digestive
  - 4. Urinary
  - 5. Respiratory
  - 6. Reproductive
  - 7. Muscle
  - 8. Nervous
  - 9. 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

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# Radiation Production and Characteristics

## Description

Content establishes 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. ionizing
    - a. Energy
    - b. Probability
- B. Radioactivity
  - 1. Radioactive decay
    - a. Alpha emission
    - b. Beta emission
    - c. Gamma emission
  - 2. Half-life ( $T_{1/2}$ )

### III. X-Ray Production

- A. Historical introduction

- B. Target interactions
  - 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/stem radiation
- D. Conditions necessary for x-ray 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)
- 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

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# Radiation Protection

## Description

Content presents 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 biological 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) Roentgen (R)
  - 2. Absorbed dose
    - a. Gray (Gy) (Rad)
  - 3. Kerma
    - a. Kinetic energy release in matter
    - b. Measurement unit in the gray
  - 4. Dose equivalent
    - a. Sievert (Sv) (Rem)
  - 5. Measurement units in CT
    - a. CTDI
    - b. MSAD

- c. DLP
- 6. Radioactivity
  - a. Becquerel (Bq)
  - b. Curie (Ci)

B. Dose reporting

- 1. U.S. Nuclear Regulatory Commission (NRC) Regulations (10 Code of Federal Regulations [CFR]) Part 20 Standards for Radiation Protection
- 2. National Council on Radiation Protection and Measurements (NCRP) Guidelines
  - a. Dose quantities
    - 1) Effective dose (E)
    - 2) Collective effective dose (S)
    - 3) Average effective dose to an individual in a group exposed to a specific source (EExp)
    - 4) Effective dose per individual in the U.S. population whether exposed to the specific source or not (EUS)

C. Radiation detectors

- 1. Area monitors
- 2. Personal detectors

**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/agencies

- 1. Nuclear Regulatory Commission (NRC)
- 2. Food and Drug Administration (FDA)
- 3. EPA
- 4. OSHA
- 5. 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. NRC Regulations (10 CFR) Part 20 Standards for Radiation Protection
  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 recordkeeping
  4. Retrieval from previous employers
- E. Effective dose limits
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
  6. Public awareness
    - a. Background equivalent radiation time (BERT)
    - b. Social marketing (Image Gently, Image Wisely)
- 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. CT
- K. Special considerations
  - 1. Pediatric patients
  - 2. Pregnant patients

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# Radiographic Pathology

## Description

Content introduces 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 Technical Considerations, Appropriate Imaging Modality)**
- A. Skeletal
  - B. Digestive
  - C. Respiratory
  - D. Urinary
  - E. Reproductive
  - F. Circulatory
  - G. Endocrine
  - H. Nervous

# Radiographic Procedures

## Description

Content provides the knowledge base necessary to perform standard imaging procedures 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/upright
  - 7. Anterior position
  - 8. Posterior position
  - 9. Oblique position
  
- C. General planes
  - 1. Sagittal or midsagittal
  - 2. Coronal or midcoronal
  - 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. Immobilization devices

H. Accessory equipment

1. Calipers
2. Lead strips
3. Lead shields or shadow shields
4. Lead markers
5. Image receptor holders

## 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
- 5. Exam sequencing
  
- 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
    - b. Common radiation safety issues and concerns
  - 2. Cultural awareness
  - 3. 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 analysis
  - 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. Special needs patients
  - 5. Trauma
  - 6. Obesity
  - 7. Cultural awareness
  - 8. 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
- h. Special studies
  - 1) Bone survey
  - 2) Long bone measurement
  - 3) Bone age
  - 4) Foreign body
- 2. Respiratory system
  - a. Upper airway
  - b. Chest
- 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 and follow-up care
- 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
    - b. Swallowing dysfunction study
    - c. Small bowel
  - 2. Biliary system
    - a. Endoscopic retrograde cholangiographic pancreatography (ERCP)
    - b. Cholangiography
      - 1) Operative cholangiography
      - 2) T-tube cholangiography

3. Genitourinary system
  - a. Intravenous urography
  - b. Retrograde urography
  - c. Cystography and cystourethrography
  - d. Hysterosalpingography

G. Procedural considerations for the following special studies:

1. Arthrography
2. Myelography

**VI. Additional Imaging Modalities and Radiation Therapy**

A. CT, MR, nuclear medicine, ultrasonography, mammography, bone densitometry, interventional radiography

1. Complement to diagnostic radiography
2. Diagnostic advantages over routine radiography
3. Sample exams(s) or procedure(s)
  - a. Patient preparation
  - b. Patient risk factors

B. Radiation therapy

1. Complement to diagnostic radiography
2. Principles of therapeutic and palliative radiation therapy
3. Sample exam(s) or procedure(s)
  - a. Patient preparation
  - b. Patient risk factors

## 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.

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## Learning Objectives

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

[Clinical Practice](#)

[Digital Image Acquisition and Display](#)

[Ethics and Law in the Radiologic Sciences](#)

[Human Structure and Function](#)

[Image Analysis](#)

[Imaging Equipment](#)

[Introduction to Computed Tomography](#)

[Introduction to Radiologic Science and Health Care](#)

[Medical Terminology](#)

[Patient Care in Radiologic Sciences](#)

[Pharmacology and Venipuncture](#)

[Principles of Imaging](#)

[Radiation Biology](#)

[Radiation Production and Characteristics](#)

[Radiation Protection](#)

[Radiographic Pathology](#)

[Radiographic Procedures](#)



## 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 electrocardiogram (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.

ASRT

## Digital Image Acquisition and Display

### Objectives

- ◆ Define terminology associated with digital imaging systems.
- ◆ Describe the various types of digital receptors.
- ◆ Describe the response of digital detectors to exposure variations.
- ◆ Compare the advantages and limits of each receptor type.
- ◆ Evaluate the spatial resolution and dose effectiveness for digital radiography detectors.
- ◆ Describe the histogram and the process or histogram analysis as it relates to automatic rescaling and determining an exposure indicator.
- ◆ Relate the receptor exposure indicator values to technical factors, system calibration, part/beam/plate alignment and patient exposure.
- ◆ Describe the response of PSP systems to background and scatter radiation.
- ◆ Use appropriate means of scatter control.
- ◆ Avoid grid use errors associated with grid cutoff and Moiré effect.
- ◆ Identify common limitations and technical problems encountered when using PSP systems.
- ◆ Employ appropriate beam/part/receptor alignment to avoid histogram analysis errors.
- ◆ Associate impact of image processing parameters to the image appearance.
- ◆ Apply the fundamental principles to 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.
- ◆ 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.
- ◆ Define digital imaging and communications in medicine (DICOM).
- ◆ Describe HIPAA concerns with electronic information.
- ◆ Identify common problems associated with retrieving/viewing images within a PACS.

## 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.
- ◆ 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 and 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.
- ◆ Differentiate between civil and criminal liability.
- ◆ Define tort and explain the differences between intentional and unintentional torts.

## 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 sectional anatomical structures found within the head/neck, thorax and abdomen.

## Image Analysis

### Objectives

- ◆ Discuss the elements of a radiographic image.
- ◆ Identify anatomy on radiographic images.
- ◆ Apply a 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 an acceptable image.
- ◆ 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.
- ◆ Differentiate images produced by various modalities.

## Imaging Equipment

### Objectives

- ◆ Define potential difference, current and resistance.
- ◆ Identify the general components and functions of the tube and filament circuits.
- ◆ 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.
- ◆ Indicate the purpose, construction and application of video camera tubes, CCD and TV monitors.
- ◆ Differentiate between quality improvement/management, quality assurance and quality control.
- ◆ List the benefits of a quality control to the patient and to the department.
- ◆ Discuss the proper test equipment/procedures for evaluating the operation of an x-ray generator.
- ◆ Evaluate the results of basic QC tests.
- ◆ Discuss the basic principles of operation of various imaging modalities and radiation therapy.



## Introduction to Computed Tomography

### Objectives

- ◆ Describe the components of the CT imaging system.
- ◆ Explain the functions of collimators in CT.
- ◆ List the CT computer data processing steps.
- ◆ Define algorithm and explain its impact on image scan factors and reconstruction.
- ◆ Define raw data and image data.
- ◆ Describe the following terms in relation to the CT data acquisition process:
  - 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).
- ◆ 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.
- ◆ Name the radiation protection devices that can be used to reduce patient dose in CT and describe the correct application of each.
- ◆ Describe the general purpose of commonly performed CT studies.
- ◆ Discuss general radiation safety and protection practices associated with examinations in CT.

## Introduction to 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.
- ◆ Describe relationships and interdependencies of departments within a health care institution.
- ◆ Discuss the responsibilities and relationships of all personnel in the radiology department.
- ◆ Differentiate between quality improvement/management, quality assurance and quality control.
- ◆ Differentiate among accreditation types.
- ◆ Define credentialing, certification, registration, licensure and regulations.
- ◆ Discuss career opportunities and advancement for the radiographer.
- ◆ Identify the benefits of continuing education as related to improved patient care and professional enhancement.

## Medical Terminology

### Objectives

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

ASRT

## 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.
- ◆ 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 dying and death from the viewpoint of both patient and radiographer.
- ◆ Describe the characteristics of each stage of grief.
- ◆ 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 incident reporting.
- ◆ Describe methods to evaluate patient physical status.
- ◆ List the information to be collected prior to a patient examination.
- ◆ Describe vital signs and lab values used to assess patient condition, including sites for assessment and normal values.
- ◆ Define terms related to infection control.
- ◆ Describe the importance of standard precautions and isolation procedures, including sources and modes of transmission of infection and disease and institutional control procedures.
- ◆ Identify symptoms related to specific emergency situations.
- ◆ Describe the institution's emergency medical code system and the role of the student during a medical emergency.
- ◆ Explain the age-specific considerations necessary when performing radiographic procedures.
- ◆ Describe appropriate procedures for management of various types of trauma situations.
- ◆ Describe the symptoms and medical interventions for a patient with a contrast agent reaction.
- ◆ Explain the role of the radiographer in patient education.
- ◆ Describe the patient preparation for contrast studies.
- ◆ Identify specific types of tubes, lines, catheters and collection devices.
- ◆ Outline the steps in the operation and maintenance of suction equipment.
- ◆ Outline the steps in the operation and maintenance of oxygen equipment and demonstrate proper use.

- ◆ Demonstrate competency in basic life support (BLS).
- ◆ Describe the steps in performing various mobile procedures.
- ◆ 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.

ASRT

## Pharmacology and Venipuncture

### Objectives

- ◆ Distinguish among the chemical, generic and trade names for drugs in general.
- ◆ Describe pharmacokinetic and pharmacodynamic principles of drugs.
- ◆ Explain the uses and impact of drug categories on the patient.
- ◆ Define the categories of contrast agents and give specific examples for each category.
- ◆ Explain the pharmacology of contrast agents.
- ◆ Describe methods and techniques for administering various types of contrast agents.
- ◆ Identify and describe the routes of drug administration.
- ◆ Demonstrate appropriate venipuncture technique.
- ◆ Differentiate between the two major sites of intravenous drug administration.
- ◆ Identify, describe and document complications associated with venipuncture and appropriate actions to resolve these complications.
- ◆ Discuss the various elements of initiating and discontinuing intravenous access.
- ◆ 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 status and professional liability issues of the radiographer's role in contrast and/or drug administration.

## Principles of Imaging

### Objectives

- ◆ Discuss practical considerations in setting standards for acceptable image quality.
- ◆ Assess radiographic exposure on radiographic images.
- ◆ Analyze the relationships of factors that control and affect image exposure.
- ◆ 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 how beam filtration affects 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.
- ◆ 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 kilovoltage peak (kVp) and variable kVp systems.
- ◆ Apply the reciprocity law to clinical situations.
- ◆ Apply conversion factors for changes in the following areas: distance, grid, image receptors, reciprocity law and 15 percent rule.

## 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 effects of 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 lethal dose (LD).
- ◆ 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 and discuss specific diseases or syndromes associated with them.
- ◆ 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 effective dose limits for the embryo and fetus in occupationally exposed women.

- ◆ Distinguish between primary and secondary radiation barriers.
- ◆ Demonstrate how the operation of various x-ray and ancillary equipment influences radiation safety and describe the potential consequences of equipment failure.
- ◆ Perform calculations of exposure with varying time, distance and shielding.
- ◆ Discuss the relationship between workload, energy, half-value layer (HVL), tenth-value layer (TVL), use factor and shielding design.
- ◆ Identify emergency procedures to be followed during failures of x-ray equipment.
- ◆ Demonstrate how time, distance and shielding can be manipulated to keep radiation exposures to a minimum.
- ◆ Explain the relationship of beam-limiting devices to patient radiation protection.
- ◆ Discuss added and inherent filtration in terms of the effect on patient dosage.
- ◆ Explain the purpose and importance of patient shielding.
- ◆ Identify various types of patient shielding and state the advantages and disadvantages of each type.
- ◆ Use the appropriate method of shielding for a given radiographic procedure.
- ◆ Explain the relationship of exposure factors to patient dosage.
- ◆ Explain how patient position affects dose to radiosensitive organs.
- ◆ Identify the appropriate image receptor that will result in an optimum diagnostic image with the minimum radiation exposure to the patient.
- ◆ Select the immobilization techniques used to eliminate voluntary motion.
- ◆ Describe the minimum source-to-tabletop distances for fixed and mobile fluoroscopic devices.
- ◆ Apply safety factors for the patient, health care personnel and family members in the room during 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 connected to 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.
- ◆ Identify the structures demonstrated on routine radiographic and fluoroscopic images.
- ◆ Adapt radiographic and fluoroscopic procedures for special considerations.
- ◆ Simulate radiographic and fluoroscopic 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 basic radiographic and fluoroscopic procedures.
- ◆ Explain the patient preparation necessary for various contrast and special studies.
- ◆ Explain the routine and special positions/projections for all radiographic/fluoroscopic procedures.
- ◆ Explain the purpose for using contrast media.
- ◆ Name the type, dosage and route of administration of contrast media commonly used to perform radiographic contrast and special studies.
- ◆ Describe the general purpose of radiographic and fluoroscopic studies.
- ◆ Apply general radiation safety and protection practices associated with radiographic and fluoroscopic examinations.

## Optional Content

This section is intended to decrease the hardship imposed on programs by requiring instructional content that is representative of technologies and technical principles that have been replaced with newer technical systems. It is recognized that traditional technologies are still part of the fabric of many communities. Content in this section will assist program planners wishing to enhance the curriculum with select topics of instruction intended to satisfy the mission of a given program and/or local employment market.

The Basic Principles of Computed Tomography content in this section will aid program planners in developing computed tomography instruction beyond a brief introduction to this technology.

ASRT

## Basic Principles of Computed Tomography

### Description

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

### Objectives

- ◆ Explain the difference between reconstructing and reformatting an image.
- ◆ Cite the structures demonstrated on commonly performed CT images.
- ◆ Simulate commonly performed CT procedures on a person or phantom.
- ◆ Evaluate images for positioning, centering, appropriate anatomy and overall image quality.
- ◆ Discuss equipment and supplies necessary to complete commonly performed CT procedures.
- ◆ Explain the CT acquisition protocol for commonly performed head/neck, thorax and abdomen procedures.
- ◆ Explain the patient preparation necessary for commonly performed CT contrast studies.
- ◆ Name the type, dosage purpose, and route of contrast administration for common CT procedures.

## **Content**

### **I. Computed Tomography Generations: Capabilities and Limitations**

- A. First
- B. Second
- C. Third
- D. Fourth
- E. Fifth
- F. Spiral
- G. Postprocessing
  - 1. Image reformation
  - 2. Image smoothing
  - 3. Edge enhancement
  - 4. Window level and width

### **II. Clinical Competencies**

- A. Head
- B. Thorax
- C. 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.*



## Film-Screen Image Acquisition and Processing

### Description

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

### Objectives

- ◆ Describe the effects of storage on image quality.
- ◆ Discuss safelight illumination appropriate for specific image receptor systems.
- ◆ Discuss darkroom-related Occupational Safety & Health Administration (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.

### Content

#### I. Darkroom/Storage Environment

##### A. Location/construction/function

##### 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. Pressure
  - 6. Inventory control
  
- D. Safety
  - 1. Occupational Safety & Health Administration (OSHA)
  - 2. Material safety data sheet (MSDS)
  - 3. Darkroom chemical sensitivity

## **II. Characteristics of Film**

- A. Properties
  - 1. Contrast
  - 2. Exposure response – speed sensitivity
  - 3. Recorded detail – spatial resolution
  
- B. Latent image formation
  
- C. Response curves – D-LogE, Hurter and Driffield (H&D) or characteristic
  - 1. Speed
  - 2. Control contrast – average gradient
  - 3. Exposure latitude

## **III. Image Receptor Holders and Intensifying Screens**

- A. Cassettes
  - 1. Purpose
  - 2. Construction
  - 3. Loading/unloading
  - 4. Maintenance
  
- B. Intensifying screens
  - 1. Purpose
  - 2. Construction/composition
  - 3. Principles of function
  - 4. Classification
    - a. Phosphor spectral emission
    - b. Absorption efficiency
    - c. Speed
  - 5. Maintenance
    - a. Handling

- b. Cleaning
- c. Evaluating

#### **IV. Automatic Processing**

- A. Purpose
- B. Components
  - 1. Developer
  - 2. Fixer
  - 3. Wash
  - 4. Dryer
- C. Systems
  - 1. Transport
  - 2. Replenishment
  - 3. Recirculation
  - 4. Temperature control
  - 5. Dryer
- D. Film feed
- E. Maintenance/cleaning
- F. Quality control and documentation

#### **V. Artifacts**

- A. Types
- B. Causes
- C. Effects
- D. Preventive/corrective maintenance

#### **VI. Silver Recovery**

- A. Rationale
- B. Methods
  - 1. Electrolytic
  - 2. Metallic replacement/ion exchange
  - 3. Discarded film
- C. Security

## Imaging Equipment

### Description

Content establishes a knowledge base in radiographic, fluoroscopic and mobile equipment requirements and design. The content also provides a basic knowledge of quality control.

### Objectives

- ◆ Apply the basic principles of linear tomography in the patient care setting.

### Content

#### I. Linear Tomography

- A. Purpose
- B. Principles
- C. Equipment
- D. Applications

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## Introduction to Forensic Radiography

### Description

Content introduces entry-level radiography students to the scientific discipline of forensic radiography.

### Objectives

- ◆ Identify common areas of forensic study enhanced with radiologic imaging.
- ◆ Identify common procedures performed by forensic radiographers.
- ◆ Discuss the importance of producing pre- and postmortem images of comparable quality.
- ◆ Discuss the importance of radiographic images as forms of evidence in a court of law.

### Content

#### I. Scope of Forensic Radiology Radiography

- A. Service
- B. Education
- C. Concerns of public health and safety
- D. Mass casualty
- E. Child abuse
- F. Research
- G. Domestic abuse
- H. Abuse of the elderly
  - I. Human rights abuse, torture, terrorism

#### II. Imaging for Investigative Procedures

- A. Basal skull
- B. Burned remains
- C. Decomposed body
- D. Gunshot wounds
- E. Intraoral investigation
- F. Missile identification

- G. Motor vehicle accidents
- H. Removal of artifacts
- I. Skeletal remains
- J. Unidentified corpse

### **III. Legal Responsibilities**

- A. Parameters of legal responsibility
- B. Scope of practice and responsibilities of the forensic assistant
- C. Legal proceedings
- D. Admissibility of scientific evidence
- E. Federal rules of evidence
- F. The expert witness
- G. Discovery and deposition
- H. Testimony in court
- I. Admissibility of radiological images and results

## Sectional Anatomy

### Description

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

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

### Objectives

- ◆ Name the anatomical structures located within the head and neck.
- ◆ Describe the relationship of each anatomical structure in the head and neck to surrounding structures.
- ◆ Describe the function of each anatomical structure in the head and neck.
- ◆ Locate each anatomical structure on CT, MR and ultrasound images in the transverse axial, coronal, sagittal and orthogonal (oblique) cross-sectional imaging planes.
- ◆ Name the anatomical structures located within the thorax.
- ◆ Describe the relationship of each thoracic structure to surrounding structures.
- ◆ Describe the function of each anatomical structure located within the thorax.
- ◆ Locate each anatomical structure of the thorax on CT, MR and ultrasound images in the transverse axial, coronal, sagittal and oblique imaging planes.
- ◆ List and describe the function of each anatomical structure located within the abdomen and pelvis.
- ◆ Describe the relationship of each anatomical structure in the abdomen and pelvis to surrounding structures.
- ◆ Locate each anatomical structure of the abdomen and pelvis on CT, MR, PET and ultrasound images in the axial, coronal, sagittal and oblique planes.
- ◆ Name and describe the function of each anatomical structure located in the upper and lower extremities.
- ◆ Locate each anatomical structure in the upper and lower extremities on CT and MR images in the transverse axial, coronal, sagittal and oblique planes.

### Content

#### I. Head and Brain

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

- a. Precentral
  - b. Postcentral
- B. Sinuses
- 1. Frontal
  - 2. Maxillary
  - 3. Ethmoidal
  - 4. Sphenoidal
- C. Facial bones
- 1. Mandible
  - 2. Maxillae
  - 3. Zygomas
  - 4. Nasal bones
- D. Facial muscles
- E. Cranial bones
- 1. Frontal
  - 2. Ethmoid
    - a. Nasal conchae (turbinates)
    - b. Nasal septum
  - 3. Parietal
  - 4. Sphenoid
    - a. Lesser wings
      - 1) Tuberculum sellae
      - 2) Sella turcica
      - 3) Dorsum sellae
      - 4) Anterior and posterior clinoid process
      - 5) Optic canals
    - b. Greater wings
      - 1) Foramen rotundum
      - 2) Foramen ovale
      - a) Foramen spinosum
  - 5. Occipital
    - a. Foramen magnum
    - b. Internal and external occipital protuberance
    - c. Jugular foramen
  - 6. Temporal
    - a. Zygomatic process
    - b. External auditory meatus (EAM)
    - c. Internal auditory canal
    - d. Mastoid process
    - e. Petrous portion or ridge
- F. Lobes of the brain and midline cerebral hemisphere structures



1. Frontal
  2. Parietal
  3. Occipital
  4. Temporal
  5. Insula (Island of Reil)
  6. Cerebellum
  7. Corpus callosum (genu, rostrum, body and splenium)
  8. Septum pellucidum
  9. Sella turcica
  10. Pineal gland
  11. Falx cerebri
  12. Septum pellucidum
- G. Cranial nerves
1. Olfactory
  2. Optic
  3. Oculomotor
  4. Trochlear
  5. Trigeminal
  6. Abducens
  7. Facial
  8. Vestibulocochlear
  9. Glossopharyngeal
  10. Vagus
  11. Accessory
  12. Hypoglossal
- H. Brainstem and adjoining structures
1. Diencephalon
    - a. Thalamus
    - b. Hypothalamus
    - c. Optic chiasm
    - d. Optic tracts
    - e. Infundibulum (pituitary stalk)
    - f. Pituitary gland
    - g. Mammillary bodies
    - h. Pineal gland
  2. Midbrain
  3. Pons
  4. Medulla oblongata
    - a. Spinal cord
- I. Arteries (Circle of Willis)
1. Vertebral
  2. Basilar
  3. Internal carotid

4. Anterior and posterior communicating
5. Anterior and posterior cerebral
6. Middle cerebral

J. Veins

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

K. Ventricular system

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

L. Meninges

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

M. Basal ganglia

1. Caudate nucleus
2. Putamen
3. Globus pallidus
4. Claustrum
5. Internal capsule
6. External capsule
7. Extreme capsule

N. Orbit

1. Globe

2. Lens
  3. Optic nerve
  4. Lacrimal gland
  5. Lateral rectus muscle
  6. Medial rectus muscle
  7. Superior rectus muscle
  8. Inferior rectus muscle
  9. Superior oblique muscle
  10. Inferior oblique muscle
  11. Orbital fat
  12. Ophthalmic artery
  13. Retinal vein
- O. Anatomical structures of brain
1. Diploe
  2. Subcutaneous soft tissue
  3. Superior sagittal sinus (anterior and posterior)
  4. Central sulcus
  5. Interhemispheric fissure
  6. Falx cerebri
  7. Centrum semiovale
  8. Corpus callosum (genu, rostrum, body and splenium)
  9. Septum pellucidum
  10. Fornix
  11. Sylvian fissure
  12. Insula
  13. Lentiform nucleus (putamen and globus pallidus)
  14. Caudate nucleus (head)
  15. Internal capsule (anterior, body and posterior sections)
  16. External capsule
  17. Claustrum
  18. Hippocampus
  19. Cerebral peduncles
  20. Mammillary bodies
  21. Tentorium cerebelli
  22. Petrous portion or ridge
  23. Cerebellar tonsil
  24. Internal auditory canal (IAC)
  25. Nasal septum
  26. External auditory canal (EAC)
  27. Clivus
  28. Mastoid air cells
- P. Lines of angulation (imaging baselines)
1. Supraorbitomeatal line
  2. Orbitomeatal line

3. Infraorbitomeatal line

Q. Anatomical landmarks

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

**II. Neck**

A. Bones

1. Cervical vertebrae

B. Organs

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

C. Vasculature and neurovasculature

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

D. Musculature

1. Anterior triangle
2. Posterior triangle

**III. Chest and Mediastinum**

A. Bony thorax

1. Thoracic vertebrae
2. Sternum
3. Ribs
4. Costal cartilages
5. Scapulae
6. Clavicles

B. Pulmonary

1. Apices (lung)
2. Diaphragm
3. Angles

4. Hilum
5. Lobes (lungs)
6. Trachea
7. Carina
8. Primary (mainstem) bronchi
9. Secondary bronchi

C. Mediastinum

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

D. Breasts

E. Musculature

**IV. Abdomen**

A. Diaphragm and openings

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

B. Surface landmarks and regions

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

C. Addison's planes (regions)

1. Left hypochondric
2. Epigastric
3. Right hypochondric
4. Left lumbar
5. Umbilical
6. Right lumbar
7. Left iliac
8. Hypogastric
9. Right iliac

D. Branches of the abdominal aorta

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

E. Tributaries of the vena cava

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

- b. Median sacral
- F. Tributaries of the portal vein
- 1. Splenic
  - 2. Inferior mesenteric
  - 3. Superior mesenteric
    - a. Left gastric
    - b. Right gastric
    - c. Cystic
- G. Abdominal organs and structures
- 1. Bony structures
    - a. Lumbar vertebrae
  - 2. Abdominal cavity
    - a. Peritoneum
    - b. Peritoneal space
    - c. Retroperitoneum
    - d. Retroperitoneal space
  - 3. Liver
    - a. Hepatic arteries
    - b. Portal venous system
  - 4. Gallbladder and biliary system
  - 5. Pancreas and pancreatic ducts
  - 6. Spleen
  - 7. Adrenal glands
  - 8. Urinary system and tract
    - a. Kidneys
    - b. Ureters
  - 9. Stomach
  - 10. Small intestine
  - 11. Colon
  - 12. Musculature
- V. Pelvis
- A. Bony structures
- 1. Proximal femur
  - 2. Ilium
  - 3. Ischium
  - 4. Pubis
  - 5. Sacrum
  - 6. Coccyx
- B. Pelvic vasculature
- 1. Arterial
    - a. Common iliacs
    - b. Internal iliacs

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

## **VI. Musculoskeletal**

- A. Upper extremities
  - 1. Shoulder
    - a. Bony anatomy
      - 1) Clavicle
      - 2) Scapula
      - 3) Humerus
      - 4) Acromioclavicular joint
    - b. Muscles and tendons
      - 1) Deltoid
      - 2) Supraspinatus
      - 3) Infraspinatus
      - 4) Teres minor



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

- 3) Radial artery
- 4) Median nerve

B. Lower Extremities

1. Hip
  - a. Bony anatomy
  - b. Labrum and ligaments
  - c. Muscle groups
  - d. Neurovasculature
2. Knee
  - a. Bony anatomy
  - b. Menisci and ligaments
  - c. Muscles
  - d. Vasculature
3. Foot and Ankle
  - a. Bony anatomy
  - b. Ligaments
  - c. Tendons
  - d. Muscles

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## Radiologic Science Resources

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.

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