Radiography Curriculum

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Radiography Curriculum *was produced by the ASRT Radiography Curriculum Revision Project Group.*

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 of 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 the entry-level of the radiologic sciences. Beginning in January 2015, candidates seeking professional certification through the American Registry of Radiologic Technologists (ARRT) are required to possess, at minimum, an associate degree. The focus of this document is on pre-professional core content that can be expanded with institution-specific content in order to fulfill the requirements for an academic degree.

Organization:

The document itself is divided into three content areas: pre-professional core, optional content and radiologic science resources.

- Pre-professional core content: This content makes up the body of the document and includes educational content the professional community supports as essential preparation to enter the field of radiography. Specific instructional methods were intentionally omitted to allow for programmatic prerogative as well as creativity in instructional delivery.
- Optional content: Content in this section will assist programs wishing to enhance the curriculum with select topics intended to satisfy the mission of their program or the requirements of their local employment market.

A list of learning objectives associated with each content area has been incorporated into this document to serve as a resource for programs. Learning objectives are offered as a guide. Faculty members are encouraged to expand these fundamental objectives as they incorporate them into their curricula.

Radiography programs are encouraged to organize the content and objectives to meet their 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 flexibility to meet the needs of the local community, yet also satisfy the requirements for accreditation standards and the ARRT examination. The curriculum also offers a

foundation for a transition to baccalaureate studies and, more importantly, for individual lifelong learning.

Professional Characteristics:

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 should exhibit the following professional characteristics:

- Prudent judgment in administering ionizing radiation to produce diagnostic images.
- A focus on providing optimal patient care in an evolving and diverse society.
- An understanding of the challenges associated with providing direct patient care in today's health care setting.
- The ability to work collaboratively in a dynamic healthcare environment.
- The skills to research and evaluate sources of information to be utilized in evidence-based practice.
- Stewardship over the security and confidentiality of patient medical information.
- Skills that promote lifelong learning.
- A willingness to collaborate with others in the community to promote standards of excellence in the medical imaging sciences.
- A willingness to contribute to the education and clinical skill development of radiologic science students.

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. All these skills 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.

Starting in 2015, the ARRT began requiring an associate degree in order to apply for the certification exam for radiography, eliminating the need for specific general education requirements in the radiography curriculum. Because individual states, accreditation agencies, and educational systems have unique general education requirements, the content listed below is designed to serve only as guidance for program development.

Postsecondary general education should be gained through courses that provide college credit and meet the general content objectives listed below:

Mathematics and reasoning

- Demonstrate skills in analysis, quantification and synthesis.
- Apply problem-solving or modeling strategies.

Communication

- Write and read critically.
- Speak and listen critically.
- Perceive, gather, organize and present information.
- Locate, evaluate and synthesize material from diverse sources and points of view.

Humanities

- Demonstrate respect for diverse populations.
- Define ethics and the role they play in personal and professional interactions.
- Critically examine personal attitudes and values.

Information systems

- Use computerized systems to acquire, transfer and store digital information.
- Use technology to retrieve, evaluate and apply information.

Social sciences

- Adapt interactions to meet the cultural and psychological needs of individuals.
- Describe individual and collective behavior.
- Exhibit and develop leadership skills.
- Exercise responsible and productive citizenship.
- Function as a public-minded individual.

Natural sciences

- Arrive at conclusions using the scientific method.
- Make informed judgments about science-related topics.
- Develop a scientific vocabulary.

Radiography Curriculum

Table of Contents

Pre-professional Core Content

This content makes up the body of the document and reflects educational content the professional community supports as essential for readiness to enter the radiography field.

Introduction to Radiologic Science and Health Care

Description
The content below provides an overview of the foundations of radiography and the practitioner's role in health care delivery. Principles, practices and policies of health care organizations should be examined and discussed in addition to the professional responsibilities of the radiographer.

Content

I. The Health Science Professions

A. Radiologic technology
1. Applications specialist
2. Bone densitometry
3. Breast sonography
4. Cardiac-interventional radiography
5. Computed tomography
6. Diagnostic medical sonography
7. Diagnostic radiography
8. Education
9. Magnetic resonance imaging
10. Mammography
11. Management
12. Medical dosimetry
13. Multiskilled (fusion technology)
14. Nuclear medicine advanced associate
15. Nuclear medicine technology
16. PACS administration/informatics
17. Quality management
18. Radiation therapy
19. Radiologist assistant
20. Vascular sonography
21. Vascular-interventional radiography

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

10. Other (e.g., jails, prisons, medical examiner offices)

B. Payment/reimbursement systems
   1. Self-pay
   2. Insurance
   3. Government programs

III. Medical Terminology

A. The word-building process
   1. Basic elements
      a. Root words
      b. Prefixes
      c. Suffixes
      d. Combination forms

B. Translation of medical terms into layman's terms

C. Correct pronunciation of medical terms

IV. Medical Abbreviations and Symbols

A. Abbreviations
   1. Examples
   2. Interpretations
   3. Restrictions (e.g., The Joint Commission's "Do Not Use" list)

B. Pharmaceutical symbols and terms

V. Procedures and Terminology

A. Radiography

B. Other imaging modalities

C. Radiation oncology

VI. Understanding Orders, Requests and Diagnostic Reports

A. Procedure orders and requests
   1. Patient identification
   2. Procedures ordered
   3. Patient history
   4. Clinical indications
   5. Ordering physician/provider

B. Diagnostic reports
   1. Content
   2. Interpretation

VII. Hospital Organization

A. Mission

B. Administrative services
   1. Governing board
   2. Hospital administration
   3. Admissions
   4. Information systems
   5. Procurement
   6. Accounting
   7. Support services
   8. Human resources

C. Medical services
   1. Physicians
   2. Clinical services
   3. Clinical support services

VIII. Radiology Organization

A. Professional personnel
   1. Administrators/managers
   2. Radiologists
   3. Radiologic technologists
   4. Radiologist assistants
   5. Radiology nurses
   6. Medical physicists

B. Support personnel
   1. Information Technology staff
   2. Clerical staff
   3. Other (e.g., patient transporters, aids)

C. Educational personnel
   1. Program director
   2. Clinical coordinator
   3. Didactic instructor
   4. Clinical instructor
   5. Clinical staff

IX. Accreditation

A. Health care institutions

B. Modalities (e.g., ACR)

C. Educational

1. Programmatic accreditation (e.g., Joint Review Committee on Education in Radiologic Technology [JRCERT])
2. Regional
3. Other

X. Regulatory Agencies

A. Federal

B. State

XI. Professional Credentialing

A. National certification and registration (e.g., American Registry of Radiologic Technologists [ARRT])

B. State licensure

XII. Professional Organizations

A. Purpose, function and activities

B. Types
   1. Local
   2. State
   3. National
   4. International
   5. Other (e.g., student)

XIII. Professional Development and Advancement

A. Required
   1. Continuing education
   2. Continuing qualifications requirements (CQR)

B. Clinical experience

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

D. Employment considerations
   1. Geographic mobility
   2. Economic factors
   3. Workforce needs

E. Advancement opportunities
   1. Education

2. Administration
3. Advanced practice
4. Medical physics
5. Research
6. Industrial
7. Medical informatics
8. Sales/applications

Introduction to Radiologic Science and Health Care

Objectives: This list of learning objectives serves as a resource for programs:

- Identify health science professions that participate in the total health care of the patient.
- 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 a health care 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 accreditation types.
- Identify state and federal regulatory agencies.
- Define credentialing, national certification and registration and state licensure.
- Describe the types, purposes and functions of professional organizations.
- Discuss career opportunities and advancement for the radiographer.
- Identify the benefits of continuing education as related to improved patient care and professional development.
- Apply the word-building process of medical terminology.
- Interpret medical abbreviations and symbols.
- Critique orders, requests and diagnostic reports.
- Define medical imaging and radiation oncology terms.
- Translate medical terms, abbreviations and symbols from medical reports into layman's terms.

Ethics and Law in the Radiologic Sciences

Description
This 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. Ethical principles

C. Moral reasoning

D. Personal behavior standards

E. Competence

F. Professional attributes

G. Standards of practice

H. Self-assessment and self-governance

I. Codes of professional ethics

J. Systematic analysis of ethical problems

K. Ethical violations and sanctions

II. Ethical Issues in Health Care

A. Individual and societal rights

B. Cultural considerations

C. Economical considerations

D. Technology

E. Scarce resources

F. Access to quality health care

G. Human experimentation and research

H. End-of-life issues

I. Ethical research
   1. Institutional review board approval
   2. Data collection
   3. Data reporting

J. Radiology-specific
   1. Operation and manipulation of electronic data
      a. Image cropping
      b. Editing metadata
      c. Editing image data
   2. ALARA
      a. Dose creep
      b. Alteration of exposure indicators

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, email, photography)

C. Torts
   1. Intentional
   2. Unintentional

IV. Legal Doctrines and Standards

A. Legal risk reduction and risk management

B. Medical records
   1. Timely, accurate and comprehensive methods of documentation
   2. Radiographic images as legal documents
   3. Manipulation of electronic data

V. Patient Consent

A. Definition

B. Types

C. Condition for valid consent

D. Documentation of consent

E. Right of refusal

Ethics and Law in the Radiologic Sciences

Objectives: This list of learning objectives serves as a resource for programs:

- Discuss the origins of medical ethics.
- Apply medical and 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 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 timely, accurate and comprehensive methods of documentation as a legal and ethical imperative.
- Explore theoretical situations and questions relating to the ethics of 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 informed consent and disclosure of protected health information.
- 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 Anatomy and Physiology

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

Content

I. Anatomical Nomenclature

A. Directional references
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. Water

D. Organic compounds
1. Carbohydrates
2. Lipids
3. Proteins
4. Nucleotides

a. DNA
b. RNA

III. Cell Structure and Genetic Control

A. Cell membrane
1. Chemistry
2. Structure
3. Physiology
4. Transport processes
a. Diffusion
b. Osmosis
c. Filtration
d. Active transport and 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 and 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. Epiphyseal line
      d. Metaphysis
   3. Classification and markings
      a. Long
      b. Short
      c. Flat
      d. Irregular
      e. Processes and bony projections
      f. Depressions and 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. Segmentation
4. Digestion
5. Absorption
6. 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 and ureters
    f. Peritoneum
    g. Retroperitoneum
    h. Gastrointestinal (GI) tract
    i. Major vessels

Human Anatomy and Physiology

Objectives: This list of learning objectives serves as a resource for programs:

- 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.
- 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 and neck, thorax and abdomen.

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 the introduction of 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 along 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. Drug Classification
- A. Chemical group
- B. Mechanism and site of action
- C. Primary effect

III. General Pharmacologic Principles

A. Pharmacokinetics

B. Pharmacodynamics

C. Pharmacogenetics

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 route

F. The right documentation

V. Drug Categories Relevant to Radiography (Uses and Impact 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 compounds
   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. Oral

B. Rectal

C. Tube or catheter

D. Inhalation

E. Topical

F. Parenteral
    1. Intravenous
    2. Intra-arterial
    3. Intrathecal
    4. Intramuscular
    5. Subcutaneous
    6. Intradermal
    7. Intraosseous

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. 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
        e. Emergency medical treatment follow-up tasks

D. Complications
    1. Infiltration
    2. Extravasation
    3. Phlebitis

4. Air embolism
5. Drug incompatibility
6. Low fluid level in container

E. Discontinuation
1. Equipment and supplies for withdrawal
2. Patient preparation
3. Application of standard precautions
4. Withdrawal procedure
5. Site observation
6. Patient observation
7. Postprocedural tasks

F. Documentation of administration

G. Documentation of complication or 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

Pharmacology and Venipuncture

Objectives: This list of learning objectives serves as a resource for programs:

- Distinguish between the chemical, generic and trade names of various drugs.
- Describe the pharmacokinetic, pharmacodynamic and pharmacogenetic principles of drugs.
- Explain the uses and impact on the patient of different categories of drugs.
- 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 or intravenous medications using aseptic technique.
- Explain the current legal status and professional liability issues of the radiographer's role in contrast and drug administration.

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. Electrical safety
   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. Three phase
   3. High frequency

II. Radiographic Equipment

A. Fixed units
   1. Components
      a. Tubes
      b. Collimators
      c. Tables
      d. Control panels
      e. Tube support systems

f. Wall units
g. Potter-Bucky mechanism

2. Equipment operation and manipulation
3. Applications

B. Mobile units
1. Components
a. Tubes
b. Collimators
c. Control panels
d. Tube support systems
2. Equipment operation and manipulation
3. Clinical applications (e.g. ED, OR, patient rooms)

C. Automatic exposure control (AEC)
1. Radiation detector
a. Ionization chamber
b. Digital image receptor
2. Minimum response time
3. Backup time
4. Alignment and positioning considerations
a. Sensor selection
b. Sensor configuration
c. Sensor sensitivity
5. Compensation issues
a. Contrast agents
b. Patient size
c. Pathology
d. Prosthetics/implants
e. Collimation
f. 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. Anode thermal capacity and exposure limits
5. Tube movement

IV. Fluoroscopy

A. Image intensified
1. Brightness gain
2. Flux gain

3. Minification gain
4. Automatic brightness control (ABC)/Automatic exposure rate control (AERC)
5. Multi-field intensifiers
    a. Magnification
    b. Dose
6. CCD/CMOS
7. Fiberoptics

B. Pulsed
1. mA level
2. Pulse rate
3. Pulse width
4. Temporal frame averaging

C. Flat panel
1. Direct
2. Indirect

D. Mobile
1. C-arm
2. Mini C-arm
3. Hand-held
4. O-arm

E. Image quality
1. Spatial resolution
2. Contrast
3. Distortion
4. Noise

F. Viewing systems

G. Image recording systems

H. Operation and manipulation

V. Overview of Quality Control

A. Radiographic
1. kVp accuracy
2. Filtration and half-value layer (HVL)
3. Exposure reproducibility
4. Exposure linearity
5. Timer accuracy
6. Beam alignment
7. Collimator accuracy
8. Image receptors

9. Automatic exposure control (AEC)

B. Fluoroscopic
   1. Exposure rate
   2. Source-to-skin distance (SSD)
   3. Automatic brightness systems (ABS)/Automatic exposure rate control (AERC)
   4. kVp accuracy
   5. Filtration and half-value layer (HVL)
   6. Exposure reproducibility
   7. Exposure linearity
   8. Focal spot size
   9. Beam alignment
   10. Collimator accuracy
   11. Visual/audible monitors

C. Protective apparel

Imaging Equipment

Objectives: This list of learning objectives serves as a resource for programs:

- Describe potential difference, current and resistance.
- Describe the general components and function of the x-ray circuit to include the tube and filament circuits.
- Compare generators in terms of radiation produced and efficiency.
- Discuss fixed and mobile radiographic equipment in terms of purpose, components, types and applications.
- Demonstrate operation of various types of fixed and mobile radiographic equipment.
- Describe the components and function of automatic exposure control (AEC) devices.
- Demonstrate proper use of AEC devices.
- Describe the components and function of diagnostic x-ray tubes.
- Explain methods used to extend x-ray tube life.
- Discuss fixed and mobile fluoroscopic equipment in terms of purpose, components, types and applications.
- Explain image-intensified, flat panel and pulsed fluoroscopy.
- Indicate the purpose, construction and application of the fluoroscopic monitor.
- Discuss quality control (QC) for imaging equipment and accessories.
- Evaluate the results of standard QC tests.

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 (e.g., frequency, wavelength, velocity)
  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 ($T_{½}$)

III. X-ray Production
- A. Historical introduction

B. Target interactions
   1. Bremsstrahlung
   2. Characteristic

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. Factors that affect x-ray emission spectrum
   1. kVp
   2. mA
   3. Time
   4. Atomic number of target
   5. Filtration
   6. Generator phasing

IV. Interaction of Photons with Matter

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

B. Types and descriptions
   1. Unmodified scattering (coherent)
   2. Photoelectric effect
   3. Modified scattering (Compton)

C. Probability of occurrence
   1. Atomic number
   2. Photon energy
   3. Tissue volume
   4. Part thickness

D. Effect on image

E. Patient and operator dose effects

Radiation Production and Characteristics

Objectives: This list of learning objectives serves as a resource for programs:

- 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 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 spectrum.
- Explain the factors that affect the x-ray emission spectrum.
- Discuss various photon interactions with matter.
- Discuss relationships of wavelength and frequency to beam characteristics.
- Discuss the clinical significance of the photoelectric and modified scattering (Compton) interactions in diagnostic imaging.

Principles of Exposure and Image Production

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

Content

I. Exposure Factors

A. Distance

B. mA

C. Time

D. Focal spot size

E. kVp

F. Grids

G. AEC

H. Beam restriction

I. Filtration

II. Receptor Exposure

A. Factors that affect exposure receptors (e.g. anode-heel, OID, patient pathology)

B. Receptor exposure calculations
   1. Reciprocity law
   2. 15 percent rule
   3. Grid conversion factor
   4. Direct square law/exposure maintenance formula

III. Differential Absorption

A. Components
   1. Anatomy
   2. Contrast agent
   3. Pathology

B. Beam quality
   1. kVp
   2. Filtration
   3. HVL

IV. Spatial Resolution

A. Motion
   1. Part
   2. Equipment

B. Geometric
   1. Focal spot size
   2. Source-to-image receptor distance (SID)
   3. Object-to-image distance (OID)

C. Digital Characteristics
   1. Pixel characteristics (e.g. size, pitch)
   2. Detector element (DEL) (e.g. size, pitch, fill-factor)
   3. Matrix size
   4. Sampling frequency

V. Shape Distortion

A. Foreshortening

B. Elongation
   1. Tube/ part/ receptor relationships
   2. Display aspect ratio

VI. Magnification

A. Geometric factors
   1. Source-to-image receptor distance (SID)
   2. Source-to-object distance (SOD)
   3. Object-to-image receptor distance (OID)

B. Display

VII. Beam Restriction

A. Function/purpose
   1. Reduce irradiated tissue volume
   2. Reduce patient dose
   3. Scatter reduction

B. Types
   1. Collimators
   2. Lead Blockers

C. Collimator components
   1. Automatic collimators
   2. Cylinders

VIII. Beam Filtration

A. Types
   1. Inherent
   2. Added
   3. Compensating

B. Function/mechanism

C. Impact on image characteristics

D. Impact on HVL

IX. Scatter Radiation

A. Prevention
   1. Collimation
   2. kVp

B. Reduction
   1. Grid
   2. Lead masking
   3. Air gap (OID)

C. Effects
   1. Image quality
   2. Patient dose
   3. 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. Grid radius/focal range
   2. Ratio
   3. Frequency

4. Grid conversion factor

E. Selection
   1. kVp
   2. Patient/exam
   3. Focal range
   4. Alignment latitude

F. Primary cutoff

XI. Exposure Factor Formulation

A. Purpose
   1. Exposure standardization
   2. Patient exposure reduction

B. Technique charts
   1. Fixed kVp/variable mAs
   2. Variable kVp/fixed mAs

C. Automated systems
   1. Automatic exposure control
   2. Anatomically programmed technique

Principles of Exposure and Image Production

Objectives: This list of learning objectives serves as a resource for programs:

- 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 spatial resolution on various radiographic images.
- Analyze the relationships of factors that control and affect spatial resolution.
- 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.
- Explain the rationale for using beam restriction.
- Describe the operation and applications for different types of beam restriction.
- Explain how beam filtration affects x-ray beam intensity, beam quality and patient exposure.
- Describe the change in the half-value layer (HVL) when filtration is added or removed.
- Summarize the relationship of factors affecting scattered 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 the 15 percent rule.

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. Image Acquisition

A. Detectors
   1. Direct conversion and thin film transistor (TFT) arrays
   2. Indirect conversion and thin film transistor (TFT) arrays
   3. Charge-coupled device (CCD) and complementary metal oxide semiconductor (CMOS) systems
   4. Photostimulable phosphor (PSP) plate

B. Evaluation of detector characteristics
   1. Detective quantum efficiency (DQE)
   2. Modulation transfer function (MTF)
   3. Spatial resolution

C. Dynamic range

D. Raw data extraction
   1. Data extraction (e.g., TFT, PSP, CCD)
   2. Analog to digital conversion
   3. Exposure field recognition
   4. Region of interest (ROI)
   5. Histogram analysis
   6. Exposure index

E. Exposure indicators and deviation index
   1. Air kerma (e.g. K indicator)
   2. Deviation index (DI)
   3. Exposure indicators
      a. Centering and beam collimation
      b. Optimal value ranges

II. Initial Processing

A. Preprocessing

B. Image analysis
   1. Segmentation
   2. Exposure field recognition
   3. Region of interest (ROI)
   4. Histogram formation
   5. Histogram analysis

C. Rescaling

D. Values of interest (VOI)

E. Grayscale/look-up table (LUT)

F. Noise reduction

G. Smoothing

H. Edge enhancement

I. Equalization

III. Post Processing

A. Brightness adjustment

B. Grayscale (contrast) adjustment

C. Equalization

D. Smoothing

E. Edge enhancement

F. Image reformatting (e.g., electronic masking, resizing, rotation)

IV. Image Acquisition Errors

A. Histogram analysis
   1. Incorrect anatomic menu selection
   2. Exposure field recognition
      a. Collimation border recognition
      b. Exposure field distribution – multiple fields/plate
   3. Unexpected material in data set (e.g., metal)
   4. Overexposure

5. Underexposure
6. Saturation
7. Failure of automatic rescaling – dark or light image

B. Low intensity radiation response
   1. Impact of accumulated background radiation
   2. Image retention (e.g., ghosting)

C. Scatter control
   1. Beam restriction
   2. Grid use
      a. Kilovoltage peak (kVp)
      b. Grid cutoff

V. Quality Management

A. Continuous quality improvement (CQI)
   1. Standards for quality
   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. Quality Assurance and Maintenance Issues
   1. Technologist responsibilities
      a. Image quality control
         1) Exposure indicator accuracy
         2) Image integrity
   2. Imaging receptor systems
      a. Receptor maintenance
         1) Cleaning and inspection
         2) Erasure
      b. Equipment calibration
      c. Uniformity
      d. Spatial resolution
   3. Reject analysis
   4. Monitor patient exposure
      a. Part of quality assurance (QA) program
      b. Vendor-supplied software
   5. Service engineer and/or medical physicist
      a. Notification process
      b. Preventive maintenance
   6. Involvement in quality control

C. Benefits
    1. Patient safety
    2. Reduced radiation exposure
    3. Efficacy of patient care
    4. Departmental efficiency
    5. Consistent image quality
    6. Cost-effectiveness

VI. Image Display

A. Monitor
    1. Characteristics
        a. Aspect ratio
        b. Spatial resolution
        c. Brightness
        d. Contrast ratio
        e. Color vs. grayscale
        f. Pixels
        g. Active matrix array (i.e., AMOLED)
        h. Nematic liquid crystals
        i. Light polarization
        j. Backlighting
    2. Care and maintenance
    3. Quality control
        a. Grayscale standard display (e.g. SMPTE)
        b. Luminance
        c. Resolution

B. Viewing conditions
    1. Ambient lighting
    2. Viewing angle

C. Hard copy (i.e., laser film)

VII. Data Management

A. Network connectivity

B. Hospital/Health 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)
        a. DICOM header

4. DICOM metadata radiographer responsibilities
    a. Access work order (worklist)
    b. Postprocessing – image operation and manipulation
    c. Annotation issues
    d. Image transmission
    e. HIPAA
    f. Workflow

E. Electronic medical record (EMR) or electronic health record (EHR)

F. Teleradiology

Digital Image Acquisition and Display

Objectives: This list of learning objectives serves as a resource for programs:

- 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 of a digital imaging system.
- Define sampling frequency.
- Describe the Nyquist-Shannon theorem as it relates to sampling frequency.
- Describe the impact of sampling frequency on spatial resolution.
- Describe the impact of detector element size on spatial resolution.
- Describe detective quantum efficiency (DQE) for digital radiography detectors.
- Describe modulation transfer function (MTF) as it relates to digital radiography detectors.
- Describe the histogram and the process of histogram analysis as it relates to automatic rescaling.
- Describe the calculation of the exposure indicator (AAPM Task Group 116).
- Define region of interest (ROI).
- Relate the location and size of the ROI to the appearance of the image and exposure indicator.
- Relate how the values of interest (VOI) impact image appearance.
- Describe the process of image stitching.
- 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.
- 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 of radiographic exposure to digital detectors.
- Evaluate the effect of a given exposure change on histogram shape, data width and image appearance.
- Formulate a procedure or process to minimize histogram analysis and rescaling errors.
- Describe continuous quality improvement (CQI).
- Differentiate between quality assurance (QA) and quality control (QC).
- List the benefits of a quality control management to the patient and to the department.
- 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.

- Discuss the appropriate use of electronic masking.
- Describe picture archival and communications system (PACS) and its function.
- Identify components of a PACS.
- Define digital imaging and communications in medicine (DICOM).
- Identify critical components of the DICOM header.
- Describe HIPAA concerns with electronic information.
- Identify common problems associated with retrieving/viewing images within a PACS.
- Compare monitor types (e.g. acquisition, display).
- Describe the components of the various types of display monitors.
- Discuss the impact of viewing angle, luminance, ambient lighting, and pixel size on image display.
- Describe display monitor aspect ratio and its impact on image display.

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 and 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 radiologic technologist
  1. Determining cause of problems
  2. Corrective actions
     a. Recommending
     b. Implementing
- D. Establishing acceptable limits

III. Image Appearance Characteristics
- A. Brightness
- B. Noise
  1. Random (e.g., quantum mottle, scatter)
  2. Periodic (e.g., electronic interference, detector malfunction, software)
- C. Grayscale (contrast)
- D. Signal-to-noise ratio (SNR)
- E. Contrast-to-noise ratio (CNR)
- F. Spatial resolution
  1. Motion

2. Geometric
3. Receptor and detector

G. Contrast resolution

H. Shape distortion

I. Magnification
1. Geometric
2. Display

IV. Procedural Factors

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

B. Positioning
1. Anatomical considerations
a. Anatomy of interest
b. Plane/baseline reference
c. Central ray
1) Location
2) Angulation
d. Anatomical variations
e. Body habitus
f. Pathology
2. Positioning aids

C. Exposure indicator appropriateness

D. Radiation protection
1. Collimation
2. Shielding
3. Repeated images

E. Patient preparation
1. Contrast agents
2. Pre-examination preparation

F. Artifacts
1. Patient-related
2. Equipment-related
a. Radiographic
b. Digital

c. Display monitor

V. Corrective Action

A. Equipment malfunction

B. Technical factors

C. Procedural factors

D. Artifacts

Image Analysis

Objectives: This list of learning objectives serves as a resource for programs:

- 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.
- Describe contrast to noise (CNR) as it relates to digital radiography detectors.
- Describe signal to noise (SNR) as it relates to digital radiography detectors.
- Describe the conditions that cause quantum mottle in a digital image.
- Apply a process for evaluating images for adequate image receptor exposure, exposure indicator contrast/grayscale/spatial resolution, identification markers and appropriate use of beam restriction.
- Apply a process for evaluating images for acceptable limits of distortion, image artifacts, radiation fog, noise and gross exposure error.
- Summarize the importance of proper positioning.
- Discuss the impact of patient preparation on the resulting radiographic image.
- 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.

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. Cardiovascular-interventional radiology
3. Nuclear medicine
4. 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 affecting energy transfer
1. Linear energy transfer (LET)
2. Relative biological effectiveness (RBE)
3. Factors influencing RBE
a. LET
b. Oxygen enhancement ratio (OER)

III. Radiation Effects

A. Subcellular radiation effects
1. Radiation effects on DNA
a. Types of damage
b. Implications for humans
2. Radiation effects on 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. Linear energy transfer (LET)
    b. Relative biologic effect (RBE)
    c. Oxygen enhancement ratio (OER)
    d. Fractionation
    e. Protraction
    f. Lethal dose and LD_{50}

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

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
   1. Relative
   2. Excess
   3. Absolute

Radiation Biology

Objectives: This list of learning objectives serves as a resource for programs:

- Differentiate between ionic and covalent molecular bonds.
- Describe principles of cellular biology.
- Identify sources of electromagnetic and particulate ionizing radiations.
- 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 and biophysical events at the cellular and subcellular level.
- Identify methods to measure radiation response.
- Describe physical, chemical and biologic factors influencing the radiation response of cells and tissues.
- Explain factors influencing radiosensitivity.
- Recognize the clinical significance of lethal dose (LD).
- Identify the radiosensitivity of specific cells.
- 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.
- Differentiate between the stochastic (probabilistic) and nonstochastic (deterministic) effects of radiation exposure.
- Discuss embryonic and fetal effects of radiation exposure.
- Discuss risk estimates for radiation-induced malignancies.
- Discuss acute radiation syndromes.

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. Système International d'Unités (SI Units)
      a. Exposure - Coulomb/kilogram (C/kg)
      b. Absorbed dose - Gray (Gy)
      c. Air kerma
         1) Kinetic energy release in matter
         2) Measurement unit in gray
      d. Dose equivalent - Sievert (Sv)
      e. Radioactivity - Becquerel (Bq)
   2. Traditional
      a. Exposure - Roentgen (R)
      b. Absorbed dose (Rad)
      c. Dose equivalent (Rem)

d. Radioactivity - 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

D. Dose area product meter (DAP)
   1. Parameters
   2. Interpretation

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 and 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. Qualifications
   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/audible monitors (e.g. fluoroscopic timer, "beam on" notification)
      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. 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. Principles (ALARA)

B. Radiation safety practices
   1. Beam restriction
   2. Shielding
   3. Exposure factors
   4. Positioning

5. Immobilization

C. Education

D. Equipment and accessories
   1. Filtration
   2. Image receptor system

E. Fluoroscopic procedures

F. Mobile radiography

G. Special considerations
   1. Pediatric patients
   2. Pregnant patients
   3. Bariatric patients

Radiation Protection

Objectives: This list of learning objectives serves as a resource for programs:

- Identify and justify the need to minimize unnecessary radiation exposure of humans.
- 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.
- Describe the operation of various interlocking systems for equipment.
- 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 qualifications 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 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 or fluoroscopic 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/fluoroscopic procedures.

Clinical Practice

Description
Content and clinical practice experience 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 prior to, during and following the radiologic procedure.

Content

I. Clinical Practice

A. Code of ethics and professional behavior
   1. ARRT Code of Ethics incident reporting mechanisms
   2. Standards for supervision
      a. Direct
      b. Indirect
   3. Understanding the patient's expectations, rights and responsibilities
   4. Understanding the radiographer's professional 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 [HIPAA] compliance)

C. Radiography Practice Standards
   1. Scope of Practice
   2. Clinical Performance Standards
   3. Quality Performance Standards
   4. Professional Performance Standards
   5. ASRT's Advisory Opinion Statements

D. Values
   1. Personal
      a. Values development
      b. Impact on patient care
   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
   d. Impact of social media

E. Culture and diversity
1. Societal and individual factors
2. Socioeconomic factors
3. Gender
4. Ethnicity
5. Race
6. Age
   a. Infant
   b. Child
   c. Adolescent
   d. Adult
   e. Middle-aged
   f. Geriatric
7. Family structure and dynamics
8. Geographical factors
9. Religion, spirituality and belief system
10. Lifestyle choices and behaviors
11. Sexual orientation
12. 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 (HIPAA)
3. Documentation
4. Infection control
5. Patient education
   a. Appropriate communication style
   b. Age-specific

c. Cultural sensitivity
d. Socioeconomic sensitivity
e. Patient-focused care

6. Medical error reduction
7. Patient safety considerations

E. Imaging
1. Positioning considerations
2. Technical considerations
3. Image acquisition
4. Image analysis

F. Radiation protection
1. Principles (ALARA)
2. Radiation safety practices
a. Protection of the patient
b. Protection of personnel
c. Protection of others
3. Education
a. Patient and family members
b. Other members of the healthcare team
4. Equipment and accessories

III. Clinical Competency

ARRT Competency Requirements (refer to the document located at www.arrt.org)*

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

Clinical Practice

Objectives: This list of learning objectives serves as a resource for programs:

- 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.

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 and 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. Colloquialisms and slang
        b. Medical terminology
    5. Patient interactions
        a. Eye contact
        b. Volume and speed of speech
        c. Effective listening
        d. Feedback
        e. Cultural sensitivity
    6. Communication with families
    7. Communication with other health care professionals (e.g. SBAR, TeamSTEPPS)

E. Psychological considerations
    1. Dying and death
        a. Understanding the process
        b. Aspects of death
            1) Emotional
            2) Personal
            3) Physical
        c. Grief and counseling
        d. Patient support services
            1) Family and 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 and 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 and 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

A. Environmental safety
1. Fire
2. Electrical
3. Hazardous materials
a. Chemicals
b. Chemotherapy
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. Log roll
c. Positioning for safety, comfort or exams
d. 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

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. Pulse oximetry
   4. Respiration
   5. Blood pressure
   6. Normal values
   7. Interfering factors
   8. Adult vs. pediatric
   9. Documentation

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_2) 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

F. Pain Assessment
   1. Description
   2. Intensity
   3. Location
   4. Duration
   5. Aggravating and alleviating factors

VI. Infection Control

A. Hospital acquired

B. Communicable

C. Infectious pathogens

D. Multidrug-resistant organisms (MDRO)

E. Other

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

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

H. Prevent disease transmission
    1. Transmission-based precautions
    2. Health care worker
        a. Immunization
        b. Booster
        c. Post-exposure protocols

I. 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
            5) Radiation
        c. Procedures
            1) Opening packs
            2) Gowning/gloving
            3) Skin preparation
            4) Draping
            5) Dressing changes
        d. Packing
        e. Storage
        f. Linen

J. Isolation techniques and communicable diseases
    1. Category-specific
    2. Disease-specific
    3. Standard precautions

K. Procedure
    1. Gowning
    2. Gloving
    3. Masking
    4. Patient transfer
    5. Cleaning and proper disposal of contaminated waste
    6. Cleaning image receptors and imaging equipment

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

M. Psychological considerations

VII. Medical Emergencies

A. Emergency equipment

B. Latex reactions

C. Shock
   1. Signs and symptoms
   2. Types
      a. Hypovolemic
      b. Distributive
         1) Anaphylactic
         2) Neurogenic
         3) Septic
      c. Cardiogenic
   3. Medical intervention

D. Diabetic emergencies – signs, symptoms and interventions
   1. Hypoglycemia
   2. Hyperglycemia (ketoacidosis)
   3. Hyperosmolar coma

E. Respiratory and cardiac failure – signs, symptoms and interventions
   1. Adult vs. pediatric
   2. Equipment

F. Airway obstruction – signs, symptoms and interventions

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

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

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

VIII. Trauma

A. Head injuries
   1. Glasgow coma scale
   2. Symptoms
   3. Medical intervention

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

C. 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. Reactions to Contrast Agents

A. Signs and symptoms

B. Medical intervention

X. Tubes, Catheters, Lines and Other Devices

A. Function and handling of devices

B. Nasogastric/nasointestinal

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

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

E. Chest (thoracostomy) tube
   1. Purpose

2. Location

F. Implanted devices
   1. Types
   2. Purpose
   3. Location

G. Venous catheters
   1. Types
   2. Purpose
   3. Location
   4. Care (e.g., infection control)
   5. Access

H. Tissue drains

I. Oxygen administration
   1. Values
   2. Oxygen therapy
   3. Oxygen delivery systems
      a. Low-flow systems
      b. High-flow systems
   4. Special precautions

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

K. Ostomies
   1. Types
   2. Purpose
   3. Location
   4. Care
   5. Access

XI. Mobile and Surgical Radiography

A. Prior to bedside procedure
   1. Verify order

B. Steps followed during bedside procedure

C. Bedside procedure for neonate

D. Bedside procedure for the orthopedic patient

E. Radiography in surgery
    1. Surgical clothing
    2. Equipment preparation
    3. Sterile field awareness
    4. Communication skills

F. Radiation protection
    1. Patient
    2. Radiographer
    3. Other

Patient Care in Radiologic Sciences

Objectives: This list of learning objectives serves as a resource for programs:

- 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.
- Identify methods for determining the correct patient for a given procedure.
- Explain the use of various communication models.
- 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 who have various health conditions.
- Describe 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 the condition of the patient, 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.

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
4. Radiographic method

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 (EAM)
12. Mastoid tip
13. Top of ear attachment (TEA)

F. Surface landmarks
1. Hyoid bone
2. Thyroid cartilage
3. Vertebra prominens
4. Jugular notch
5. Sternal angle
6. Inferior angles of the scapula
7. Xiphoid process
8. Inferior costal margin
9. Superior most aspect of iliac crest
10. ASIS
11. Pubic symphysis
12. Greater trochanter
13. PSIS

G. 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

H. Positioning aids
1. Sponges
2. Sandbags
3. Immobilization devices (e.g., tape, Velcro straps, Pigg-O-Stat

I. Accessory equipment
1. Calipers
2. Lead strips
3. Lead shields
4. Lead markers
5. Image receptor holders

6. Compensating filters

II. General Considerations

A. Evaluation of radiographic orders
   1. Patient identification by two means
   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, appearance and safety
   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. Culture, ethnicity and diversity
   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. Special considerations
   1. Atypical conditions
   2. Mobile procedures
   3. Surgical procedures
   4. Trauma
   5. Body mass index
   6. Cultural awareness
   7. Claustrophobia

C. 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/Patella
         7) Femur
      d. Pelvic girdle
         1) Pelvis
         2) Hip
      e. Vertebral column
         1) Cervical
         2) Thoracic
         3) Lumbar
         4) Sacrum
         5) Coccyx
         6) Sacroiliac articulations
      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
5) Scoliosis survey
6) Hysterosalpinography
7) Myelography
8) Arthrography

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. Patient education
1. General procedure
2. Patient preparation
3. Follow-up care

B. Equipment and materials needed

C. General procedure and follow-up care

D. Patient and body part positioning

E. Structures and functions demonstrated

F. Positioning for abdomen and GI studies
1. Abdomen and GI studies
a. Abdomen
b. Esophagus

c. Swallowing dysfunctional study
d. Upper GI series, single or double contrast
e. Small bowel series
f. Contrast enema, single or double
g. Surgical cholangiography
h. Endoscopic retrograde cholangiopancreatography (ERCP)

2. Positioning for urological studies
   a. Cystography
   b. Cystourethography
   c. Intravenous urography
   d. Retrograde urography

Radiographic Procedures

Objectives: This list of learning objectives serves as a resource for programs:

- 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 and 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 and projections for all radiographic and 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.

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. Manifestations of pathology

H. Incidence

I. Prevalence

J. Morbidity

K. Mortality

L. Epidemiology

II. 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

G. Congenital

III. 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

IV. Implications for Practice

A. Indications for procedure

B. Relevance to radiographic procedures
   1. Technical considerations
   2. Patient considerations

Radiographic Pathology

Objectives: This list of learning objectives serves as a resource for programs:

- 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.

Additional Modalities and Radiation Therapy

Description
Content is designed to provide a brief overview of other imaging modalities and patient treatments.

Content

I. **Bone Densitometry**

II. **Cardiac-interventional**

III. **Computed Tomography**

IV. **Magnetic Resonance**

V. **Mammography**

VI. **Medical Dosimetry**

VII. **Nuclear Medicine**

VIII. **Radiation Therapy**

IX. **Ultrasound/Sonography**

X. **Vascular-interventional**

Additional Modalities and Radiation Therapy

Objectives: This list of learning objectives serves as a resource for programs:

- Recognize and compare basic equipment used in various imaging modalities and radiation therapy.
- Define basic terms related to dose differences.
- Compare and contrast different types of radiation.
- Explain basic terms related to patient preparations.
- Define basic terms related to indications and contraindications.
- Identify educational and certification requirements.
- Discuss the image appearance and basic principles of operation for equipment used in various imaging modalities and radiation therapy.

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 programs wishing to enhance the curriculum with select topics of instruction intended to satisfy the mission of a given program or local employment market.

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

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

Content

I. Computed Tomography Generations: Capabilities and Limitations

A. First

B. Second

C. Third

D. Fourth

E. Fifth

F. Spiral

II. Components, Operations and Processes

A. Data acquisition
   1. Methods
      a. Slice-by-slice
      b. Volumetric
   2. Elements
      a. Beam geometry
         1) Parallel
         2) Fan
         3) Spiral
   3. Data acquisition system (DAS)
      a. Components
         1) Tube
         2) Detectors
         3) Filters
         4) Collimators
         5) 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
            (1) Water equal to 0
            (2) Bone (white) equal to 400 to 1000 HU
            (3) 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
    1. Artifacts
    2. Contrast resolution (window width)
    3. Grayscale manipulation (window level)
    4. Distortion
    5. Noise
    6. Spatial resolution

C. Postprocessing
    1. Image reformation
    2. Image smoothing
    3. Edge enhancement
    4. Window level and width

III. Radiation Protection

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

B. Reducing the radiographer's exposure to scatter radiation

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
   3. IV arm boards

Basic Principles of Computed Tomography

Objectives: This list of learning objectives serves as a resource for programs:

- Explain the difference between reconstructing and reformatting an image.
- Cite the structures demonstrated on commonly performed CT images.
- Describe commonly performed CT procedures.
- 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.
- 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.

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.

Content

I. Head and Brain

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

B. Sinuses
   1. Frontal
   2. Maxillary
   3. Ethmoidal
   4. Sphenoidal

C. Facial bones
   1. Mandible
   2. Maxillae
   3. Zygomas
   4. Nasal bones

D. Facial muscles

E. Cranial bones
   1. Frontal
   2. Ethmoid
      a. Nasal conchae (turbinates)
      b. Nasal septum
   3. Parietal
   4. Sphenoid

a. Lesser wings
    1) Tuberculum sellae
    2) Sella turcica
    3) Dorsum sellae
    4) Anterior and posterior clinoid process
    5) Optic canals
b. Greater wings
    1) Foramen rotundum
    2) Foramen ovale
        a) Foramen spinosum

5. Occipital
    a. Foramen magnum
    b. Internal and external occipital protuberance
    c. Jugular foramen
6. Temporal
    a. Zygomatic process
    b. External auditory meatus (EAM)
    c. Internal auditory canal
    d. Mastoid process
    e. Petrous portion or ridge

F. Lobes of the brain and midline cerebral hemisphere structures
1. Frontal
2. Parietal
3. Occipital
4. Temporal
5. Insula (Island of Reil)
6. Cerebellum
7. Corpus callosum (genu, rostrum, body and splenium)
8. Septum pellucidum
9. Sella turcica
10. Pineal gland
11. Falx cerebri
12. Septum pellucidum

G. Cranial nerves
1. Olfactory
2. Optic
3. Oculomotor
4. Trochlear
5. Trigeminal
6. Abducens
7. Facial
8. Vestibulocochlear
9. Glossopharyngeal
10. Vagus

11. Accessory
12. Hypoglossal

H. Brainstem and adjoining structures
    1. Diencephalon
        a. Thalamus
        b. Hypothalamus
        c. Optic chiasm
        d. Optic tracts
        e. Infundibulum (pituitary stalk)
        f. Pituitary gland
        g. Mammillary bodies
        h. Pineal gland
    2. Midbrain
    3. Pons
    4. Medulla oblongata
        a. Spinal cord

I. Arteries (Circle of Willis)
    1. Vertebral
    2. Basilar
    3. Internal carotid
    4. Anterior and posterior communicating
    5. Anterior and posterior cerebral
    6. Middle cerebral

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

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

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

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

D. Branches of the abdominal aorta
   1. Anterior visceral branches
      a. Celiac axis
         1) Left gastric
         2) Splenic
         3) Hepatic
   2. Superior mesenteric
      a. Jejunal and ileal
      b. Inferior pancreaticoduodenal
      c. Middle colic
      d. Right colic
      e. Ileocolic
   3. Inferior mesenteric
      a. Left colic

b. Sigmoid
c. Superior rectal

4. Lateral visceral branches
   a. Suprarenal
   b. Renal
   c. Testicular or ovarian
5. Parietal branches
   a. Inferior phrenics
   b. Lumbars
   c. Middle sacral
6. Terminal branches
   a. Common iliacs

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

F. Tributaries of the portal vein
1. Splenic
2. Inferior mesenteric
3. Superior mesenteric
   a. Left gastric
   b. Right gastric
   c. Cystic

G. Abdominal organs and structures
1. Bony structures
   a. Lumbar vertebrae
2. Abdominal cavity
   a. Peritoneum
   b. Peritoneal space
   c. Retroperitoneum
   d. Retroperitoneal space
3. Liver
   a. Hepatic arteries
   b. Portal veinous 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

Sectional Anatomy

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.

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.

Textbooks

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

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

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