Radiography Curriculum

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

The 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 Medical Imaging and Radiologic Sciences. The focus of this document is on pre-professional core content that can be expanded with institution-specific content to fulfill the requirements for an academic degree.

Organization:

The document is divided into two main content areas: pre-professional core content and optional content.

- Pre-professional core content: This content makes up the bulk of the document and includes educational content that the professional community supports as essential to enter the profession of radiography. Specific instructional methods are intentionally omitted to allow for creativity in program development and instructional delivery.
- Optional content: Content in this section is to assist programs that want to enhance their curriculum with select topics, either 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 general, students must develop skills in areas such as information literacy, scientific inquiry, self-reflection, collaboration, and mentoring. However, advances in technology and employer expectations may 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 standards of the profession. In the medical imaging and radiologic sciences, students must learn the essential clinical skills that employers expect of graduates, while educators must ensure that students are afforded the opportunity to prepare for the 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 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 be able to:

- Exercise prudent judgment in administering ionizing radiation.
- Provide optimal patient care in an evolving and interconnected society.
- Recognize the challenges of providing direct patient care in today's health care setting.
- Work collaboratively in a dynamic healthcare environment.
- Interpret (or conduct) research and evaluate sources of information to be used in evidence-based practice.
- Ensure the security and confidentiality of patient medical information.
- Explain the value of lifelong learning.
- Collaborate with others in the community to promote standards of excellence in the medical imaging and radiologic sciences.
- Contribute to the education and clinical skill development of medical imaging and radiologic sciences students.
- Promote an welcome, safe environment.
- Advocate for all patient populations.

General Education:

General education is an integral part of the development of a radiographer. This content is designed to assist in developing skills in communication, Understanding that patients have varying backgrounds and needs, 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.

The ARRT® requires an associate degree (or higher) to apply for the certification exam for radiography. Specific general education requirements have been eliminated from the radiography curriculum. The content listed below is designed only to serve as guidance for program development. Individual states, accreditation agencies, and educational systems have unique general education requirements

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.
- Gather, organize, and present information.
- Locate, evaluate, and synthesize material from different sources and points of view.

Humanities

- Demonstrate respect for all populations.
- Define ethics and its role 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, apply, and disseminate 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.

Table of Contents

Pre-professional Core Content

Content reflects educational content the professional community supports as essential for readiness to enter the radiography profession.

Introduction to Medical Imaging and Radiologic Sciences and Health Care

Objectives:

- Recognize and discuss medical procedures and terminology.
- Analyze medical reports, orders, and requests.
- List medical imaging, radiologic sciences, and other health professions.
- Evaluate evidence-based health care practices.
- Describe health care environments, organizations, and regulatory agencies.
- Discuss radiology organization and staffing.
- Explain professional credentialing and the associated organizations.
- Demonstrate professional development and advancement.

Content:

I. Medical Terminology

A. The word-building process
   1. Root words
   2. Prefixes
   3. Suffixes
   4. Combination forms

B. Translation of medical terms into layman's terms

C. Correct pronunciation of medical terms

D. Correct spelling of medical terms

E. Medical abbreviations and symbols
   1. Abbreviations
      a. Examples
      b. Interpretations
      c. Restrictions (e.g., The Joint Commission's "Do Not Use" list)
   2. Pharmaceutical symbols and terms

II. Procedures and Terminology

A. Radiography

B. Other imaging modalities

C. Radiation oncology

D. Surgery

III. 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

IV. Health Professions

A. Medical imaging and radiologic sciences
    1. Applications specialist
    2. Bone densitometry
    3. Breast sonography
    4. Cardiac-interventional radiography
    5. Clinical leadership
    6. Computed tomography
    7. Diagnostic medical sonography
    8. Diagnostic radiography
    9. Echocardiography
    10. Education
    11. Health physics
    12. Imaging informatics
    13. Magnetic resonance imaging
    14. Mammography
    15. Medical dosimetry
    16. Medical physics
    17. Molecular imaging
    18. Multi-credentialed
    19. Nuclear medicine advanced associate
    20. Nuclear medicine technology
    21. Quality management
    22. Radiation therapy
    23. Radiologist assistant
    24. Research
    25. Vascular sonography
    26. Vascular-interventional radiography

B. Other health professions

V. Interprofessional Practice & Education

A. Interprofessional education
B. Collaborative practice

VI. Evidence-based Practice

VII. Health Care Environment

A. Health care settings
   1. Hospitals
   2. Clinics/pain clinics
   3. Mental health facilities
   4. Long-term/residential facilities
   5. Hospice
   6. Outpatient/ambulatory care
   7. Free Standing Imaging Center (e.g. general, women's, and vascular)
   8. Home health care
   9. Telehealth
   10. Other (e.g., jails, prisons, medical examiner offices)

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

VIII. Health Provider Organization

A. Mission

B. Vision

C. Values

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

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

IX. Accreditation

A. Health care institutions (e.g., The Joint Commission)

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. Radiology Organization

A. Professional personnel
   1. Administrators/managers
   2. Radiologists
   3. Radiologic technologists
   4. Radiologist assistants
   5. Radiology nurses
   6. Medical physicists
   7. Other medical imaging and radiologic sciences professionals

B. Support personnel
   1. Information technology staff
   2. Administrative personnel
   3. Other (e.g., patient transporters, aides)

C. Educational personnel
   1. Program director
   2. Clinical coordinator
   3. Didactic faculty
   4. Adjunct faculty
   5. Clinical preceptor
   6. Clinical staff

XII. Professional Credentialing

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

B. State licensure

XIII. Professional Organizations

A. Purpose, function and activities

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

XIV. 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
   5. Webinars
   6. Other (e.g., vendor programs)

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

E. Advancement opportunities
   1. Administration
   2. Advanced practice
   3. Education
   4. Industrial
   5. Medical informatics
   6. Medical physics
   7. Research
   8. Sales/applications
   9. Safety Officer

Ethics and Law in Medical Imaging and Radiologic Sciences

Objectives:

- Describe the basis of ethics and characteristics of ethical behavior.
- List ethical dilemmas and ethically-complex areas of health care and medical imaging.
- Discuss the basis of law and major legal concerns in health care.
- Explain the types of consent, as well as the conditions and documentation of consent.

Content

I. Ethics and Ethical Behavior

A. Origins and history of ethics

B. Ethical principles

C. Moral reasoning

D. Personal behavior standards

E. Competence

F. Professional attributes

G. Standards of practice

H. Standards of professional ethics

I. Systematic analysis of ethical problems

J. Ethical violations and sanctions

K. American Hospital Association (AHA) Patient Care Partnership (Patients' Bill of Rights)

II. Ethical Dilemmas

A. Individual and societal rights

B. Cultural considerations

C. Economic considerations

D. Technology

E. Resource scarcity

F. Access to quality health care

G. Human experimentation and research

H. Patient-centered, quality care for all

I. End-of-life

J. Ethics committee
   1. Structure
   2. Goals
   3. Function

K. Ethical conduct of research
   1. Historical events
   2. Institutional review board
   3. Data collection
   4. Data reporting

L. Ethical dilemmas in medical imaging
   1. Image cropping or masking
   2. Electronic annotations
   3. Manipulation of metadata
   4. Manipulation of electronic data (e.g., exposure indicator, processing algorithm, brightness, contrast)
   5. R/L electronic markers
   6. ALARA
      a. Dose creep
      b. Manipulation of exposure indicators

III. Legal Issues

A. Sources of law

B. Parameters of legal responsibility

C. HIPAA
   1. Confidentiality of patient medical records (written and electronic)
   2. Electronic communication (e.g., cell phones, social networking sites, email, photography)

D. Tort law (e.g., negligence)

E. Criminal law

F. American Hospital Association (AHA) Patient Care Partnership

1. Privacy
2. Access to information
3. Living will, health care proxy, advanced directives

IV. Legal Doctrines and Standards

A. Legal risk reduction and risk management

B. Health 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 (e.g., informed, oral, implied)

C. Conditions for valid consent

D. Documentation of consent

E. Consent revocation

F. Patient Rights and Responsibilities

G. Patient restraints

Patient Care and Services in the Medical Imaging and Radiologic Sciences

Considerations
Before the introduction of this educational content, students should complete patient safety training (including CPR and basic life support [BLS] for health professionals certification), and be familiar with the anatomy and physiology of the circulatory and excretory systems.

Regulations of R.T. practice vary by state and institution. However, the official position of the American Society of Radiologic Technologists is that the content of the ASRT Practice Standards should be included in educational programs, regardless of the limitations of the state or institution where the curriculum is taught.
In states or institutions where students are permitted to perform intravenous injections, the educational program has 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 of competency occurs before venipuncture is performed unsupervised.

Objectives:

- Recognize the members of the health care team and their responsibilities.
- Describe the elements of professionalism in health care, including attitudes, communication techniques, and psychological aspects of patient care.
- Apply environmental, occupational, and patient safety techniques.
- Evaluate patient health using vital signs, laboratory tests, pain assessments, and patient records.
- Discuss the types, characteristics, and spread of infectious pathogens.
- Demonstrate infection control practices, procedures, and equipment.
- Identify and respond to medical emergencies.
- Recognize and accommodate traumatic injuries.
- Explain drug classifications, naming, routes of administration, and safety practices.
- List drug categories relevant to radiography.
- Describe types of contrast agents and their application.
- Demonstrate safe venipuncture technique and management of tubes, catheters, lines, and other interventional medical devices.

Content

I. Health Care Team

A. Responsibilities of the health care facility

1. Care for all patients

2. Promote health
3. Prevent illness
4. Education
5. Research

B. Members and responsibilities (e.g. physicians, nurses, allied health professionals, etc.)

C. Responsibilities of the radiographer
   1. Perform radiographic examination
   2. Perform patient care and assessment
   3. Adhere to radiation protection guidelines
   4. Follow practice standards
   5. Assist the radiologist or radiologist assistant (R.R.A.)

II. Professionalism in Patient Care

A. Health and illness continuum

B. Patient-centered, quality care for all

C. Emotional intelligence
   1. Self-awareness
   2. Self-regulation
   3. Motivation
   4. Empathy
   5. Social skills

D. Developing professional attitudes
   1. Teamwork
   2. Work ethic
   3. Health role model
   4. Sympathy
   5. Compassion
   6. Assertiveness

E. Age- and generation-specific communication
   1. Neonates
   2. Adolescents
   3. Young adults
   4. Middle adults
   5. Geriatrics

F. Communication
   1. Verbal
   2. Nonverbal
   3. Language and cultural variations

4. Accessibility
    a. Hearing, vision, and speech impairments
    b. Neurological impairments
    c. Developmental impairments
    d. Altered states of consciousness
    e. Varied backgrounds and needs of patients
    f. Artificial speech
5. Other factors that impede communication
    a. Colloquialisms and slang
    b. Medical terminology
6. Patient interactions
    a. Eye contact
    b. Volume and speed of speech
    c. Hand gestures
    d. Effective listening
    e. Feedback
    f. Cultural sensitivity
7. Communication with families or authorized representatives
8. Communication with other health care professionals (e.g. SBAR, TeamSTEPPS)

G. 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. 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 bands
4. Institution-specific

B. Procedure explanation
1. Positioning
2. Length of procedure
3. Immobilization devices
4. Equipment movement/sounds
5. Pre and postexposure instructions

C. Interactions with patient's family members, friends, or authorized representatives

IV. Safety and Transfer

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

B. Body mechanics
1. Body alignment
2. Movement techniques

C. Patient transfer and movement
1. Assessing patient mobility
2. Rules for safe patient transfer
3. Positioning for safety, comfort, or exams
4. Wheelchair transfers
5. Stretcher transfers
   a. Sheet transfer
   b. Log roll
   c. 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 Patient Needs

A. Social factors influencing health

B. Assessing patient status
   1. Evaluation methodology
   2. Clinical information

C. Vital signs
   1. Temperature
   2. Pulse
   3. Pulse oximetry
   4. Respiration
   5. Blood pressure
   6. Normal ranges and values
   7. Interfering factors
   8. Adult vs. pediatric
   9. Acquiring and recording vital signs

a. Procedures
b. Demonstration

D. Laboratory tests
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 Record
1. Elements of a patient record
2. Retrieving specific information
3. Documentation in the chart

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

VI. Infection Control

A. Infectious pathogens
1. Types
2. Hospital-acquired
3. Communicable
4. Multidrug-resistant organisms (MDRO)
5. Other

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

C. Cycle of infection
1. Reservoir of infection
2. Susceptible host
3. Transmission of disease
a. Direct
b. Indirect
c. Routes (e.g., bloodborne, airborne)

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

E. Asepsis
    1. Medical
        a. Hand washing
        b. Chemical disinfectants
    2. Surgical
        a. Growth requirements for microorganisms
        b. Methods used to control microorganisms
            1) Moist heat
            2) Dry heat
            3) Gas
            4) Chemicals
            5) Radiation
        c. Procedures
            1) Opening packs
            2) Gowning/gloving
            3) Skin preparation
            4) Draping
            5) Dressing changes
        d. Packing
        e. Storage
        f. Linen

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

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

H. Precautions for the compromised patient (reverse isolation)
    1. Purpose

2. Procedure

I. Psychological considerations

VII. Medical Emergencies

A. 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 interventions

D. Diabetic emergencies
   1. Signs and symptoms
   2. Types
      a. Hypoglycemia
      b. Hyperglycemia (ketoacidosis)
      c. Hyperosmolar coma
   3. Medical interventions

E. Respiratory and cardiac failure
   1. Adult vs. pediatric
   2. Signs and symptoms
   3. Equipment
   4. Medical interventions

F. Airway obstruction
   1. Signs and symptoms
   2. Medical interventions

G. Cerebrovascular accident (stroke)
   1. Signs and symptoms
   2. Medical interventions

H. Fainting and convulsive seizures
   1. Signs and symptoms
   2. Types

a. Nonconvulsive (petit mal)
b. Convulsive (grand mal)
3. Reasons for fainting
4. Medical interventions

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 interventions

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

C. Fractures
1. Types
2. Symptoms
3. Orthopedic devices
4. Positioning

D. Wounds
1. Symptoms
2. Medical interventions

E. Burns
1. Classifications
2. Medical interventions

IX. Drug Nomenclature

A. Chemical name

B. Generic name

C. Trade/brand name

X. Drug Classification

A. Chemical group

B. Mechanism and site of action

C. Primary effect

XI. General Pharmacologic Principles

A. Pharmacokinetics

B. Pharmacodynamics

C. Pharmacogenetics

XII. 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

XIII. Drug Categories Relevant to Radiography (uses and effects)

A. Analgesics

B. Anesthetics

C. Antianxiety drugs

D. Antiarrhythmics

E. Antibacterial drugs

F. Anticholinergics

G. Anticoagulants

H. Anticonvulsants

I. Antidepressants

J. Antidiabetics

K. Antiemetics

L. Antihistamines

M. Antihypertensive drugs

N. Anti-inflammatory drugs

O. Antiseptic and disinfectant agents

P. Antiviral drugs

Q. Bronchodilators

R. Cathartic and antidiarrheal drugs

S. Coagulants

T. Corticosteroids

U. Diuretics

V. Hormones

W. Laxatives

X. Sedatives and hypnotic drugs

Y. Vasodilators and vasoconstrictors

XIV. Contrast Agents

A. Types of contrast agents
   1. Metallic salts
   2. Organic iodides
      a. Ionic contrast agents
      b. Nonionic contrast agents
   3. Gases

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

C. Pharmacologic profile
    1. Chemical composition
    2. Absorption
    3. Distribution
    4. Metabolism
    5. Elimination
    6. Indications
    7. Effects
    8. Interactions and contraindications
    9. Patient reactions

D. Appropriateness to examination
    1. Patient condition (e.g., perforated bowel)
    2. Patient age and weight
    3. Laboratory values (e.g., BUN, creatinine, eGFR)
    4. Check for allergies
    5. Contrast media dose calculation

E. Preparation

F. Reactions to Contrast Agents
    1. Signs
    2. Symptoms
    3. Medical intervention

XV. Routes of Drug Administration

A. Enteral
    1. Sublingual
    2. Buccal
    3. Rectal

B. Tube or catheter

C. Inhalation

D. Topical

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

7. Intraosseous

XVI. Pharmacology and Venipuncture

A. Current Practice Status
   1. Professional standards
      a. Scope of practice
      b. Practice standards
      c. Professional liability and negligence
   2. State statutes
   3. Employer policy

B. Methods
   1. Infusion
   2. Intermittent infusion
   3. Direct injection
      a. Hand injection
      b. Automatic power injection

C. Sites of administration
   1. Peripheral
   2. Central

D. Venipuncture procedures
   1. Equipment and supplies
   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. Radiographer's response and documentation

E. Complications
   1. Infiltration
   2. Extravasation

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

F. 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

G. Documentation of administration

H. Technologist's response and documentation

II. Tubes, Catheters, Lines, and Other Devices

A. Function and handling of devices

B. Nasogastric/nasointestinal

C. Endotracheal tube

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

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

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

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

H. Venous catheters
1. Types
2. Purpose

3. Location
4. Care (e.g., infection control)
5. Access

I. Tissue drains

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

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

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

Human Anatomy and Physiology

Objectives:

- Label anatomy using directional terminology, planes of reference, and body cavities.
- Explain the chemical composition of the body, including inorganic and organic compounds.
- Describe cellular structures and genetic processes of cell function and reproduction.
- Define different types of metabolism and related body processes.
- Explain the tissues, divisions, and functions of the body's systems.
- Recognize major sectional anatomy of the body.

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. Sagittal
   2. Coronal
   3. Transverse (axial/horizontal)
   4. 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
    a. Nucleic acids
    b. DNA
    c. RNA

III. Cell Structure and Genetic Control

A. Cell membranes
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
   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 including the Haversian System
      c. Cancellous bone
      d. Periosteum
      e. Cartilage
   2. Development and growth
      a. Physis
      b. Diaphysis
      c. Epiphyseal line
      d. Metaphysis
   3. Classification and features
      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. Shoulder girdle
    b. Upper extremities
    c. Pelvic girdle
    d. Lower extremities
3. Sesamoids

C. Functions

D. Joints
1. Types
    a. Synarthroses
    b. Amphiarthroses
    c. Diarthroses
2. Joint Anatomy
    a. Meniscus
    b. Articular cartilage
    c. Synovial membranes
    d. Fibrous membranes
    e. Ligaments
    f. Tendons
3. Articulation

VII. Muscular System

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

B. Functions

VIII. Nervous System

A. Neural tissue
1. Neurons
2. Neuroglia

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

C. Peripheral nervous system
    1. Sympathetic nerves
    2. Parasympathetic nerves

IX. Sensory System

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

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

X. Endocrine System

A. Primary organs

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
    1. Oral cavity
    2. Pharynx
    3. Esophagus
    4. Stomach
    5. Small intestine
    6. Large intestine

B. Accessory organs
    1. Salivary glands
    2. Pancreas
    3. Liver
    4. Gallbladder and biliary tree

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

XIII. Lymphatic System and Immunity

A. Lymphatic system
    1. Lymph vessels
    2. Lymph nodes
    3. Lymphatic organs
        a. Thymus
        b. Lymph nodes
        c. Spleen
    4. Lymphatic tissue
        a. Tonsils and adenoids
        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. Nasal 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. Kidneys
1. Macroscopic Anatomy
    a. Renal capsules
    b. Renal cortex
    c. Medulla
2. Microscopic anatomy
    a. Nephrons
    b. Glomerulus
    c. Collecting tubes

B. Ureters

C. Bladder

D. Urethra

E. Urine
   1. Physical characteristics
   2. Chemical composition

F. Micturition

XVI. Reproductive System

A. Male
   1. External organs
   2. Internal organs

B. Female
   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. Head/neck
   1. Brain
   2. Cranium
   3. Major vessels

B. Thorax
   1. Mediastinum
   2. Lung
   3. Heart
   4. Airway
   5. Major vessels

C. Abdomen
   1. Liver
   2. Biliary
   3. Spleen
   4. Pancreas
   5. Kidneys and ureters
   6. Peritoneum
   7. Retroperitoneum
   8. Gastrointestinal (GI) tract
   9. Major vessels

Radiographic Procedures

Objectives:

- Discuss radiographic technique using anatomic, positioning, and projection terminology.
- Evaluate radiographic orders and preparation for procedures.
- Describe patient communication techniques and planning.
- Apply patient positioning techniques for common exams.
- Conduct contrast studies, including patient preparation and positioning.
- Recognize special concerns and techniques for mobile and surgical radiography.

Content

I. Positioning and Projection Terminology

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. Lateral
   5. Trendelenburg
   6. Decubitus
   7. Erect/upright
   8. Anterior position
   9. Posterior position
   10. 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. Anterior superior iliac spine (ASIS)
    11. Pubic symphysis
    12. Greater trochanter
    13. Posterior superior iliac spine (PSIS)

G. Movement and direction terminology
    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. Lead shields
   2. Lead markers
   3. Image receptor/detector holders
   4. Compensating filters

II. General Considerations

A. Evaluation of radiographic orders
   1. Patient identification (two means)
   2. Verification of procedure(s) ordered
   3. 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
   4. Exam sequencing

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

III. Patient Considerations

A. Establishing rapport
   1. Patient education
      a. Communication
      b. Common radiation safety issues and concerns
   2. Culture, different backgrounds and needs
   3. Pregnancy status

B. Patient preparation
   1. Verification of dietary preparation
   2. Verification of medication preparation
   3. Disrobing and gowning
   4. Removal of artifact-causing items

C. Patient assistance

D. Patient monitoring

E. Patient discharge

IV. Positioning Considerations for Routine Radiographic Procedures

A. Patient instructions

B. Special considerations
   1. Atypical conditions procedures
   2. Surgical procedures
   3. Trauma
   4. Cultural awareness
   5. Claustrophobia

C. Study-specific positioning
   1. Skeletal system
      a. Upper extremity
         1) Fingers
         2) Hand
         3) Wrist
         4) Forearm
         5) Elbow
         6) Humerus
      b. Shoulder girdle
         1) Shoulder joint
         2) Scapula
         3) Clavicle
         4) Acromioclavicular joints
      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 joints
f. Bony thorax
1) Ribs
2) Sternum
3) Sternoclavicular joints
g. Cranium
1) Skull
2) Facial bones
3) Nasal bones
4) Orbits
5) Mandible
6) Temporomandibular joints
7) Paranasal sinuses
h. Special studies
1) Bone survey
2) Long bone measurement
3) Bone age
4) Foreign body
5) Scoliosis survey
6) Myelography
7) Arthrography

2. Respiratory system
a. Upper airway/soft tissue neck
b. Chest
3. Abdominal viscera
a. Abdomen and gastrointestinal (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. Indications and contraindications

C. Equipment and materials

D. General procedure and follow-up care

E. Patient and body part positioning

F. Structures and functions demonstrated

G. Positioning for abdomen, GI, and GU 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 contrast)
    g. Surgical cholangiography
    h. Endoscopic retrograde cholangiopancreatography (ERCP)
2. Positioning for GU studies
    a. Cystography
    b. Cystourethography
    c. Intravenous urography
    d. Retrograde urography
    e. Hysterosalpingography

VI. Mobile and Surgical Radiography

A. Verify order prior to bedside procedure

B. Steps for bedside procedure
    1. Standard procedure
    2. Neonates
    3. Orthopedic patients

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

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

Radiographic Pathology

Objectives:

- Define common terms related to pathology.
- Describe the causes of disease.
- Explain radiologic pathology, including body systems, complications, and procedural considerations.
- Discuss the relevance of pathology to radiographic procedures.

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 vs. heredity

G. Congenital

III. Radiologic Pathology

A. Body systems
   1. Skeletal
   2. Digestive
   3. Respiratory
   4. Urinary
   5. Reproductive
   6. Circulatory/cardiovascular
   7. Endocrine
   8. Nervous

B. Definitions

C. Etiology

D. Sites

E. Complications

F. Prognosis

G. Radiographic appearance

H. Procedural and technical considerations

I. Appropriate imaging concentration

IV. Implications for Practice

A. Indications for procedure

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

Radiation Physics and Instrumentation

Objectives:

- Describe the structure of atoms and types of radiation.
- Explain x-ray production and the effect of various factors.
- Discuss photon interactions with matter.
- Diagram the elements of the x-ray circuit and x-ray tube.
- Employ radiographic equipment of various types.
- Describe the elements and operation of fluoroscopy systems.
- Apply quality control measures to imaging equipment and accessories.

Content

I. Structure of the Atom

A. Nucleus

B. Subatomic structure

C. Electron shells
   1. Binding energy
   2. Valence shell
   3. Ionization
   4. Excitation

D. Nomenclature
   1. Atomic number
   2. Mass number

II. Nature of Radiation

A. Types of radiation
   1. Electromagnetic
      a. Spectrum
      b. Wave-particle duality
      c. Properties (e.g., frequency, wavelength, energy, velocity)
   2. Particulate
   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
3. Anode heat

C. Describing the x-ray beam
1. Frequency and wavelength
2. Beam characteristics
a. Quality
b. Quantity
c. Primary versus remnant (exit)
3. Leakage radiation
4. Off-focus/stem radiation

D. Conditions for x-ray production
1. Source of free electrons (e.g., thermionic emission)
2. Acceleration of electrons
3. Focusing the electron stream
4. Deceleration of electrons

E. Factors affecting x-ray emission spectrum
1. kVp
2. mA
3. Time
4. Atomic number of target
5. Filtration
6. Generator phase

IV. Photon Interactions with Matter

A. Photon transmission
1. Exit/remnant radiation

B. Types and descriptions
1. Unmodified scattering (coherent or classical)
2. Photoelectric
3. Compton
4. Pair production

C. Probability of photon interactions

1. Atomic number
2. Energy
3. Tissue volume
4. Part thickness

D. Effect on image

E. Patient and operator dose effects

V. 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. Autotransformer

D. Components and functions
   1. Operating (control) console
   2. Filament circuit
   3. Tube circuit

E. Rectification
   1. Purpose
   2. Mechanisms

F. High-frequency generators

VI. Radiographic Equipment

A. Fixed units
   1. Components
      a. Tubes
      b. Beam restriction
      c. Tables
      d. Operating (control) console
      e. Tube support systems

f. Wall units
g. Potter-Bucky mechanism
h. Image receptors

2. Equipment operation and manipulation
3. Applications

B. Mobile units
1. Components
a. Tubes
b. Beam restriction
c. Operating (control) console
d. Tube support systems
e. Image receptors

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. Solid state

2. Minimum response time
3. Backup time
4. Alignment and positioning considerations
a. Radiation detector selection
b. Radiation detector configuration
c. Radiation detector sensitivity

5. Compensation issues
a. Contrast agents
b. Patient size
c. Pathology
d. Prosthetics/implants
e. Collimation
f. Image receptor variations

D. Manual exposure control

VII. 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

VIII. Fluoroscopy

A. Flat panel detectors
   1. Detective quantum efficiency (DQE)
   2. Modulation transfer function (MTF)
      a. Line spread function (LSF)
      b. Point spread function (PSF)
      c. Edge spread function (ESF)
   3. Contrast-to-noise ratio (CNR)
   4. Binning
   5. File sizes
   6. Data management
   7. Image monitoring
      a. CCD
      b. CMOS

B. Controls
   1. Automatic exposure rate control (AERC)/Automatic brightness control (ABC)
   2. Field of view (FOV)
      a. Magnification
      b. Dose

C. Operation modes
   1. Fluoroscopy (real-time viewing)
      a. Continuous
      b. Pulsed
         1) Pulse width
         2) Pulse height
         3) Pulse interval
         4) Frame rate
         5) Dose rate
         6) Temporal averaging
   2. Fluorography (image recording and storage)
      a. Unsubtracted
      b. Digital subtraction angiography (DSA)
      c. Cine

D. Image viewing
   1. Last-image-hold (LIH)
   2. Last-sequence-display
   3. Display monitors

E. Image quality
   1. Image signal
   2. Signal-to-noise ratio (SNR)

3. Contrast-to-noise ratio (CNR)
4. Resolution
    a. Contrast
    b. Temporal
    c. Spatial

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

G. Operation and manipulation
H. Detector elements (DEL) binning

IX. Quality Control of Imaging Equipment and Accessories

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. SID indicator
9. Image receptors
10. Automatic exposure control (AEC)
11. Display monitors
12. Erasure thoroughness (CR)

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. Personnel protective apparel

D. Recognizing and reporting malfunctions

Image Production

Objectives:

- Explain exposure factors and their effect on the final image.
- Describe the image acquisition process and associated errors.
- Recognize the purpose and management of exposure factors.
- Discuss the computer processing and image display process.
- Apply quality management techniques and programs.
- Recognize the mechanisms for transfer, storage, and remote assessment of medical images.
- List common downtime procedures for radiologic technologists.

I. Exposure Factors

A. Milliampere-seconds (mAs)
   1. Beam quantity
   2. Milliamperes (mA)
   3. Time
   4. Direct square law/exposure maintenance formula

B. Kilovoltage peak (kVp)
   1. Beam quality/penetrability
   2. Beam quantity
   3. Subject contrast
   4. 15 percent rule

C. Beam Restriction
   1. Function/purpose
      a. Reduce irradiated tissue volume
      b. Reduce patient dose
      c. Reduce scatter radiation
   2. Types
      a. Manual collimators
      b. Automatic collimators
      c. Cylinders and cones
      d. Ancillary devices (e.g., lead blockers/lead masks)
   3. Collimator components
      a. Lead shutters
      b. Light source

D. Distance
   1. Source-to-image receptor distance (SID)
   2. Source-to-object distance (SOD)
   3. Object-to-image receptor distance (OID)
   4. Inverse square law

5. Anode heel effect

E. Focal spot size

F. Filtration
   1. Total
      a. Inherent
      b. Added
   2. Compensating
   3. Measurement
      a. Aluminum equivalency
      b. Half-value layer (HVL)
   4. Material
      a. Aluminum
      b. Copper
      c. Clear lead

G. Scatter radiation
   1. Production
      a. Collimation
      b. Kilovoltage peak (kVp)
      c. Irradiated tissue
         1) Thickness
         2) Composition
   2. Reduction
      a. Grid
      b. Lead masking

H. Grids
   1. Purpose/mechanism
   2. Construction
   3. Types
      a. Linear
         1) parallel
         2) focused
      b. Crossed
      c. Moving
      d. Stationary
      e. Virtual
   4. Characteristics
      a. Grid radius
      b. Ratio
      c. Frequency
   5. Grid conversion factors
   6. Selection

a. kVp
b. Patient/exam
c. Focal range
d. Alignment latitude
e. Short axis
f. Long axis

7. Grid errors
   a. Off-level
   b. Off-center
   c. Off-focus
   d. Upside down
   e. Moiré effect (aliasing)

II. Image Acquisition

A. Algorithm selection

B. Entrance exposure

C. Absorbed exposure
   1. Differential absorption
      a. Irradiated material (amount and type)
         1) Anatomy
         2) Pathology
   2. Beam quality

D. Remnant exposure
   1. Exposure indicators
   2. Deviation index
   3. Air kerma (K indicators)

E. Image receptors
   1. Direct conversion
   2. Indirect conversion
      a. Thin film transistor (TFT) arrays
      b. Charge-coupled device (CCD)
      c. Complementary metal oxide semiconductor (CMOS) systems
   3. Photostimulable phosphor (PSP) plate
   4. Evaluation of characteristics
      a. Detective quantum efficiency (DQE)
      b. Modulation transfer function (MTF)
         1) Line spread function (LSF)
         2) Point spread function (PSF)
         3) Edge spread function (ESF)
      c. Spatial resolution
      d. Bit depth
   5. Detector element (DEL)

a. Size
b. Fill factor
c. Pitch

F. Analog-to-digital conversion/data extraction
1. Sampling frequency
2. Quantization

III. Image Acquisition Errors

A. Histogram analysis errors
1. Incorrect anatomic menu selection
2. Exposure field recognition
a. Collimation border recognition
b. Exposure field distribution (segmentation error)
3. Unexpected material in data set (e.g., metal)
4. Overexposure/saturation
5. Underexposure/starvation

B. Low-intensity radiation response
1. Accumulated background radiation
2. Image retention (e.g., ghosting)

IV. 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

D. Other considerations
1. Casts
2. Pathology
3. Age
4. Part size
5. Body mass index
6. Contrast media
7. Grids
8. Distance

V. Computer Preprocessing

A. Histogram
   1. Creation and analysis
   2. Values of Interest (VOI)
   3. Automatic rescaling
   4. Look-up table (LUT) application

B. Automatic Electronic Masking

VI. Image Display

A. Characteristics
   1. Aspect ratio
   2. Spatial resolution
      a. Matrix size
      b. Pixel dimensions
         1) Size
         2) pitch
   3. Contrast resolution
   4. Luminance
      a. Pixel intensity
      b. Color

B. Viewing conditions
   1. Ambient lighting (peripheral glare)
   2. Viewing angle/on-axis viewing (viewing direction)
   3. Veil glare

C. Types
   1. Liquid crystal displays (LCD)
   2. Light emitting diodes (LED)
   3. Active matrix arrays (e.g., AMOLED)

D. Operator Processing (postprocessing)
   1. Windowing
      a. Display brightness (window level)
      b. Display contrast (window width)
   2. Spatial domain processing
      a. Look-up table (LUT) reprocessing
      b. Equalization
   3. Spatial frequency processing
      a. Low-frequency (smoothing)
      b. High-frequency (edge enhancement)
   4. Image reformatting
      a. Electronic masking
      b. Magnification/zoom/pan
      c. Rotation

d. Image flip (inversion)
e. Region of interest (ROI)
f. Field of view (FOV)

.

VII. 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
1. Image quality control
   a. Exposure indicator accuracy
   b. Image integrity
2. Image receptor systems
   a. Image receptor maintenance
      1) Cleaning and inspection
      2) Erasure
   b. Equipment calibration
   c. Uniformity
   d. Spatial resolution
3. Image display systems
   a. Care and maintenance
   b. Grayscale standard display (e.g., SMPTE)
   c. Luminance
   d. Spatial resolution
   e. Contrast resolution
   f. Veiling glare
4. Reject analysis
5. Patient exposure monitoring
6. Service engineer and/or medical physicist responsibilities
   a. Notification process
   b. Preventive maintenance
7. 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

VIII. Image Informatics and Archiving

A. System architecture
   1. Enterprise imaging
   2. Image distribution and viewing
   3. Integrating the healthcare enterprise (IHE)
   4. Health level seven standard (HL7)
   5. Cloud-based computing
   6. Database health monitoring
   7. Cybersecurity

B. Network connectivity
   1. Information management
      a. Hospital/health information system (HIS)
      b. Radiology information system (RIS)
      c. Electronic medical record (EMR)/electronic health record (EHR)
   2. Network architecture
      a. Network protocols
      b. Transmission protocols
      c. Network components
      d. Network configuration

C. Data file
   1. Raw data
   2. Image data

D. Medical image management and processing system (MIMPS) (formerly picture archiving and communication system [PACS])
   1. System components and functions
   2. Emergency contingency plan
   3. Digital imaging and communication in medicine (DICOM) standards
   4. Technologist responsibilities
      a. Accessing work order (worklist)
      b. Postprocessing (e.g. image operation and manipulation)
      c. Annotation issues
      d. Image transmission
      e. HIPAA
      f. Workflow
      g. Metadata

E. Medical image storage and communications devices
   1. Architectures
      a. Network attached storage (NAS)

b. Storage area network (SAN)
c. Direct attached storage (DAS)

2. Archive media and management
   a. Short-term digital memory (Redundant array of independent discs [RAID])
   b. Long-term
      1) Optical discs
      2) Tapes
3. Vendor neutral archives (VNA)
4. DICOM storage considerations
   a.Service object pair (SOP) digital image storage
      1) Digital image compression
         a) Types of compression
            (1) Lossless
            (2) Lossy
         b) Compression ratios

IX. Teleradiology

X. Downtime Procedures

A. Patient scheduling

B. Order creation

C. Image acquisition

D. Image processing

E. Image informatics and archiving

F. Post-downtime data entry

G. Review and quality control

Image Analysis

Objectives:

- List image appearance standards.
- Justify the need for imaging standards.
- Explain technical, procedural, and clinical factors affecting image appearance.
- Recognize patient-related and equipment-related artifacts.
- Describe corrective actions that can be taken to improve image appearance.

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. Technical Factors

A. Brightness

B. Contrast (grayscale)
   1. Subject contrast
   2. Latent image contrast (raw image contrast)
   3. Displayed image contrast (processed image contrast)

C. Noise
   1. Random (e.g., quantum mottle, scatter)
   2. Electronic (e.g., electronic interference, detector malfunction, software)
   3. Quantum

4. System
5. Background

D. Signal-to-noise ratio (SNR)

E. Contrast-to-noise ratio (CNR)

F. Gross exposure errors (e.g., saturation, loss of contrast)

G. Spatial resolution
   1. Temporal resolution
   2. Geometric resolution
   3. Image receptor resolution

H. Distortion
   1. Shape
      a. Foreshortening
      b. Elongation
   2. Size
      a. Source-to-image receptor distance (SID)
      b. Source-to-object distance (SOD)
      c. Object-to-image receptor distance (OID)

I. Contrast resolution

III. Procedural Factors

A. Image identification
   1. Patient information
   2. Date of examination
   3. Lead 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. Radiation protection

1. Collimation
2. Shielding
3. Repeated images

IV. Clinical Factors

A. Contrast agents

B. Pre-examination preparation

V. Artifacts

A. Patient-related

B. Equipment-related
   1. Digital
   2. Display monitor

VI. Equipment Malfunction

VII. Corrective Action

A. Technical factors

B. Procedural factors

C. Artifacts

D. Equipment malfunction

Radiation Biology and Health Physics

Objectives:

- Describe basic cellular biology and the molecular effects of ionizing radiation.
- Recognize the various health effects of radiation exposure.
- Explain variations in cell radiosensitivity and response.
- List the units and measures used to evaluate radiation exposure.
- Discuss the agencies and regulations involved in radiation safety.
- Outline the elements of a personnel monitoring program.
- Identify radiation protection tools and methods.
- Apply personnel and patient radiation protection techniques.

Content

I. Introduction

A. Molecules
   1. Ionic bonds
   2. Covalent bonds

B. Cellular biology
   1. Cellular structure
      a. Cell membranes
      b. Cytoplasm
      c. Protoplasm
      d. Organelles
      e. Nuclei
   2. Cellular function
      a. 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 radiation
      a. Alpha
      b. Beta
      c. Neutrons
      d. Protons

D. Sources of medical radiation exposure
   1. Diagnostic radiology
   2. Computed tomography (CT)
   3. Cardiac interventional radiology
   4. Vascular-Interventional radiology
   5. Nuclear medicine
   6. 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. Linear energy transfer (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/tissue reactions
    2. 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. Age
        g. Chemical agents
        h. 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/tissue reactions
4. Genetic effects
5. Occupational risks for radiation workers

G. Risk estimates
1. Relative
2. Excess
3. Absolute

V. Introduction to Health Physics

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

B. Potential biological damage of ionizing radiation
1. Stochastic (probabilistic) effects/tissue reactions
2. Nonstochastic (deterministic) effects/tissue reactions
3. Tissue reactions

C. Objectives of a radiation protection program
1. Documentation
2. Occupational and nonoccupational dose limits
3. ALARA concept (personnel protection)
4. Comparable risk
5. Negligible individual dose (NID)
6. Sources of radiation
    a. Natural
    b. Man-made (artificial)

D. Legal and ethical responsibilities

VI. Units, Detection, and Measurement

A. Système International d'Unités (SI Units)
   1. Exposure - Coulomb/kilogram (C/kg)
   2. Absorbed dose - Gray (Gy_t)
   3. Air kerma (Gya)
   4. Dose equivalent - Sievert (Sv)
   5. Effective dose- Sievert (Sv)
   6. Radioactivity - Becquerel (Bq)

B. Dose documentation and 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 detection devices
   1. Area monitors
   2. Personal detection devices

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

VII. 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. Environmental Protection Agency (EPA)
4. Occupational Safety and Health Administration (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

VIII. 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. Personnel monitors
   1. Types
      a. Thermoluminescent dosimeter (TLD)
         1) Body dosimeter
         2) Ring dosimeter
      b. Optically stimulated luminescent dosimeter (OSLD)
      c. Pocket ionization chamber dosimeter
      d. Digital ionization dosimeter
   2. Proper use

D. Records of accumulated dose
   1. Purpose
   2. Interpretation
   3. Content
   4. Length of recordkeeping
   5. Retrieval from previous employers

E. Effective dose limits
    1. Occupational
    2. Public
    3. Critical organ sites
    4. Embryo and fetus

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

IX. Application

A. Design
    1. Materials
    2. Primary barrier
    3. Secondary barrier (scatter and leakage)
    4. Half-value layer (HVL)
    5. Factors
        a. Use (U)
        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. Awareness campaigns (Image Gently, Image Wisely)

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

3. Shielding

D. Emergency procedures

X. Patient Protection

A. Principles (ALARA)

B. Radiation safety practices
   1. Beam restriction
   2. Shielding
   3. Exposure factors
   4. Patient considerations
      a. Positioning (e.g., AP versus PA)
      b. Communication
      c. Pediatric
      d. Morbid obesity
      e. Pregnancy
   5. Immobilization

C. Education
   1. Image Gently®
   2. Image Wisely®
   3. CARES Committee

D. Equipment and accessories
   1. Filtration
   2. Image receptor
   3. Grid

E. Fluoroscopic procedures

F. Mobile radiography

XI. Personnel Protection

A. Exposure sources:
   1. Primary radiation
   2. Scatter radiation

B. Protective devices (e.g., aprons, barriers)

C. Fluoroscopy procedures
   1. Protective curtain
   2. Bucky slot cover
   3. Cumulative timer
   4. Remote control

D. Mobile procedures
    1. Protective garments
    2. Distance
    3. Beam – patient line

Clinical Practice

Objectives:

- Discuss ethics and the characteristics of professional behavior.
- Apply professional communication techniques.
- List the radiography practice standards.
- Demonstrate positive values and a commitment to patient-centered, quality care for all.
- Explain the elements of procedural performance and radiation protection.
- Recognize the requirements for clinical competency.

Content

I. Professionalism

A. Standards of ethics and professional behavior
   1. ARRT Standards of Ethics incident reporting mechanisms
   2. Student supervision
      a. Direct
      b. Indirect
   3. The patient's expectations, rights, and responsibilities
   4. The radiographer's professional responsibilities

B. Professional communication
   1. Patients
   2. Patient's family or authorized representatives
   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
   6. ASRT's Best Practices in Digital Radiography

D. Values
   1. Personal
      a. Values development
      b. Effect on patient care
   2. Societal
      a. Rights and privileges
      b. Community values
      c. Effect on patient care

3. Professional
    a. Values development
    b. Values conflict
    c. Effect on patient care
    d. Effect of social media

II. Patient-centered, quality care for all

A. Societal and individual factors
    1. Socioeconomic factors
        a. Effects on health care
        b. Access to care
        c. Relationship to disease occurrence
    2. Varying backgrounds and lived experiences
        a. Social factors
        b. Medical treatment barriers
        c. Cultural differences
    3. Family structure and dynamics
    4. Geographical factors
        a. Availability of health care services
        b. Social acceptance of cultural differences
    5. Religion, spirituality, and belief system
    6. Lifestyle choices and behaviors
    7. Disability
    8. Cognitive processing

B. Optimal wellness and quality care for all patients
    1. Barriers
    2. Health outcomes, including morbidity and mortality
    3. Social factors
    4. Patient and family centered care
    5. Adapting to patient needs
        a. Processes
        b. Interpersonal engagement

III. 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
   a. Personal protective equipment (PPE)
      1) Types
      2) Proper use
5. Patient education
   a. Appropriate communication style
   b. Age-specific
   c. Cultural sensitivity
   d. Socioeconomic sensitivity
   e. Patient-centered 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 (AAPM recommendations)
      b. Protection of personnel
      c. Protection of others
   3. Education
      a. Patient, family members, or authorized representatives
      b. Other members of the healthcare team
   4. Equipment and accessories

IV. Clinical Competency

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

Additional Concentrations

Objectives:

- Differentiate the equipment used in various imaging concentrations.
- Discuss the dose differences between imaging and radiation therapy doses.
- Compare and contrast the various methods of image creation.
- Explain the basic indications and contraindications for various imaging concentrations.
- List the educational and certification requirements for different imaging concentrations.
- Discuss the image appearance and principles of operation for equipment used in various imaging concentrations.

Content

I. Bone Densitometry

II. Cardiac Interventional

III. Computed Tomography

IV. Magnetic Resonance

V. Mammography

VI. Medical Dosimetry

VII. Nuclear Medicine/Molecular Imaging

VIII. Radiation Therapy

IX. Sonography

X. Vascular Interventional

Optional Content

This section includes instructional content covering specialized or advanced content areas that may not be necessary for all educational programs. This includes additional computed tomography content, advancements in artificial intelligence, and much more detailed sectional anatomy.

Also included is a section on older technologies and technical principles that have been replaced with newer systems. These older systems are still part of the fabric of many communities, and may be included as needed by educational programs.

Basic Principles of Computed Tomography

Objectives:

- Describe the types and components of CT scanners.
- Describe the operations and processes by which CT scanners generate images.
- List the factors and postprocessing operations that affect image appearance.
- Apply radiation protection techniques specific to CT practice.

Content

I. Computed Tomography Scanners

A. Helical

B. Multi-detector

II. Components, Operations, and Processes

A. Data acquisition

1. Methods
   a. Slice-by-slice
   b. Volumetric
2. Beam geometry
   1) Parallel
   2) Fan
   3) Cone
3. Data acquisition system (DAS)
   a. Components
      1) Gantry
      2) Tube
      3) Detectors
      4) Filters
      5) Collimators
      6) Analog-to-digital conversion (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)

c. Selectable scan factors
   1) Scan field of view
   2) Display field of view
   3) Matrix size
   4) Scanning interval
   5) Slice thickness
   6) Algorithm
   7) Scan time and rotational arc
   8) Radiographic tube output
   9) Annotation
   10) Region of interest (ROI)
   11) Magnification
   12) Focal spot size and tube geometry

B. Contrast administration
   1. Type
   2. Dosage
   3. Route

C. Factors controlling image appearance
   1. Artifacts
   2. Contrast resolution (window width)
   3. Grayscale manipulation (window level)
   4. Distortion
   5. Noise
   6. Spatial resolution
   7. Temporal resolution

D. Postprocessing
   1. Image reformatting
   2. Image smoothing
   3. Edge enhancement
   4. Window level and width
   5. 3D reconstruction

III. Radiation Protection

A. Patient dose reduction
   1. Technical factor selection
   2. Technical adjustments for children
   3. Scatter radiation reduction

B. Reducing 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

Sectional Anatomy

Objectives:

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

Content

I. Anatomical Nomenclature

A. Directional references

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. 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)

III. 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

IV. 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

V. 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 venous system
4. Gallbladder and biliary system
5. Pancreas and pancreatic ducts
6. Spleen
7. Adrenal glands
8. Urinary system and tract
   a. Kidneys
   b. Ureters
9. Stomach
10. Small intestine
11. Colon
12. Musculature

VI. 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

VII. 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

Artificial Intelligence

The content in this section is a developing area of science, and the language used to describe and differentiate these technologies and techniques is similarly developing. Programs and educators are encouraged to frequently re-examine content in this field to stay current with the latest developments.

Objectives:

- Define terminology associated with artificial intelligence.
- Discuss data and data sets as they apply to artificial intelligence.
- Explain the principles of machine learning, deep learning, natural language processing, and neural networks.
- Outline artificial intelligence applications in health care and medical imaging.
- Recognize the standards and ethics applicable to artificial intelligence in medical imaging.
- Describe artificial intelligence regulation and workflow integration.
- Discuss the role of artificial intelligence in precision medicine.

Content

I. Terminology and concepts

A. Algorithm

B. Automation

C. Artificial intelligence (AI)
   1. Artificial narrow intelligence
   2. Artificial general intelligence
   3. Artificial super intelligence

D. AI-enabled

E. AI-bias

F. Machine learning (ML)
   1. Supervised
   2. Unsupervised
   3. Deep learning (DL)

G. Neural networks
   1. Artificial neural networks (ANN)
   2. Convolutional neural networks (CNN)
   3. Recurrent neural networks (RNN)

H. Software as a medical device (SaMD)

I. Recursion

J. Natural language processing (NLP)
   1. Pattern recognition
   2. Visual perception
   3. Decision making

II. Data and Data Sets

III. Applications in Healthcare

IV. AI in Medical Imaging

A. Order scheduling and patient screening

B. Exam protocoling

C. Image acquisition

D. Image analysis
   1. Automated detection of findings
   2. Automated interpretation of findings

E. Automated clinical decision support (CDS)

F. Image post-processing

V. Ethics, Legality, and Liability

VI. Regulation and Workflow Integration

VII. Precision Medicine

Advancements in Medical Imaging

These traditional medical imaging technologies are considered to be outdated, as they have largely been replaced by newer technologies and techniques. However, in some areas this equipment may still be in use and radiographers may need to understand the principles of its operation. Other programs and instructors may find value in discussing these topics as historical context and to assist in understanding the ongoing development of the field.

Objectives:

- Describe the mechanisms of flat panel and photon-counting imaging detectors.
- Explain slot scan, tomosynthesis, and dual energy imaging systems.
- Discuss multiplanar reconstruction, viewing, and printing techniques for volumetric imaging.

I. Imaging Detectors

A. Flat panel detector advancements (e.g., sampling technology, glass-free substrate, AEC assistance)

B. Photon counting detector (PCD)

II. Imaging Technologies

A. Slot scan

B. Tomosynthesis

C. Dual energy

III. Volumetric Imaging (3D)

A. Multiplanar reconstruction

B. Viewing

C. Printing

IV. Dynamic Digital Receptors (DDR)

Imaging and Radiologic Sciences Resources

This list of resources is to assist educators in sampling the references and study materials available in the medical imaging and radiologic sciences. The resources list should be viewed as a snapshot of available materials and is not exhaustive. Omission of any one title is not intentional. Because the pool of literature and media related to the profession is dynamic, educators are encouraged to find additional sources for recent updates, revisions, and additions to this collection of titles.

Textbooks and Reports

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Radiography. The College of Radiographers, St. Louis, MO.

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

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

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

Appendix

Curriculum Revision Workgroup

We would like to extend special recognition to the outstanding professionals who volunteered their time as members of the curriculum revision project:

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