

Radiography Curriculum

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Introduction

The first ASRT Radiography Curriculum was written in 1952. Throughout its history, the goal of this document has been to outline a common body of knowledge that is essential for entry-level radiographers. The challenge 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 preprofessional 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: preprofessional core content and optional content.

- Preprofessional 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 health care 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 a 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 people 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.

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Preprofessional Core Content

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

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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, including advancement pathways for imaging professionals.

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, Requisitions, and Diagnostic Reports

A. Procedure orders and requisitions

1. Patient identification
2. Procedures ordered
3. Patient history
4. Clinical indications
5. Ordering physician/provider

B. Diagnostic reports

1. Content
2. Radiologist 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 assistant (general and magnetic resonance)
13. Magnetic resonance imaging
14. Mammography
15. Medical dosimetry
16. Medical physics
17. Medical Imaging Reconstruction Specialist
18. MIMPS Specialist
19. Molecular imaging
20. Multicredentialed
21. Nuclear medicine advanced associate
22. Nuclear medicine technology
23. Quality management
24. Radiation safety
25. Radiation therapy
26. Radiologist assistant
27. Research
28. Vascular sonography
29. Vascular-interventional radiography
30. Imaging informatics professional

B. Other health professions

V. Interprofessional Practice & Education

- A. Interprofessional education
 - 1. Collaborative practice
 - 2. Interprofessional Education Collaborative (IPEC)
 - a. Values and ethics
 - b. Roles and responsibilities
 - c. Communication
 - d. Teams and teamwork

VI. Evidence-Based Practice

- A. Foundations
- B. Research literacy
- C. Literature search
- D. Application to clinical practice

VII. Health Care Environment

- A. Health care settings
 - 1. Hospitals
 - 2. Specialty clinics (e.g., pain, orthopedic, oncology)
 - 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, vascular)
 - 8. Home health care
 - 9. Telehealth
 - 10. Mobile health care/mobile imaging services
 - 11. Other (e.g., correctional health care facilities, rehabilitation, medical examiner offices)
- B. Payment/reimbursement systems
 - 1. Self-pay
 - 2. Insurance
 - 3. Government programs

VIII. Artificial Intelligence (AI) and Emerging Technologies

- A. Definition and basic AI concepts
- B. AI in imaging acquisition, reconstruction, analysis, and detection

- C. Computer aided detection (CAD)
- D. Ethical considerations and limitations
- E. Human-AI collaboration
- F. Impact on radiographer responsibilities
- G. Future imaging technology trends

IX. 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

X. Accreditation

- A. Health care institutions (e.g., The Joint Commission)
- B. Modalities (e.g., American College of Radiology [ACR])
- C. Educational
 - 1. Programmatic accreditation (e.g., Joint Review Committee on Education in Radiologic Technology [JRCERT])
 - 2. Regional accreditation
 - 3. National accreditation
 - 4. Other

XI. Regulatory Agencies

A. Federal

B. State

XII. Radiology Organization

A. Professional personnel

1. Administrators/managers
2. Radiologists
3. Radiologic technologists
4. Radiologist assistants
5. Radiology nurses
6. Other medical imaging and radiologic sciences professionals
 - a. Medical physicists
 - b. Imaging assistants (general and magnetic resonance)

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

XIII. Professional Credentialing

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

B. State licensure

XIV. Professional Organizations

A. Purpose, function, and activities

B. Types

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

XV. Professional Development and Advancement

- A. Required
 - 1. Continuing education
 - 2. Continuing qualifications requirements (CQR)
- B. Clinical experience
- C. Continuing education opportunities
 - 1. Post-primary 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. Consulting
 - 4. Education
 - 5. Forensics
 - 6. Medical dosimetry
 - 7. Industrial radiography
 - 8. Imaging informatics
 - 9. Medical physics
 - 10. Research
 - 11. Sales/applications
 - 12. Radiation 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.
- Apply consent and legal doctrines to data use and artificial intelligence (AI)-assisted imaging workflows.
- Explain the basics of digital privacy and security (e.g., access controls, audit trails, breach response).
- Document AI involvement, limitations, and escalation procedures.

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 (formerly the Patients' Bill of Rights)

II. Ethical Dilemmas

- A. Individual and societal rights
- B. Cultural considerations
- C. Economic considerations

- D. Technology
- E. Artificial intelligence
- F. Resource scarcity
- G. Access to quality health care
- H. Human experimentation and research
- I. Patient-centered, quality care for all
- J. End-of-life
- K. Ethics committee
 - 1. Structure
 - 2. Goals
 - 3. Function
- L. Ethical conduct of research
 - 1. Historical events
 - 2. Institutional review board
 - 3. Data collection
 - 4. Data reporting
 - 5. Use of artificial intelligence
 - 6. Use of protected health information (PHI)
- M. Ethical dilemmas in medical imaging
 - 1. Image cropping, masking, or duplication
 - 2. Electronic annotations (e.g., R/L electronic markers, patient positioning indications)
 - 3. Manipulation of metadata
 - 4. ALARA
 - a. Dose creep
 - b. Documentation of dose
 - 5. Artificial intelligence (AI) use in radiography
 - 6. Documentation
 - a. Changes to order
 - b. Medical events

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., personal devices, 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

II. 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

III. Patient Consent

- A. Definition
- B. Types (e.g., informed, oral, implied)
- C. Conditions for valid consent (e.g., legally required vs. organizational policy)
- D. Documentation of consent
- E. Consent revocation
- F. Patient Rights and Responsibilities
- G. Patient restraints
- H. Use of AI-enabled applications (e.g., modeling, optimization, interpretation, acquisition, analysis, quality control)

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 radiologic technology 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 media and their application.
- Demonstrate safe venipuncture techniques and management of tubes, catheters, lines, and other interventional medical devices.

Content

I. Health Care Team

A. Responsibilities of the health care facility

1. Provide care for all patients
2. Promote health
3. Prevent illness
4. Educate patients and community
5. Research

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

C. Responsibilities of the radiographer

1. Perform radiographic examinations
2. Perform patient care and assessment
3. Adhere to radiation protection/safety principles
4. Follow practice standards and ethical guidelines
5. Assist the radiologist or radiologist assistant (R.R.A.)

II. Professionalism in Patient Care

A. Health and illness continuum

B. Emotional intelligence

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

C. Developing professional attitudes

1. Teamwork
2. Work ethic
3. Health role model

D. Empathy vs. sympathy

1. Compassion
2. Assertiveness

E. Age- and generation-specific communication

1. Neonates
2. Pediatrics
3. Adolescents
4. Young adults
5. Middle-aged adults
6. Older adults

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 background and needs of humans
5. Communication supports (AAC)
6. Other factors that impede communication
 - a. Colloquialisms and slang
 - b. Medical terminology
7. Patient interactions
 - a. Eye contact
 - b. Volume and speed of speech
 - c. Hand gestures
 - d. Effective listening
 - e. Feedback

A. Cultural sensitivity

B. Trauma-informed care

1. Communication with families or authorized representatives
2. Communication with other health care professionals (e.g., SBAR, TeamSTEPPS)

C. Psychological considerations

D. Mental health awareness

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. Personal biases
- l. Self-awareness

III. Patient/Radiographer Interactions

- A. Patient identification methods using two identifiers
 - 1. Interviewing and questioning
 - 2. Chart/requisition
 - 3. Identification wristbands
 - 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. Transfer devices
4. Positioning for safety, comfort, or exams
5. Wheelchair transfers
6. Stretcher transfers
 - a. Sheet transfer
 - b. Log roll
7. Assisting patients with medical equipment (e.g., tubes, catheters, lines)

D. Fall prevention

E. General patient positions

1. Supine
2. Prone
3. Decubitus
4. Oblique
5. Fowler's
6. Semi-Fowler's
7. Left semiprone
8. Left lateral recumbent
9. Lithotomy
10. Trendelenburg

F. Safety and immobilization

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

G. Magnetic resonance (MR) safety

1. Patient checklist/screening
2. MR imaging safety zones
3. Response to emergencies in MR (fire, code)

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 (O₂) saturation
8. Prothrombin
9. Partial thromboplastin time
10. Human chorionic gonadotropin (hCG)

E. Patient Record

1. Elements of a patient record
2. Retrieving specific information

F. Documentation in the chart

G. 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. Postexposure 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 (enteric, contact, droplet, airborne)

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. Syncope and seizures

1. Syncope
 - a. Signs and symptoms
 - b. Reasons for fainting
 - c. Response to syncope
2. Seizures
 - a. Seizure Types
 - 1) Focal
 - 2) Generalized
 - 3) Unknown
 - 4) Onset, Awareness and Movements
3. Medical interventions

I. Other medical conditions

1. Epistaxis
2. Nausea/vomiting
3. Postural hypotension
4. Vertigo
5. Asthma
6. Opioid overdose

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
3. Healing classifications (primary, secondary, tertiary)

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 Media

A. Types of contrast media

1. Metallic salts
2. Organic iodides
 - a. Ionic contrast media
 - b. Nonionic contrast media
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, pre- and postoperative)
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 media

1. Signs
2. Symptoms
3. Medical intervention

XV. Routes of Drug Administration

- A. Enteral
 - 1. Sublingual
 - 2. Buccal
 - 3. Oral
 - 4. 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

XVII. 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
 - 3. Care, drainage 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

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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
4. Nucleic acids
 - a. DNA
 - b. 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

1. Smooth
2. Cardiac
3. Skeletal

B. Functions and Characteristics

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 examinations.
- 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. Fowler's
7. Semi-Fowler's
8. Decubitus
9. Erect/upright
10. Anterior position
11. Posterior position
12. Oblique position

C. General planes

1. Sagittal or midsagittal
2. Coronal or midcoronal
3. Transverse or axial
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 angle 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

I. Accessory equipment

1. Lead shields
2. Lead markers
3. Image receptor holders
4. Compensating filters

II. General Considerations

A. Evaluation of radiographic orders

1. Patient identification (two means)
2. Verification of procedure(s) ordered (correct laterality, correct body part)
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. Examination 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 genitourinary (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 individuals

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.
- Adjust technical factors for additive/destructive conditions; document findings using controlled terminology.

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
 - 1. Technique adjustment guidance linked to pathology-specific attenuation
- I. Appropriate imaging concentration

IV. Implications for Practice

- A. Indications for procedure
- B. Relevance to radiographic procedures

1. Technical considerations
2. Patient considerations

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Radiation Physics and Instrumentation

Objectives:

- Describe the structure of atoms and types of radiation.
- Explain x-ray production and the effect of various factors on the resulting beam.
- Discuss photon interactions with matter.
- Diagram the components of the x-ray circuit and x-ray tube.
- Employ radiographic equipment of various types.
- Describe the components and operation of fluoroscopy systems.

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 ($T_{1/2}$)

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 (penetrability)
 - b. Quantity (intensity)
 - c. Primary vs. remnant (exit) radiation
 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. Exposure 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
 5. Photodisintegration
- C. Probability of photon interactions

1. Atomic number
2. Photon energy
3. Tissue volume
4. Mass density
5. Tissue 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. X-ray tube
 - b. Beam restriction
 - c. Radiolucent table
 - d. Operating (control) console

- e. Tube support systems
 - f. Wall unit
 - g. Potter-Bucky mechanism and grid
 - h. Automatic exposure control
 - i. Image receptors
 - j. Generator
 - 2. Equipment operation and manipulation
 - 3. Applications
- B. Mobile units
- 1. Components
 - a. X-ray tube
 - b. Beam restriction
 - c. Operating (control) console
 - d. Tube support systems
 - e. Image receptors
 - f. Generator
 - g. Power source
 - h. Mobile base and drive system
 - 2. Equipment operation and manipulation
 - 3. Clinical applications (e.g. emergency department, operating room, 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 considerations
 - a. Contrast media
 - b. Patient size
 - c. Pathology
 - d. Prosthetics/implants
 - e. Collimation
 - f. Image receptor variations
 - 6. Image receptor-based exposure control
 - 7. Automatic exposure detection (AED)
 - 8. Signal monitoring
 - 9. Software-based exposure termination
 - 10. Manual exposure control

VII. Diagnostic X-ray Tubes

- A. Construction
- B. Cathode assembly
- C. Anode assembly
- D. Envelope
- E. Protective housing
- F. 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. Single-detector
 - 2. Multiple-detector
 - 3. Readout
 - 4. File sizes
 - 5. Data management
- 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. Real-time viewing
 - a. Continuous
 - b. Pulsed
 - 1) Pulse width
 - 2) Pulse height
 - 3) Pulse interval
 - 4) Frame rate
 - 5) Dose rate
 - 2. Image recording and storage
 - a. Unsubtracted
 - b. Digital subtraction angiography (DSA)
 - c. Cine
 - d. Static image
- 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
5. Image processing
 - a. Detector elements (DEL) binning
 - b. Temporal processing/averaging
 - c. Spatial processing
 - d. Noise reduction

F. Mobile units

1. Types
 - a. C-arm
 - b. Mini C-arm
 - c. Hand-held
 - d. O-arm
2. Operation and manipulation

IX. Dynamic Digital Radiography (DDR)

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's digital processing and image display process.
- Select exposure factors using detector-specific indicators; differentiate artifact sources; apply virtual grid tools.

I. Exposure Factors and Beam Control

A. Milliampere-seconds (mAs)

1. Beam quantity
2. Milliamperes (mA)
3. Exposure time
4. Direct square law/exposure maintenance formula

B. Kilovoltage peak (kVp)

1. Beam quality/penetrability
2. Beam quantity
3. Subject contrast
4. 15% rule

C. 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

F. Focal spot size

1. Actual versus effective
2. Line focus principle
3. Anode heel effect

G. 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

H. 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

I. Scatter radiation

1. Production
 - a. Kilovoltage peak (kVp)
 - b. Irradiated tissue
 - c. Volume
 - d. Field size
 - e. Part thickness
 - f. Part composition
2. Reduction
 - a. Collimation
 - b. Grid
 - c. Lead masking
 - d. Air-gap technique

J. 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. Radius
 - b. Ratio

- c. Frequency
 - d. Lead content
- 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. Latent image formation
- F. 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. Characteristics
 - a. Detector element (DEL)
 - 1) Size

- 2) Fill factor
 - 3) Pitch
 - b. Phosphor layer
 - 1) Crystal size
 - 2) Thickness
 - c. Bit depth
 - d. Dynamic range
- G. Performance metrics
 - 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. Spatial resolution
 - 4. Contrast resolution
 - 5. Exposure latitude
- H. Analog-to-digital conversion/data extraction
 - 1. Sampling
 - 2. Quantization
- I. Low-intensity radiation response
 - 1. Accumulated background radiation
 - 2. Scatter radiation

III. 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
 - a. Effects of changing exposure factors on radiographic quality
 - b. Detector selection
 - c. Anatomic alignment
 - d. Exposure adjustment (e.g. density +1 or -1)
 - 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

IV. 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

V. 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. Grayscale postprocessing
 - a. Display brightness (window level)
 - b. Display contrast (window width)
 - c. Look-up table (LUT) reprocessing

- d. Equalization
- e. Inversion
- 2. Spatial domain processing
 - a. Edge enhancement
 - b. Smoothing
- 3. Spatial frequency processing
 - a. Low-frequency filtering(smoothing)
 - b. High-frequency filtering (edge enhancement)
- 4. Image reformatting
 - a. Electronic masking
 - b. Magnification/zoom/pan
 - c. Rotation
 - d. Image flip
 - e. Region of interest (ROI)
 - f. Field of view (FOV)

Imaging Informatics

Objectives

- Discuss the terminology for key systems and standards used in imaging informatics.
- Outline key principles of image management.
- Discuss key principles of information technology.
- Explain the key principles of systems management.
- Recognize the key integration standards and align with imaging standards and laws.
- Discuss downtime procedures for radiologic technologists.
- Implement quality assurance/quality control plans that include informatics checkpoints; analyze reject trends and propose corrective actions.

I. Key Systems and Standards

- A. Medical Image Management and Processing System (MIMPS), formerly known as Picture Archiving and Communication System (PACS)
- B. Vendor Neutral Archive (VNA)
- C. Radiology Information System (RIS)
- D. Electronic Medical Record (EMR)/Electronic Health Record (EHR)
- E. Radiology Reporting Platform
- F. Digital Imaging and Communication in Medicine (DICOM)
- G. Health Level Seven (HL7)
 1. Fast Healthcare Interoperability Resources (FHIR)
- H. Integrating the Healthcare Enterprise (IHE)

II. Image Management

- A. Imaging workflow
 1. Standard workflow (eg, IHE Scheduled Workflow Profile)
 2. Downtime procedures
 - a. Scheduled downtime
 - b. Unscheduled downtime
 3. Teleradiology
- B. DICOM
 1. DICOM objects
 - a. DICOM header

- b. Pixel data
 - c. Information object definitions
 - 2. DICOM services
 - a. Store
 - b. Query/retrieve
 - c. Modality worklist
 - d. Additional DICOM services
 - 3. DICOM presentation states
 - 4. Service-object pairs (SOP)
- C. Data Integrity
 - 1. Merging patients
 - 2. Linking patients
 - 3. Merging studies
 - 4. Moving images
 - 5. Correcting information at all levels of MIMPS (formerly PACS) hierarchy
- D. Enterprise image management strategies

III. Information Technology

- A. Servers and client workstations
- B. Image storage
 - 1. Modality/device storage
 - 2. Archive storage
 - 3. Compression
 - a. Lossless
 - b. Lossy
 - 4. Storage types
 - a. Cloud
 - b. Direct attached storage (DAS)
 - c. Network attached storage (NAS)
 - d. Storage area network (SAN)
- C. Networking
 - 1. Network architecture
 - a. Local area network (LAN)
 - b. Wide area network (WAN)
 - c. Bandwidth
 - 1) Mbps
 - 2) Gbps
 - 2. TCP/IP network protocol
 - 3. Network components
 - a. Switch
 - b. Routers

- c. Hub
- d. Bridge

D. Cybersecurity

IV. Systems Management

- A. Performance monitoring and optimization
- B. Disaster recovery (DR)
- C. Business continuity
- D. Upgrades and testing procedures
- E. Data and system migration

V. Medical Imaging Informatics

- A. System integrations
 - 1. HL7 interfaces
 - 2. DICOM integrations
 - 3. Application programming interface (API) integrations
- B. Aligning with imaging standards and laws
 - 1. Health Insurance Portability and Accountability Act of 1996 (HIPAA)
 - 2. State medical record retention laws
 - 3. ACR-AAPM-SIIM Practice Parameter for Electronic Medical Information Privacy and Security

Image Analysis

Objectives:

- List image appearance standards.
- Justify the need for imaging standards.
- Explain technical, procedural, and clinical factors affecting image appearance.
- Recognize various types of artifacts.
- Describe corrective actions that can be taken to improve image appearance.
- Apply quality management techniques and programs.
- Apply quality control measures to imaging equipment and accessories.

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 (quality assurance 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 Quality Factors

- A. Contrast
 - 1. Subject contrast
 - 2. Latent image contrast (raw image contrast)
 - 3. Displayed image contrast (processed image contrast)
- B. Noise
 - 1. Electronic
 - 2. Quantum

- 3. System
- 4. Background
- C. Signal-to-noise ratio (SNR)
- D. Contrast-to-noise ratio (CNR)
- E. Image resolution
 - 1. Spatial resolution
 - 2. Contrast resolution
 - 3. Temporal resolution
- F. 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)

IV. Procedural Factors

- A. Pre-examination preparation
- B. Image identification
 - 1. Patient information
 - 2. Date of examination
 - 3. Anatomic lead markers
 - 4. Institutional data
- C. 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
- D. Radiation protection
 - 1. Collimation
 - 2. Time

3. Distance
4. Shielding per current recommendations
5. Repeated images

V. Clinical Factors

- A. Contrast media
- B. Postexamination instructions

VI. Artifacts

- A. Image acquisition
 1. Exposure field recognition
 2. Collimation border recognition
 3. Exposure field distribution (segmentation error)
 4. Unexpected material in data set (e.g., metal)
 5. Overexposure/saturation
 6. Underexposure/starvation
 7. Overpenetration
 8. Underpenetration
- B. Equipment
 1. Ghosting
 2. Data drop
 3. Backscatter artifact
 4. Electronic
 5. Fogging (CR)
 6. Display monitor
 7. Processing
 8. Algorithm error
 9. Image transmission error
 10. Histogram analysis error

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. Corrective action
 10. 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. Acceptance testing
 - c. Equipment calibration
 - d. Uniformity
 - e. 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. Quality Control of Imaging Equipment and Accessories

- A. Radiographic
 - 1. kV accuracy
 - 2. Filtration and half-value layer (HVL)
 - 3. Exposure reproducibility
 - 4. Exposure linearity
 - 5. Timer accuracy
 - 6. Focal spot size
 - 7. Beam alignment
 - 8. Collimator accuracy
 - 9. SID indicator

10. Image receptors
11. Automatic exposure control (AEC)
12. Exposure indicator accuracy
13. Detector uniformity
14. Display monitors
15. Computed radiography (CR) erasure thoroughness

B. Fluoroscopic

1. Exposure rate
2. Source-to-skin distance (SSD)
3. Automatic brightness systems (ABS)/Automatic exposure rate control (AERC)
4. kV 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 accuracy
12. Display monitors

C. Personal protective equipment

D. Recognizing and reporting equipment malfunctions

IX. Corrective Action

- A. Image quality 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. General radiography
2. Fluoroscopy
3. Computed Tomography (CT)
4. Cardiac-interventional radiology
5. Vascular-interventional radiology
6. Mammography
7. Nuclear medicine
8. 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 LD₅₀

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. Human-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 (Gy_a)
 - 4. Equivalent dose - 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 (E_{exp})
 - 4) Effective dose per individual in the U.S. population whether exposed to the specific source or not (E_{US})
- 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 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)
- 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 vs. 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

DRAFT

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
- C. Health care team
 3. 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
- E. Patient-centered, quality care for all
 - 1. Societal and individual factors
 - a. Socioeconomic
 - b. Effects on health care
 - c. Access to care
 - 2. Relationship to disease occurrence
 - a. Varying backgrounds and lived experiences
 - b. Social factors
 - c. Medical treatment barriers
 - d. 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. Trauma-informed care
 - 7. Disability
 - 8. Cognitive processing
- F. 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
 - 6. Health literacy

II. Procedural Performance

- A. Scheduling and sequencing of examinations
- 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 health care team
 - 4. Equipment and accessories

III. 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 and Vascular Interventional**
- III. **Computed Tomography**
- IV. **Magnetic Resonance Imaging**
- V. **Mammography**
- VI. **Medical Dosimetry**
- VII. **Nuclear Medicine/Molecular Imaging**
- VIII. **Radiation Therapy**
- IX. **Sonography**
- X. **Imaging Informatics**

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 content.

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.

Advanced Contrast Management

Considerations

Before the introduction of this advanced educational content, students should have received appropriate instruction and have demonstrated clinical competence (where applicable) in the basic patient care concepts detailed in the **Patient Care and Services in the Medical Imaging and Radiologic Sciences** section of this curriculum. In addition, students should achieve advanced cardiac life support (ACLS) certification as a prerequisite to this advanced level of patient care.

Objectives:

- Review patient medical data for indications, contraindications, and alterations to procedures.
- Obtain and analyze the patient's vital signs.
- Identify and respond to changes in patient status, procedural complications, and emergencies.
- Determine the appropriate use of contrast media based on patient factors and procedural requirements.
- Describe the physical properties, structural differences, and pharmacologic characteristics of contrast media.
- Differentiate drug names (generic, chemical, trade, official).
- Identify patients at increased risk of an adverse reaction to contrast media.
- Identify the response strategies for patients with a predisposition for allergic reaction to contrast media.
- List common variables affecting drug action within the body.
- Recognize unexpected responses or reactions to drugs.
- Classify the indicators and symptoms associated with mild, moderate or severe reaction to contrast media and respond appropriately.
- Implement protocols to treat a patient experiencing an adverse reaction to contrast media.
- Perform calculations for drug dose delivery.
- Describe various forms of drug preparations and supplies. Incorporate the principles of responsible drug administration in the patient care setting to prevent medication errors.
- Apply medical techniques of drug administration for common delivery routes.
- Modify drug doses for pediatric and geriatric patients.
- Assess and manage the patient prior to and during examinations requiring medication administration.
- Describe guidelines for preparation and dispensation of medications, including compounding, for imaging procedures per approved protocols.
- Demonstrate best-practice communication during contrast reactions.

- Review incidence of contrast reactions and identify the difference between high-osmolar contrast media (HOCM) and low-osmolar contrast media.

Content:

I. Patient Assessment and Management

- A. Obtaining and assessing patient vital signs
 1. Pulse
 2. Blood pressure
 3. Respiration
 4. Oxygen saturation
 5. Pain scale
 6. Temperature
- B. Airway management
- C. Patient recovery
- D. Patient disposition
 1. Activating emergency response
 2. Observation
 3. Return precautions
- E. Focused physical examinations
 1. Skin examination
 - a. Assess for rash, hives, flushing, or swelling
 - b. Identify localized vs. generalized involvement
 2. Lung examination
 - a. Auscultate for wheezing, stridor, or crackles
 - b. Observe work of breathing and oxygenation status
 3. Oropharynx examination
 - a. Inspect lips, tongue, and throat for swelling or angioedema
 - b. Listen for voice changes or stridor suggesting airway compromise
 4. Upper extremity examination
 - a. Evaluate for swelling, discoloration, or firmness at the intravenous (IV) site (e.g., extravasation, infiltration)
 - b. Assess circulation, sensation, and motor function in the affected limb

II. Pharmacology

- A. Drug interactions

- B. Accurate drug administration
- C. Dosage
 - 1. Safe dose calculation
 - 2. Factors affecting dose
- D. Route
- E. Patient considerations
- F. Pharmacokinetic and pharmacodynamic considerations
- G. Contraindications, allergies, warnings, adverse effects and events, and adverse reactions
- H. Medication error avoidance
- I. Documentation
- J. Noncontrast reaction medications brief overview
 - 1. Anxiolytics (e.g., benzodiazepines)
 - 2. Beta blockers
 - 3. Nitroglycerin

III. Care Interventions

- A. Airway and oxygen administration
 - 1. Assess airway patency (ability to speak, presence of stridor, obstruction)
 - 2. Optimize ventilation (head-tilt chin-lift, nasopharyngeal airway [NPA])
 - 3. Administer supplemental oxygen as directed:
 - a. Nasal cannula (1–6 L/min)
 - b. Simple facemask (6–10 L/min)
 - c. Nonrebreather mask (10–15 L/min)
 - 4. Monitor oxygen saturation continuously with pulse oximetry
- B. Medication administration
 - 1. Intramuscular (IM) injection
 - a. Identify appropriate site (deltoid, thigh, gluteal muscle)
 - b. Use correct needle gauge and length based on patient factors
 - c. Administer epinephrine or other emergency medications per protocol

2. Auto-injector
 - a. Confirm correct medication and dosage
 - b. Apply firmly to the mid-outer thigh until the injector activates
 - c. Hold in place as instructed, then massage site to promote absorption
3. IV administration
 - a. Establish IV access using aseptic technique
 - b. Confirm patency of line with saline flush before administration
 - c. Deliver medication as IV push, infusion, or piggyback as directed
4. Oral (PO) administration
 - a. Confirm the patient can safely swallow without aspiration risk
 - b. Provide medication in appropriate form (tablet, capsule, liquid)
 - c. Administer with water

IV. Contrast Media

- A. Risk reduction
 1. Patient assessment
 2. Premedication and hydration protocols
 3. Dosage considerations
 4. Alternative procedure consultation
- B. Complications
 1. Nephrotoxicity
 2. Nephrogenic systemic fibrosis (NSF)
 3. Adverse reaction
 - a. Signs
 - b. Symptoms
- C. American College of Radiology (ACR) contrast reaction treatment and guidelines
 1. Standing protocols
 2. Verbal orders
- D. Medical complications and emergency intervention
 1. Emergency codes
 2. Resuscitation

V. Communication

- A. Principles of effective communication
 1. Use clear, concise, and direct language when conveying patient information or instructions

2. Emphasize the importance of timely communication during all stages of patient care, particularly in emergencies
3. Incorporate structured communication techniques (e.g., SBAR: situation, background, assessment, recommendation) to ensure clarity

B. Closed-loop communication

1. Repeat back physician instructions to confirm accuracy and reduce miscommunication
2. Seek verbal confirmation from the supervising physician to validate that instructions were heard and understood
3. Apply this technique consistently during critical interventions such as contrast reaction management

C. Communication modalities

1. Audio-visual communication: maintain continuous connection with supervising physicians through secure two-way audio-video platforms during contrast administration
2. In-person communication: when a physician is on-site, employ the same structured techniques to ensure clarity and accuracy of patient care directions

Basic Principles of Computed Tomography

Objectives:

- Describe the types and components of computed tomography (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. Multidetector

II. Components, Operations, and Processes

A. Data acquisition

1. Methods

- a. Slice-by-slice
- b. Volumetric

2. Beam geometry

- a. Parallel
- b. Fan
- c. 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

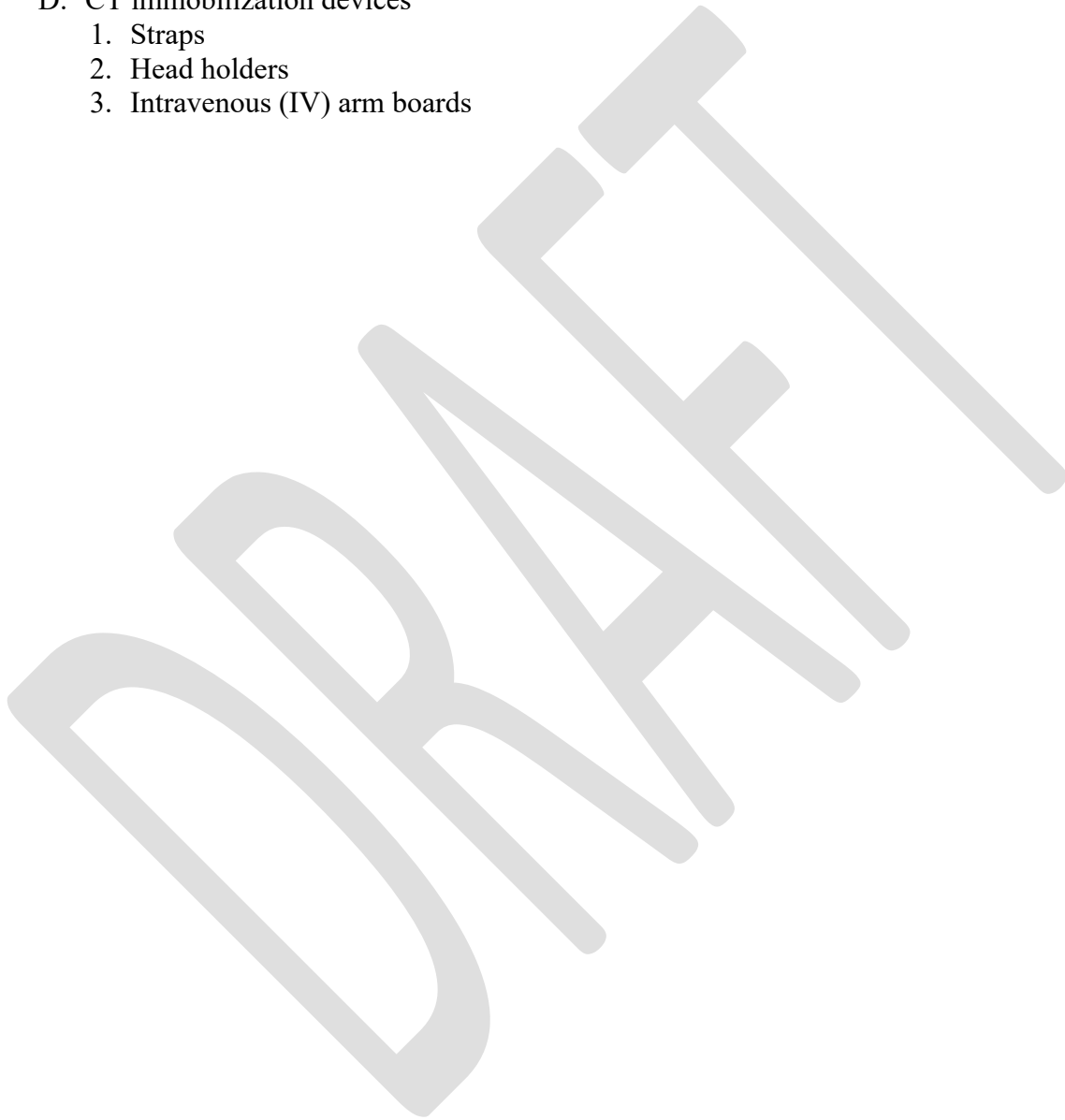
- 1) Linear attenuation coefficients

- 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)
- D. Brightness manipulation (window level)
 - 1. Distortion
 - 2. Noise
 - 3. Spatial resolution
 - 4. Temporal resolution
- E. Postprocessing
 - 1. Image reformatting
 - 2. Image smoothing
 - 3. Edge enhancement
 - 4. Window level and width
 - 5. 3D reconstruction
 - a. 3D printing

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. Intravenous (IV) arm boards



Sectional Anatomy

Objectives:

- Locate major anatomical structures on computed tomography (CT), magnetic resonance (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 atrium)
2. Interventricular foramen (of Monro)
3. Third ventricle
4. Cerebral aqueduct (of Sylvius)
5. Fourth ventricle
6. Foramen of Luschka
7. Foramen of Magendie
8. Choroid plexus

L. Meninges

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

M. Basal ganglia

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

N. Orbit

1. Globe

2. Lens
3. Optic nerve
4. Lacrimal gland
5. Lateral rectus muscle
6. Medial rectus muscle
7. Superior rectus muscle
8. Inferior rectus muscle
9. Superior oblique muscle
10. Inferior oblique muscle
11. Orbital fat
12. Ophthalmic artery
13. Retinal vein

O. Anatomical structures of brain

1. Diploe
2. Subcutaneous soft tissue
3. Superior sagittal sinus (anterior, posterior)
4. Central sulcus
5. Interhemispheric fissure
6. Falx cerebri
7. Centrum semiovale
8. Corpus callosum (genu, rostrum, body, splenium)
9. Septum pellucidum
10. Fornix
11. Sylvian fissure
12. Insula
13. Lentiform nucleus (putamen, globus pallidus)
14. Caudate nucleus (head)
15. Internal capsule (anterior, body, 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 hypochondric
2. Epigastric
3. Right hypochondric
4. Left lumbar
5. Umbilical
6. Right lumbar
7. Left iliac
8. Hypogastric
9. Right iliac

D. Branches of the abdominal aorta

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

E. Tributaries of the vena cava

1. Anterior visceral
 - a. Hepatic veins
2. Lateral visceral
 - a. Right suprarenal

- b. Renal veins
 - c. Right testicular or ovarian
 - 3. Tributaries of origin
 - a. Common iliacs
 - b. Median sacral
- F. Tributaries of the portal vein
 - 1. Splenic
 - 2. Inferior mesenteric
 - 3. Superior mesenteric
 - a. Left gastric
 - b. Right gastric
 - c. Cystic
- G. Abdominal organs and structures
 - 1. Bony structures
 - a. Lumbar vertebrae
 - 2. Abdominal cavity
 - a. Peritoneum
 - b. Peritoneal space
 - c. Retroperitoneum
 - d. Retroperitoneal space
 - 3. Liver
 - a. Hepatic arteries
 - b. Portal venous system
 - 4. Gallbladder and biliary system
 - 5. Pancreas and pancreatic ducts
 - 6. Spleen
 - 7. Adrenal glands
 - 8. Urinary system and tract
 - a. Kidneys
 - b. Ureters
 - 9. Stomach
 - 10. Small intestine
 - 11. Colon
 - 12. Musculature

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 (AI).
- Discuss data and data sets as they apply to AI.
- Explain the principles of machine learning, deep learning, neural networks, digital twinning, natural language processing, generative AI, and agentic AI.
- Outline AI applications in health care and medical imaging.
- Recognize the standards applicable to AI in medical imaging.
- Describe AI regulation and workflow integration.
- Understand the safe use of AI in the clinical environment.
- Explain AI integration into imaging workflows and identify limits necessitating human oversight.

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. Digital twinning

I. Natural language processing (NLP)

1. Pattern recognition
2. Visual perception
3. Decision making

J. Generative AI

1. Large language model (LLM)
2. Large multimodal model (LMM)
3. Large vision model (LVM)

K. Agentic AI

L. Software as a medical device (SaMD)

M. Recursion

II. Data and Data Sets

III. Applications in Health Care

IV. Human–AI Interaction and Oversight

- A. Radiographer oversight of AI-generated outputs
- B. Human validation of AI recommendations
- C. Limitations of autonomous or semiautonomous systems

V. AI in Medical Imaging

- A. The AI-assisted imaging workflow
 1. Order scheduling and patient screening
 2. Examination protocoling
 3. Image acquisition
 4. Image analysis
 - (a) Automated detection of findings
 - (b) Automated interpretation of findings
 5. Automated clinical decision support (CDS)
 6. Image post-processing

- B. Safe use of AI in Imaging
 - 1. Understanding AI outputs
 - 2. Error recognition
 - 3. Radiation safety
 - 4. AI-assisted radiation dose optimization and monitoring
 - 5. Model development best practices
 - (a) Training, validation, and testing data
 - (b) Deidentification
 - (i) Safe harbor
 - (ii) Expert determination
 - 6. Regulatory frameworks (eg, FDA, EU AI Act)
 - C. AI Governance
 - 1. Documentation
 - 2. Model selection
 - 3. Acceptance testing
 - 4. Maintaining an inventory of deployed models
 - (a) Model version
 - (b) Deployment date
 - (c) Instructions for use
 - 5. Performance Monitoring
 - (a) Model drift
 - (b) Discrepancy analysis
 - 6. Legal requirements and professional guidelines (eg, ACR ARCH-AI)
- VI. Workflow Orchestration**
- A. Routing data inputs and outputs
 - B. Integration of AI outputs to downstream systems
 - C. Display of AI outputs

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.

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

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Appendix

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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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