# Limited X-Ray Machine Operator Curriculum

# Contents

# Introduction

Clinical and Didactic Performance Standards

The ASRT defines a limited x-ray machine operator (LXMO) as an individual other than a radiologic technologist who performs diagnostic x-ray procedures on selected anatomical sites. *LXMO* is the term that replaces other terms such as *radiologic technician*, *x-ray technician* and *limited permittee*.

Although LXMOs perform imaging tasks within a limited scope, the ASRT believes that, within the specific area of radiography, the knowledge and cognitive skills underlying the intelligent performance of the LXMO must be sufficient, promoting sound patient care, high quality radiography and radiation protection.

*The ASRT does not endorse the adoption of provisions relating to limited x-ray machine operators unless these individuals are currently licensed by the state to perform limited medical imaging services.* This curriculum document is intended to establish national standardized educational guidelines for LXMOs, including clinical and didactic components. The document contains education appropriate to body areas as defined through the limited scope examinations offered by the American Registry of Radiologic Technologists (ARRT) or other nationally recognized certifying agencies. The content is designed to ensure quality patient care, radiation protection and production of quality images.

This curriculum is divided into specific content areas that represent the essential components of a LXMO program. The content and objectives should be organized to meet the mission, goals, and needs of each LXMO program. Proposed minimum hours of didactic instruction and clinical experience have been included to assist in program planning. Faculty members are encouraged to expand and broaden these fundamental objectives as they incorporate them into their curricula. Specific instructional methods were intentionally omitted to allow for programmatic prerogative as well as creativity in instructional delivery.

The recommended minimum number of didactic instruction hours is 150 to 200. This ensures that students receive comprehensive exposure to the subject matter, equipping them with the necessary knowledge and skills to succeed in their field of study. In line with academic best practices, the aim is to provide an effective balance between theoretical concepts and practical applications, fostering a deep understanding of the curriculum.

Simulations can be a valuable tool to supplement clinical practice, particularly in areas where certain procedures or patient examinations are not as commonly performed. By providing realistic, controlled environments for practicing these skills, simulations can enhance learning and build confidence in students. However, it is important to note that simulations should not completely replace actual clinical experience. The best practice remains to perform as many hands-on patient examinations as possible for each anatomical area, as direct interaction with patients offers irreplaceable insights and learning opportunities that simulations cannot fully replicate. Combining both approaches ensures a well-rounded clinical education. Performing all required procedures under simulated conditions would not provide appropriate learning.

Competency-based standards are basic statements of outcomes; they are attributes required to fulfill the LXMO role at the beginning level. They reflect the knowledge, attitudes, values and skills associated with each aspect of performance in the workplace and are expressed in terms of proficient practice. ASRT curriculum documents are created with best practices in mind and are intended to serve as a guide for developing a program curriculum tailored to the specific needs of each institution. However, it's important to note that state regulations and requirements may differ from the recommended number of didactic instruction hours outlined in this document.

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

Advances in diagnostic imaging and employer expectations demand independent judgment by LXMOs. Consequently, critical-thinking skills must be fostered, developed and assessed in the educational process. Critical thinking has been incorporated in multiple content areas. It is expected that the faculty will develop and implement critical thinking throughout the curriculum.

Students typically migrate through a sequence in which they observe examples of a given examination being performed by a radiographer or licensed practitioner, assist in the performance of a number of the same examination and then perform the examination several times under the supervision of a radiographer or licensed practitioner. Programs have the prerogative to set values for the number of examinations of a given type that students would be expected to observe, provide assistance and perform under supervision before a competency assessment is conducted.

Student Supervision Policies and Assessment Criteria

1) Clinical supervisors and/or qualified radiographers evaluate the procedure the student is about to perform and ensure that they have the skills necessary to perform it, then ensure the student is able to perform the examination on the specific patient based on the patient’s condition. Additionally, a qualified radiographer must be physically present in the room with the student while they complete the examination and to review the final images to ensure that everything was completed properly. This is called direct supervision.
2) Students who have performed a procedure multiple times still need supervision to ensure that the educational process is proceeding appropriately and that the safety of the patient is not compromised. For these students, indirect supervision would apply. Indirect supervision means that the student can perform an examination independently with a qualified radiographer immediately available and physically located in the next room, work area or hallway. If the student has a problem, question or needs help, they must be able to count on a qualified radiographer’s expertise immediately.
3) Until they graduate from a program, whenever a student needs to repeat an examination a qualified program represenative needs to be physically present in the room during the

repeat. It is important to determine the reason for the unsatisfactory image and check the student's technical factors, positioning and other setup procedures before allowing the student to repeat the acquisition. In the event of a repeat, it is imperative that a qualified radiographer reviews all of their examination procedures and are physically present in the room. If the patient's condition or other factors warrant a registered technologist to step in, then one must be available to do so. In this case, a qualified radiographer should complete the repeat image and explain the process to the student, either during the repeat or afterwards in the work area. The patient's safety and the quality of the examination are the most important factors to consider.

Competent clinical performance is more than the demonstration of certain behaviors associated with the completion of a single task. Successful students' clinical practice encompasses attributes of knowledge, problem solving, technical skills, comprehension, attitudes and ethics. It enables an individual or group to perform a role or set of tasks to an appropriate level, grade, quality or achievement, thus determining the individual to be competent in that role. Assessment should not only be concerned with psychomotor skills, but also with an understanding of the principles underlying professional practice.

Elements to consider in structuring the performance criteria for student success assessments are:

- Evaluation of requisition and patient assessment
- Radiographic room readiness
- Patient care and management
- Equipment operation and technique selection
- Positioning skills
- Radiation protection for patient, self and others
- Image processing and evaluating whether the resulting images demonstrate proper:
    - Anatomical part(s)
    - Alignment
    - Radiographic techniques
    - Image identification
    - Radiation protection

Each of these items should have a written definition and description of the criteria used to satisfy the expectations of student performance. Example: Images demonstrate effective use of beam collimation. Criteria: Evidence of effective beam collimation will be determined by the visible appearance of radiation field collimation to the part(s) of interest on finished radiographs and/or projections. Field borders shall not exceed 1.25" beyond the part of interest.

**Note:** Some consideration should be given to the progression of student performance as experience is gained in the clinical setting. Expectation of student performance should be reasonable and obtainable during the early, middle and terminal periods of clinical exposure while at the same time incorporating increasing levels of skill improvement. Example: It may be reasonable to expect that early in students' clinical experience they could place a patient's wrist in an oblique position, with the clinical evaluator verifying proper positioning and adjusting as needed. However, it would be expected that the same

student would be consistent in positioning an oblique wrist properly without adjustment by the clinical evaluator in the final phases of clinical experience.

A student behavioral assessment can be a valuable component of an overall clinical assessment plan. Different from the clinical experience assessment, the behavioral assessment is an opportunity to give students feedback on their development in the affective domain and in development of traits and characteristics valued by employers.

In line with the curriculum goals, students should be equipped to interpret and evaluate sources of information for use in evidence-based practice, which is fundamental to fostering critical thinking, professional decision-making and a continuous pursuit of quality improvement in patient care. This commitment is reflected in the emphasis on evaluating evidence-based health care practices, ensuring that students are prepared to make informed, effective decisions in clinical settings based on the best available evidence. Through this approach, students will develop the skills necessary to contribute to the advancement of health care and improve patient outcomes.

Summary

The LXMO core curriculum is based on data relevant to today's health care environment. The curriculum offers a foundation for lifelong learning and transition to general radiography studies. It allows for faculty flexibility in the development of a curriculum designed to meet the needs of individuals performing diagnostic x-ray procedures within a limited scope of practice.

# Recommendations for General Education

General education is an integral part of the development of the provider of patient care services. The content is designed to assist in the development of communication understanding that patients have different backgrounds and needs, scientific inquiry, critical thinking and judgment skills required to perform the responsibilities of a LXMO. Knowledge gained from general education serves to enhance the content and application of the LXMO curriculum.

An additional goal of general education is to provide students with opportunities to explore broad areas of commonly held knowledge and to prepare them to contribute to society through personal, social and professional interactions with others. General education provides intellectual flexibility and knowledge to support lifelong learning that will prepare students for success in a rapidly changing world.

Recommended Postsecondary General Education:

- Mathematical/Logical Reasoning
  - Develop skills in analysis, quantification and synthesis.
  - Apply problem-solving or modeling strategies.

- Communication
  - Write, read, speak and listen critically.
  - Develop the ability to perceive, gather, organize and present information.
  - Locate, evaluate and synthesize material from different sources and points of view.

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

- Anatomy and Physiology
  - Label anatomy using directional terminology, planes of reference and body cavities.
  - Explain the tissues, divisions and functions of the body's systems.

# Core Content

# Clinical Practice

**Below are the proposed minimum hours of clinical experience and number of procedures within each anatomic area.**

**Optional by State:**

- Chest – 50 to 80 hours and 25 to 50 procedures
- Upper extremity and pectoral girdle – 80 to 120 hours and 50 to 100 procedures
- Lower extremity – 80 to 120 hours and 50 to 100 procedures
- Skull/Sinuses – 50 to 80 hours and 25 to 40 procedures
- Spine – 80 to 120 hours and 100 to 200 procedures
- Podiatric – 50 to 80 hours and 25 to 50 procedures
- Abdomen/Pelvis – 80 hours and 50 procedures

**Objectives**

- Discuss the basis of ethics and characteristics of ethical behavior.
- Describe the elements of professionalism in health care, including attitudes, communication techniques and psychological aspects of patient care.
- Understand personal, societal and professional values as it relates to medical imaging.
- List the steps of a radiographic examination, from scheduling to image analysis.
- Perform the recommended number of clinical competencies in each of the five main areas (this may vary by state).

**Content**

**I. Clinical Practice***

A. Code of ethics/professional behavior
   1. Scope of practice
   2. Incident reporting mechanisms
   3. Standards for LXMO supervision
   4. The patient care partnership: understanding expectations, rights and responsibilities

B. Professional communication
   1. Patients
   2. Patient's family
   3. Health care team
   4. Confidentiality of patient records (HIPAA compliance)

C. LXMO practice standards
   1. Technical
   2. Professional
   3. Equipment operation
   4. Ability to adapt to varying clinical situations

5. Emergency response

D. Values
   1. Personal
      a. Values development
      b. Effect on medical care
      c. Effect on patient care
      d. Values clarification
   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

**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

E. Patient verification
   1. Patient monitoring – emergency and nonemergency
      a. Vitals signs
      b. Assessment and clinical history
      c. Equipment
      d. Patient emergencies
   2. Patient privacy and confidentiality
   3. Documentation and charting
   4. Infection control
   5. Patient education
      a. Communication style
      b. Age-specific
      c. Cultural and socioeconomic sensitivity
      d. Patient-focused care
   6. Medical error reduction

F. Imaging
   1. Positioning considerations
   2. Technical considerations
   3. Image acquisition

4. Image analysis

G. Radiation protection
   1. Principles
   2. Equipment and accessories

**III. Clinical Competency***

A. Chest
   1. Routine
   2. Other

B. Abdomen/pelvis/hip
   1. Routine supine abdomen
   2. Erect abdomen series
   3. Decubitus abdomen
   4. AP Pelvis
   5. AP hip
   6. Frog lateral hip

C. Extremities
   1. Upper extremity
      a. Fingers
      b. Hand
      c. Wrist
      d. Forearm
      e. Elbow
      f. Humerus
   2. Pectoral girdle
      a. Shoulder
      b. Clavicle
      c. Scapula
      d. Acromioclavicular joints
   3. Lower extremity
      a. Toes
      b. Foot
      c. Ankle
      d. Calcaneus
      e. Tibia/fibula
      f. Knee/patella
      g. Distal femur

D. Skull/Sinuses
   1. Skull
   2. Facial bones
   3. Nasal bones
   4. Orbits

5. Paranasal sinuses

E. Spine
   1. Cervical
   2. Thoracic
   3. Lumbar
   4. Scoliosis survey
   5. Sacrum
   6. Coccyx
   7. Sacroiliac joints

F. Podiatric (there are no podiatric programs in CA at this time)
   1. Foot/toes
   2. Ankle
   3. Calcaneus (os calcis)

# Digital Image Acquisition and Display

**Objectives**

- Describe the image acquisition process and types of detectors used.
- Recognize the purpose and management of exposure factors.
- Discuss the computer processing and image display process.
- Apply image quality assurance techniques.
- Recognize the mechanisms for transfer, storage and remote assessment of medical images.
- Understand commonly used data management systems.

**Content**

**I. Image Acquisition**

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

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

C. Dynamic range

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

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

**II. Initial Processing**

A. Preprocessing

B. Image analysis

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

C. Rescaling

D. Values of interest (VOI)

E. Grayscale/look-up table (LUT)

F. Noise reduction

G. Smoothing

H. Edge enhancement

I. Equalization

**III. Post Processing**

A. Brightness adjustment

B. Grayscale (contrast) adjustment

C. Equalization

D. Smoothing

E. Edge enhancement

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

G. Legal issues (e.g., manipulation of electronic data)

**IV. Image Acquisition Errors**

A. Histogram analysis
1. Incorrect anatomic menu selection
2. Exposure field recognition
   a. Collimation border recognition
   b. Exposure field distribution – multiple fields/plate
3. Unexpected material in data set (e.g., metal)
4. Overexposure
5. Underexposure
6. Saturation
7. Failure of automatic rescaling (i.e., dark or light image)

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

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

**V. Image Evaluation**

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

B. Contrast

C. Recorded detail

D. Artifacts
    1. Patient
    2. Equipment
    3. Exposure
    4. Processing

**VI. Quality Assurance and Maintenance Issues**

A. Technologist responsibilities
    1. Image quality control
        a. Exposure indicator accuracy
        b. Image integrity
    2. Imaging receptor systems
        a. Receptor maintenance (e.g., cleaning and inspection)
        b. Equipment calibration
        c. Uniformity
        d. Spatial resolution
    3. Reject analysis
    4. Monitor patient exposure
        a. Part of quality assurance (QA) program
        b. Vendor-supplied software
    5. Service engineer and/or medical physicist
        a. Notification process
        b. Preventive maintenance

6. Involvement in quality control
7. Shielding accessories

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

## VII. Image Display

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

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

## VIII. Data Management

A. Network connectivity

B. Hospital/Health information system (HIS)

C. Radiology information system (RIS)

D. Medical image management and processing system (MIMPS, formerly picture archiving and communication system [PACS])
1. System components and functions
2. Emergency contingency plan
3. Digital imaging and communication in medicine (DICOM)

a. DICOM header

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

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

F. Teleradiology

# Fundamentals, Ethics and Laws of Health Care

**Objectives**

- List types of medical imaging modalities and other health professions.
- Describe health care environments, organizations and regulatory agencies.
- Apply quality management techniques and programs.
- Explain professional credentialing and professional development.
- Describe the basis of ethics and characteristics of ethical behavior.
- Discuss the basis of law and major legal concerns in health care.
- Explain the types of consent, as well as the conditions and documentation of consent.

**Content**

**I. The Health Science Professions**

A. Medical imaging and radiologic sciences

1. Radiography
    a. General diagnostic imaging
    b. Computed tomography
    c. Mammography
    d. Cardiovascular-interventional radiography
    e. Vascular-interventional radiography
    f. Bone densitometry
    g. Radiologist assistant
2. Radiation therapy
3. Nuclear medicine technology
4. Multiskilled (fusion technology)
5. Diagnostic medical sonography
6. Magnetic resonance imaging
7. MIMPS (formerly PACS) administration/informatics
8. Education
9. Management
10. Applications specialist
11. Breast sonography
12. Cardiac-interventional radiography
13. Clinical leadership
14. Diagnostic medical sonography
15. Echocardiography
16. Health physics
17. Mammography
18. Medical dosimetry
19. Medical physics
20. Molecular imaging
21. Multi-credentialed
22. Nuclear medicine advanced associate
23. Nuclear medicine technology

24. Quality management
25. Research
26. Vascular sonography

B. Other allied health professions

## II. The Health Care Environment

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

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

C. Quality management
   1. Quality management and improvement
   2. Quality assurance
   3. Quality control

D. Benefits
   1. Patient safety
   2. Efficacy of patient care
   3. Efficiency
   4. Consistency
   5. Cost effectiveness

## III. Health Provider Facility Organization

A. Philosophy and Mission
B. Vision
C. Values
D. Administrative services
   1. Governing board
   2. Administrative services
   3. Human resources
   4. Procurement

5. Accounting and billing
6. Admissions and registration
7. Information systems
8. Support services

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

## IV. Radiology Organization

A. Administrative personnel
   1. Administrator
   2. Director and manager
   3. Supervisor

B. Clinical personnel
   1. Radiologist assistant
   2. Medical imaging professional
   3. Radiation therapist
   4. MIMPS (formerly PACS) administrator
   5. Clinical informatics
   6. Radiology nurse
   7. Imaging medical assistant (IMA)

C. Physician
   1. Interpreting radiologist
   2. Interventional radiologist
   3. Specialists

D. Support staff
   1. Radiation physicist
   2. Clerical staff
   3. Technical assistant
   4. Transport staff

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

B. Support personnel

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

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

**II. Accreditation**

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

B. Modalities (e.g., ACR)

C. Educational programs
1. Programmatic accreditation (e.g., Joint Review Committee on Education in Radiologic Technology [JRCERT])
2. Regional
3. Other
4. Facility level
5. Departmental level
6. Intradepartmental

D. Educational programs
1. Programmatic
2. Regional/facility
3. Other

**III. Regulatory Agencies**

A. Federal

B. State

**IV. Professional Credentialing**

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

B. State licensure

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

D. Agencies
    1. National
    2. State

## V. Professional Organizations

A. Purpose, function and activities

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

## VI. Professional Development

A. Required continuing education

B. Clinical experience

C. Continuing education opportunities
    1. Collegiate/educational programs
    2. Self-learning activities
    3. Professional conferences
    4. Webinars
    5. Other (e.g., vendor programs)

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

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

F. Clinical experience requirements

G. Continuing education opportunities
    1. Continuing education programs

2. General radiography programs
3. Collegiate/educational programs

H. Continued qualifications

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

J. Advancement opportunities
   1. Radiographer
   2. Education
      a. Administration
      b. Faculty
         1) Didactic
         2) Clinical
   3. Radiologist assistant
   4. Administration and management
   5. Physics
   6. Research

**II. Ethics in Health Care**

A. Origins and history of medical ethics

B. Moral reasoning

C. Personal behavior standards

D. Competence

E. Professional attributes

F. Limited scope of practice defined
   1. Lines of authority
   2. Areas of responsibility
   3. Limitations

G. Self-assessment and self-governance

H. Code of professional ethics

I. Ethical principals concepts

J. Systematic analysis of ethical problems

K. Ethical violations and sanctions

L. American Hospital Association (AHA) Patient Care Partnership (patient's Bill of Rights)

**III. Ethical Issues in Health Care**

A. Individual and societal rights

B. Cultural considerations

C. Economic considerations

D. Access to quality health care

E. Technology

F. Resource scarcity

G. Human experimentation and research

H. Patient-centered, quality care for all

I. End-of-life decisions
   1. Living wills
   2. Advance directives
   3. Health care power of attorney
   4. Nonintervention (e.g., DNR order)

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

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

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

a. Dose creep
b. Manipulation of exposure indicators

M. Radiology specific
1. Dose creep
2. ALARA
3. Risks vs. benefits

**IV. Legal Responsibilities**

A. Sources of law

B. Parameters of legal responsibility
1. Professional liability
2. Intentional misconduct
a. Libel and slander
b. Assault and battery
c. False imprisonment
d. Invasion of privacy
e. Breach of confidentiality
3. Negligence/malpractice
a. Definitions
1) Gross negligence
2) Contributory negligence
b. Elements of malpractice
1) Duty
2) Dereliction (breach)
3) Causation
4) Damage

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

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

E. Criminal law
1. Legal and professional standards
a. Standard of care
b. American Hospital Association (AHA) Patient Care Partnership Patient's Bill of Rights
2. Privacy
3. Access to information
4. Living will, health care proxy, advanced directives

F. Legal doctrines and standards

1. Legal risk reduction and risk management
2. Health records
    a. Timely, accurate, and comprehensive methods of documentation
    b. Radiographic images as legal documents
    c. Manipulation of electronic data
        1) Individual
        2) Institutional
3. Legal doctrines (e.g., respondeat superior, res ipsa loquitur)
4. Medical records
5. Legal risk reduction and risk management

G. Scope of practice and responsibilities of the LXMO
    1. Definition
    2. Supervision
    3. State statute
    4. Limitations
        a. Anatomic areas
        b. Radiographic procedures
        c. Medication administration
        d. Fluoroscopy

**V. Patient Consent**

A. Definition and rationale

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

C. Conditions for valid consent

D. Documentation of consent

E. Consent revocation

F. Patient rights and responsibilities

G. Patient restraints

H. Definition
    1. Implied
    2. Written
    3. Oral

I. Condition for legal or valid consent
    1. Legal age
    2. Competence
    3. Capacity
    4. Voluntary

5. Provision of adequate information regarding case, procedure, alternatives and risk
6. American Hospital Association (AHA) and The Joint Commission standards for disclosure

J. Documentation of consent

K. Right of refusal

# Human Anatomy and Physiology

**Objectives**

- Label anatomy using directional terminology, planes of reference, and body cavities.
- Explain the tissues, divisions, and functions of the body's major systems.

**Content**

**I. Anatomical Nomenclature**

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

B. Body planes
   1. Median/midsagittal
   2. Sagittal
   3. Coronal
   4. Transverse (axial/horizontal)
   5. Longitudinal

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

**II. Landmarks and Underlying Anatomy**

A. Cranium

B. Neck

C. Spine

D. Thorax

E. Abdomen

F. Pelvis

G. Extremities

**III. Skeletal System**

A. Osseous tissue
   1. Structural organization

a. Medullary cavity/marrow
b. Compact bone
c. Cancellous bone
d. Periosteum
e. Cartilage

2. Development and growth
   a. Physis
   b. Diaphysis
   c. Diaphysis/epiphyseal line
   d. Metaphysis
3. Classification and markings
   a. Long
   b. Short
   c. Flat
   d. Irregular
   e. Processes and bony projections
   f. Depressions/openings

B. Divisions
1. Axial
   a. Skull
   b. Hyoid bone
   c. Vertebral column
   d. Thorax
2. Appendicular
   a. Shoulder/pectoral girdle
   b. Upper extremities
   c. Pelvic girdle
   d. Lower extremities
3. Sesamoids
4. Functions

C. 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

4. Function/joint classifications
    a. Synarthroses, fibrosis
    b. Amphiarthroses, cartilaginous
    c. Diarthroses, synovial
5. Physiology

**IV. Cardiovascular System**

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

B. Heart and vessels
1. Anatomy
2. Function

**V. Respiratory System**

A. Components, structure and function
1. Nose and sinus cavities
2. Pharynx
3. Larynx
4. Trachea
5. Bronchi
6. Lungs
7. Thorax

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

**VI. Digestive System**

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

B. Accessory organs – structure, function and location
    a. Salivary glands
    b. Pancreas

c. Liver
d. Gallbladder and biliary tree

C. Digestive processes
1. Ingestion
2. Peristalsis
3. Segmentation
4. Digestion
5. Absorption
6. Defacation

D. Urinary system – structure, function and location
1. Kidneys
2. Ureters
3. Bladder
4. Urethra
5. Urine
a. Physical characteristics
b. Chemical composition
6. Micturition

E. Reproductive systems – structure, function and location
1. Male
a. External organs
b. Internal organs

2. Female
a. External organs
b. Internal organs
c. Mammary glands

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

# Image Production and Analysis

**Objectives**

- Explain exposure factors and their effect on the final image.
- Recognize the purpose and management of exposure factors.
- Explain technical, procedural and clinical factors affecting image appearance.
- Discuss the computer processing and image display process.
- Describe corrective actions that can be taken to improve image appearance.

**Content**

**I. Exposure Factors**

A. Distance

B. mA

C. Time

D. Focal spot size

E. kVp

F. Grids

G. AEC

H. Beam restriction

I. Filtration

**II. Receptor Exposure**

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

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

**III. Differential Absorption**

A. Components
   1. Anatomy
   2. Contrast agent
   3. Pathology
   4. Casts
   5. Age

6. Grids

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

**IV. Spatial Resolution**

A. Motion
   1. Part
   2. Equipment

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

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

**V. Shape Distortion**

A. Foreshortening

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

**VI. Magnification**

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

B. Display

**VII. Beam Restriction**

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

B. Types
   1. Manual collimators

2. Automatic collimators
3. Ancillary devices

C. Collimator components
1. Lead shutters
2. Light source

**VIII. Beam Filtration**

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

B. Function/mechanism

C. Effect on image characteristics

D. Effect on HVL

**IX. Scatter Radiation**

A. Prevention
1. Collimation
2. kVp

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

C. Effects
1. Image quality
2. Patient dose
3. Occupational exposure

**X. Grids**

A. Purpose/mechanism

B. Construction

C. Types
1. Linear
   a. Parallel
   b. Focused
2. Crossed
3. Moving
4. Stationary

5. Virtual
6. Short dimension
7. Long dimension

D. Characteristics
   1. Grid radius/focal range
   2. Ratio
   3. Frequency
   4. Grid conversion factor

E. Grid conversion factors

F. Selection
   1. kVp
   2. Patient/examination
   3. Focal range
   4. Alignment latitude
   5. Short axis
   6. Long axis

G. Grid errors

H. Primary cutoff

I. Off-level

J. Off-center

K. Off-focus

L. Upside down

M. Moire effect (aliasing)

**XI. Exposure Factor Formulation**

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

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

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

## XII. Imaging Standards

A. Purpose

B. Problem-solving process

C. Role of LXMO
   1. Determining cause of problems
   2. Recommending corrective actions
      a. Recommending
      b. Implementing

D. Establishing acceptable limits

## XIII. Image Appearance Characteristics

A. Brightness

B. Noise
   1. Random (e.g., quantum mottle, scatter)
   2. Periodic (e.g., electronic interference, detector malfunction, software)

C. Grayscale (contrast)

D. Signal-to-noise ratio (SNR)

E. Contrast-to-noise ratio (CNR)

F. Spatial resolution
   1. Motion
   2. Geometric
   3. Receptor and detector

G. Contrast resolution

H. Shape distortion

I. Magnification
   1. Geometric
   2. Display

## XIV. Procedural Factors

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

5. Procedure(s) performed
6. Proper use of identification makers
7. Institutional data

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

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

D. Exposure indicator appropriateness

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

F. Patient preparation

G. Artifacts

**XV. Corrective Action**

A. Equipment malfunction

B. Technical factors

C. Procedural factors

D. Artifacts

# Imaging Equipment and Radiation Production

**Objectives**

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

**Content**

**I. X-ray Circuit**

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

B. Electrical safety
   1. Ground
   2. Circuit breaker

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

D. Rectification
   1. Purpose
   2. Mechanisms

E. High frequency generators

**II. Radiographic Equipment**

A. Fixed units
   1. Components
      a. Tubes
      b. Collimators
      c. Tables
      d. Operating console panels
      e. Tube support systems
      f. Wall units
      g. Potter-Bucky mechanism
      h. Image receptors
   2. Equipment operation and manipulation

3. Applications

B. Mobile units
   1. Components
      a. Tubes
      b. Beam restriction
      c. Collimators
      d. Operating (control) console panels
      e. Tube support systems
      f. Image receptors
   2. Equipment operation and manipulation
   3. Clinical applications

C. Automatic exposure control devices
   1. Radiation detector
   2. Ionization chambers
   3. Minimum reaction time
   4. Backup time
   5. Alignment and positioning considerations
      a. Radiation detector sensor selection
      b. Radiation detector sensor configuration
      c. Radiation detector sensor sensitivity
   6. Compensation issues
      a. Patient size
      b. Pathology
      c. Prosthetics/implants
      d. Collimation
      e. Image receptor variations

**II. Diagnostic X-ray Tubes**

A. Design, function and construction
   1. Anode
   2. Cathode
   3. Tube housing
   4. Induction motor

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

C. Components of digital radiography image receptors
   1. Flat panel
   2. Charge coupled device (CCD)

3. Complementary metal oxide semiconductor (CMOS)

**III. Quality Control**

A. Definitions

B. Benefits
   1. Patient
   2. Department/office

C. Areas of focus
   1. Beam restriction
      a. Light field to radiation field alignment
      b. Central ray alignment
   2. Digital imaging receptor systems
      a. Artifacts
      b. Maintenance
      c. Monitor display and calibration
   3. Shielding accessories

D. Recognition and reporting of malfunctions

**IV. Structure of the Atom**

A. Composition
   1. Nucleus
   2. Subatomic structure – proton and electron balance
   3. Electron shells
      a. Binding energy
      b. Valence shell
      c. Ionization
      d. Excitation

B. Nomenclature
   1. Atomic number
   2. Mass number

**V. Nature of Radiation**

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

**VI. X-ray Production**

A. Principles
   1. Inverse square law
   2. Fundamental properties of x-rays

3. Frequency and wavelength
4. Beam characteristics
    a. Quality
    b. Quantity
    c. Primary versus remnant (exit)

B. Target Interactions
1. Bremsstrahlung
2. Characteristic
3. Anode heat

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

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

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

**VII. Interaction of Photons With Matter**

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

B. Types and descriptions

C. Unmodified scattering (coherent or classical scattering)
1. Photoelectric
2. Compton
3. Pair production

D. Probability of photon interactions
1. Atomic number
2. Energy
3. Tissue volume

4. Part thickness

E. Effect on image

F. Patient and operator dose effects
   1. Description of interaction
   2. Relation to atomic number
   3. Photon energy
   4. Probability of occurrence
   5. Tissue volume
   6. Part thickness
   7. Resulting image

B. Photoelectric effect
   1. Description of interaction
   2. Relation to atomic number
   3. Photon energy
   4. Probability of occurrence
   5. Tissue volume
   6. Part thickness
   7. Resulting image

C. Modified scattering (Compton scattering)
   1. Description of interaction
   2. Relation to atomic number
   3. Photon energy
   4. Probability of occurrence
   5. Tissue volume
   6. Part thickness
   7. Resulting image

# Medical Terminology

**Objectives**

- Recognize and discuss medical procedures and terminology.
- Analyze medical reports, orders, and requests.

**Content**

**I. The Word Building Process**

A. Basic elements
   1. Root words
   2. Prefixes
   3. Suffixes
   4. Combination forms

B. Parts of speech
   1. Nouns
   2. Verbs
   3. Adjectives
   4. Adverbs

C. Translation of terms into common layman's terms

D. Correct pronunciation of medical terms

E. Correct spelling of medical terms

F. 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. Medical Abbreviations and Symbols**

A. Role in communications

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

C. Symbols
   1. Pharmaceutical symbols and terms
   2. Math and science symbols and constants
      a. Examples

b. Interpretations

**III. Radiologic Technology Procedures and Terminology**

A. Radiography

B. Other imaging modalities

C. Radiation oncology

D. Surgery

**IV. Understanding Orders, Requests and Diagnostic Reports**

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

B. Diagnostic reports
   1. Content
   2. Interpretation

# Patient Care in Radiologic Sciences

**Objectives**

- Recognize the role of the LXMO and other members of the health care team.
- Describe the elements of professionalism in health care, including attitudes, communication techniques and psychological aspects of patient care.
- Apply 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.

**Content**

**I. LXMO and the Health Care Team**

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

B. Responsibilities of the LXMO
   1. Review examination requisition
   2. Perform radiographic examination
   3. Assist the licensed practitioner
   4. Provide patient care

**II. Professionalism and Communication in Patient Care**

A. Health and illness continuum
B. Patient-centered, quality care for all
C. Emotional intelligence
   1. Self-awareness
   2. Self-regulation
   3. Motivation
   4. Empathy
   5. Social skills

D. Developing professional attitudes
   1. Teamwork

2. Work ethic
3. Health role model
4. Sympathy
5. Empathy
6. Compassion
7. Assertiveness

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

F. Communication
   1. Verbal
      a. Presentation of material
      b. Voice tone and volume
      c. Effective listening
   2. Nonverbal
      a. Facial expression
      b. Physical appearance
      c. Touch
      d. Eye contact
   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. Different backgrounds and needs of patients
      f. Artificial speech
   5. Other factors that impede communication
      a. Colloquialisms and slang
      b. Medical terminology
   6. Patient interactions
      a. Eye contact
      b. Volume and speed of speech
      c. Hand gestures
      d. Effective listening
      e. Feedback
      f. Cultural sensitivity
   7. Communication with families or authorized representative
   8. Communication with other health care professionals
   9. Written

10. Cultural sensitivity
11. Challenges of communication
    a. Language barriers
    b. Hearing, vision and speech impairments
    c. Impaired mental function
    d. Altered states of consciousness
    e. Age-specific communication
    f. Communicating under stress
    g. Different backgrounds and needs of patients
    h. Artificial speech
        1) Transesophageal puncture (TEP)
        2) Esophageal speech
        3) Electrolarynx devices
12. Other factors that impede communication
    a. Colloquialism/slang
    b. Medical terminology
13. Patient interactions
    a. Establishing communication guidelines
    b. Reducing distance
    c. Listening
    d. Feedback
        1) Using therapeutic silence
        2) Responding to the feeling and the meaning of the patient's statement
        3) Restating the main idea
        4) Reflecting the main idea
        5) Making observations
14. Communicating with families
15. Communicating with other health care professionals

G. Psychological considerations
    1. Dying and death
        a. Understanding the process
        b. Aspects of death
            1) Emotional
            2) Personal
            3) Physical
        c. Grief and counseling
        d. Patient support services
            1) Family and friends
            2) Pastoral care
            3) Patient-to-patient support groups
            4) Psychological support groups
            5) Hospice
            6) Home care
    2. Factors affecting Patient's emotional responses
        a. Age

b. Gender
c. Marital/family status
d. Socioeconomic factors
e. Cultural and religious variations
f. Physical condition
g. Self-image
h. Past health care experiences
i. Beliefs
j. Attitudes
k. Prejudices
l. Self-awareness

**III. Patient-LXMO Interactions**

A. Patient identification methods
1. Interview/questioning
2. Chart/requisition
3. Wristband
4. Institution-specific

B. Procedure questions and explanations
1. Positioning
2. Length of procedure
3. Immobilization devices
4. Equipment movement/sounds
5. Pre- and post-exposure instructions
6. Audio and visual intercommunication systems
7. Room noises
8. Immobilization devices
9. Machine type
10. Machine movement
11. Machine-patient contact
12. Application of auxiliary equipment

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

**IV. Safety and Transfer Positioning**

A. Environmental safety
1. Fire
2. Electrical
3. Hazardous materials
a. Chemicals
b. Chemotherapy agents
c. Safety data sheet (SDS)
4. Radioactive materials
5. Personal belongings
6. Occupational Safety & Health Administration (OSHA)

7. Environmental Protection Agency (EPA)

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

C. Patient transfer and movement
   1. Assessing the patient's mobility
   2. Rules for safe patient transfer
   3. Positioning for safety, comfort or examinations
   4. Wheelchair transfers
   5. Stretcher transfers
      a. Sheet transfer
      b. Log roll
      c. Transfer devices
   6. Patients with disabilities
   7. Age-specific considerations
   8. Patients with medical equipment
      a. Tubes
      b. Oxygen delivery
      c. Catheters
      d. Lines
      e. Collection devices
   9. Fall prevention

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

E. Safety and immobilization techniques
   1. Types
   2. Applications
   3. Devices
      a. Adult
      b. Pediatric

F. MR safety

G. Accident and incident reporting
   1. Purpose
   2. Legal considerations
   3. Documentation
   4. Procedures

**V. Evaluating Physical Patient Needs**

A. Social factors impacting health

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

C. Vital signs – ranges and values
   1. Temperature
   2. Pulse
   3. Pulse oximetry
   4. Respiration
   5. Blood pressure
   6. Normal ranges and values
   7. Interfering factors
   8. Terminology
   9. Adult vs. pediatric
   10. Acquiring and recording vitals
      a. Procedures
      b. Demonstration
   11. Documentation
   12. Pain assessment
   13. Weight

D. Acquiring and recording vital signs

E. Patient records or patient health information (PHI)
   1. Elements of a patient record
   2. Retrieving specific information
   3. Documentation in a chart
   4. Components
   5. Confidentiality
   6. Retrieval
   7. Documentation
   8. Release of information
   9. HIPAA

F. Pain Assessment
   1. Description

2. Intensity
3. Location
4. Duration
5. Aggravating and alleviating factors

## VI. Infection Control

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

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

C. Cycle of infection
   1. Infectious pathogens
   2. Reservoir
   3. Susceptible host
   4. Transmission of disease
      a. Direct
      b. Indirect
      c. Routes (e.g., bloodborne, airborne)
      d. Droplet
      e. Airborne/suspended
      f. Fomites
      g. Common vehicle
      h. Vector-borne

D. Preventing disease transmission

E. Transmission-based
   1. Health care worker protection
      a. Immunization
      b. Booster
      c. Post-exposure protocols

F. Medical asepsis
   1. Definition
   2. Procedures
      a. Hand washing
      b. Chemical disinfectants

G. Isolation techniques and communicable disease
   1. Category-specific
   2. Disease-specific
   3. Standard precautions

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

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

J. Psychological considerations

K. Environmental asepsis
   1. Handling linens
   2. Equipment disinfection
   3. Techniques
      a. Dress
      b. Hair
      c. Hand washing
      d. Gloves
      e. Eye protection
      f. Cleaning and proper disposal of contaminated waste
      g. Needles

L. Standard precautions
   1. Human immunodeficiency virus (HIV) and acquired immunodeficiency syndrome (AIDS)
   2. Hepatitis
      a. Type A
      b. Type B
      c. Type C (non-A or non-B)
   3. Tuberculosis (TB)
   4. Respiratory syncytial virus (RSV)
   5. Methicillin-resistant *Staphylococcus aureus* (MRSA)
   6. *Clostridium difficile* (*C. diff*)
   7. Other

**VII. Medical Emergencies and First Aid**

A. Basic first-aid technique

B. Emergency equipment

C. Allergic reactions
   1. Latex
   2. Contrast media

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

E. Diabetic emergencies – signs, symptoms and interventions
   1. Signs and symptoms
   2. Types
   3. Hypoglycemia
   4. Hyperglycemia (ketoacidosis)
   5. Hyperosmolar coma

F. Respiratory and cardiac failure – signs, symptoms and interventions
   1. Adult vs. pediatric
   2. Signs and symptoms
   3. Equipment
   4. Medical interventions

G. Airway obstruction – signs, symptoms and interventions
   1. Signs and symptoms
   2. Medical interventions

H. Cerebral vascular accident (stroke) – signs, symptoms and interventions
   1. Signs and symptoms
   2. Medical interventions

I. Fainting and convulsive seizures – signs, symptoms and interventions
   1. Signs and symptoms
   2. Types
      a. Nonconvulsive (petit mal)

b. Convulsive (grand mal)
3. Reasons for fainting

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

K. Trauma or physical injury

**VIII. Tubes, Catheters, Lines and Other Devices**

A. Function and handling of devices

B. Nasogastric/nasointestinal

C. Endotracheal tube

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

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

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

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

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

I. Tissue drains

J. Oxygen administration

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

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

L. Ostomies
1. Types
    a. Tracheostomy
    b. Ileostomy
    c. Ureteroileostomy
2. Purpose
3. Location
4. Care
5. Access

**IX. Values**

A. Personal
1. Values development
2. Conflict
3. Effect on patient care

B. Societal
1. Rights and privileges
2. Community values
3. Effect on patient care

C. Professional
1. Values development
2. Values conflict
3. Effect on patient care
4. Effect on social media

**X. Patient-centered, quality care for all**

A. Societal and individual factors
1. Socioeconomic
    a. Effects on health care
    b. Access to care

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

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

# Radiographic Anatomy, Procedures and Pathology

**Radiographs on actual patients must be exposed only for diagnostic purposes, not solely to demonstrate techniques or obtain experience, and they must be prescribed by a licensed practitioner.*

**Objectives**

- Identify terminology related to radiographic positioning, including anatomical relationships, body planes, patient positions and projections.
- Discuss the radiographic order evaluation process.
- Explain positioning considerations for common radiographic procedures.
- Recognize common pathologies on radiographic images.

**Content**

**I. Standard Terminology for Positioning and Projection**

A. Anatomic relationships and locations

1. Anterior
2. Caudal/caudad
3. Central
4. Cephalic/cephalad
5. Distal
6. Dorsal
7. External
8. Inferior
9. Internal
10. Lateral
11. Medial
12. Palmar
13. Parietal
14. Peripheral
15. Plantar
16. Posterior
17. Proximal
18. Superior
19. Ventral
20. Visceral

B. Body planes

1. Sagittal
2. Midsagittal/median
3. Coronal
4. Midcoronal/midfrontal
5. Transverse/horizontal

C. Positioning

1. Supine
2. Prone
3. Lateral
4. Oblique
5. Recumbent
    a. Dorsal
    b. Lateral
    c. Ventral
6. Upright
    a. Erect
    b. Semierect
    c. Standing
    d. Seated
7. Trendelenburg
8. Decubitus
    a. Lateral
    b. Dorsal
    c. Ventral
9. Lordotic

D. Radiographic projections
    1. Anteroposterior (AP)
    2. Posteroanterior (PA)
    3. Lateral
    4. Oblique
    5. Axial
    6. Tangential

E. Joint movements
    1. Abduct/abduction
    2. Adduct/adduction
    3. Evert/eversion
    4. Extend/extension
    5. Flex/flexion
    6. Invert/inversion
    7. Pronate/pronation
    8. Supine/supination

F. Positioning aids
    1. Sponges
    2. Sandbags
    3. Compression bands
    4. Immobilization devices

G. Accessory equipment
    1. Calipers

2. Lead strips
3. Lead shields or shadow shields
4. Lead markers
5. Image receptor holders
6. Grids

**II. Evaluation of Radiographic Orders**

A. Patient identification (two means)

B. Verification of procedure(s) ordered

C. Review of clinical history and patient assessment
1. Role of LXMO
2. Questioning skills
3. Chief complaint
4. Allergy history
5. Localization
6. Chronology
7. Severity
8. Onset
9. Aggravating and alleviating factors
10. Associated manifestations

D. Special considerations

E. Taking clinical history and patient assessment
1. Questioning/interviewing skills
2. Establishing pregnancy status and documenting outcome
3. Determining the chief complaint
   a. Localization
   b. Chronology
   c. Quality
   d. Severity
   e. Onset
   f. Aggravating or alleviating factors
   g. Associated manifestations
4. Special considerations for age, disability and cultural background

F. Patient preparation
1. Verification of dietary preparation
2. Procedure explanation
3. Verification of medication preparation
4. Disrobing and gowning
5. Removal of artifact-causing items
6. Removal of clothing
7. Removal of radiopaque items

G. Room preparation
   1. Cleanliness
   2. Organization
   3. Appearance
   4. Supplies
   5. Accessory equipment

H. Patient assistance

I. Patient monitoring

J. Patient dismissal

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

**III. Positioning Considerations for Routine Radiographic Procedures**

A. Patient instructions

B. Patient positioning

C. Part alignment
   1. Lines of reference
   2. Surface landmarks

D. Image receptor selection and orientation

E. Grid use

F. Tube, body part and image receptor alignment

G. Marker placement

H. Beam alignment and angulation

I. Beam limitation

J. Shielding

K. Special considerations
   1. Atypical patient conditions
   2. Age
   3. Special needs patients

L. Anatomy and positioning for the following studies:
   1. Chest
      a. Routine
      b. Other
   2. Abdomen/pelvis/hip
      a. Routine supine abdomen
      b. Erect abdomen series
      c. Decubitus adomen
      d. AP pelvis
      e. AP hip
      f. Frog lateral hip
   3. Extremities
      a. Upper extremity
         1) Fingers
         2) Thumb
         3) Hand
         4) Wrist
         5) Forearm
         6) Elbow
         7) Humerus
      b. Pectoral girdle
         1) Shoulder
         2) Clavicle
         3) Scapula
         4) Acromioclavicular joints
      c. Lower extremity
         1) Toes
         2) Foot
         3) Ankle
         4) Calcaneus
         5) Tibia/fibula
         6) Knee/patella
         7) Distal femur
   4. Podiatric
      a. Foot and toes
      b. Ankle
      c. Calcaneus
   5. Spine
      a. Cervical
      b. Thoracic
      c. Lumbar
      d. Scoliosis series
      e. Sacrum
      f. Coccyx
      g. Sacroiliac joints

6. Skull/sinuses
    a. Skull
    b. Facial bones
    c. Nasal bones
    d. Orbits
    e. Paranasal sinuses

M. Image evaluation
    1. Technical factors
    2. Displayed anatomical structures
    3. Anatomical and lead markers

**IV. Patient Communication**

A. Barriers to communication
    1. Types
    2. Strategies

B. Clinical situations

C. Radiation safety

**V. Pathology**

A. Definitions/terminology
    1. Pathology
    2. Disease

B. Terminology classification
    1. Acute
    2. Chronic
    3. Pathogenesis
    4. Etiology
    5. Diagnosis
        a. Signs (objective)
        b. Symptoms (subjective)
    6. Prognosis
    7. Manifestations of pathology
    8. Incidence
    9. Prevalence
    10. Morbidity
    11. Mortality
    12. Epidemiology

C. Body Systems
    1. Skeletal
    2. Digestive
    3. Respiratory

4. Urinary
5. Reproductive
6. Circulatory/cardiovascular
7. Endocrine
8. Nervous
9. Definitions
    a. Sites
    b. Complications
    c. Radiographic appearance
    d. Procedural and technical considerations
    e. Appropriate imaging concentration

D. Implications for practice
1. Indications for procedure
2. Relevance to radiographic procedures
    a. Technical considerations
    b. Patient considerations

E. Disease process
1. Inflammation
    a. Edema
    b. Degeneration
    c. Atrophy
    d. Hyperplasia
    e. Hypertrophy
2. Neoplasms
    a. Benign
    b. Malignant
    c. Metastasis

F. Fractures

**VI. Relevance of Pathology to Radiographic Procedures**

A. Clinical indication

B. Technical considerations

C. Patient considerations

D. Physical manifestations

E. Radiographic appearance
1. Chest
2. Abdomen/Pelvis
3. Extremities

4. Spine
5. Skull/Sinuses
6. Podiatric

# Radiation Protection and Radiobiology

**Objectives**

- Outline the elements of a radiation monitoring program.
- List the units and measures used to evaluate radiation exposure.
- Identify radiation protection tools and methods.
- Apply personnel and patient radiation protection techniques.
- Describe basic cellular biology and the molecular effects of ionizing radiation.

**Content**

**I. Introduction**

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

B. Potential biological damage of ioninzing 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 (optimization)
   4. Comparable risk
   5. Negligible individual dose (NID)

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

E. Legal, ethical and social responsibilities

**II.** Système International d'Unités (SI) units of measurement

A. Exposure - coulomb/kilogram (C/kg)

B. Absorbed dose - gray ($Gy_t$)Gy)

C. Air kerma ($Gy_a$)
   1. Kinetic energy release in matter
   2. Measurement unit in gray

D. Dose equivalent - sievert (Sv)

E. Effective dose – sievert (Sv)

F. Radioactivity - becquerel (Bq)

**III.** Occupational dose

A. Radiation weighting factor ($W_r$)

B. Equivalent dose (EqD)

**IV. 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 Safetty 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)
      a. Report #102
      b. Report #116
   3. Biological Effects of Ionizing Radiation (BEIR)
      a. Radiation safety officer
      b. Qualifications
      c. Responsibilities

**V. Personnel Monitoring**

A. 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)

B. Methods and types of personnel monitors
   1. Types
      a. OSL
      b. Extremity dosimeter (TLD) ring dosimeter
      c. Direct ion storage dosimeter

   2. Proper use
   3. Film badge
   4. Thermoluminescent dosimeter (TLD)
   5. Optically stimulable luminescent dosimeter (OSLD)

C. Records of accumulated dose
   1. Purpose
   2. Content
   3. Interpretation/evaluation
   4. Length of record keeping
   5. Retrieval from previous employers

D. Effective dose limits
   1. Occupational
   2. Nonoccupational
   3. Critical organ sites
   4. Embryo and fetus

E. Responsibilities for radiation protection
   1. Facility
   2. LXMO
   3. Radiation safety officer

**VI. Application**

A. Materials

B. Primary barrier

C. Secondary (scatter and leakage) barrier

D. X-ray and ancillary equipment
   1. Beam-defining devices
   2. Exposure control devices
   3. On and off switches
   4. Interlocks
   5. Visual/audio monitors
   6. Emergency controls

E. Emergency procedures

F. Current regulations and recommendations
   1. NRC
   2. NCRP
   3. Applicable state regulations

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

**VII. Patient Protection**

A. Radiation safety practices
   1. Beam restriction
      a. Types
      b. Purpose
   2. Shielding
   3. Exposure factors
   4. Patient considerations
   5. Positioning (e.g., AP vs. PA)
      a. Communication
      b. Pediatric
      c. Morbid obesity
      d. Pregnancy
   6. Patient education
   **7.** Education
      a. Image Gently
      b. Image Wisely
      c. CARES Committee
   8. Immobilization

B. Entrance skin exposure

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

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

**VIII. Elements of Radiation Biology**

A. Molecule

B. Basic cellular biology
    1. Cellular structure
        a. Cell membrane
        b. Cytoplasm
        c. Protoplasm
        d. Organelles
        e. Nucleus
    2. Cellular function
        a. Basic cell chemistry
        b. Metabolism
        c. Organic and inorganic compounds
    3. Cell proliferation
        a. Cell cycle
        b. Mitosis
        c. Meiosis
        d. Differentiation

C. Sources of medical radiation exposure

**IX. Radiation Energy Transfer**

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

B. Factors affecting energy transfer
    1. Linear energy transfer (LET)
    2. Relative biological effectiveness (RBE)
    3. Factors influencing RBE
        a. LET
        b. Oxygen enhancement ratio (OER)

**X. Radiation Effects**

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

B. Cellular radiation effects
    1. Types of cell death
        a. Interphase death

b. Mitotic (genetic) death
2. Other effects
a. Mitotic delay
b. Reproductive failure
c. Interference of function

C. Individual radiation effects
1. Somatic effects
a. Short term
b. Long term
c. Stochastic (probabilistic) effects
d. Nonstochastic (deterministic) effects
2. Genetic effects
a. Mutagenesis
b. Genetically significant dose (GSD)
3. Embryo and fetal effects

D. Factors influencing radiation response

**XI. 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. Chemical agents
g. Lethal dose and $LD_{50}$

C. Systemic response to radiation
1. Hemopoietic system
2. Integumentary
3. Digestive
4. Urinary
5. Respiratory
6. Reproductive
7. Nervous
8. Muscle
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 influencing response
    4. Medical interventions of response

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

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

# Optional Content

# Artificial Intelligence

**Objectives:**

- Define terminology and concepts associated with artificial intelligence.
- Discuss data and datasets as they apply to artificial intelligence.
- Outline artificial intelligence applications to medical imaging.
- Explain standards and ethics that are applicable to artificial intelligence in medical imaging.
- Outline artificial intelligence regulation and workflow integration.
- Discuss the role of artificial intelligence in precision medicine.

**Content**

**I. Terminology and Concepts**

A. Algorithm

B. Automation

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

D. AI-enabled

E. AI-bias

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

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

H. Software as a medical device (SaMD)

I. Recursion

J. Natural sanguage processing (NLP)
   1. Pattern recognition
   2. Visual perception

3. Decision making

**II. Data and Datasets**

**III. Applications in Health Care**

**IV. AI in Medical Imaging**

A. Order scheduling & patient screening

B. Examination protocoling

C. Image acquisition

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

E. Automated clinical decision support (CDS)

F. Image post-processing

**V. Ethics, Legality and Liability**

**VI. Regulatory and Workflow Integration**

**VII. Precision Medicine**

# Resources

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

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# Appendix

## Curriculum Revision Workgroup

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

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