Limited X-Ray Machine Operator Curriculum

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Introduction

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 equivalent to that of the general radiographer.

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 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.

In 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 curriculum designed to meet the needs of individuals performing diagnostic x-ray procedures within a limited scope of practice.

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LXMO Operator Curriculum

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Core Content

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Clinical Practice

Description
Content and clinical practice experience should be designed to sequentially develop, apply, critically analyze, integrate, synthesize and evaluate concepts and theories in the performance of radiologic procedures. Through structured, sequential, competency-based clinical assignments, concepts of team practice, patient-centered clinical practice and professional development are discussed, examined and evaluated.

Clinical practice experiences should be designed to provide patient care and assessment, competent performance of radiologic imaging and total quality management. Levels of competency and outcomes measurement ensure the well-being of the patient prior to, during and following the radiologic procedure.

Clinical practice sites must be able to offer students an opportunity to experience patient procedures in a sufficient volume, variety and frequency within anatomic areas to develop skills that support competent exam performance. The proposed hours of clinical experience and number of procedures by anatomic area listed below are an expression of minimum values that need to be factored into the selection of clinical sites and planning of student clinical assignments. Individual states that have existing provisions for limited x-ray machine operators may have eligibility requirements that exceed the clinical hours or number of exams listed here.

Proposed minimum hours of clinical experience and number of procedures within each anatomic area:

- **Chest – 160 hours and 100 procedures.**
- **Extremities:**
  - **Upper extremity and pectoral girdle – 240 hours and 50 procedures.**
  - **Lower extremity – 240 hours and 50 procedures.**
- **Skull/Sinuses – 240 hours and 50 procedures.**
- **Spine – 240 hours and 50 procedures.**
- **Podiatric – 160 hours and 50 procedures.**

Objectives

1. Execute imaging procedures under the appropriate level of supervision.
2. Adhere to concepts of team practice that focus on organizational theories, roles of team members and conflict resolution.
3. Adapt to changes and varying clinical situations.
4. Provide patient-centered clinically effective service for all patients regardless of age, gender, disability, special needs, ethnicity or culture.
5. Integrate the use of appropriate and effective written, oral and nonverbal communication with patients, the public and members of the health care team (peers, licensed practitioners, administration, etc.) in the clinical setting.
6. Manage interactions with the patient and family in a manner that provides the desired psychosocial support.

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7. Demonstrate competent assessment skills through effective management of the patient's physical and mental status.
8. Examine demographic factors that influence patient compliance with medical care.
9. Adapt procedures to meet age-specific, disease-specific and cultural needs of patients.
10. Assess the patient and record clinical histories.
11. Demonstrate basic life-support procedures.
12. Respond appropriately to patient emergencies.
13. Use appropriate charting methods.
14. Apply standard and transmission-based precautions.
15. Apply the appropriate medical asepsis.
16. Demonstrate competency in the principles of radiation protection standards.
17. Apply the principles of total quality management.
18. Report equipment malfunctions.
19. Examine procedure orders for accuracy and follow up to make corrective changes when applicable.
20. Demonstrate safe, ethical and legal practices.
21. Integrate the LXMO's scope of practice and practice standards into a clinical practice setting.
22. Maintain patient confidentiality standards and meet Health Insurance Portability and Accountability Act (HIPAA) requirements.
23. Demonstrate principles of transferring, positioning and immobilizing patients.
24. Comply with departmental and institutional response to emergencies, disasters and accidents.
25. Differentiate between emergency and nonemergency procedures.
26. Adhere to national, institutional and/or department standards, policies and procedures regarding care of patients, provision of radiologic procedures and the reduction of medical errors.
27. Select technical factors to produce quality diagnostic images with the lowest radiation exposure possible.
28. Critique images for appropriate anatomy, image quality and patient identification.
29. Determine corrective measures to improve inadequate images.

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Content

I. Clinical Practice*

A. Code of ethics/professional behavior
   1. Scope of practice
   2. Incident reporting mechanisms
   3. Standards for LXMO supervision
      a. Precompetency assessment
      b. Postcompetency assessment
   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
   6. Total quality management

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

E. Culture, ethnicity and diversity
   1. Societal and individual factors
   2. Socioeconomic
   3. Gender
   4. Age
      a. Infant
      b. Child

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c. Adolescent
d. Adult
e. Middle-aged
f. Geriatric

5. Family structure and dynamics
6. Geographical factors
7. Religion
8. Lifestyle choices and behaviors
9. Sexual orientation
10. Disability

II. Procedural Performance

A. Scheduling and sequencing of exams

B. Order/requisition evaluation and corrective measures

C. Facilities setup

D. Patient assessment, clinical history, education and care
1. Patient monitoring – emergency and nonemergency
   a. 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

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

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

III. Clinical Competency*

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A. Chest
    1. Routine
    2. Other

B. 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

C. Skull/Sinuses
    1. Skull
    2. Facial bones
    3. Nasal bones
    4. Orbits
    5. Paranasal sinuses

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

E. Podiatric
    1. Foot/toes
    2. Ankle
    3. Calcaneus (os calcis)

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**Refer to Appendix A, an inventory of clinical competencies, for mandatory and elective requirements.*

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Digital Image Acquisition and Display

Description
Content imparts an understanding of the components, principles and operation of digital imaging systems found in diagnostic radiology. Factors that affect image acquisition, display, archiving and retrieval are discussed. Principles of digital system quality assurance and maintenance are presented.

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

Proposed minimum hours of instruction: 40

Objectives
1. Define terminology associated with digital imaging systems.
2. Describe the various types of digital receptors.
3. Describe the response of digital detectors to exposure variations.
4. Compare the advantages and limits of each receptor type.
5. Evaluate the spatial resolution and dose effectiveness of digital radiography detectors.
6. Define sampling frequency.
7. Describe the effect of sampling frequency on spatial resolution.
8. Describe the effect of detector element size on spatial resolution.
9. Describe detective quantum efficiency (DQE) for digital radiography detectors.
10. Describe modulation transfer function (MTF) as it relates to digital radiography detectors.
11. Describe the histogram and the process of histogram analysis as it relates to automatic rescaling and determining an exposure indicator.
12. Define region of interest (ROI).
13. Relate the location and size of the ROI to the appearance of the image and exposure indicator.
14. Relate how the values of interest (VOI) affect image appearance.
15. Describe the process of image stitching.
16. Relate the receptor exposure indicator values to technical factors, system calibration, part/beam/plate alignment and patient exposure.
17. Describe the response of photostimulable phosphor (PSP) systems to background and scatter radiation.
18. Use appropriate means of scatter control.
19. Avoid grid-use errors associated with grid cutoff.
20. Identify common limitations and technical problems encountered when using PSP systems.
21. Employ appropriate beam/part/receptor alignment to avoid histogram analysis errors.
22. Associate effect of image-processing parameters to the image appearance.
23. Apply the fundamental principles to digital detectors.

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24. Evaluate the effect of a given exposure change on histogram shape, data width and image appearance.
25. Formulate a procedure or process to minimize histogram analysis and rescaling errors.
26. Examine the potential effect of digital radiographic systems on patient exposure and methods of practicing the as low as reasonably achievable (ALARA) concept with digital systems.
27. List the benefits of quality control management to the patient and to the department.
28. Discuss the appropriate use of electronic masking.
29. Describe a picture archiving and communication system (PACS) and its function.
30. Identify components of a PACS.
31. Define Digital Imaging and Communications in Medicine (DICOM).
32. Describe HIPAA concerns with electronic information.
33. Identify common problems associated with retrieving/viewing images within a PACS.
34. Compare monitor types (e.g., acquisition, display).
35. List the components of the various types of display monitors.
36. Discuss the effect of viewing angle, luminance, ambient lighting and pixel size on image display.

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Content

I. Image Acquisition

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

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

C. Dynamic range

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

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

II. Initial Processing

A. Preprocessing

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

C. Rescaling

D. Values of interest (VOI)

E. Grayscale/look-up table (LUT)

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F. Noise reduction

G. Smoothing

H. Edge enhancement

I. Equalization

III. Post Processing

A. Brightness adjustment

B. Grayscale (contrast) adjustment

C. Equalization

D. Smoothing

E. Edge enhancement

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

IV. Image Acquisition Errors

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

B. Low intensity radiation response
   1. 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)

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1. Exposure indicator range
2. Noise
    a. Material mottle
    b. Computer noise
    c. Electronic noise
    d. 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
            1) Cleaning and inspection
            2) Erasure
        b. Equipment calibration
        c. Uniformity
        d. Spatial resolution
    3. Reject analysis
    4. Monitor patient exposure
        a. Part of quality assurance (QA) program
        b. Vendor-supplied software
    5. Service engineer and/or medical physicist
        a. Notification process
        b. Preventive maintenance
    6. Involvement in quality control
    7. Shielding accessories

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

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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

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

VIII. Data Management

A. Network connectivity

B. Hospital/Health information system (HIS)

C. Radiology information system (RIS)

D. Picture archiving and communication system (PACS)
   1. System components and functions
   2. Emergency contingency plan
   3. Digital imaging and communication in medicine (DICOM)
      a. DICOM header
   4. DICOM metadata radiographer responsibilities
      a. Access work order (worklist)
      b. Postprocessing – image operation and manipulation
      c. Annotation issues
      d. Image transmission
      e. HIPAA
      f. Workflow

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

F. Teleradiology

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Fundamentals, Ethics and Laws of Health Care

Description
Content is designed to provide an overview of the foundations in radiologic science and the LXMO's role in the health care delivery system. Principles, practices and policies of health care organization(s) will be examined and discussed in addition to the professional responsibilities of the LXMO. The elements of ethical behavior will be discussed, as well as a variety of ethical and legal issues found in clinical practice. An introduction to terminology, concepts and principles also will be presented. The importance of proper documentation and consent is emphasized.

Proposed minimum hours of instruction: 8

Objectives
1. Identify other health science professionals who participate in the patient's total health care.
2. Describe the relationship of health science professionals to the integrated care of patients.
3. Identify various settings involved in the delivery of health care.
4. Discuss the reimbursement/payment options for health care services.
5. Describe relationships and interdependencies within health care.
6. List patient services that might be available in a radiology department.
7. Define *accreditation*, *credentialing*, *certification*, *licensure* and *regulations*.
8. Identify the benefits of continuing education as related to improved patient care and professional enhancement.
9. Describe the moral, social and cultural basis of ethics.
10. Explain the role of ethical behavior in health care delivery.
11. Differentiate between empathetic rapport and sympathetic involvement in relationships with patients and relate these to ethical conduct.
12. Explain concepts of personal honesty, integrity, accountability, competence and compassion as ethical imperatives in health care.
13. List legal/professional standards and their relationship to practice in health professions.
14. Identify specific situations and conditions that give rise to ethical dilemmas in health care.
15. Employ a basic system of examination, clarification, determination of alternatives and decision making in addressing ethical questions.
16. Explain select concepts embodied in HIPAA, principles of patients' rights, the doctrine of patient consent and other issues related to patients' rights.
17. Explain the legal implications of LXMO liability, malpractice, negligence/carelessness and other legal doctrines applicable to limited-scope practice.
18. Describe the importance of accurate, complete, correct methods of documentation as a legal/ethical imperative.
19. Describe the scope of practice for the LXMO, the elements that comprise it and responsibilities of the LXMO.
20. Describe institutional and professional liability protection typically available to the LXMO.

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Content

I. The Health Science Professions

A. Radiologic technology
   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. PACS administration/informatics
   8. Education
   9. Management

B. Allied health professions

II. The Health Care Environment

A. Health care settings
   1. Hospitals
   2. 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

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

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

III. Facility Organization

A. Philosophy and mission

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

C. 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. PACS administrator
5. Clinical informatics
6. Radiology nurse

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

D. Support staff
1. Radiation physicist
2. Clerical staff

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3. Technical assistant
4. Transport staff

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

V. Accreditation

A. Health care institutions
1. Facility level
2. Departmental level
3. Intradepartmental (modality)

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

VI. Regulatory Agencies

A. Federal

B. State

VII. Professional Credentialing

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

B. Agencies
1. National
2. State

VIII. Professional Organizations

A. Purpose, function and activities

B. Types
1. Local
2. State
3. National
4. International

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IX. Professional Development

A. Clinical experience requirements

B. Continuing education opportunities
   1. Continuing education programs
   2. General radiography programs
   3. Postprimary certification
   4. Collegiate/educational programs

C. Continued qualifications

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

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

X. 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

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G. Self-assessment and self-governance

H. Code of professional ethics

I. Ethical concepts

J. Systematic analysis of ethical problems

XI. Ethical Issues in Health Care

A. Individual and societal rights

B. Cultural considerations

C. Economic considerations

D. Access to quality health care

E. Technology and scarce resources

F. Medical/health care research

G. End-of-life decisions
   1. Living wills
   2. Advanced directives
   3. Health care power of attorney
   4. Nonintervention

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

XII. Legal Responsibilities

A. 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

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1) Duty
2) Dereliction (breach)
3) Causation
4) Damage

4. Legal and professional standards
   a. Standard of care
   b. Patients' bill of rights
   c. HIPAA
      1) Individual
      2) Institutional
5. Legal doctrines (i.e., *respondeat superior, res ipsa loquitur*)
6. Medical records
7. Legal risk reduction and risk management

B. Scope of practice and responsibilities of the LXMO
   1. Definition
   2. Supervision
   3. State statute
   4. Limitations
      a. Anatomic areas
      b. Radiographic procedures

XIII. Patient Consent

A. Rationale

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

C. 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 Joint Commission standards for disclosure

D. Documentation of consent

E. Right of refusal

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Human Anatomy and Physiology

Description
Content is designed to establish a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and systems will be described and discussed.

Proposed minimum hours of instruction: 25

Objectives
1. Identify the location of anatomical structures using directional and orientation terms.
2. Indicate where various planes lie in relation to the body.
3. Demonstrate the use of topographical landmarks to locate internal structures.
4. Identify the structural limits, functions and contents of each of the body cavities.
5. Identify and locate the bones of the human skeleton.
6. Identify bony processes and depressions found on the human skeleton.
7. Describe articulations of the axial and appendicular skeleton.
8. Summarize the functions of the skeletal system.
9. Compare the types, locations and movements permitted by the different types of articulations.
10. Describe the function of the primary and accessory organs of the digestive system.
11. Describe the composition and characteristics of blood.
12. Label the parts of the human heart.
13. Describe the flow of blood through the body and identify the main vessels.
14. Describe the structure and function of arteries, veins and capillaries.
15. Label the components of the respiratory system.
16. Describe the physiology of respiration.
17. Describe the function of each organ of the urinary system.
18. Label the anatomy of the male and female reproductive organs.
19. Describe the functions of the different types of muscles.
20. Describe the functions of the nervous system.

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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
   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

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a. Physis
b. Diaphysis
c. Diaphysis/epiphyseal line
d. Metaphysis

3. Classification and markings
   a. Long
   b. Short
   c. Flat
   d. Irregular
   e. Processes and bony projections
   f. Depressions/openings

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

C. Articulations
1. Function/joint classifications
   a. Synarthroses, fibrosis
   b. Amphiarthroses, cartilaginous
   c. Diarthroses, synovial
2. 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

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A. Components and structure
   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. Abdomen

A. Digestive system
   1. Primary organs – structure, function and location
      a. Oral cavity
      b. Esophagus
      c. Stomach
      d. Small intestine
      e. Large intestine
      f. Rectum
   2. Accessory organs – structure, function and location
      a. Salivary glands
      b. Pancreas
      c. Liver
      d. Gallbladder

B. Urinary system – structure, function and location
   1. Kidneys
   2. Ureters
   3. Bladder
   4. Urethra

C. Reproductive systems – structure, function and location
   1. Male
   2. Female

VII. Muscular System – Types, Characteristics and Functions

A. Smooth

B. Cardiac

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C. Skeletal

VIII. Nervous System

A. Introduction
   1. Neural tissue
   2. Function
   3. Central nervous system
   4. Peripheral nervous system

B. Neural tissue
   1. Types, location and physiology
      a. Neurons
      b. Neuroglia

C. Anatomy and functions
   1. Central nervous system
   2. Peripheral nervous system

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Image Production and Analysis

Description
Content is designed to establish a knowledge base in factors that govern the image production process.

Proposed minimum hours of instruction: 50

Objectives
1. Discuss standards for acceptable image quality.
2. Analyze the relationships of factors that control and affect image exposure.
3. Assess radiographic exposure on radiographic images.
4. Critique the radiographic contrast within various radiographic images.
5. Differentiate between subject contrast and image receptor contrast.
6. Compare long-scale and short-scale contrast images.
7. Analyze the relationships of factors that control and affect radiographic contrast.
8. Critique spatial resolution on various radiographic images.
9. Analyze the relationships of factors affecting spatial resolution.
10. Differentiate between shape and size distortion.
11. Summarize the relationships of factors affecting distortion.
12. Explain the rationale for using beam restriction.
13. Describe the operation and applications for different types of beam restriction.
14. Explain how beam filtration affects x-ray beam intensity, beam quality and patient exposure.
15. Summarize the relationships of factors affecting secondary radiation.
16. Evaluate the effects of scattered radiation on the image.
17. Compare types of grids.
18. Select the most appropriate grid for a given clinical situation.
19. Interpret grid efficiency in terms of grid ratio and frequency.
20. Summarize the factors that influence grid cutoff.
21. Evaluate grid artifacts.
22. Explain the use of standardized radiographic technique charts.
23. Explain exposure factor considerations involved in technique selection.
24. Compare fixed kilovolt peak (kVp) and variable kVp systems.
25. Apply the reciprocity law to clinical situations.
26. Summarize the importance of proper positioning, centering and collimating.
27. Apply the process for evaluating images for adequate exposure, contrast, spatial resolution and acceptable limits of distortion.
28. Discuss the effect of patient preparation on the resulting radiographic image.
29. Analyze images to determine the appropriate use of beam restriction.
30. Identify common equipment malfunctions that affect image quality.
31. Differentiate between technical factor problems, procedural factor problems and equipment malfunctions.

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Content

I. Exposure Factors

A. Distance

B. mA

C. Time

D. Focal spot size

E. kVp

F. Grids

G. AEC

H. Beam restriction

I. Filtration

II. Receptor Exposure

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

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

III. Differential Absorption

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

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

IV. Spatial Resolution

A. Motion
   1. Part
   2. Equipment

B. Geometric

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

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

V. Shape Distortion

A. Foreshortening

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

VI. Magnification

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

B. Display

VII. Beam Restriction

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

B. Types
1. Collimators
2. Lead Blockers

C. Collimator components
1. Automatic collimators
2. Cylinders

VIII. Beam Filtration

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

B. Function/mechanism

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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. Function/mechanism

B. Construction

C. Types
1. Focused
2. Parallel
3. Linear
4. Crossed
5. Moving
6. Stationary
7. Short dimension
8. Long dimension

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

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

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F. Primary cutoff

XI. Exposure Factor Formulation

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

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

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

XII. Imaging Standards

A. Purpose

B. Problem-solving process
   1. Determining cause of problems
   2. Recommending corrective action

C. 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

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I. Magnification
   1. Geometric
   2. Display

XIV. Procedural Factors

A. Image identification
   1. Patient information
   2. Date of examination
   3. Procedure(s) performed
   4. Proper use of identification makers
   5. Institutional data

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

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. Repeats

F. Patient preparation

G. Artifacts

XV. Corrective Action

A. Equipment malfunction

B. Technical factors

C. Procedural factors

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D. Artifacts

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Imaging Equipment and Radiation Production

Description
Content is designed to establish a knowledge base in radiographic equipment and x-ray production. Topics include atomic structure, the nature and characteristics of radiation and the fundamentals of photon interactions with matter.

Proposed minimum hours of instruction: 40

Objectives
1. Define potential difference, current and resistance.
2. Describe electrical protective devices.
3. Identify the function of the rectification system.
4. Compare generators in terms of radiation produced and efficiency.
5. Demonstrate operation of radiographic equipment including manual exposure controls.
6. Discuss the application of AEC devices.
7. Describe the structure of the atom.
8. Discuss the energy levels of the atom.
9. Explain the processes of ionization and excitation.
10. Describe the electromagnetic spectrum.
11. Define and describe wavelength and frequency and how they are related to velocity.
12. Identify the properties of x-rays.
13. State the principles of x-ray production.
14. Compare the production of bremsstrahlung and characteristic radiations.
15. Describe the conditions necessary to produce x-radiation.
16. Describe the x-ray emission spectrum.
17. Identify the factors affecting the x-ray emission spectrum.
18. Discuss various photon interactions with matter.
19. Discuss relationships of wavelength and frequency to beam characteristics.
20. Discuss the clinical significance of the photoelectric and modified scattering (Compton) interactions in diagnostic imaging.

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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. Generators

II. Radiographic Equipment

A. Fixed units
   1. Components
      a. Tubes
      b. Collimators
      c. Tables
      d. Control panels
      e. Tube support systems
      f. Wall units
      g. Potter-Bucky mechanism
   2. Equipment operation and manipulation
   3. Applications

B. Mobile units
   1. Components
      a. Tubes
      b. Collimators
      c. Control panels
      d. Tube support systems
   2. Equipment operation and manipulation

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C. AEC devices
    1. Ionization chambers
    2. Minimum reaction time
    3. Backup time
    4. Alignment and positioning considerations
        a. Sensor selection
        b. Sensor configuration
        c. Sensor sensitivity
    5. 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 imaging
    1. CR components
        a. Plate (e.g., photo-stimulable phosphor [PSP])
        b. Plate reader
    2. DR image receptors
        a. Flat panel
        b. Charge coupled device (CCD)
        c. Complementary metal oxide semiconductor (CMOS)

III. Quality Control

A. Definitions

B. Benefits
    1. Patient
    2. Department/office

C. Areas of focus

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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. 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. Radiation
1. Electromagnetic
    a. Spectrum
    b. Properties
    c. Ionization and excitation

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. Types
1. Bremsstrahlung
2. Characteristic

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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 phasing

VII. Interaction of Photons With Matter

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

B. Unmodified scattering (coherent 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

C. 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

D. Modified scattering (Compton scattering)
    1. Description of interaction
    2. Relation to atomic number
    3. Photon energy

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4. Probability of occurrence
5. Tissue volume
6. Part thickness
7. Resulting image

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Medical Terminology

Description
Content is designed to provide an introduction to the origins of medical terminology. A word-building system will be introduced, and abbreviations and symbols will be discussed. Also introduced will be an orientation to the understanding of radiographic orders and interpretation of diagnostic reports. Related terminology is addressed.

Proposed minimum hours of instruction: 10

Objectives
1. Apply the word-building process.
2. Interpret medical abbreviations and symbols.
3. Critique orders, requests and diagnostic reports.
4. Define medical imaging terms.
5. Translate medical terms, abbreviations and symbols into common language from a medical report.

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Content

I. The Word-building Process

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

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

C. Translation of terms into common language

D. Correct pronunciation of medical terms

II. Medical Abbreviations and Symbols

A. Role in communications

B. Abbreviations
   1. Examples
   2. Interpretations
   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

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

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B. Diagnostic reports
    1. Content
    2. Interpretation

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Patient Care in Radiologic Sciences

Description
Content is designed to provide the basic concepts of patient care, including consideration for the physical and psychological needs of the patient and family. Routine patient care procedures will be described, as well as infection control procedures using standard precautions. The role of the LXMO in patient education will be identified. Content also will include the study of factors that influence relationships with patients and professional peers. Understanding human diversity assists the student in providing better patient care.

Proposed minimum hours of instruction: 30

Objectives
1. Identify the responsibilities of the health care facility and members of the health care team.
2. Describe the scope of practice for the LXMO as defined by state licensure.
3. Describe ethical, emotional, personal and physical aspects of death.
4. Identify methods for determining the correct patient for a given procedure.
5. Explain the use of various communication methods.
6. Explain specific aspects of a radiographic procedure to the patient.
7. Demonstrate correct principles of body mechanics applicable to patient care.
8. Demonstrate techniques for specific types of patient transfer.
9. Demonstrate select procedures for turning patients with various health conditions.
10. Describe select immobilization techniques for various procedures and patient conditions.
11. Explain the purpose, legal considerations and procedures for reporting an accident or incident.
12. Describe methods for evaluating patient status.
13. List the information to be collected prior to patient examination.
14. Describe vital signs used to assess patient condition.
15. Assess patient vital signs.
16. Define terms related to infection control.
17. Describe the importance of standard precautions.
18. Explain sources and modes of infection and disease transmission.
19. List institutional/departmental procedures for infection control.
20. Describe methods for the prevention of infection to the health worker and patient.
21. Identify symptoms related to specific emergency situations.
22. Describe the emergency medical code system for the institution and the role of the LXMO during a medical emergency.
23. Explain the age-specific considerations necessary when performing radiographic procedures.
24. Explain the types, immobilization devices and positioning for upper and lower extremity fractures.
25. Identify specific types of tubes, lines, catheters and collection devices.
26. Demonstrate competence in basic life support (BLS).
27. Demonstrate select first-aid techniques.

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28. Explain the influence a person's value system has on his or her behavior.
29. Describe how professional values influence patient care.
30. Differentiate between culture and ethnicity.
31. Explain how a person's cultural beliefs toward illness and health affect his or her health status.
32. Use patient and family education strategies appropriate to the comprehension level of the patient/family.
33. Provide desired psychosocial support to the patient and family.
34. Examine cultural and socioeconomic factors that influence patient compliance with medical care.

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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-illness continuum

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

C. Age-specific communication
1. Neonates
2. Pediatric
3. Adolescence
4. Young adulthood
5. Middle adulthood
6. Geriatric

D. Communication
1. Verbal
   a. Presentation of material
   b. Voice tone and volume
   c. Effective listening
2. Nonverbal
   a. Facial expression

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b. Physical appearance
c. Touch
d. Eye contact

3. Written
4. Cultural sensitivity
5. 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. Human diversity
    h. Artificial speech
        1) Transesophageal puncture (TEP)
        2) Esophageal speech
        3) Electrolarynx devices
6. Other factors that impede communication
    a. Colloquialism/slang
    b. Medical terminology
7. 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
8. Communicating with families
9. Communicating with other health care professionals

E. Psychological considerations
    1. Dying and death
        a. Understanding the process
        b. Aspects of death
            1) Emotional
            2) Personal
            3) Physical
        c. Grief and counseling
        d. Patient support services
            1) Family and friends
            2) Pastoral care
            3) Patient-to-patient support groups
            4) Psychological support groups

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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

B. Procedure questions and explanations
   1. Positioning
   2. Length of procedure
   3. Audio and visual intercommunication systems
   4. Room noises
   5. Immobilization devices
   6. Machine type
   7. Machine movement
   8. Machine-patient contact
   9. Application of auxiliary equipment

IV. Safety and Transfer Positioning

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

B. Body mechanics

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1. Proper body alignment
2. Proper movement
3. Proper balance
4. Center of balance in the body

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

F. Accident and incident reporting
   1. Purpose
   2. Legal considerations
   3. Documentation

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4. Procedures

V. Evaluating Physical Needs

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

B. Vital signs – ranges and values
   1. Temperature
   2. Pulse
   3. Pulse oximetry
   4. Respiration
   5. Blood pressure
   6. Normal values
   7. Interfering factors
   8. Terminology
   9. Adult vs. pediatric
   10. Documentation
   11. Pain assessment
   12. Weight

C. Acquiring and recording vital signs

D. Patient records or patient health information (PHI)
   1. Components
   2. Confidentiality
   3. Retrieval
   4. Documentation
   5. Release of information
   6. HIPAA

VI. Infection Control

A. Terminology
   1. Nosocomial
   2. Communicable
   3. Infectious pathogens
   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. Infectious pathogens – blood-borne and airborne
   2. Reservoir of infection

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3. Susceptible host
4. Transmission of disease
    a. Direct
    b. Indirect
    c. Droplet
    d. Airborne/suspended
    e. Fomites
    f. Common vehicle
    g. Vector-borne

D. Preventing disease transmission

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

F. 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

G. 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

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B. Emergency equipment

C. Allergic reactions
   1. Latex
   2. Contrast media

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

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

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

G. Airway obstruction – signs, symptoms and interventions

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

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

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

K. Trauma or physical injury

VIII. Tubes, Catheters, Lines and Collection Devices

A. Terminology

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B. Nasogastric/nasointestinal

C. Ostomies
   1. Types
      a. tracheostomy
      b. ileostomy
      c. ureteroileostomy
   2. Purpose
   3. Location
   4. Care
   5. Access

D. Chest tube

E. Venous catheters

F. Implanted devices

G. Tissue drains

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

I. Urinary collection
   1. Procedure
      a. Male
      b. Female
   2. Alternative methods of urinary drainage
   3. Documentation

IX. Values

A. Personal
   1. Development
   2. Conflict
   3. Effect on patient care

B. Professional
   1. Development
   2. Conflict

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3. Effect on patient care

X. Culture, Ethnicity and Diversity

A. Societal and individual factors
   1. Socioeconomic
      a. Effects on health care
      b. Culture of poverty
      c. Relationship to disease occurrence
   2. Gender
      a. Social bias
      b. Medical treatment bias
      c. Cultural differences
   3. Family structure and dynamics
   4. Geographical factors
      a. Availability of health care services
      b. Social acceptance of diverse cultural differences
   5. Religion, spirituality and belief system
   6. Lifestyle choices and behaviors
   7. Disability

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Radiographic Anatomy, Procedures and Pathology

Description
Content is designed to provide a knowledge base necessary to perform standard radiographic procedures within a limited scope of practice. Consideration will be given to the production of images of optimal diagnostic quality. The LXMO will be introduced to clinical manifestations of pathologic processes, their radiographic appearance and their relevance to radiographic procedures. Laboratory experience should be used to complement the didactic portion.

Note: It is recognized that the scope of practice for LXMOs vary based on state statutes and licensing/permit restriction. The procedures taught and emphasis given to the scope of practice of the LXMO must not exceed the area of diagnostic study allowed by state license or permit.

Proposed minimum hours of instruction:

- **Chest – 20 hours.**
- **Extremities:**
  - **Upper extremity and pectoral girdle – 20 hours.**
  - **Lower extremity – 20 hours.**
- **Spine – 20 hours.**
- **Skull/Sinuses – 20 hours.**
- **Podiatric – 10 hours.**

Objectives

1. Define standard positioning and procedure terminology.
2. Demonstrate body and radiographic positions.
3. Demonstrate proper use of anatomic relationships and locations.
4. Apply the proper use of body planes when positioning patients for radiographic examinations.
5. Demonstrate proper use of positioning aids.
6. Discuss general procedural considerations for radiographic examinations.
7. Adapt general procedural considerations to specific clinical settings.
8. Identify the structures demonstrated on routine radiographic images.
9. Adapt radiographic procedures based on patient assessment.
10. Simulate radiographic procedures on a person* or phantom in a laboratory setting.
11. Evaluate images for positioning, centering, appropriate anatomy and overall image quality.
12. Discuss equipment and supplies necessary to complete radiographic procedures.
13. List and explain the routine and special projections for assigned radiographic procedures performed within limited scope(s) of practice.
14. Explain radiographic procedures to patients and family members.
15. Modify directions to patients with various communication challenges.
16. Apply general radiation safety and protection practices associated with radiologic examinations.
17. Define basic terms related to pathology that are used to classify and identify diseases.

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18. Classify diseases according to the disease process.
19. Describe the basic manifestations of pathological conditions.
20. Describe the radiographic appearance of selected diseases.
21. Describe adaptive techniques relevant to radiographic examination of selected diseases.

**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.*

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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

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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

B. Verification of procedure(s) ordered

C. Review of clinical history

D. Taking clinical history and patient assessment

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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

E. Patient preparation
    1. Procedure explanation
    2. Removal of clothing
    3. Removal of radiopaque items
F. Room preparation
    1. Cleanliness
    2. Organization
    3. Appearance
    4. Supplies
    5. Accessory equipment

G. Patient assistance

H. Patient monitoring

I. Patient dismissal

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

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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. 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
   3. Podiatric
      a. Foot and toes
      b. Ankle
      c. Calcaneus
   4. Spine
      a. Cervical
      b. Thoracic
      c. Lumbar
      d. Scoliosis series

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e. Sacrum
f. Coccyx
g. Sacroiliac joints

5. 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. Disease classification
   1. Acute
   2. Chronic
   3. Structural
   4. Functional
   5. Hereditary
   6. Congenital

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

C. Fractures

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D. Etiology

E. Diagnosis
   1. Signs (objective)
   2. Symptoms (subjective)

F. Prognosis

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. Extremities
   3. Spine
   4. Skull/Sinuses
   5. Podiatric

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Radiation Protection and Radiobiology

Description
Content is designed to present an overview of the responsibilities for protecting patients, personnel and the public from excessive radiation exposure. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated. An overview of the principles of the interaction of radiation in living matter and radiation effects of molecules, cells, tissues and the body as a whole are presented. Factors affecting biological response also are presented to include acute and chronic effects of radiation.

Proposed minimum hours of instruction: 60

Objectives
1. Identify and justify the need to minimize unnecessary radiation exposure to humans.
2. Explain the objectives of a radiation protection program.
3. Define the units of radiation measurement.
4. Explain the importance of minimizing entrance skin dose.
5. Identify effective dose limits (EDL) for occupational and nonoccupational radiation exposure.
6. Describe the ALARA concept.
7. Identify the basis for occupational exposure limits.
8. Distinguish between perceived risk and comparable risk.
9. Describe the concept of negligible individual dose (NID).
10. Identify ionizing radiation sources from natural and man-made sources.
11. Comply with legal and ethical radiation protection responsibilities of radiation workers.
12. Describe the operation of various interlocking systems for equipment.
13. Distinguish between controlled and noncontrolled areas and list acceptable exposure levels.
14. Describe “Radiation Area” signs and identify appropriate placement sites.
15. Describe the function of federal, state and local regulations governing radiation protection practices.
16. Express the need and importance of personnel monitoring for radiation workers.
17. Describe personnel monitoring devices, including applications, advantages and limitations for each device.
18. Interpret personnel monitoring reports.
19. Compare values for individual effective dose limits for occupational radiation exposures.
20. Identify anatomical structures that are considered critical for potential late effects of whole-body irradiation exposure.
21. Distinguish between primary and secondary radiation barriers.
22. Demonstrate how the operation of various x-ray and ancillary equipment influence radiation safety.
23. Demonstrate how time, distance and shielding can be manipulated to minimize radiation exposures.
24. Explain the relationship of beam-limiting devices to patient radiation protection.

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25. Discuss added and inherent filtration in terms of the effect on patient dosage.
26. Explain the purpose of, types of and rationale for patient shielding.
27. Explain the relationship of exposure factors to patient dose.
28. Identify the appropriate image receptor that will result in an optimum diagnostic image with the minimum radiation exposure to the patient.
29. Identify proper exposure index and/or dose area product (DAP) value for equipment.
30. Select the immobilization techniques used to eliminate voluntary motion.
31. Describe the characteristics of a molecule.
32. Describe cellular biology of the human cell.
33. Differentiate between the direct and indirect effects of radiation.
34. Describe radiation-induced chemical reactions and potential biologic damage.
35. Evaluate factors influencing radiobiologic and biophysical events at the cellular and subcellular level.
36. Identify methods to measure radiation response.
37. Describe physical, chemical and biological factors influencing radiation response of cells and tissues.
38. Explain factors influencing radiosensitivity.
39. Recognize the clinical significance of lethal dose (LD).
40. Examine effects of limited vs. total body exposure.
41. Relate short-term and long-term effects as a consequence of high and low radiation doses.
42. Differentiate between somatic and genetic radiation effects and discuss specific diseases or syndromes associated with them.
43. Discuss stochastic (probabilistic) and nonstochastic (deterministic) effects.
44. Discuss risk estimates for radiation-induced malignancies.
45. Discuss embryonic and fetal effects of radiation exposure.
46. Discuss acute radiation syndromes.

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Content

I. Introduction

A. Justification for radiation protection

B. 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)

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

D. 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)

C. Air kerma
   1. Kinetic energy release in matter
   2. Measurement unit in gray

D. Dose equivalent - Sievert (Sv)

E. 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

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2. Conditions
3. Recommendations
4. "Radiation Area" sign posting
5. Monitors

D. Regulatory/agencies
1. Nuclear Regulatory Commission (NRC)
2. Food and Drug Administration (FDA)
3. EPA
4. OSHA
5. State agencies

E. Advisory agencies
1. International Council on Radiation Protection and Measurements (ICRP)
2. National Council on Radiation Protection and Measurements (NCRP)
3. Biological Effects of Ionizing Radiation (BEIR)

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. Film badge
2. Thermoluminescent dosimeter (TLD)
3. 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 limits
3. Critical organ sites
4. Embryo and fetus

E. Responsibilities for radiation protection
1. Facility
2. LXMO

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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. Positioning
   5. Patient education
   6. Immobilization

B. Entrance skin exposure

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

D. Special considerations
   1. Pediatric patients

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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
      a. Radiolysis of water

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

X. Radiation Effects

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

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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. Lethal dose and LD_{50}

C. Systemic response to radiation
1. Hemopoietic system
2. Integumentary
3. Digestive
4. Urinary
5. Respiratory

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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

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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, human diversity, 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 diverse sources and points of view.

- Arts and Humanities
  - Develop a knowledge and understanding of the human condition.
  - Demonstrate respect for diverse populations.
  - Develop an understanding of ethics and the role they play in personal and professional lives.
  - Recognize and critically examine attitudes and values.

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

- Social/Behavioral Sciences
  - Adapt interactions to meet people's cultural and psychological needs.
  - Develop an understanding of individual and collective behavior.
  - Promote the development of leadership skills.
  - Develop the capacity to exercise responsible and productive citizenship.
  - Function as a public-minded individual.

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- Natural Sciences
  - Develop an understanding of the scientific method.
  - Make informed judgments about science-related topics.
  - Develop a vocabulary of science.

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Appendix A

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LXMO Clinical Competencies and Assessment of Competency

The following table is intended to be used as a tool for documenting the successful completion of recommended mandatory and elective clinical competencies. It is recognized that within a given state the scope of practice of a LXMO may be restricted to one or two categories on this form.

Mandatory competencies are those believed to be particularly important to the role of the LXMO. The mandatory list represents a baseline of studies that will allow the student to demonstrate proficiency in a given category of patient exams. Observations generally are based on one sample of the student's performance because it is impossible for the clinical instructor to be present in all clinical situations. Because inference regarding the student's competence cannot be made from one situation, an adequate number of observations need to be recorded by a variety of assessors. Multiple sampling of student performance can potentially make the assessment more valid and reliable. Students typically migrate through a sequence in which they observe examples of a given exam being performed by a radiographer or licensed practitioner, assist in the performance of a number of the same exam, then perform the exam several times under the supervision of a radiographer or licensed practitioner. Programs have the prerogative to set values for the number of exams of a given type that students would be expected to observe, provide assistance and perform under supervision before a competency assessment is conducted.

One of the column headings indicates whether the competency assessment was conducted during an actual patient exam or through simulation. It is recognized that, in the clinical setting, not all patient exams are requested often enough to ensure competency testing can be conducted on patients only. However, performing all required procedures under simulated conditions would not provide appropriate learning.

	Mandatory	Elective	Date and Time Completed	Patient or Simulation	Verified by
Chest	Proposed number of procedures within this category = 100				
Chest single view	☆				
Chest two view	☆				
Chest, age 6 years or younger		☆			
Chest, patient uses a wheelchair		☆			
Apical lordotic		☆			
Upper Extremity	Proposed number of procedures within this category = 100				
Finger	☆				
Hand	☆				

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Wrist	☆				
Forearm	☆				
Elbow	☆				
Humerus	☆				
Extremity, age 6 years or younger		☆			
Pectoral girdle	(Included in Upper Extremity category)				
Shoulder	☆				
Clavicle		☆			
Scapula		☆			
Acromioclavicular joints		☆			
Lower Extremity	Proposed number of procedures within this category = 50				
Toes	☆				
Foot	☆				
Ankle	☆				
Calcaneus	☆				
Tibia/fibula	☆				
Knee/patella	☆				
Distal femur	☆				
Extremity, age 6 years or younger		☆			
Podiatric	Proposed number of procedures within this category = 50				
Foot	☆				
Toes	☆				
Ankle	☆				
Calcaneous	☆				

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Spine	Proposed number of procedures within this category = 50				
Cervical	☆				
Thoracic	☆				
Lumbar	☆				
Scoliosis series		☆			
Sacrum		☆			
Coccyx		☆			
Sacroiliac joints		☆			
Skull/Sinuses	Proposed number of procedures within this category = 50				
Skull	☆				
Facial bones	☆				
Nasal bones		☆			
Orbits		☆			
Paranasal sinuses	☆				

General Patient Care		
Students are to demonstrate competency in the following patient care simulations.	Date Completed	Verified by
Basic life support (BLS) certified		
Vital signs (blood pressure, pulse, respiration, temperature)		

The evaluation of competence in the performance of clinical procedures is a key element in the development of the LXMO. 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.

Performing competently in the clinical setting is more than the demonstration of certain behaviors associated with the completion of a single task. Competence in 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 making the individual competent in that role.

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Competency is a complex concept requiring multiple assessment strategies to evaluate the effectiveness of student learning. Assessment should not only be concerned with psychomotor skills, but also an understanding of the principles underlying professional practice.

Elements to consider in structuring the performance criteria for a clinical competency assessment 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 a student's clinical experience he or she 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 competency 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.

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Resources

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

Textbooks

Adler A, Carlton R. *Introduction to Radiologic and Imaging Sciences and Patient Care*. 6th ed. St. Louis, MO: Elsevier Saunders; 2015.
ISBN 0323315798

Biedrzycki A. *The Radiography Procedure and Competency Manual.* 3rd ed. Philadelphia, PA: F.A. Davis; 2017.
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Bonnick SL. *Bone Densitometry in Clinical Practice: Application & Interpretation.* 3rd ed. Totowa, NJ: Humana Press; 2009.
ISBN 1603274987

Browne MN, Keeley SM. *Asking the Right Questions: A Guide to Critical Thinking*. 11th ed. Upper Saddle Rivers, NJ: Pearson Prentice Hall; 2014.
ISBN 0321907957

Bull S. *Skeletal Radiography: A Concise Introduction to Projection Radiography*. 2nd ed. Stanley, UK: Toolkit Publications; 2005.
ISBN 0955131103

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