

# Bone Densitometry Curriculum

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# Introduction

The goal of this curriculum is to provide the bone densitometry community with a clear summary of entry-level education. The curriculum is suitable for all programs in this specialty, including limited fellowships, short-term certificate programs and college-based education programs. The educational elements of this curriculum are not static, but are periodically updated to represent current practice and trends in the field. It is important for educators to incorporate new concepts and trends into the classroom as they appear.

The curriculum is divided into several content areas, each representing an essential component of a bone densitometry educational program. No particular sequence is suggested. The content and objectives should be organized to meet the mission and goals of each program. Faculty members are encouraged to expand on these fundamental objectives as they incorporate them into their classroom curricula. Specific instructional methods are intentionally omitted to allow for creativity in instructional delivery.

The curriculum document consists of four sections: foundations, core content, optional content and clinical experience requirements. The foundations section is an inventory of the pre-existing knowledge and skills students should have gained from entry-level radiography education and reinforced through professional practice. The content in the foundations section is intended to help technologists plan their career, and help program managers develop preassessment tools for candidate selection.

The practice of bone densitometry requires knowledge and skills generally not obtained from standard radiography education. The core content section includes essential content to prepare technologists for postprimary practice in bone densitometry.

The optional content section enhances the core curriculum with topics that better serve the specific mission of various programs or the requirements of their local employment market.

The clinical experience requirements section provides information about the development of a well-rounded clinical experience. Eligibility requirements and information about the postprimary certification exam in bone densitometry is provided in this section.

## **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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# Foundations

The foundations section is an inventory of the pre-existing knowledge and skills students should have gained from entry-level radiography education and reinforced through professional practice. The content in the foundations section is intended to help technologists plan their career, and help program managers develop preassessment tools for candidate selection.

## **Clinical Practice**

Content and clinical practice experiences 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.

## **Ethics and Law in the Radiologic Sciences**

Content provides a foundation in ethics and law related to the practice of medical imaging. An introduction to terminology, concepts and principles will be presented. Students will examine a variety of ethical and legal issues found in clinical practice.

## **Human Anatomy and Physiology**

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

## **Introduction to Computed Tomography**

Content is designed to provide entry-level radiography students with an introduction to and basic understanding of the operation of a computed tomography (CT) device. Content is not intended to result in clinical competency.

## **Patient Care in Radiologic Science**

Content provides the concepts of optimal patient care, including consideration for the physical and psychological needs of the patient and family. Routine and emergency patient care procedures are described, as well as infection control procedures using standard precautions. The role of the radiographer in patient education is identified.

## **Radiation Biology**

Content provides an overview of the principles of the interaction of radiation with living systems. Radiation effects on molecules, cells, tissues and the body as a whole are presented. Factors affecting biological response are presented, including acute and chronic effects of radiation.

### **Radiation Production and Characteristics**

Content establishes a basic knowledge of atomic structure and terminology. Also presented are the nature and characteristics of radiation, x-ray production and the fundamentals of photon interactions with matter.

### **Radiation Protection**

Content presents an overview of the principles of radiation protection, including the responsibilities of the radiographer for patients, personnel and the public. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated.

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Refer to Appendix A for a detailed list of objectives for each content area.

## Core Content

The professional practice of bone densitometry requires specific knowledge and skills generally not obtained in standard radiography programs. The core content section presents curriculum elements that are considered essential for technologists in the postprimary practice of bone densitometry.

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# Osteoporosis and Bone Remodeling

## Description

Osteoporosis content covers knowledge of bone remodeling and how remodeling imbalance results in the disease osteoporosis. Osteoporosis is defined and its consequences, risk factors, prevention and treatment are discussed. The diagnosis of osteoporosis by DXA is described, and reference populations, T-score, Z-score, World Health Organization (WHO) criteria and fracture risk assessment are discussed.

## Objectives

1. Describe cortical and trabecular bone and the locations of each.
2. Describe the bone remodeling sequence, how it changes throughout the life span and factors that affect remodeling.
3. Discuss how the definition of osteoporosis has evolved over time.
4. Compare and contrast the reference populations available for DXA.
5. Define and contrast young normal peak bone mass and age-adjusted bone mass.
6. Define standard deviation and relate it to Z-scores and T-scores.
7. Define the WHO criteria for diagnosis of osteoporosis and discuss their advantages and disadvantages.
8. Discuss fracture risk assessment.
9. Identify the consequences of osteoporosis.
10. Describe the risk factors, prevention and treatment of osteoporosis.

## Content

### I. Bone Physiology

- A. Functions of bone
  - 1. Nutrient storage
  - 2. Support, movement, protection
  - 3. Production of blood cells
  - 4. Endocrine regulation
  
- B. Structural anatomy
  - 1. Cellular anatomy
    - a. Osteoclasts
    - b. Osteoblasts
  
- C. Types of bone
  - 1. Cortical
    - a. Relevant anatomical sites with high percentage
  - 2. Trabecular
    - a. Relevant anatomical sites with high percentage
  - 3. Ratio of cortical to trabecular bone in total body
  
- D. Bone Remodeling
  - 1. Remodeling sequence
    - a. Bone resorption
    - b. Bone formation
  - 2. Bone mass throughout the life span
    - a. Bone accrual
    - b. Peak bone mass
    - c. Postmenopausal bone loss
    - d. Bone loss in the elderly
  - 3. Factors that affect remodeling
    - a. Calcium
    - b. Vitamin D
    - c. Estrogen
    - d. Other hormones
  - 4. Factors that affect peak bone mass
    - a. Genetics
    - b. Diet
    - c. Exercise
    - d. Disease

### II. Osteoporosis

- A. Definitions
  - 1. Historically based on fragility fracture
  - 2. 1990 Consensus Development Panel
  - 3. 1994 WHO criteria

- B. Types
  - 1. Primary
  - 2. Secondary
  
- C. Diagnosis by DXA
  - 1. Reference populations
    - a. Manufacturer specific
    - b. National Health and Nutrition Examination Survey (NHANES)
    - c. Young normal peak bone mass
    - d. Age-adjusted bone mass
  - 2. Standard deviations
    - a. Z-score
    - b. T-score
    - c. WHO criteria
      - 1) Clinical need for cutpoint definition
      - 2) Disadvantages of cutpoint definition
  - 3. Fracture risk assessment
  
- D. Consequences
  - 1. Fragility fractures
    - a. Wrist
    - b. Spine
    - c. Hip
    - d. Other
  - 2. Chronic complications of fracture
    - a. Kyphosis
    - b. Pain
    - c. Digestive difficulties
    - d. Pulmonary compromise
    - e. Ambulation difficulties
    - f. Depression
    - g. Loss of self-esteem
    - h. Loss of independence or nursing home admission
    - i. Increased risk for subsequent fractures
  - 3. Acute complications of fracture
    - a. Hospitalization
    - b. Surgery
    - c. Infection
    - d. Thromboembolism
    - e. Death
      - 1) Secondary to acute and chronic complications
      - 2) Increased mortality due to hip fracture
  
- E. Risk factors
  - 1. Gender
  - 2. Age

3. Race/ethnicity
  4. Menopause
  5. Family history and genetics
  6. Use of certain medications
  7. Presence of certain diseases or conditions
  8. Lifestyle
  9. Diet
  10. Body habitus
  11. Propensity to fall
  12. Smoking
  13. Alcohol abuse
- F. Prevention and treatment
1. Lifestyle
    - a. Exercise
    - b. Diet
    - c. Smoking cessation
  2. Drug Therapies
    - a. Antiresorptive
    - b. Formation
    - c. Hormonal and others
  3. Fall prevention
- G. Treatment
1. Mechanisms of action for therapeutic intervention
    - a. Decrease rate of bone resorption
    - b. Actively build new bone
  2. Estrogens
  3. Bisphosphonates
  4. Selective estrogen receptor modulator (SERM)
  5. Calcitonin
  6. Parathyroid hormone
  7. Receptor activator of NF- $\kappa$ B ligand (RANKL) inhibitor human monoclonal antibody
  8. Calcium
  9. Vitamin D
  10. Others

# Bone Densitometry Overview

## Description

Bone densitometry overview content establishes a basic knowledge of bone densitometry and its purpose. Techniques are explained, with an emphasis on dual-energy x-ray absorptiometry (DXA) and how it compares with other imaging modalities. The content highlights the role of DXA as the gold standard for quantitative evaluation of bone mineral density.

## Objectives

1. Define bone densitometry.
2. Discuss the various uses for bone densitometry.
3. Explain current techniques, including peripheral adaptations.
4. Discuss advantages of DXA.
5. Compare and contrast DXA to other imaging modalities.
6. Explain the application of DXA technology in vertebral fracture assessment (VFA).

## **Content**

### **I. Bone Densitometry**

- A. Definition
  
- B. Uses
  - 1. Quantitative measurement of bone density
  - 2. Monitoring therapy
  - 3. Predicting future fracture risk
  - 4. Pediatrics and adolescents
  - 5. VFA
  
- C. DXA
  - 1. Most versatile method
  - 2. Advantages
    - a. Low radiation dose
    - b. High-resolution images
    - c. Good precision
    - d. Stable calibration
  - 3. Gold standard
  
- D. DXA compared with other imaging modalities (e.g. peripheral DXA, quantitative CT, quantitative ultrasound)
  - 1. Only two x-ray photon energies used
  - 2. Images used for positioning and region of interest (ROI), not for diagnosis
  - 3. Manufacturer-specific operation
  - 4. Low radiation dose

# Physical Principles and Instrumentation of DXA

## Description

Physical principles and instrumentation content establishes a fundamental knowledge of the operation of dual-energy x-ray absorptiometry (DXA) equipment. The various x-ray production and detection techniques, fan beam geometry and data analysis processes are described. Accuracy and precision are defined. Special applications of DXA technique to body composition, VFA and orthopedics are presented.

## Objectives

1. Describe the relationship between subject density and x-ray absorption.
2. Explain the use of two photon energies to separate soft tissue from bone in DXA.
3. Discuss the advantages and limitations of DXA.
4. Define accuracy and precision and discuss their importance in bone densitometry and scanner replacement.
5. Describe the two methods of x-ray production and detection in DXA.
6. Discuss the geometry of fan beam systems.
7. Explain the importance of soft-tissue calculation and bone edge detection during scan analysis.
8. Define BMD, BMC and area, including related formulas.
9. Describe the application of DXA to body composition, VFA and orthopedics.
10. Describe the process and frequency of precision and cross-calibration studies and their value regarding serial measurements.

## **Content**

### **I. Fundamental Principles**

- A. Relationship between subject density and absorption of x-rays
- B. Two x-ray energies
  - 1. Typical energies
  - 2. DXA calculations
  - 3. Advantages and limitations of DXA
- C. Accuracy and precision
  - 1. Definitions
  - 2. Importance

### **II. DXA Components**

- A. X-ray production
  - 1. K-edge filtering
  - 2. Energy switching
- B. Radiation detection
  - 1. Scintillation detector systems
  - 2. Photon counting detector systems
  - 3. Solid-state detector systems
    - a. High-voltage switching circuitry
    - b. Calibration drum

### **III. Fan Beam Systems**

- A. Mechanics of fan beams
  - 1. Beam collimation
  - 2. Multiple detector system
  - 3. Detector uniformity correction
  - 4. Scan arm motion
- B. Fan beam geometry
  - 1. Source-to-object-to-detector distances
  - 2. Magnification and distortion
  - 3. Object centering
  - 4. Estimated BMC and area

### **IV. Scan Analysis Software**

- A. Calculating soft-tissue density or baseline
- B. Bone edge detection
- C. Definition and calculation of BMC, area, BMD

### **V. Sources of Accuracy and Precision Errors**

- A. Scanner speed and current
  - 1. Effect of incorrect settings
  - 2. Reproducing settings for follow-up scans
- B. Positioning
  - 1. Effect on BMC, area and BMD
  - 2. Reproducing positions for follow-up scans
  - 3. Establishing the least significant change (LSC)
- C. Anatomy and pathology
  - 1. Variations from normal
    - a. Effect on BMC, area and BMD
    - b. Bone edge detection problems
    - c. Comparison to reference population
  - 2. Body habitus
    - a. Decrease current in thin patients
    - b. Increase current, decrease speed in thick patients
- D. Geometry
  - 1. Centering
  - 2. Small areas subject to large percent changes, poorer precision
- E. Scanner calibration
  - 1. Stability
  - 2. Quality control
- F. Precision assessment
  - 1. Purpose
  - 2. Frequency
  - 3. Performing precision analysis
    - a. Minimum acceptable precision
    - b. Cross-calibration
    - c. Establishing new baseline information

## **VI. Special DXA Applications**

- A. Total-body scans
  - 1. Body composition
  - 2. Bone density
- B. C-arm
  - 1. Lateral spine
  - 2. VFA
- C. VFA
  - 1. Purpose: detecting vertebral fractures
  - 2. Decubitus lateral position

### 3. Grading system for fracture severity

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# Radiation Safety and Protection

## Description

Radiation safety content prepares students to adapt general radiation safety and protection principles to bone densitometry techniques that use ionizing radiation, particularly DXA.

## Objectives

1. Identify applicable state regulations concerning license and registration to own and operate radiation-producing bone densitometry equipment.
2. Recall applicable state regulations concerning surveys of radiation-producing bone densitometry equipment by qualified physicists.
3. Describe applicable state regulations concerning registration or permit to perform bone densitometry scans.
4. Calculate comparable effective doses of diagnostic radiographs, various bone density measurement techniques and background radiation.
5. Explain the meaning of the as low as reasonably achievable (ALARA) principle.
6. Describe radiation safety practices relevant to bone densitometry equipment, operators and patients.

## Content

### I. Basic Principles

- A. Effective doses in microsieverts ( $\mu\text{Sv}$ )
  - 1. Background radiation
  - 2. Diagnostic radiographs
  - 3. Bone density measurement techniques
    - a. Fan beam
    - b. Pencil beam
  
- B. As low as reasonably achievable (ALARA)

### II. Safety Practices

- A. Equipment
  - 1. License and registration
  - 2. Survey by qualified physicist
  - 3. Preventive maintenance and repair
  - 4. Quality control
  - 5. Monitoring
    - a. Scatter radiation
    - b. Climate control
  - 6. Posting radiation caution signs
  
- B. Operator
  - 1. Registration and permit
  - 2. Education
    - a. Device-specific education by manufacturer
    - b. Certification
      - 1) ARRT Bone Densitometry postprimary certification
      - 2) International Society for Clinical Densitometry (ISCD)
    - c. Continuing education
      - 1) Local bone densitometry clubs and lectures
      - 2) National and international conferences and courses
      - 3) ISCD courses
      - 4) Online credits
      - 5) Journals
      - 6) Other
  - 3. Personal radiation monitor
  - 4. Recommended distance between workstation and scanner
    - a. > 1 meter for fan beam
  - 5. Pregnancy
    - a. Voluntary disclosure to supervisor
  
- C. Patient
  - 1. Scan request verification
  - 2. Patient cooperation
    - a. Explain exam and answer patient questions

- b. Artifacts
  - 1) Remove external artifacts
  - 2) Document removable artifacts
- c. Motion and breathing
  - 1) Proper instructions
- 3. Pregnancy
  - a. Documentation
  - b. Patient inquiries
    - 1) 10-day rule
    - 2) 28-day rule
  - c. Reschedule when appropriate

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# Quality Control

## Description

Quality control content provides fundamental knowledge of quality control (QC) methods and procedures for bone densitometry instruments, particularly DXA scanners. Phantom measurement methods, plotting longitudinal QC data, and making pass or fail decisions are discussed. QC procedures for scanner maintenance, repair, relocation, software modification or upgrade are described.

## Objectives

1. Define QC.
2. Discuss the purpose and importance of instrument QC in bone densitometry.
3. Demonstrate manufacturer-specific QC procedures for at least one model of scanner.
4. Identify several types of QC phantoms.
5. Create a longitudinal QC plot of phantom data.
6. Apply pass or fail criteria to QC data from at least one model of scanner.
7. Describe QC procedures for preventive maintenance, repair, relocation, software modification or scanner upgrade.

## **Content**

### **I. Basic Concepts**

- A. Definition of quality control
  
- B. Purpose
  - 1. Monitor scanner function and calibration
  - 2. Timely repairs and recalibration
  - 3. Effects of scanner function
  
- C. Importance
  - 1. Reproducibility of results

### **II. Phantom Methods and Procedures**

- A. Manufacturer-specific QC
  - 1. Operator's manual
  - 2. Position, acquire, analyze and interpret consistently
  - 3. Frequency of performance
  - 4. QC data archive
  
- B. Types of phantoms
  - 1. Calibration block
  - 2. Anthropomorphic or semianthropomorphic
    - a. Hydroxyapatite spine and hip block
    - b. Aluminum spine
    - c. Others
  
- C. Statistics
  - 1. Average (mean)
  - 2. Standard deviation (SD)
  - 3. Percent coefficient of variation (%CV or CV)
  
- D. Longitudinal QC plots
  - 1. Automated
  
- E. Pass or fail criteria
  - 1. When to repeat QC tests
  - 2. When to postpone scanning and contact service provider

### **III. Scanner Maintenance, Repair and Upgrade**

- A. Preventive maintenance
  
- B. Relocation, repair or hardware and software modification
  - 1. Calibration check and reset
  - 2. Re-establish QC plot mean and standard deviation
  
- C. Upgrade to new scanner

1. Intra-manufacturer
  - a. Cross-calibrate new scanner to old
  - b. Re-establish QC plot mean and standard deviation
2. Inter-manufacturer
  - a. Re-establish QC plot mean and standard deviation, as necessary

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# Patient Care and Preparation for DXA Scanning

## Description

Patient care and prep content establishes basic guidelines for patient care and safety during DXA scanning, and patient and scanner preparation for baseline and follow-up scanning. Equipment safety guidelines are also discussed.

## Objectives

1. Design a safe environment for the DXA patient.
2. List specific steps to prevent patients from falling.
3. Describe proper care for patients with special needs.
4. Explain the DXA scan procedures accurately and thoroughly to a patient.
5. Describe correct patient preparation and enlist the patient's cooperation to produce a scan free of motion and artifacts.
6. Design, collect, record and interpret a relevant DXA history.
7. Recognize and compensate for physical conditions that adversely affect DXA.
8. Document relevant patient history, extraordinary scanning procedures and sources of error for the reporting physician.
9. List necessary steps for producing a follow-up scan that is comparable to baseline.
10. Discuss DXA equipment safety, including electrical safety.
11. List applicable state DXA scanner registration and inspection requirements.
12. Demonstrate use of scanner emergency stop button and location of pinch points.

## **Content**

### **I. Patient Preparation**

- A. Care and safety
  - 1. Fall prevention
    - a. Wheelchair ramps
    - b. Clear walkways
    - c. Long-handled shoe horn
    - d. Assistance on and off table
    - e. Step stool with handrail
      - 1) Check for vertigo before exiting table
  - 2. Special needs
    - a. Wheelchair, walker and stretcher
    - b. IV pole and oxygen
    - c. Parkinson's disease, Alzheimer's disease, mental impairment and pediatrics
- B. Scan information
  - 1. Staff introductions
  - 2. Explain exam
    - a. Movement and proximity of scanner arm
    - b. Noise of motor
    - c. Time
    - d. Number and types of scans
    - e. Reporting system
  - 3. Discuss motion and breathing
  - 4. Answer patient's questions
- C. Clothing
  - 1. Remove heavy, constricting clothing (gown or scrubs preferred)
  - 2. Remove shoes
  - 3. Document non-removable external or internal artifacts
  - 4. Remove all metal from scan field
- D. Relevant DXA history
  - 1. Fracture
  - 2. Surgery, prosthesis and implants
  - 3. Metabolic and degenerative diseases
  - 4. Recent radiopaque dye, radioisotope or barium
  - 5. Pregnancy
  - 6. Previous DXA scans
  - 7. Medications and supplements
    - a. Time of last calcium supplement
  - 8. Physical activity level
  - 9. Lifestyle choices

### **II. Scanning Preparation**

- A. Measure and record height (without shoes) and weight at every visit

1. Effect of body habitus and dramatic weight change on DXA
  2. Scan mode adjustment
- B. Enter accurate patient information
    1. How to correct after scanning
  - C. Patient-specific considerations
    1. Thin
    2. Thick/obese
    3. Large weight change between scans
    4. Low bone density
    5. Degenerative disease
    6. Very elderly
  - D. Motion prevention
    1. Immobilization and positioning devices
  - E. Document extraordinary positioning, acquisition or analysis procedures
  - F. Document sources of error
    1. Anatomy
    2. Pathology
    3. Body habitus
    4. Non-removable artifacts
- III. Follow-up Scanning**
- A. Update patient information
  - B. Compare scan
  - C. Reproduce baseline acquisition parameters, positioning and ROI placement
  - D. Document changes from baseline procedures and patient history
- IV. Equipment Safety**
- A. Electrical safety
  - B. Table weight limits
  - C. Emergency stop button
  - D. Registration per state regulations
  - E. Inspections
    1. Manufacturer preventive maintenance
    2. Annual physicist inspection

# PA Lumbar Spine DXA Scanning

## Description

PA lumbar scanning content provides a base of knowledge for competent performance of PA lumbar spine DXA scans. Relevant skeletal anatomy and pathology, patient positioning and scan acquisition, analysis and reporting are described and demonstrated. Common problems are discussed.

## Objectives

1. Identify gross anatomical structures of the skeleton relevant to lumbar spine positioning and scan analysis.
2. Describe and demonstrate selection of scanning parameters, lumbar spine positioning and scan acquisition.
3. Describe and demonstrate scan analysis, including standard placement of ROIs.
4. Describe common positioning, acquisition and analysis problems and possible solutions.

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## Content

### I. Gross Anatomy and Pathology

- A. Bones and bony landmarks
  - 1. Pelvis
    - a. Iliac crest
    - b. Anterior superior iliac spine
    - c. Symphysis pubis
  - 2. Thoracic spine
    - a. T12 vertebra
    - b. Ribs
    - c. Thoracic-lumbar junction
  - 3. Lumbar spine
    - a. L1 to L5 vertebrae
      - 1) Spinous processes
      - 2) Posterior elements
      - 3) Characteristic shapes in DXA
      - 4) Vertebral endplates
      - 5) Intervertebral disk spaces
    - b. L4-L5 junction
      - 1) Relationship to iliac crest
    - c. Variant number of standard five lumbar vertebrae
    - d. Lumbar rib
    - e. Lordotic curve
    - f. Kyphosis
    - g. Scoliosis
- B. Common pathology
  - 1. Arthritis
  - 2. Vertebral fracture or deformity
  - 3. Scoliosis
  - 4. Degenerative changes
    - a. Osteophytes
    - b. Facet hypertrophy
    - c. Disk space narrowing
    - d. Sclerosis
  - 5. Aortic and other calcifications
  - 6. Surgery
    - a. Harrington rods or other hardware
    - b. Laminectomy
    - c. Fusion
    - d. Vertebroplasty
    - e. Kyphoplasty
    - f. Spina bifida

### II. Scan Acquisition

- A. Select scan parameters according to manufacturer recommendations

- B. Position patient and scan according to manufacturer recommendations
  - 1. Leg block under knees
  - 2. Identify iliac crest and lowest set of ribs
  - 3. Square pelvis with shoulders
  - 4. Align mid-sagittal plane
- C. Common positioning problems
  - 1. Asymmetry due to scoliosis
  - 2. Misalignment of central skeleton (tilt)

### **III. Scan Analysis**

- A. Place ROIs according to manufacturer recommendations
  - 1. Use characteristic shapes and landmarks
- B. Common analysis problems
  - 1. Intervertebral spaces obscured
  - 2. Scoliosis
  - 3. Overlying calcifications
  - 4. Variant number of standard five lumbar vertebrae
  - 5. Poor bone edge detection
  - 6. Deleting vertebra(e)
    - a. When and how
    - b. Comparison to reference population
  - 7. Follow-up scans

# Proximal Femur DXA Scanning

## Description

Proximal femur scanning content establishes a base of knowledge for competent performance of proximal femur DXA scans. The relevant skeletal anatomy and pathology, patient positioning and scan acquisition, analysis and reporting are described and demonstrated. Common problems are discussed.

## Objectives

1. Identify gross anatomical structures of the skeleton relevant to proximal femur positioning and scan analysis.
2. Describe and demonstrate selection of scanning parameters.
3. Describe and demonstrate proximal femur and dual femur positioning.
4. Describe and demonstrate scan acquisition and scan analysis, including standard placement of ROIs.
5. Describe common positioning, acquisition and analysis problems and possible solutions.

## **Content**

### **I. Gross Anatomy and Pathology**

- A. Bones and bony landmarks
  - 1. Pelvis
    - a. Iliac crest
    - b. Anterior superior iliac spine
    - c. Symphysis pubis
    - d. Ischium
    - e. Acetabulum
  - 2. Proximal femur
    - a. Head
    - b. Neck
    - c. Greater trochanter
    - d. Lesser trochanter
    - e. Shaft
- B. Common pathology
  - 1. Arthritis
  - 2. Fracture
  - 3. Paget's disease

### **II. Scan Acquisition**

- A. Select appropriate femur or dual hips
  - 1. Fractures or surgical procedures/hardware
  - 2. Arthritis or congenital anomalies
  - 3. Prolonged immobilization
  - 4. Polio
- B. Position patient and scan according to manufacturer recommendations
  - 1. Optimal femoral neck rotation
    - a. Manufacturer foot positioner
  - 2. Optimal abduction or adduction of femoral shaft
  - 3. Positioning for dual femur scan
- C. Select scan parameters according to manufacturer recommendations
- D. Common positioning problems
  - 1. Inability to rotate or abduct leg
  - 2. Motion
  - 3. Inability to lay flat

### **III. Scan Analysis**

- A. Adjust ROIs according to manufacturer recommendations
  - 1. Automatic analysis
  - 2. Technologist intervention

3. Femoral neck ROI placed medially or laterally according to manufacturer recommendations
- B. Common analysis problems
1. Short femoral neck
  2. Inadequate space between ischium and femur
  3. Ischium underlying neck
  4. Poor bone edge detection
  5. Small ROI areas very sensitive to changes in positioning or bone edge detection
  6. Bone islands
- C. Research techniques
1. Hip axis length
  2. Cross-sectional moment of inertia (CSMI)

ASRT

# Forearm DXA Scanning

## Description

Forearm scanning content establishes a base of knowledge for competent performance of forearm scans with a table DXA scanner. (See Peripheral Skeleton Scanning section for peripheral technologies.) The relevant skeletal anatomy and pathology, patient positioning and scan acquisition, analysis and reporting are described and demonstrated. Common problems are discussed.

## Objectives

1. Identify gross anatomical structures of the skeleton relevant to forearm positioning and scan analysis.
2. Describe and demonstrate selection of scanning parameters.
3. Describe and demonstrate forearm positioning.
4. Describe and demonstrate scan acquisition.
5. Describe and demonstrate scan analysis, including standard placement of ROIs.
6. Describe common positioning, acquisition and analysis problems and possible solutions.

## **Content**

### **I. Gross Anatomy and Pathology**

- A. Bones and bony landmarks
    - 1. Radius
      - a. Styloid process
        - 1) How to palpate
    - b. Distal cortical endplate
  - 2. Ulna
    - a. Olecranon process
      - 1) How to palpate
    - b. Styloid process
      - 1) How to palpate
  - 3. Carpal bones
    - a. Scaphoid
    - b. Lunate
- B. Common pathology
  - 1. Colle's fracture
  - 2. Arthritis

### **II. Scan Acquisition**

- A. Select appropriate forearm
  - 1. Dominant vs. nondominant
  - 2. Fractures, surgical procedures and hardware
  - 3. Arthritis or congenital anomalies
  - 4. Prolonged immobilization
- B. Position patient and scan
  - 1. Measure forearm length and record
  - 2. Designate one stable chair (no wheels or armrests)
  - 3. Stabilize forearm
    - a. Immobilization devices cannot be in scan field
  - 4. Common scan problems
    - a. 33% radius or ulnar styloid not in scan field
    - b. Forearm not straight and centered
    - c. Motion
    - d. Loss of bone edge when density is too low
- C. Select scan parameters according to manufacturer specifications
  - 1. Forearm centered in scan field and aligned
  - 2. Radius and ulna aligned to starting point

### **III. Scan Analysis**

- A. Various locations for radius and ulna ROI
  - 1. 33% based on length of ulna

2. Ultradistal radius based on cortical endplate

B. Common analysis problems

1. Manual correction to ultradistal bone edges
2. Small ROI areas very sensitive to changes in positioning or bone edge detection
3. Pathological problems (e.g., arthritis, joint disease)

ASRT

# Fracture Risk Assessment (FRAX)

## Description

Fracture risk assessment content establishes basic knowledge and competence in fracture risk assessment (FRAX) studies.

## Objectives

1. Define FRAX.
2. Discuss the importance of the FRAX score.
3. Identify clinical risk factors used in determining FRAX score.
4. Identify the contraindications for using the FRAX tool.
5. Describe values used for the consideration of treatment.

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## **Content**

### **I. Definition**

- A. Computer application for purchase
- B. Determines an individual's risk for fracture
- C. Available as part of manufacturers' software
- D. Also available online

### **II. Calculation**

- A. FRAX tool
- B. Bone mineral density (BMD) of femoral neck
- C. Used to estimate an individual's 10-year fracture probability.
- D. May assist in identifying patients at high risk for fractures
- E. Age range is 40-90

### **III. Risk Factors for FRAX Calculation**

- A. Age
- B. Sex
- C. Height and weight
- D. Previous fracture
- E. Parent fracture of hip
- F. Smoking
- G. Steroids
- H. Rheumatoid arthritis

### **IV. Contraindications for Using FRAX**

- A. Patient is on treatment for osteoporosis
- B. Previous fracture of hip or vertebra(e)
- C. Premenopausal

### **V. Consideration for Treatment**

- A. 10-year probability of hip fracture
  - 1. Greater than or equal to 3 percent
  
- B. 10-year probability of major osteoporotic related fracture
  - 1. Greater than or equal to 20 percent
  
- C. National Osteoporosis Foundation (NOF) and International Society for Clinical Densitometry (ISCD) recommendations

ASRT

# Pediatrics

## Description

Pediatrics content establishes basic knowledge and competence in the skeletal health assessment of pediatrics and adolescents.

## Objectives

1. Explain pediatric risk factors.
2. Explain the importance of radiation protection for the pediatric patient.
3. Describe different referral methods for assessing BMC and areal BMD.
4. Identify the different protocols required for ordering pediatric scanning.
5. Compare and contrast pediatric and adult anatomy.
6. Explain the importance of PA lumbar and Total Body Less Head (TBLH) scanning.
7. Identify scanning sites appropriate to the pediatric patient.

ASRT

## **Content**

### **I. Risk Factors**

- A. Diseases and immobilization
  - 1. Congenital
    - a. Osteomalacia
    - b. Osteogenesis imperfecta
  - 2. Eating disorders
    - a. Anorexia nervosa
    - b. Bulimia
  - 3. Immobilization
    - a. Injury
- B. Fractures due to primary or secondary bone disease
  - 1. Long bone fracture of the lower extremities
  - 2. Vertebral compression fracture
  - 3. Two or more long bone fractures of the upper extremities
- C. Long-term medication and treatment
  - 1. Glucocorticoids
  - 2. Chemotherapy
  - 3. Radiation therapy

### **II. Methods of Assessment**

- A. DXA
  - 1. Preferred method for assessment of BMC and areal BMD
  - 2. Baseline
    - a. Prior to initiation of bone treatment
    - b. Serial scans to monitor treatment effectiveness

### **III. Scanning Order Protocols**

- A. PA spine
  - 1. Most accurate and reproducible scanning site
- B. Whole body (total body less head)
  - 1. Most accurate and reproducible scanning site

### **IV. Pediatric Anatomy**

- A. Comparison to adult anatomy
  - 1. Epiphyseal joints in long bones

### **V. Radiation Protection**

- A. Time, distance, shielding (ALARA)
- B. Image Gently®

## Optional Content

Content in this section will assist educators wishing to enhance the curriculum with select topics of instruction intended to satisfy the mission of their program or local employment market.

ASRT

# Whole-body DXA Scanning

## Description

Whole-body scanning content establishes a base of knowledge for competent performance of total-body DXA scans. The relevant skeletal anatomy and pathology, patient positioning and scan acquisition, analysis and reporting are described and discussed. The additional parameters of body composition are described. Common problems are discussed.

## Objectives

1. Identify gross anatomical structures and pathology of the skeleton relevant to whole-body DXA positioning and scan analysis.
2. Describe and demonstrate patient positioning and alternative positioning for large body size (hemiskeleton) or abnormal anatomy.
3. Demonstrate scan analysis, including standard placement of ROIs and alternative placements due to unusual patient positioning because of large body size or abnormal anatomy.
4. Describe the differences between reporting bone mass and body composition.
5. Describe common positioning, acquisition and analysis problems and possible solutions.
6. Explain the analysis report.

## **Content**

### **I. Gross Anatomy and Pathology**

- A. Basic bones and regions
  - 1. Head
  - 2. Long bones
  - 3. Cervical, thoracic and lumbar spine
  - 4. Pelvis
  - 5. Appendages
    - a. Hands
    - b. Feet
- B. Major joints
  - 1. Shoulder
  - 2. Hip
- C. Pathology
  - 1. Scoliosis
  - 2. Long-bone deformity

### **II. Scan Acquisition**

- A. Select scan parameters according to manufacturer recommendations
- B. Position patient and scan according to manufacturer recommendations
  - 1. Common positioning and scanning challenges
    - a. Tall
    - b. Obese
    - c. Placement of hands and feet
    - d. Motion
    - e. Non-removable artifacts
    - f. Reflection or mirror scans
  - 2. Pediatrics and adolescents

### **III. Scan Analysis and Report**

- A. Place ROIs according to manufacturer specifications
  - 1. Common analysis challenges
    - a. Obesity
    - b. Scoliosis
    - c. Artifacts
- B. Report
  - 1. Bone mineral parameters
    - a. Area
    - b. BMC
    - c. BMD
  - 2. Body composition parameters
    - a. BMC

- b. Fat
  - c. Lean
  - d. Total
  - e. Percent fat
  - f. Android-Gynoid
  - g. Visceral Fat Analysis
3. Pediatrics and adolescents

ASRT

# Body Composition

## Description

Body composition content provides a basic understanding of the role dual-energy x-ray absorptiometry (DXA) technology plays in evaluating body composition (fat, lean and bone mineral mass).

## Objectives

1. Identify indications for body composition analysis.
2. Describe methods for calculating body composition.
3. Explain concepts of body composition.
4. Describe limitations of body composition analysis.

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## **Content**

### **I. Indications**

- A. Bariatric surgery
- B. Nutritional and behavioral evaluation
- C. Evaluation of cardiovascular risk
- D. Eating disorders

### **II. Method**

- A. Three compartment model (fat, lean and bone mineral)
- B. Reportable values total and regional
- C. Trending change

### **III. Concepts**

- A. Android and Gynoid analysis
- B. Visceral fat analysis
- C. Increased accuracy vs. BMI

### **IV. Limitations**

- A. Body habitus
  - 1. Sthenic
  - 2. Hyposthenic
  - 3. Asthenic
  - 4. Hypersthenic
- B. Eating disorders
  - 1. Anorexia
  - 2. Bulimia
- C. Artifacts

# Vertebral Fracture Assessment (VFA)

## Description

Vertebral fracture assessment (VFA) content establishes basic knowledge and competence in fracture risk assessment of the vertebral column.

## Objectives

1. Recognize indications for VFA.
1. Describe methods for defining and reporting fractures on VFA.
2. Explain protocol for scanning.
3. List advantages of DXA use for VFA compared to conventional x-ray.
4. Describe limitations of DXA use for VFA.
5. Describe radiation safety practices employed during DXA use for VFA.

ASRT

## **Content**

### **I. Risk Factors**

- A. Post-menopausal females with low bone mass
  - 1. Age greater than 70 years
  - 2. Decreased height
  - 3. Vertebral fracture, not previously reported
  - 4. Chronic glucocorticoid therapy
  - 5. Chronic systemic disease
  - 6. Hip or forearm fracture
  
- B. Men with low bone mass
  - 1. Age greater than 80 years
  - 2. Decreased height
  - 3. Vertebral fracture not previously reported
  - 4. Chronic glucocorticoid therapy
  - 5. Chronic systemic disease
  - 6. Hip or forearm fracture

### **II. Defining Fractures**

- A. Qualitative visual assessment
  
- B. Semi-quantitative visual method (Genant)
  
- C. Quantitative morphometry
  
- D. Algorithm-based qualitative assessment (ABQ) and modified ABQ

### **III. Advantages**

- A. Reduced radiation to patient
  
- B. Cost effective

### **IV. Limitations**

- A. Artifacts
  
- B. Mild fractures
  
- C. Positioning

### **V. Radiation Safety**

- A. Time, distance and shielding (ALARA)
  
- B. Image Wisely®

# Peripheral Skeleton Scanning

## Description

Peripheral skeleton scanning content establishes basic knowledge and competence in the technologies and methods for measuring bone density of the peripheral skeleton. The advantages and disadvantages of peripheral densitometry compared to central densitometry are evaluated. Anatomy, pathology and proper scanning of the peripheral skeleton are demonstrated.

## Objectives

1. State the anatomical sites and technologies approved for central and peripheral bone densitometry.
2. Evaluate the advantages and disadvantages of peripheral densitometry, especially in relation to central densitometry.
3. Identify gross anatomical structures, ROIs and pathology of the peripheral skeleton relevant to bone densitometry.
4. Describe and demonstrate selection of scanning parameters, anatomical positioning, scan acquisition and scan analysis for peripheral densitometry.

## **Content**

### **I. Basic Comparison of Peripheral With Central Bone Densitometry**

- A. Central sites and technology
  - 1. Lumbar spine
    - a. DXA and QCT
  - 2. Proximal femur
    - a. DXA
  
- B. Peripheral sites and technology
  - 1. Distal forearm
    - a. DXA, SXA and peripheral QCT (pQCT)
  - 2. Calcaneus
    - a. SXA and QUS
  - 3. Finger phalanges
    - a. DXA and conventional x-ray
  - 4. Tibia
    - a. QUS
  
- C. Uses for peripheral densitometry
  - 1. Screening
    - a. Indications for referral
  - 2. Fracture risk prediction
    - a. Reliability and accuracy of modality
  
- D. Comparison of peripheral with central bone densitometry
  - 1. Advantages of peripheral
    - a. Facilitates screening
      - 1) Lower cost
      - 2) Smaller size
      - 3) Some portable
    - b. No special scanner for conventional x-ray technique
    - c. No ionizing radiation for QUS
  - 2. Disadvantages of peripheral
    - a. Does not measure at sites of most important fragility fractures
    - b. T-scores may vary significantly from T-scores at spine or proximal femur
    - c. No image to check positioning on nonimaging scanners

### **II. Gross Anatomy and Pathology**

- A. Distal forearm – see forearm DXA scanning section
  
- B. Calcaneus
  - 1. Fracture or surgical procedures
  - 2. Severe bone spurs
  - 3. Congenital anomalies or deformities
  - 4. Arthritis
    - a. Rheumatoid arthritis (RA)

b. Osteoarthritis (OA)

- C. Finger phalanges
  - 1. Fracture or surgical procedures
  - 2. Arthritis
  - 3. Congenital anomalies, deformities, amputation
  - 4. Gout

**III. Scan Acquisition and Analysis**

- A. Select scan parameters according to manufacturer specifications
  - 1. Most fully automatic
- B. Select appropriate side of body
  - 1. Dominant vs. nondominant
  - 2. Fracture or pathology
  - 3. Prolonged immobilization
- C. Position and scan according to manufacturer specifications
  - 1. Designate one stable chair (no wheels or armrests) and use consistently
  - 2. Restraining devices cannot be in scan field
- D. Analyze scan according to manufacturer specifications
  - 1. Most fully automatic
  - 2. Review for accuracy

**IV. Scan Quality Checklist**

- A. Calcaneus (as appropriate for scanner model)
  - 1. Heel straight and fully inserted into scanner
  - 2. ROI centered and completely within image
  - 3. Bone edge markers displayed
  - 4. No internal, external or movement artifacts
  - 5. Side scanned matches side mode selected
  - 6. Anatomical or degenerative changes that affect analysis noted
- B. Forearm (as appropriate for scanner model)
  - 1. Forearm straight and centered
  - 2. All landmarks in scan field
  - 3. Appropriate amounts of soft tissue and air
  - 4. Ulna/radius intercept and 30 mm length correctly identified
  - 5. Bone edge markers displayed
  - 6. No internal, external or movement artifacts
  - 7. Side scanned matches side mode selected
  - 8. Anatomical or degenerative changes that affect analysis noted
- C. Finger phalanges (as appropriate for scanner model)
  - 1. Conventional x-ray: correct positioning, exposure of fingers and step wedge

2. DXA: fully automated

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# Bone Density Laboratory Organization, Record Keeping and Quality Improvement

## Description

Content establishes basic guidelines for bone density laboratory organization, record keeping and quality improvement. Emphasis is on reception training and organization, scanning room setup, proper record keeping procedures, quality control monitoring and staff communication.

## Objectives

1. Identify reception staff responsibilities and training needs.
2. Identify sources of patient education materials appropriate for the reception area.
3. List accessory equipment and documents that should be readily accessible in the patient scanning room.
4. Apply established charting rules to written medical records.
5. Identify patient, scanner and personnel records that should be documented and stored.
6. Explain the importance of periodic data backup and the basic concepts of copying and archiving DXA data.
7. Describe the application of networking for file and image transfer to DXA.
8. Set up a quality improvement program.

## **Content**

### **I. Reception Area**

- A. Staff responsibilities
  - 1. Scheduling protocol
  - 2. Patient preparation instructions
  - 3. Technologist responsibility for checking correct coding
  - 4. Bone Mass Measurement Act
  
- B. Literature for patient education
  - 1. Sources
    - a. National Osteoporosis Foundation
    - b. Pharmaceutical companies
    - c. Government agencies
    - d. Others

### **II. Scanning Room**

- A. Manufacturer patient positioning aids accessible and in good repair
  - 1. Accessories (e.g., pillows, sponges and immobilization devices)
  
- B. Manufacturer quality control phantoms
  
- C. Manufacturer operator's manual for specific scanner models

### **III. Record Keeping**

- A. Documentation rules
  - 1. All entries dated and initialed
  - 2. Corrections dated and initialed
  - 3. All repeat scans or analyses documented with reason and date where state rules apply
  
- B. Patient records
  - 1. Electronic file name and archive location
  - 2. Comments about unusual positioning, scanning or analysis procedures
  - 3. Physician's report and other correspondence
  - 4. State, local and institutional policies regarding how long to keep records
  
- C. Scanner records
  - 1. Quality control binder
    - a. Installation and upgrade records
    - b. Preventive maintenance and repair records
  
- D. Backup and archive procedures
  - 1. Differences between backup, archive, copy and move in DXA software
  - 2. Why and when
  - 3. Types
    - a. Complete

- b. Incremental
- c. Differential

- E. Personnel records
  - 1. Résumés or curriculum vitae
  - 2. Licenses required by state and county
  - 3. Training records
  - 4. Precision assessment studies
  - 5. Signature and initial form

#### **IV. DXA Networks and Data Transfer**

- A. Basic concepts of computer networks
  - 1. Why and when
  - 2. Shared resources
  - 3. Modem
  - 4. Transport protocols
  - 5. Terminology
    - a. Local area network (LAN)
    - b. Wide area network (WAN)
    - c. Digital Imaging and Communications in Medicine (DICOM)
- B. DXA applications
  - 1. Network scanners and workstations
  - 2. Remote access
    - a. Image, scan file and database transfer
    - b. Backup and archive
  - 3. Security
    - a. Passwords and access rights
  - 4. Picture Archiving and Communication Systems (PACS)

#### **V. Quality Improvement**

- A. Monitoring
  - 1. Scanner quality control data
  - 2. Patient scan acquisition and analysis
  - 3. Patient education, flow through lab and satisfaction
  - 4. Patient report distribution and other interactions
  - 5. Staff training with clinician
  - 6. Record keeping
- B. Communication via regular staff meetings
  - 1. Discuss and resolve quality control issues
  - 2. Determine and document routine protocols
    - a. Who chooses anatomical sites to scan?
      - 1) Reporting clinician
      - 2) Protocol specific to diagnosis or history
    - b. Areas in which the radiologic technologist may alter the routine

- 1) Which side of body to scan
- 2) How to analyze variant numbers of standard four vertebrae
- 3) Arthritis
- 4) Vertebral fracture or deformity
- 5) Scoliosis
- 6) Degenerative changes
- 7) Aortic or other calcifications
- 8) Surgery and hardware

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## Appendix A

The foundations section represents an inventory of pre-existing knowledge and skills gained through an entry-level radiography educational experience and reinforced through professional practice. The content in the foundations section is intended to aid technologists in career planning and program managers in the development of preassessment tools for candidate selection.

ASRT

## Clinical Practice

### Description

Content and clinical practice experiences 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 preparatory to, during and following the radiologic procedure.

### Objectives

- Exercise the priorities required in daily clinical practice.
- Execute medical imaging procedures under the appropriate level of supervision.
- Adhere to team practice concepts that focus on organizational theories, roles of team members and conflict resolution.
- Adapt to changes and varying clinical situations.
- Describe the role of health care team members in responding/reacting to a local or national emergency.
- Provide patient-centered, clinically effective care for all patients regardless of age, gender, disability, special needs, ethnicity or culture.
- Integrate the use of appropriate and effective written, oral and nonverbal communication with patients, the public and members of the health care team in the clinical setting.
- Integrate appropriate personal and professional values into clinical practice.
- Recognize the influence of professional values on patient care.
- Explain how a person's cultural beliefs toward illness and health affect his or her health status.
- Use patient and family education strategies appropriate to the comprehension level of the patient/family.
- Provide desired psychosocial support to the patient and family.
- Demonstrate competent assessment skills through effective management of the patient's physical and mental status.
- Respond appropriately to medical emergencies.
- Examine demographic factors that influence patient compliance with medical care.
- Adapt procedures to meet age-specific, disease-specific and cultural needs of patients.
- Assess the patient and record clinical history.
- Demonstrate basic life support procedures.
- Use appropriate charting methods.
- Recognize life-threatening electrocardiogram (ECG) tracing.
- Apply standard and transmission-based precautions.
- Apply medical asepsis and sterile techniques.

- Demonstrate competency in the principles of radiation protection standards.
- Apply the principles of total quality management.
- Report equipment malfunctions.
- Examine procedure orders for accuracy and make corrective actions when applicable.
- Demonstrate safe, ethical and legal practices.
- Integrate the radiographer's practice standards into clinical practice setting.
- Maintain patient confidentiality standards and meet HIPAA requirements.
- Demonstrate the principles of transferring, positioning and immobilizing patients.
- Comply with departmental and institutional response to emergencies, disasters and accidents.
- Differentiate between emergency and non-emergency procedures.
- Adhere to national, institutional and departmental standards, policies and procedures regarding care of patients, providing radiologic procedures and reducing medical errors.
- Select technical factors to produce quality diagnostic images with the lowest radiation exposure possible.
- Critique images for appropriate anatomy, image quality and patient identification.
- Determine corrective measures to improve inadequate images.

## Ethics and Law in the Radiologic Sciences

### Description

Content provides a foundation in ethics and law related to the practice of medical imaging. An introduction to terminology, concepts and principles will be presented. Students will examine a variety of ethical and legal issues found in clinical practice.

### Objectives

- Discuss the origins of medical ethics.
- Apply medical/professional ethics in the context of a broader societal ethic.
- Explain the role of ethical behavior in health care delivery.
- Explain concepts of personal honesty, integrity, accountability, competence and compassion as ethical imperatives in health care.
- Identify legal and professional standards and relate each to practice in health professions.
- Identify specific situations and conditions that give rise to ethical dilemmas in health care.
- Explain select concepts embodied in the principles of patients' rights, the doctrine of informed consent and other issues related to patients' rights.
- Explain the legal implications of professional liability, malpractice, professional negligence and other legal doctrines applicable to professional practice.
- Describe the importance of accurate, complete, correct methods of documentation as a legal/ethical imperative.
- Explore theoretical situations and questions relating to the ethics of care and health care delivery.
- Explain legal terms, principles, doctrines and laws specific to the radiologic sciences.
- Outline the conditions necessary for a valid malpractice claim.
- Describe institutional and professional liability protection typically available to the radiographer.
- Describe the components and implications of informed consent.
- Identify standards for informed consent and disclosure of protected health information.
- Describe how consent forms are used relative to specific radiographic procedures.
- Differentiate between civil and criminal liability.
- Define tort and explain the differences between intentional and unintentional torts.

# Human Anatomy and Physiology

## Description

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

## Objectives

- Discuss the basics of anatomical nomenclature.
- Describe the chemical composition of the human body.
- Identify cell structure and elements of genetic control.
- Explain the essentials of human metabolism.
- Describe the types and functions of human tissues.
- Classify tissue types, describe the functional characteristics of each and give examples of their location within the human body.
- Describe the composition and characteristics of bone.
- Identify and locate the bones of the human skeleton.
- Identify bony processes and depressions found on the human skeleton.
- Describe articulations of the axial and appendicular skeleton.
- Differentiate the primary and secondary curves of the spine.
- Summarize the functions of the skeletal system.
- Label different types of articulations.
- Compare the types, locations and movements permitted by the different types of articulations.
- Examine how muscle is organized at the gross and microscopic levels.
- Differentiate between the structures of each type of muscle tissue.
- State the function of each type of muscle tissue.
- Name and locate the major muscles of the skeleton.
- Differentiate between the structure and function of different types of nerve cells.
- State the structure of the brain and the relationship of its component parts.
- Describe brain functions.
- List the meninges and describe the function of each.
- Outline how cerebrospinal fluid forms, circulates and functions.
- Describe the structure and function of the spinal cord.
- Determine the distribution and function of cranial and spinal nerves.
- Summarize the structure and function of components that comprise the autonomic nervous system.
- Describe the structures and functions of the components that comprise the human eye and ear.
- List the component body parts involved in the senses of smell and taste.
- List the somatic senses.
- Define endocrine.

- Describe the characteristics and functions of the components that comprise the endocrine system.
- Describe the hard and soft palates.
- Describe the structure and function of the tongue.
- Identify the structure, function and locations of the salivary glands.
- Describe the composition and characteristics of the primary organs of the digestive system.
- Describe the function(s) of each primary organ of the digestive system.
- Differentiate between the layers of tissue that comprise the esophagus, stomach, small intestine, large intestine and rectum.
- Differentiate between peritoneum, omentum and mesentery.
- List and label the accessory organs of the digestive system and describe their function.
- Identify the secretions and function of each accessory organ of the digestive system.
- Explain the purpose of digestion.
- List the digestive processes that occur in the body.
- Describe the composition and characteristics of blood.
- List the types of blood cells and state their functions.
- Differentiate between blood plasma and serum.
- Outline the clotting mechanism.
- List the blood types.
- Explain the term Rh factor.
- Explain the antigen/antibody relationship and its use in blood typing.
- Label the parts of the human heart.
- Describe the flow of blood through the body and identify the main vessels.
- Describe the structure and function of arteries, veins and capillaries.
- Differentiate between arterial blood in systemic circulation and arterial blood in pulmonary circulation.
- Outline the major pathways of lymphatic circulation.
- Correlate cardiac electrophysiology to a normal ECG tracing.
- Differentiate between nonspecific defenses and specific immunity.
- Explain antibody production and function.
- List the different types and functions of T- and B-cells and explain their functions.
- Label the components of the respiratory system.
- Describe the physiology and regulation of respiration.
- Label the parts of the kidneys, ureters, bladder and urethra.
- Describe the function of each organ of the urinary system.
- Describe the composition and formation of urine.
- Explain micturition.
- Label the anatomy of the male and female reproductive organs.
- Analyze the function of each of the male and female reproductive organs.
- Identify major sectional anatomical structures found within the head/neck, thorax and abdomen.

## Introduction to Computed Tomography

### Description

Content is designed to provide entry-level radiography students with an introduction to and basic understanding of the operation of a computed tomography (CT) device. Content is not intended to result in clinical competency.

### Objectives

- Describe the components of the CT imaging system.
- Explain the functions of collimators in CT.
- List the CT computer data processing steps.
- Define algorithm and explain its impact on image scan factors and reconstruction.
- Define raw and image data.
- Describe the following terms in relation to the CT data acquisition process:
  - Pixel.
  - Matrix.
  - Voxel.
  - Linear attenuation coefficient.
  - CT/Hounsfield number.
  - Partial volume averaging.
  - Window width (ww) and window level (wl).
  - Spatial resolution.
  - Contrast resolution.
  - Noise.
  - Annotation.
  - Region of interest (ROI).
- Name the common controls found on CT operator consoles and describe how and why each is used.
- Identify the types and appearance of artifacts most commonly affecting CT images.
- Name the radiation protection devices that can be used to reduce patient dose in CT and describe the correct application of each.
- Describe the general purpose of commonly performed CT studies.
- Discuss general radiation safety and protection practices associated with examinations in CT.

## Patient Care in Radiologic Sciences

### Description

Content provides the concepts of optimal patient care, including consideration for the physical and psychological needs of the patient and family. Routine and emergency patient care procedures are described, as well as infection control procedures using standard precautions. The role of the radiographer in patient education is identified.

### Objectives

- Identify the responsibilities of the health care facility and members of the health care team.
- List the general responsibilities of the radiographer.
- Describe the practice standards for the radiographer as defined by the ASRT and state licensure.
- Differentiate between culture and ethnicity.
- Explain how a person's cultural beliefs toward illness and health affect his or her health status.
- Explain perceptions of dying and death from the viewpoint of both patient and radiographer.
- Identify methods for determining the correct patient for a given procedure.
- Explain the use of various communication methods.
- Explain specific aspects of a radiographic procedure to the patient.
- Demonstrate correct principles of body mechanics applicable to patient care.
- Demonstrate techniques for specific types of patient transfer.
- Demonstrate select procedures to turn patients who have various health conditions.
- Describe immobilization techniques for various types of procedures and patient conditions.
- Describe specific patient safety measures and concerns.
- Explain the purpose, legal considerations and procedures for incident reporting.
- Describe methods to evaluate patient physical status.
- List the information to be collected prior to a patient examination.
- Describe vital signs and lab values used to assess patient condition, including sites for assessment and normal values.
- Define terms related to infection control.
- Describe the importance of standard precautions and isolation procedures, including sources and modes of transmission of infection and disease and institutional control procedures.
- Identify symptoms related to specific emergency situations.
- Describe the institution's emergency medical code system and the role of the student during a medical emergency.
- Explain the age-specific considerations necessary when performing radiographic procedures.
- Describe appropriate procedures for management of various types of trauma situations.
- Describe the symptoms and medical interventions for a patient with a contrast agent reaction.
- Explain the role of the radiographer in patient education.

- Describe the patient preparation for contrast studies.
- Identify specific types of tubes, lines, catheters and collection devices.
- Outline the steps in the operation and maintenance of suction equipment.
- Outline the steps in the operation and maintenance of oxygen equipment and demonstrate proper use.
- Demonstrate competency in basic life support (BLS).
- Describe the steps in performing various mobile procedures.
- Describe the special problems faced in performing procedures on a patient with a tracheotomy and specific tubes, drains and catheters.
- Describe the procedure for producing diagnostic images in the surgical suite.
- Explain the appropriate radiation protection required when performing mobile/surgical radiography.

ASRT

# Radiation Biology

## Description

Content provides an overview of the principles of the interaction of radiation with living systems. Radiation effects on molecules, cells, tissues and the body as a whole are presented. Factors affecting biological response are presented, including acute and chronic effects of radiation.

## Objectives

- Differentiate between ionic and covalent molecular bonds.
- Describe principles of cellular biology.
- Identify sources of electromagnetic and particulate ionizing radiations.
- Discriminate between the direct and indirect effects of radiation.
- Identify sources of radiation exposure.
- Describe radiation-induced chemical reactions and potential biologic damage.
- Evaluate factors influencing radiobiologic/biophysical events at the cellular and subcellular level.
- Identify methods to measure radiation response.
- Describe physical, chemical and biologic factors influencing radiation response of cells and tissues.
- Explain factors influencing radiosensitivity.
- Recognize the clinical significance of lethal dose (LD).
- Identify the radiosensitivity of specific cells.
- Employ dose response curves to study the relationship between radiation dose levels and the degree of biologic response.
- Examine effects of limited vs. total body exposure.
- Relate short-term and long-term effects as a consequence of high and low radiation doses.
- Differentiate between somatic and genetic radiation effects and discuss specific diseases or syndromes associated with them.
- Discuss stochastic (probabilistic) and nonstochastic (deterministic) effects.
- Discuss embryo and fetal effects of radiation exposure.
- Discuss risk estimates for radiation-induced malignancies.
- Discuss acute radiation syndromes.

## Radiation Production and Characteristics

### Description

Content establishes a basic knowledge of atomic structure and terminology. Also presented are the nature and characteristics of radiation, x-ray production and the fundamentals of photon interactions with matter.

### Objectives

- Describe fundamental atomic structure.
- Explain the processes of ionization and excitation.
- Describe the electromagnetic spectrum.
- Describe wavelength and frequency and how they are related to velocity.
- Explain the relationship of energy, wavelength and frequency.
- Explain the wave-particle duality phenomena.
- Identify the properties of x-rays.
- Describe particulate radiation.
- Differentiate between ionizing and nonionizing radiation.
- Describe radioactivity and radioactive decay in terms of alpha, beta and gamma emission.
- Compare the production of bremsstrahlung and characteristic radiations.
- Describe the conditions necessary to produce x-radiation.
- Describe the x-ray emission spectra.
- Identify the factors that affect the x-ray emission spectra.
- Discuss various photon interactions with.
- Discuss relationships of wavelength and frequency to beam characteristics.
- Discuss the clinical significance of the photoelectric and modified scattering (Compton) interactions in diagnostic imaging.

# Radiation Protection

## Description

Content presents an overview of the principles of radiation protection, including the responsibilities of the radiographer for patients, personnel and the public. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated.

## Objectives

- Identify and justify the need to minimize unnecessary radiation exposure of humans.
- Explain the objectives of a radiation protection program.
- Define radiation and radioactivity units of measurement.
- Identify effective dose limits (EDL) for occupational and nonoccupational radiation exposure.
- Describe the ALARA concept.
- Identify the basis for occupational exposure limits.
- Distinguish between perceived risk and comparable risk.
- Describe the concept of the negligible individual dose (NID).
- Identify ionizing radiation sources from natural and man-made sources.
- Comply with legal and ethical radiation protection responsibilities of radiation workers.
- Describe the relationship between irradiated area and effective dose.
- Describe the theory and operation of radiation detection devices.
- Identify appropriate applications and limitations for each radiation detection device.
- Describe how isoexposure curves are used for radiation protection.
- Identify performance standards for beam-limiting devices.
- Describe procedures used to verify performance standards for equipment.
- Describe the operation of various interlocking systems for equipment.
- Identify conditions and locations evaluated in an area survey for radiation protection.
- Distinguish between controlled and non-controlled areas and list acceptable exposure levels.
- Describe “Radiation Area” signs and identify appropriate placement sites.
- Describe the function of federal, state and local regulations governing radiation protection practices.
- Describe the qualifications and responsibilities of a radiation safety officer.
- Express the need and importance of personnel monitoring for radiation workers.
- Describe personnel monitoring devices, including applications, advantages and limitations for each device.
- Interpret personnel monitoring reports.
- Compare values for individual effective dose limits for occupational radiation exposures (annual and lifetime).
- Identify effective dose limits for the embryo and fetus in occupationally exposed women.
- Distinguish between primary and secondary radiation barriers.

- Demonstrate how the operation of various x-ray and ancillary equipment influences radiation safety and describe the potential consequences of equipment failure.
- Perform calculations of exposure with varying time, distance and shielding.
- Discuss the relationship between workload, energy, half-value layer (HVL), tenth-value layer (TVL), use factor and shielding design.
- Identify emergency procedures to be followed during failures of x-ray equipment.
- Demonstrate how time, distance and shielding can be manipulated to keep radiation exposures to a minimum.
- Explain the relationship of beam-limiting devices to patient radiation protection.
- Discuss added and inherent filtration in terms of the effect on patient dosage.
- Explain the purpose and importance of patient shielding.
- Identify various types of patient shielding and state the advantages and disadvantages of each type.
- Use the appropriate method of shielding for a given radiographic procedure.
- Explain the relationship of exposure factors to patient dosage.
- Explain how patient position affects dose to radiosensitive organs.
- Identify the appropriate image receptor that will result in an optimum diagnostic image with the minimum radiation exposure to the patient.
- Select the immobilization techniques used to eliminate voluntary motion.
- Describe the minimum source-to-tabletop distances for fixed and mobile fluoroscopic devices.
- Apply safety factors for the patient, health care personnel and family members in the room during radiographic procedures.

## Appendix B

The clinical experience requirements section is intended to provide information regarding the development of a well-rounded clinical experience. Information regarding the eligibility requirements for a postprimary certification examination in bone densitometry is provided in this section.

ASRT

## Clinical Experience Requirements

The most current information regarding the eligibility requirements for a postprimary certification examination in bone densitometry can be found at the link below.

The ARRT Clinical Experience Requirements document is located at <https://www.arrt.org/art-reference-documents/by-document-type/clinical-experience-requirements>.

ARRT

## Resources

This list of resources is designed to help educators sample the pool of available references and study materials that pertain to medical imaging. The resources list should be viewed as a snapshot of available materials. Omission of any one title is not intentional. Because the body 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.

*ACR-SPR-SSR Practice Parameter for the Performance of Dual-Energy X-ray Absorptiometry.* Reston, VA: American College of Radiology; 2018.

Arden NK, Spector TD. *Osteoporosis Illustrated.* London, England: Current Medical Literature Ltd; 1997.

Blake GM, Wahner HW, Fogelman I. *The Evaluation of Osteoporosis: Dual Energy X-ray Absorptiometry and Ultrasound in Clinical Practice.* 2nd ed. London, England: Martin Dunitz Ltd; 1998.

Bilezikian JP, ed. *Primer on the Metabolic Bone Diseases and Disorders of Mineral Metabolism.* 9th ed. Oxford: Wiley Blackwell; 2018.

FRAX<sup>®</sup> WHO Fracture Risk Assessment Tool. [www.shef.ac.uk/FRAX](http://www.shef.ac.uk/FRAX).

Genant HK, Guglielmi G, Jergas M. *Bone Densitometry and Osteoporosis.* New York, NY: Springer-Verlag; 1998.

ISCD Official Positions. <https://www.iscd.org/official-positions/>

Kanis JA. *Osteoporosis.* London, England: Blackwell Healthcare Communications Ltd; 1999.

*Postprimary Eligibility Pathway Handbook.* St. Paul, MN: American Registry of Radiologic Technologists; 2018.

Rosen CJ. *Osteoporosis: Diagnostic and Therapeutic Principles.* Totowa, NJ: Humana Press; 1996.

Technical White Paper: Bone Densitometry. *J Am Coll Radiol*, Volume 4; Issue 5. May 2007; pages 320-327.

Wartenbee SR. *Bone Densitometry.* In: Long BW, Rollins, JH, Smith BJ. *Merrill's Atlas of Radiographic Positioning & Procedures.* 13th ed. Volume 3. St. Louis, MO: Elsevier/Mosby; 2016.

## **Journals**

*Bone*. 12 issues/year. New York, NY: Elsevier Science, Inc.

*J Bone and Miner Res*. 12 issues/year. Malden, MA: Blackwell Science, Inc.

*J Clinical Densitometry*. 4 issues/year. Totowa, NJ: Humana Press.

*Osteoporosis Int*. 6 issues/year. Godalming, Surrey, England: Springer-Verlag London Ltd.

*Radiol Technol*. 6 issues/year. Albuquerque, NM: American Society of Radiologic Technologists.

## **Organizations**

International Society for Clinical Densitometry (ISCD) provides certification courses for technologists and physicians, site accreditation and continuing education. The society newsletter, *SCAN*, and the website provide listings of domestic and international meetings and courses with relevant content for technologists. Contact: ISCD at [www.iscd.org](http://www.iscd.org)

National Osteoporosis Foundation (NOF) provides osteoporosis information and educational materials for staff and patients. Contact: NOF, 1232 22nd St. N.W., Washington, DC 20037-1292; [www.nof.org](http://www.nof.org)