Bone Densitometry Curriculum

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Introduction

The goal of this curriculum is to provide the professional community with a cognitive base of entry-level education in the practice of bone densitometry. The curriculum is suitable for all programs in this specialty, including limited fellowships, short-term certificate programs and college-based education programs. The curriculum recognizes that the educational components are not static, but are representative of current practice and trends in the field. It is the responsibility of educators to incorporate new concepts and trends in the curriculum as they occur.

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

The curriculum document consists of three sections: foundations, core content and clinical experience requirements. 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.

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

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.

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Contents

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Foundations

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.

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 Structure and Function
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.

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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.

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Core Content

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

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Body Composition

Description
Content defines a basic understanding of the importance dual-energy x-ray absorptiometry (DXA) technology plays in evaluating body composition (fat, lean and bone mineral).

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, 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

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Bone Densitometry Overview

Description
Content establishes a basic knowledge of bone densitometry and its purposes. The techniques from the past and present are explained, with an emphasis on dual-energy x-ray absorptiometry (DXA) and how it compares with conventional radiography.

Objectives
1. Define bone densitometry.
2. Discuss the various uses for bone densitometry.
3. Explain the historical and current techniques, including peripheral adaptations.
4. Discuss and evaluate advantages and disadvantages of DXA.
5. Compare and contrast DXA to conventional radiography.
6. Explain the application of DXA technology in body composition assessment.
7. Explain the application of DXA technology in vertebral fracture assessment (VFA).

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Content

I. Bone Densitometry

A. Definition

B. Uses
   1. Quantitative measurement of bone density
   2. Monitor therapy
   3. Predict future fracture risk
   4. Pediatrics and adolescents
   5. Body composition
   6. VFA
   7. Other

C. DXA
   1. Most versatile method
   2. Advantages
      a. Low radiation dose
      b. High-resolution images
      c. Good precision
      d. Stable calibration
      e. Other
   3. Disadvantages
      a. Higher cost for equipment and scans
      b. Generally not portable
      c. More operator training and skill required
      d. Other

D. DXA compared with conventional radiography
   1. Only two x-ray photon energies used
   2. Computer manipulation required
   3. Images used for positioning and region of interest (ROI), not for diagnosis
   4. Manufacturer-specific operation
   5. Low radiation dose

II. Technique History and Overview

A. Radiographic absorptiometry (RA)

B. Radiogrammetry

C. Quantitative computed tomography (QCT)

D. Single and dual photon absorptiometry (SPA/DPA)

E. Single and dual-energy x-ray absorptiometry (SXA/DXA)

F. Quantitative ultrasound (QUS)

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G. Peripheral skeleton adaptations

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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 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.

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Content

I. Reception Area

A. Staff responsibilities and training
   1. Scheduling protocol
   2. Patient preparation instructions
   3. Patient medical history form distribution
   4. Insurance coding and billing

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. Additional equipment
      a. Caliper for measuring patient thickness if required by manufacturer
      b. Pillows, positioning sponges, restraint devices

B. Manufacturer quality control phantoms

C. Manufacturer operator's manual for specific scanner models

III. Record Keeping

A. Charting rules
   1. All entries legible, dated and initialed
   2. Corrections legible, dated and initialed
      a. No liquid erasure
   3. All repeat scans or analyses documented with reason and date where state rules apply

B. Patient records
   1. Scan log filled out at time of scanning
      a. Patient and technologist identification
      b. Scans performed
      c. Electronic file name and archive location
      d. Comments about unusual positioning, scanning or analysis procedures
   2. Hard copies of scans
   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. Daily phantom plots and other quality control printouts

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b. Installation and upgrade records
c. 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 for scanning or reporting by state and county
3. Training records
4. 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

V. Quality Improvement

A. Monitoring by designated quality control staff
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 with referring physicians
5. Staff training
6. Record keeping

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B. Communication via regular staff meetings
    1. Discuss and resolve quality control issues
    2. Determine and document routine protocols with reporting physician
        a. Who chooses anatomical sites to scan?
            1) Referring physician
            2) Laboratory routine
            3) 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

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Bone Remodeling and Osteoporosis

Description

Content establishes knowledge of bone remodeling and how a remodeling imbalance produces the disease osteoporosis. Osteoporosis is defined and its consequences, risk factors, prevention and treatment are discussed. The diagnosis of osteoporosis by DXA is developed through definition and discussion of reference populations, T-score, Z-score, World Health Organization (WHO) criteria and fracture risk assessment.

Objectives

1. Describe cortical and trabecular bone and locations with a high percentage 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 a standard deviation and relate it to a Z-score and T-score.
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 and discuss the risk factors, prevention and treatment of osteoporosis.

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Content

I. Bone Remodeling

A. 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

B. Remodeling sequence
   1. Bone resorption
   2. Bone formation

C. Bone mass throughout the life span
   1. Bone accrual
   2. Peak bone mass
   3. Postmenopausal bone loss
   4. Bone loss in the elderly

D. Factors that affect remodeling
   1. Calcium
   2. Vitamin D
   3. Estrogen
   4. Other hormones

E. Factors that affect peak bone mass
   1. Genetics
   2. Diet
   3. Exercise
   4. Disease

II. Osteoporosis

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

B. Diagnosis by DXA
   1. Reference populations
      a. Manufacturer specific
      b. National Health and Nutrition Examination Survey (NHANES) for total hip
      c. Young normal peak bone mass
      d. Age-adjusted bone mass
   2. Standard deviations
      a. Z-score
      b. T-score

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c. WHO criteria
    1) Clinical need for cutpoint definition
    2) Disadvantages of cutpoint definition
3. Fracture risk assessment

C. 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

D. 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. Build
11. Propensity to fall
12. Smoking
13. Alcohol abuse

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E. Prevention
   1. Exercise
   2. Diet
   3. Hormone replacement therapy
   4. Other medications

F. Treatment
   1. Mechanisms of action
      a. Decrease rate of bone resorption
      b. Actively build new bone
   2. Estrogens
      a. Mechanism
      b. Oral
         1) Major brand names
      c. Transdermal
         1) Major brand names
      d. Vaginal
         1) Major brand names
   3. Bisphosphonates
      a. Mechanism
      b. Major brand names
   4. Selective estrogen receptor modulator (SERM)
      a. Mechanism
      b. Major brand names
   5. Calcitonin
      a. Mechanism
      b. Major brand names
   6. Parathyroid hormone
      a. Mechanism
      b. Major brand names
   7. Receptor activator of NF-κB ligand (RANKL) inhibitor human monoclonal antibody
      a. Mechanism
      b. Major brand names
   8. Calcium
      a. Mechanism
      b. Different forms
      c. Major brand names
   9. Vitamin D
      a. Mechanism
      b. Sunlight
      c. Supplementation
   10. Others
      a. Fluoride
      b. Others under development

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Forearm DXA Scanning

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

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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 or surgical procedures
   3. Arthritis or congenital anomalies
   4. Prolonged immobilization

B. Select scan parameters according to manufacturer specifications
   1. Adjust field width to include air
   2. Radius and ulna aligned to vertical positioning lines

C. Position patient and scan
   1. Measure forearm length only once and record
   2. Designate one stable chair
   3. Stabilize forearm
      a. Restraining devices cannot be in scan field
   4. Common scan problems
      a. 33% radius or ulna styloid not in scan field
      b. Forearm not straight and centered
      c. Motion
      d. Loss of bone edge when density is too low

III. Scan Analysis and Report

A. Various locations for radius and ulna ROI
   1. 33% based on length of ulna
   2. Ultradistal radius based on cortical endplate

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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

C. Report
    1. Define regions

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Fracture Risk Assessment (FRAX)

Description
Content establishes basic knowledge and competence in the fracture risk assessment studies.

Objectives
1. Define FRAX.
2. Discuss the importance of knowing your 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 based program

B. Determines an individual's risk for fracture

C. Available on manufacturers' software

D. Also available for purchase 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

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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

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Patient Care and Preparation for DXA Scanning

Description
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 discussed.

Objectives
1. Design and provide 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.

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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, stretcher
    b. IV pole, oxygen
    c. Parkinson's disease, Alzheimer's disease, mental impairment, 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
2. Remove shoes if required by scanning device
3. Document nonremovable external or internal artifacts
4. Remove all metal from scan field

D. Relevant DXA history
1. Fracture
2. Surgery, prosthesis, 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 and weight at every visit

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1. Effect of body habitus and weight change on DXA
2. Scan mode adjustment

B. Enter accurate patient information on computer screen(s)
1. How to correct after scanning

C. Recognize and compensate for difficult patients
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. Restraining and positioning devices

E. Document extraordinary positioning, acquisition or analysis procedures

F. Document sources of error
1. Anatomy
2. Pathology
3. Body habitus
4. Nonremovable artifacts

III. Follow-up Scanning

A. Update patient information on computer screen(s)

B. Baseline printout available

C. Reproduce baseline acquisition parameters, positioning, ROI placement

D. Document changes from baseline procedures and patient history

IV. Equipment Safety

A. Registration per state regulations

B. Electrical safety

C. Pinch points

D. Emergency stop button

E. Inspections
1. Manufacturer preventive maintenance
2. Annual physicist inspection

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F. Table weight limits

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Pediatrics

Description
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 accessing 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.

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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 extremity
  2. Vertebral compression fracture
  3. Two or more long bone fractures of the upper extremity

- 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

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Peripheral Skeleton Scanning

Description
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 and label gross anatomical structures, ROIs and pathology of the peripheral skeleton relevant to bone densitometry.
4. Describe and demonstrate correct selection of scanning parameters for peripheral densitometry.
5. Describe and demonstrate correct anatomical positioning for peripheral densitometry.
6. Describe and demonstrate correct scan acquisition for peripheral densitometry.
7. Describe and demonstrate correct scan analysis for peripheral densitometry.

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Content

I. Basic Comparison of Peripheral With Central Bone Densitometry

A. Central sites and technology
   1. Lumbar spine
      a. DXA, QCT
   2. Proximal femur
      a. DXA

B. Peripheral sites and technology
   1. Distal forearm
      a. DXA, SXA, peripheral QCT (pQCT)
   2. Calcaneus
      a. SXA, QUS
   3. Finger phalanges
      a. DXA, 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
   3. Monitoring therapy
      a. Limitations

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. Limited utility for monitoring therapy
      d. 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

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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 and use consistently
2. Restraining devices cannot be in scan field

D. Analyze scan according to manufacturer specifications
1. Most fully automatic

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

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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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Physical Principles and Instrumentation of Quantitative Ultrasound

Description

Content establishes a basic knowledge of the physical principles and instrumentation of quantitative ultrasound (QUS) of bone. The generation and mechanical characteristics of ultrasound are explained. The two types of instrumentation and their operation are described and the reported parameters are defined.

Objectives

1. Describe the purpose of ultrasound transducers.
2. Describe the behavior and parameters of mechanical waves.
3. List the characteristics, intensity and power levels of the ultrasound beam.
4. Explain sound-tissue interaction, including propagation speed and attenuation.
5. Define the QUS-reported parameters and what they measure.
6. Describe the operation of through transmission devices.
7. List the classes of through transmission devices.
8. Interpret the display and results of through transmission devices.
9. Describe the operation of speed-of-sound, refraction-based devices.
10. List the classes of speed-of-sound, refraction-based devices.
11. Interpret the display and results of speed-of-sound, refraction-based devices.

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Content

I. Fundamental Principles

A. Ultrasound generation
   1. Transducers
   2. Mechanical wave behavior
   3. Wave parameters
      a. Wavelength
      b. Frequency
   4. Intensity and power levels
      a. Spatial peak temporal average (SPTA) intensity
      b. Safety of diagnostic ultrasound

B. Sound-tissue interaction
   1. Characteristics of the ultrasound beam
      a. Definition of beam
      b. Echo
   2. Propagation speed
   3. Attenuation
      a. Reflection
      b. Scattering
      c. Absorption
      d. Other

II. Reported Parameters

A. Measured

B. Speed of sound (SOS)

C. Broadband ultrasound attenuation (BUA)
   1. Derived
   2. Stiffness

D. Quantitative ultrasound index (QUI)

E. Estimated heel BMD

F. Ultrasound bone profile score

III. Instrumentation and Operation

A. Through transmission devices
   1. Transducers
      a. Materials and construction
      b. Stationary configurations
      c. Moving configurations
   2. Classes
      a. Water-coupled

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b. Gel-coupled, contact
3. Signal processing
   a. Frequency range
   b. Detection methods
   c. Calculation algorithms
4. Display and results
   a. Imaging
   b. Presentation and quality
      1) ROI determination
         a) Device-integrated
         b) Printers
         c) Ancillary computers
         d) Reported parameters

B. Speed-of-sound, refraction-based devices
1. Classes
   a. Single site (tibia)
   b. Multiple site (tibia, phalanges, radius, calcaneus)
2. Principles of operation
   a. Refraction and Snell's Law (acoustic refractive index)
   b. Transducer configuration (multielement)
   c. Patient measurement procedure
3. Signal processing
   a. Frequency range
   b. Detection
   c. Calculation algorithms
4. Display and results
   a. Device-integrated
   b. Printers
   c. Ancillary computers
   d. Reported parameters

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Physical Principles and Instrumentation of DXA

Description

Content establishes a basic knowledge of the physical principles and instrumentation of dual-energy x-ray absorptiometry (DXA). The various x-ray production and detection techniques, pencil vs. fan and smart fan beam methodologies and geometry and fundamental data analysis processes and parameters are defined and discussed. The principles of 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.
5. Define accuracy and precision and discuss their importance in scanner replacement.
6. Describe the two methods of x-ray production in DXA.
7. Describe the two methods of x-ray detection in DXA.
8. Discuss the differences between pencil and fan beam systems.
9. Discuss the geometric considerations of fan beam systems.
10. Explain the importance of soft-tissue calculation during scan analysis.
11. Explain the issue of bone edge detection during scan analysis.
12. Define BMD, BMC and area, including the calculation formulas.
13. Describe the application of DXA to body composition, VFA and orthopedics.
14. Describe the process and frequency of precision and cross-calibration studies and their value regarding serial measurements.

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Content

I. Fundamental Principles

A. Relationship between subject density and absorption of x-rays

B. Two x-ray energies
   1. Typical energies
   2. DXA equations
   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
      a. Photo-multiplier tube
      b. Energy discrimination
      c. Spillover (cross-over) correction
   2. Solid-state detector systems
      a. High-voltage switching circuitry
      b. Calibration wheel or drum

III. Pencil Beam vs. Fan Beam Systems

A. Mechanics of pencil beam
   1. Beam collimation
   2. Single detector
   3. Scan arm motion
      a. Raster
      b. Longitudinal/transverse

B. Mechanics of fan beam
   1. Beam collimation
   2. Multiple detector system
   3. Detector uniformity correction
   4. Scan arm motion

C. Fan beam geometry
   1. Source-to-object-to-detector distances
   2. Magnification and distortion
   3. Object centering
   4. Estimated BMC and area

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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 wrong settings
   2. Reproducing settings at follow-up scan

B. Positioning
   1. Effect on BMC, area, BMD
   2. Reproducing positions at follow-up scan
   3. Establishing the least significant change (LSC)

C. Anatomy and pathology
   1. Variations from normal
      a. Effect on BMC, area, 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 studies
   1. Purpose
   2. Frequency
   3. Scanner replacement
      a. Cross-calibration
      b. Establishing new baseline information

VI. Special DXA Applications

A. Total-body scans
   1. Body composition
   2. Bone density

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B. C-arm
    1. Lateral spine
    2. VFA
    3. Anatomy, pathology and artifacts

C. VFA
    1. Lateral vertebral assessment (LVA)
    2. Instant vertebral assessment (IVA)
    3. Anterior posterior vertebral assessment (APVA)
    4. Purpose: detecting vertebral fractures
    5. Decubitus lateral position
    6. Grading system

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Proximal Femur DXA Scanning

Description
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 and label gross anatomical structures of the skeleton relevant to proximal femur positioning and scan analysis.
2. Describe and demonstrate correct selection of scanning parameters.
3. Describe and demonstrate correct proximal femur positioning.
4. Describe and demonstrate correct dual femur positioning.
5. Describe and demonstrate correct scan acquisition.
6. Describe and demonstrate correct scan analysis, including standard placement of ROIs.
7. Describe common positioning, acquisition and analysis problems and possible solutions.
8. Explain the scan report.

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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
      d. Ischium
      e. Acetabulum
   2. Proximal femur
      a. Head
      b. Neck
      c. Ward's area
      d. Greater trochanter
      e. Lesser trochanter
      f. Shaft

B. Common pathology
   1. Arthritis
   2. Fracture
   3. Paget's disease

II. Scan Acquisition

A. Select appropriate femur
   1. Left side most common or accessible
   2. Fractures or surgical procedures
   3. Arthritis or congenital anomalies
   4. Prolonged immobilization
   5. Polio

B. Select scan parameters according to manufacturer recommendations
   1. Adjust to thickness of scan site selection

C. 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
   4. Proper placement of manufacturer tissue-equivalent material

D. Common positioning problems
   1. Inability to rotate or abduct leg
   2. Motion

III. Scan Analysis and Report

A. Place ROIs according to manufacturer recommendations

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1. Automatic analysis
2. Manual analysis
3. Technologist intervention
4. 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 – osteoids

C. Report
   1. Define regions
   2. Total hip
      a. How calculated
      b. Used for NHANES reference population
      c. More precise due to larger area
   3. Dual hips
      a. Mean BMD value
      b. Hip axis length
      c. Cross-sectional moment of inertia (CSMI)

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Quality Control

Description
Content establishes a basic knowledge of quality control (QC) methods and procedures for bone densitometry instruments, particularly DXA scanners. Phantom measurement methods, plotting longitudinal QC data, applying statistical and Shewhart rules and making proper pass or fail decisions are demonstrated. 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 correct statistical and Shewhart rules to a QC plot.
7. Apply correct pass or fail criteria to QC data from at least one model of scanner.
8. Describe proper QC procedures for preventive maintenance, repair, relocation, software modification or scanner upgrade.

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Content

I. Basic Concepts

A. Definition of QC

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)
   4. Shewhart rules

D. Longitudinal QC plots
   1. Automated
   2. Shewhart control chart

E. Pass or fail criteria
   1. When to repeat QC test
   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

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C. Upgrade to new scanner
    1. Intramanufacturer
        a. Cross-calibrate new scanner to old
        b. Re-establish QC plot mean and standard deviation
    2. Intermanufacturer
        a. Not recommended
        b. Apply standardized BMD (sBMD) formulas with caution
        c. Re-establish QC plot mean and standard deviation

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Quantitative Computed Tomography

Description
Content establishes a base of knowledge for competent performance of spine quantitative computed tomography (QCT) scans performed on a standard computed tomography (CT) scanner. The relevant skeletal anatomy and pathology are described; QCT physics is discussed, and quality control, patient positioning and scan acquisition and analysis are demonstrated.

Objectives
1. Identify and label gross anatomical structures of the skeleton relevant to spine QCT.
2. Recognize relevant degenerative conditions.
3. Describe the equipment and software required for QCT.
4. Describe how standard CT is adapted to perform QCT.
5. Compare and contrast the different methods for performing QCT.
6. Describe and evaluate the various calibration phantoms.
7. Demonstrate correct quality control procedures.
8. Demonstrate correct patient positioning.
9. Demonstrate correct scan acquisition and analysis.
10. Demonstrate correct scan archival.

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Content

I. Gross Anatomy and Pathology

A. Vertebral column
   1. Thoracic
   2. Lumbar
   3. Thoracolumbar junction
   4. Vertebral body
      a. Cortical bone
      b. Trabecular bone
      c. Cross-sectional anatomy

B. Relevant degenerative conditions
   1. Deformity of vertebral body
   2. Fracture of vertebral body
   3. Scoliosis

II. Physics

A. Equipment
   1. Standard CT scanner
   2. QCT software and hardware packages
   3. Archive system
      a. Tape
      b. Optical disk

B. Adaptation of standard CT
   1. Low radiation dose scan
   2. Purpose of calibration phantom
      a. Simultaneous imaging
      b. ROI placements
      c. Relating mean Hounsfield units to equivalent bone mineral density

C. Methods
   1. Single energy
   2. Dual energy

III. Quality Control

A. Calibration phantoms
   1. Liquid
      a. Construction
      b. Advantages and disadvantages
   2. Solid
      a. Construction
      b. Advantages and disadvantages

B. Phantomless system
   1. Advantages and disadvantages

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C. Scanning procedures
   1. Frequency

D. Analysis and interpretation
   1. Common problems

E. Cross-calibration of replacement scanner

IV. Patient Positioning

A. Supine

B. Feet first into gantry

C. T11 – L5 centered over phantom
   1. Fill air gap with gel pack

V. Scan Acquisition and Analysis

A. Acquisition
   1. Patient biography
   2. Table height
   3. Number of slices
   4. Gantry angle
   5. Technique
      a. kVp
      b. mA
      c. Time
   6. Field of view size
   7. Matrix size

B. Analysis
   1. Use available automated functions
   2. Check lines are centered through vertebral body
   3. Identify artifacts

VI. Scan Archiving

A. Tape

B. Optical disk

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Radiation Safety and Protection

Description
Content establishes a knowledge base for how to adapt general radiation safety and protection principles and practices to bone densitometry techniques using ionizing radiation, in particular DXA.

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

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Content

I. Basic Principles

A. Effective doses in microsieverts (µSv)
   1. Background radiation
   2. Diagnostic radiographs
   3. Bone density measurement techniques
      a. Pencil
      b. Fan

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 by manufacturer
      b. Certification
         1) International Society for Clinical Densitometry (ISCD)
         2) ARRT Bone Densitometry added Qualifications Exam
         3) Other
      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 at full aperture
      b. = 1 meter for pencil beam
   5. Pregnancy
      a. Voluntary disclosure in writing

C. Patient
   1. Scan request verification

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2. Patient cooperation
    a. Explain exam and answer patient questions
    b. Artifacts
        1) Remove external artifacts
        2) Document nonremoveable 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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PA Lumbar Spine DXA Scanning

Description
Content establishes a base of knowledge for competent performance of PA lumbar spine 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 and label gross anatomical structures of the skeleton relevant to lumbar spine positioning and scan analysis.
2. Describe and demonstrate correct selection of scanning parameters.
3. Describe and demonstrate correct lumbar spine positioning.
4. Describe and demonstrate correct scan acquisition.
5. Describe and demonstrate correct scan analysis, including standard placement of ROIs.
6. Describe common positioning, acquisition and analysis problems and possible solutions.
7. Explain the scan report.

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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
   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
   1. Adjust to thickness of scan site selected

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2. Pediatrics and adolescents

B. Position patient and scan according to manufacturer recommendations
   1. Leg block under knees
   2. Identify iliac crest and lowest set of ribs

C. Common positioning problems
   1. Asymmetry due to scoliosis
   2. Misalignment of central skeleton (tilt)
   3. Use of automatic position and reposition

III. Scan Analysis and Report

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
      a. When and how to change bone edges
   6. Deleting vertebra(e)
      a. When and how
      b. Comparison to reference population
   7. Follow-up scans

C. Report
   1. Explain regions
   2. Total BMD
      a. Manual calculation

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Whole-body DXA Scanning

Description
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 and label gross anatomical structures and pathology of the skeleton relevant to whole-body DXA positioning and scan analysis.
2. Describe and demonstrate correct patient positioning and alternative positioning for large body size (hemiskeleton) or abnormal anatomy.
3. Demonstrate correct 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 scan report.

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Content

I. Gross Anatomy and Pathology

A. Basic bones and regions
   1. Head
   2. Long bones
   3. Cervical, thoracic and lumbar spines
   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 specifications

B. Position patient and scan according to manufacturer specifications
   1. Common positioning and scanning problems
      a. Tall
      b. Obese
      c. Placement of hands and feet
      d. Motion
      e. Nonremovable artifacts
   2. Pediatrics and adolescents

III. Scan Analysis and Report

A. Place ROIs according to manufacturer specifications
   1. Common analysis problems
      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

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c. Lean
d. Total
e. Percent fat
f. Android-Gynoid
g. Visceral Fat Analysis

3. Pediatrics and adolescents

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Vertebral Fracture Assessment (VFA) or Lateral Vertebral Assessment (LVA)

Description
Content establishes basic knowledge and competence in the fracture risk assessment of the vertebral column.

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

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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

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

II. Defining Fractures

A. Qualitative visual assessment

B. Semi-quantitative visual method (Genant)

C. Quantitative morphometry

III. Scanning Protocol

A. Lateral Vertebral Assessment (LVA)

B. Instant Vertebral Assessment (IVA)

C. Anterior Posterior Vertebral Assessment (APVA)

IV. Advantages

A. Reduced radiation to patient

B. Cost effective

V. Limitations

A. Artifacts

B. Mild fractures

C. Positioning

VI. Radiation Safety

A. Time, distance, shielding (ALARA)

B. Image Wisely

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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.

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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 the appropriate medical asepsis and sterile technique.

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- 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.

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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.
- Differentiate between empathetic rapport and sympathetic involvement in relationships with patients and relate these to ethical conduct.
- 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 (patient) 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 disclosure relative to informed consent.
- Describe how consent forms are used relative to specific radiographic procedures.
- Identify the four sources of law to include statutory, administrative, common and constitutional.
- Differentiate between civil and criminal liability.
- Define tort and explain the differences between intentional and unintentional torts.
- Exhibit critical data research retrieval and analysis skills composing an evidence-based narrative that addresses an ethical dilemma found in the patient care setting.

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Human Structure and Function

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.

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- 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.

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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.
- Differentiate between conventional and spiral/helical CT scanning.
- Explain the functions of collimators in CT.
- List the CT computer data processing steps.
- Name the functions of the array processor used for image reconstruction.
- Define the term "algorithm" and explain its impact on image scan factors and reconstruction.
- Define the terms "raw data" and "image data."
- Explain the difference between reconstructing and reformatting an image.
- Describe the application of the following terms to CT:
  - 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).
  - Standard vs. volumetric data acquisition.
- 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.
- Explain how artifacts can be reduced or eliminated.
- List and describe current data storage techniques used in CT.
- Name the radiation protection devices that can be used to reduce patient dose in CT and describe the correct application of each.

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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.
- Describe the characteristics of each stage of grief.
- Identify methods for determining the correct patient for a given procedure.
- Explain the use of various communication devices and systems.
- 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 with various health conditions.
- Describe select 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.

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- 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.

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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 direct and indirect ionizing radiation.
- 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 specific cells from most radiosensitive to least radiosensitive.
- 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.

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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 the processes of ionization and excitation.
- Describe charged and uncharged forms of 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 matter by describing the interaction, relation to atomic number, photon energy and part density, and their applications in diagnostic radiology.
- Discuss relationships of wavelength and frequency to beam characteristics.
- Discuss the clinical significance of the photoelectric and modified scattering interactions in diagnostic imaging.

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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.
- Distinguish between somatic and genetic radiation effects.
- Differentiate between the stochastic (probabilistic) and nonstochastic (deterministic) effects of radiation exposure.
- 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 and indicate the potential consequences if the performance standards fail.
- Describe the operation of various interlocking systems for equipment and indicate potential consequences of interlock system failure.
- 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 requirements for 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.

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- Compare values for individual effective dose limits for occupational radiation exposures (annual and lifetime).
- Identify anatomical structures that are considered critical for potential late effects of whole body irradiation exposure.
- 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.

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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.

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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 www.arrt.org/pdfs/disciplines/clinical-experience/bd-clinical-experience.pdf.

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Resources

Textbooks

ACR Standard for Performance of Adult Dual or Single X-ray Absorptiometry (DXA/pDXA/SXA). Reston, VA: American College of Radiology; 1998.

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

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

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

Journals

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

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

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

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

White Paper

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

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

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

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