

# Mammography Curriculum

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# Introduction

This curriculum provides the professional community with a cognitive base of entry-level education in the practice of mammography. The curriculum is suitable for all programs in this specialty, including limited fellowships, short-term certificate programs and collegiate-based education programs. The curriculum recognizes that the educational components are dynamic, and therefore represent 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 that represent the essential components of a mammography educational program. No particular sequence is suggested. Each program should organize the content and objectives to meet its mission, goals and needs. 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 has four sections: foundations, core content, clinical experience requirements and optional content. The foundations section presents an inventory of pre-existing knowledge and skills gained during an entry-level radiography educational experience and reinforced through professional practice. The content in the foundations section is intended to aid technologists in planning their careers and program managers in developing preassessment tools for candidate selection.

The professional practice of mammography 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 to educate technologists in the postprimary practice of mammography.

The clinical experience requirements section acts as a guide in developing a well-rounded clinical experience. The section also includes information to aid in meeting the eligibility requirements for a postprimary certification examination in mammography.

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

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# Foundations

This section presents an inventory of pre-existing knowledge and skills gained during an entry-level radiography educational experience and reinforced through professional practice. The content in this section is intended to aid technologists in planning their careers and program managers in developing 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 preparatory to, during and following the radiologic procedure.

## **Digital Image Acquisition and Display**

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

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

## **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 Radiologic Science and Health Care**

Content provides an overview of the foundations of radiography and the practitioner's role in the health care delivery system. Principles, practices and policies of health care organizations are examined and discussed in addition to the professional responsibilities of the radiographer.

### **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.

### **Pharmacology and Venipuncture**

Content provides basic concepts of pharmacology, venipuncture and administration of diagnostic contrast agents and intravenous medications. The appropriate delivery of patient care during these procedures is emphasized.

### **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 Physics**

Content is designed to establish a basic knowledge of physics pertinent to developing an understanding of radiations used in the clinical setting. Fundamental physical units, measurements, principles, atomic structure and types of radiation are emphasized. Also presented are the fundamentals of x-ray generating equipment, x-ray production and its interaction with matter.

### **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.

### **Radiographic Pathology**

Content introduces concepts related to disease and etiological considerations with emphasis on radiographic appearance of disease and impact on exposure factor selection.

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

## Core Content

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

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# Breast Anatomy and Mammographic Correlation

## Description

Content establishes a knowledge base in breast anatomy and physiology. Correlation between breast anatomical structures and mammographic anatomical structure are described and discussed.

## Objectives

1. Describe the breast, male and female, and the developmental stages.
2. Identify and label external and internal anatomy of the breast.
3. Identify and label the breakdown of the single lobe.
4. Identify the three arterial branches supplying the breast and the three venous drainage channels.
5. Describe the lymphatic system and lymphatic drainage.
6. Correlate breast anatomical structures to mammographic anatomical structures.
7. Identify and label mammographic anatomical structures when presented with a mammographic image.

## **Content**

### **I. Definition of the Breast**

- A. Male vs. female
  
- B. Developmental stages
  - 1. Fetal
  - 2. Puberty
  - 3. Menstruation
  - 4. Pregnancy
  - 5. Lactation
  - 6. Menopause
  - 7. Postmenopause
  
- C. Divisions of breast
  - 1. Quadrants
  - 2. Clockface references

### **II. Gross Anatomy of the Normal Breast**

- A. External anatomy
  - 1. Breast margins
  - 2. Nipple
  - 3. Areola
  - 4. Montgomery's glands
  - 5. Morgagni's tubercles
  - 6. Skin
    - a. Sebaceous glands
    - b. Sweat (sudiferous) glands
    - c. Hair follicles
  - 7. Axillary tail
  - 8. Inframammary fold
  - 9. Breast margins
    - a. Superior-inferior
    - b. Axillary-medial
  
- B. Internal anatomy
  - 1. Fascial layers
  - 2. Retromammary (fat) space
  - 3. Breast parenchymal components
    - a. Fibrous tissues
    - b. Glandular (secretory) tissues
      - 1) Glandular lobes
        - a) Lobules
        - b) Terminal ductal lobular unit (TDLU)
    - c. Adipose (fatty) tissues
    - d. Connective and Support Stroma
      - 1) Cooper's ligaments



- 2) Extralobular/intralobular stroma
- e. Lymphatic channels
- f. Circulatory (blood supply) system
  - 1) Arteries
  - 2) Veins
- 4. Pectoral muscle

C. Histology of the breast

- 1. Terminal ductal lobular unit
  - a. Extralobular terminal duct
  - b. Intralobular terminal duct
  - c. Ductal sinus (acinus)
- 2. Cellular components
  - a. Epithelial cells
  - b. Myoepithelial cells
  - c. Basement membrane

**III. Mammographic Appearance of Breast Anatomy**

- A. External anatomy
  
- B. Internal anatomy

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# Breast Pathology

## Description

Content introduces the concepts of breast pathology detection and diagnosis. This section presents characteristics of benign and cancerous pathologies and their mammographic appearance.

## Objectives

1. Discuss the factors and physiologic changes that will affect breast tissue composition.
2. Identify physical changes of the breast.
3. Correlate clinical breast changes with imaging findings, and comparison with previous mammograms.
4. Identify the mammographic appearance of pathologies.
5. Identify the high risk and low risk factors limited to breast cancer.
6. Describe the etiology, mammographic appearance, diagnosis and treatment of benign breast pathologies.
7. Describe the etiology, mammographic appearance, diagnosis and treatment of malignant breast pathologies.
8. Identify the procedures used to diagnosis breast cancer.
9. Describe treatment options for breast cancer.
10. Explain breast cancer stages 0 to IV and stage characteristics.
11. Explain tumor node metastasis (TNM) classifications of breast cancer.
12. Identify the significance of early detection of breast cancer through patient screening and diagnostic mammograms, clinical examinations and breast self-examinations.
13. Identify the risk factors associated with breast cancer.

## **Content**

### **I. Breast Anomalies**

- A. Asymmetry
- B. Inverted nipples
- C. Accessory nipples
- D. Accessory breast tissue
- E. Other

### **II. Clinical Breast Changes**

- A. Lumps
  - 1. Location
  - 2. Size
  - 3. Pain
  - 4. Mobility
- B. Thickening
  - 1. Location
- C. Swelling
- D. Dimpling
  - 1. Location
- E. Skin irritation
  - 1. Location
- F. Pain
  - 1. Location
  - 2. Duration of time
- G. Discharge
  - 1. Duration of time
  - 2. Color of discharge
  - 3. Ipsilateral or bilateral
  - 4. Spontaneous vs. expressed
- H. Nipple retraction and areola changes
  - 1. Location
  - 2. Duration of time
- I. Edema

- J. Erythema
- K. Implants
  - 1. Types
    - a. Silicone
    - b. Saline
    - c. Other
- L. Breast reduction
- M. Postsurgical excision
- N. Radiation changes
- O. Other

### **III. Mammographic Appearance of Pathology**

- A. Masses
  - 1. Definition
  - 2. Margins
    - a. Circumscribed
    - b. Ill-defined (indistinct)
    - c. Spiculated
- B. Asymmetric density
  - 1. Definition
- C. Focal asymmetry
  - 1. Definition
- D. Calcifications
  - 1. Characteristics
    - a. Number (quantity)
    - d. Size
    - e. Shape
    - f. Distribution
      - 1) Clustered or grouped
      - 2) Segmental
      - 3) Regional
      - 4) Diffuse (scattered)
      - 5) Multiple groups
    - g. Margins
  - 2. Benign characteristics (typical)
    - a. Coarse
    - b. Rim or eggshell
    - c. Milk of calcium (teacup-like)

- d. Dystrophic
  - e. Vascular
  - f. Skin (superficial)
  - g. Secretory
  - h. Fat necrosis
  - i. Punctate
- 3. Malignant (nondeterminate characteristics)
    - a. Indistinct (amorphous)
    - b. Granular (clustered)
    - c. Irregular
    - d. Casting

#### **IV. Benign Breast Pathology**

- A. Cyst
  - 1. Etiology
  - 2. Mammographic appearance
  - 3. Diagnosis
  - 4. Treatment
- B. Galactocele
  - 1. Etiology
  - 2. Mammographic appearance
  - 3. Diagnosis
  - 4. Treatment
- C. Fibroadenoma
  - 1. Etiology
  - 2. Mammographic appearance
  - 3. Diagnosis
  - 4. Treatment
- D. Lipoma
  - 1. Etiology
  - 2. Mammographic appearance
  - 3. Diagnosis
  - 4. Treatment
- E. Hamartoma (fibroadenolipoma)
  - 1. Etiology
  - 2. Mammographic appearance
  - 3. Diagnosis
  - 4. Treatment
- F. Papilloma
  - 1. Etiology

2. Mammographic appearance
  3. Diagnosis
  4. Treatment
- G. Ductal ectasia
1. Etiology
  2. Mammographic appearance
  3. Diagnosis
  4. Treatment
- H. Breast infection/abscess
1. Etiology
  2. Mammographic appearance
  3. Diagnosis
  4. Treatment
- I. Hematoma
1. Etiology
  2. Mammographic appearance
  3. Diagnosis
  4. Treatment
- J. Fat necrosis
1. Etiology
  2. Mammographic appearance
  3. Diagnosis
  4. Treatment
- K. Radial scarring
1. Etiology
  2. Mammographic appearance
  3. Diagnosis
  4. Treatment
- L. Lymph node
1. Etiology
  2. Mammographic appearance
  3. Diagnosis
  4. Treatment
- M. Gynecomastia
1. Etiology
  2. Mammographic appearance
  3. Diagnosis
  4. Treatment

## **V. High Risk Breast Pathology**

- A. Atypical ductal hyperplasia
  - 1. Etiology
  - 2. Mammographic appearance
  - 3. Diagnosis
  - 4. Treatment
  
- B. Atypical lobular hyperplasia
  - 1. Etiology
  - 2. Mammographic appearance
  - 3. Diagnosis
  - 4. Treatment
  
- C. Lobular carcinoma in situ
  - 1. Etiology
  - 2. Mammographic appearance
  - 3. Diagnosis
  - 4. Treatment
  
- D. Phyllodes tumor
  - 1. Etiology
  - 2. Mammographic appearance
  - 3. Diagnosis
  - 4. Treatment

## **VI. Malignant Breast Pathology**

- A. Ductal carcinoma in situ
  - 1. Etiology
  - 2. Mammographic appearance
  - 3. Diagnosis
  - 4. Treatment
  
- B. Invasive/infiltrating ductal carcinoma
  - 1. Etiology
  - 2. Mammographic appearance
  - 3. Diagnosis
  - 4. Treatment
  
- C. Invasive lobular carcinoma
  - 1. Etiology
  - 2. Mammographic appearance
  - 3. Diagnosis
  - 4. Treatment
  
- D. Inflammatory carcinoma
  - 1. Etiology

2. Mammographic appearance
3. Diagnosis
4. Treatment

- E. Paget disease
1. Etiology
  2. Mammographic appearance
  3. Diagnosis
  4. Treatment

- F. Sarcoma
1. Etiology
  2. Mammographic appearance
  3. Diagnosis
  4. Treatment

- G. Tubular
1. Etiology
  2. Mammographic appearance
  3. Diagnosis
  4. Treatment

- H. Medullary
1. Etiology
  2. Mammographic appearance
  3. Diagnosis
  4. Treatment

- I. Mucinous
1. Etiology
  2. Mammographic appearance
  3. Diagnosis
  4. Treatment

- J. Papillary
1. Etiology
  2. Mammographic appearance
  3. Diagnosis
  4. Treatment

- K. Metastatic carcinoma

## **VII. Diagnosis of Breast Carcinoma**

- A. Fine-needle aspiration

- B. Core biopsy



- C. Vacuum assisted breast biopsy
- D. Surgical biopsy
- E. Other
- F. Correlation to mammographic findings
  - 1. Concordance
  - 2. Nonconcordance

### **VIII. Treatment Options for Breast Cancer**

- A. Surgery
  - 1. Lumpectomy
  - 2. Partial mastectomy
  - 3. Simple mastectomy
  - 4. Modified radical mastectomy
  - 5. Prophylactic mastectomy
  - 6. Sentinel, axillary node and axillar dissection
  - 7. Clear surgical margins
- B. Reconstructive surgery
  - 1. Implant and tissue expander
  - 2. Tissue flap reconstruction methods
    - a. Abdominal free flap method
      - 1) Tram
      - 2) Deep inferior epigastric perforator (DIEP)
      - 3) Superficial inferior epigastric artery (SIEA)
    - b. Latissimus dorsi (LD) flap (back)
    - c. Gluteal artery perforator (GAP) (buttock)
    - d. Transverse upper gracilis (TUG) flap (inner thigh)
- C. Radiation therapy
  - 1. Whole breast
  - 2. Focal
- D. Chemotherapy
- E. Hormone therapy

### **IX. Breast Cancer Classifications**

- A. Stage Characteristics
  - 1. Description
    - a. Size
    - b. Invasive vs. noninvasive
    - c. Lymph node involvement

- d. Spread beyond the breast
- 2. Stages
  - a. Stage 0
  - b. Stage I
  - c. Stage II
  - d. Stage III
  - e. Stage IV

**B. TNM classification characteristics**

- 1. TNM description
  - a. Size
  - b. Lymph node involvement
  - c. Metastasis
- 2. T – size
  - a. TX
  - b. T0
  - c. Tis
  - d. T1, T2, T3, T4
- 3. N – lymph node involvement
  - a. NX
  - b. N0
  - c. N1, N2, N3
- 4. M – metastasis
  - a. MX
  - b. M0
  - c. M1

**C. Cell grade**

- 1. Definition
- 2. Grade 1
- 3. Grade 2
- 4. Grade 3

**D. Multifocal**

**E. Multicentric**

**F. Hormone receptors and HER2**

- 1. Importance of tests
- 2. Estrogen
- 3. Progesterone
- 4. HER2

**X. Hormonal Influences**

**A. Birth control pills**

- B. Estrogen
- C. Progesterone
- D. Prolactin
- E. Testosterone
- F. Other

**XI. Early Detection of Breast Cancer**

- A. Screening mammograms
  - 1. Women 40 and older, annual mammograms
- B. Diagnostic mammograms
  - 1. Clinical findings
  - 2. Recall from screening
- C. Clinical examinations
  - 1. Women aged 20 to 40 years, every 3 years
  - 2. Women older than 40 years, every year
- D. Breast self-examinations

**XII. Risk Factors Associated With Breast Cancer**

- A. Gender
- B. Age
- C. Breast density and breast composition
- D. Personal history of breast cancer
- E. Family history of breast cancer
- F. Personal history of female cancer
- G. Genetic predisposition
- H. Menses
  - 1. Early age at menarche
  - 2. Late age at menopause
- I. Parity
  - 1. Nulliparity
  - 2. Primiparity

J. Hormone replacement therapy

K. Obesity

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# Correlative Physical Breast Assessment

## Description

Content introduces technologist-performed physical breast assessment. Content includes discussions regarding preliminary patient assessment, physical breast assessment and documentation of findings required of a comprehensive examination to correlate breast imaging.

## Objectives

1. Identify current epidemiology and risk factors of breast cancer.
2. Describe elements of breast cancer screening protocols.
3. Demonstrate an understanding of breast anatomy and topographical orientation.
4. Detail a breast assessment.
5. Implement proper techniques and procedures for conducting a breast assessment.
6. Use nondiagnostic descriptors to record findings and document observations arising from the breast exam.
7. Participate in patient education regarding breast self-examination.
8. Modify procedures to assist patients with special needs.

## **Content**

### **I. Description of Physical Breast Assessment for Imaging Correlation**

- A. Benefits
- B. Disadvantages
- C. Focused medical history
  - 1. General risk factors
  - 2. Family history
- D. Physical examination
  - 1. Area to be examined
  - 2. Visual inspection of breasts
  - 3. Visual inspection of nipples
  - 4. Palpation
- E. Upright exam
- F. Supine exam
- G. Palpation techniques
  - 1. Vertical strip method
  - 2. Grid method
  - 3. Circular method
- H. Examination of lumpectomy/mastectomy site
- I. Examination after reconstruction/augmentation/reduction
- J. Normal breast examination features
  - 1. Consistent features
  - 2. Variations in parenchyma
  - 3. Fibrocystic changes
- K. Abnormal clinical breast examination findings
  - 1. Characteristics of abnormal findings
    - a. Infection
    - b. Abscess
    - c. Nipple discharge
    - d. Mass
    - e. Breast pain
    - f. Skin findings
    - g. Nipple findings
    - h. Previous surgeries
  - 2. Documentation of findings
    - a. Clockface description

- b. Accuracy of measurements
- 3. Mammographic correlation

## **II. Patient Education: Breast Self-examination (BSE)**

- A. Target population
- B. Benefits
- C. Rationale for performing BSE
- D. Possible reasons for not performing BSE
- E. When to do BSE

## **III. Patients With Special Needs**

- A. Patients in a wheelchair
- B. Cultural barriers
- C. Morbidly obese patients

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# Departmental Structure and Regulatory Guidelines

## Description

Content provides technologists with an overview of the mammography departmental structure and essential personnel. The content also provides specific guidelines set forth by regulatory agencies and accrediting bodies, which provide the foundation for quality patient services offered by a facility, as well as how these regulations affect daily operation of a facility or the services they provide.

## Objectives

1. Identify the different types of mammography departments, and discuss the various roles of the mammographer within each setting.
2. Identify essential personnel, and discuss the responsibilities for: training, experience, certification, and continuing education.
3. Outline the types of patient services and procedures provided within the mammography department and facility.
4. Define the current national guidelines and standards set forth by the Mammography Quality Assurance Advisory Committee, the Food and Drug Administration (FDA) and the American College of Radiology (ACR).
5. Review and discuss the Mammography Quality Standards Act (MQSA) of 1992.



## **Content**

### **I. Types of Mammography Departments**

- A. Hospitals
- B. Outpatient departments
- C. Clinics
- D. Private radiology practices
- E. Mobile units
- F. Government-owned facilities
- G. Other

### **II. Essential Personnel Requirements and Responsibilities**

- A. Interpreting physicians
  - 1. Initial qualifications
    - a. Medical licensing
  - 2. Clinical experience
    - a. Interpretation of mammograms according to MQSA guidelines
  - 3. Certification
  - 4. Continuing education
    - a. Regulations
    - b. Requirements
  - 5. Continuing clinical experience
  - 6. Re-establishing qualifications
  - 7. Lead interpreting physician
    - a. Responsibilities
    - b. Duties
- B. Mammographers
  - 1. Initial qualifications
    - a. Licensing
    - b. Certification
  - 2. Clinical experience
  - 3. Continuing education
    - a. Regulations
    - b. Requirements
      - 1) General
      - 2) Modality-specific
  - 4. Continuing clinical experience
  - 5. Re-establishing qualifications
  - 6. Quality control (QC) technologist
    - a. Responsibilities

- b. Duties
- C. Medical physicist
  - 1. Initial qualifications
    - a. License or approval by state
  - 2. Clinical experience
  - 3. Certification
  - 4. Continuing education
    - a. Regulations
    - b. Requirements
  - 5. Continuing clinical experience
  - 6. Re-establishing qualifications
- D. Retention of personnel records

### **III. Patient Services and Procedures Offered**

- A. Screening mammography
  - 1. Asymptomatic patients
  - 2. Self-referring
  - 3. Self-requesting
- B. Diagnostic mammography (consultative mammography)
  - 1. Clinical signs, symptoms or physical findings
  - 2. Abnormal or questionable screening mammogram
  - 3. History of breast cancer
  - 4. Augmented breasts
- C. Other breast imaging services
  - 1. Ultrasonography
  - 2. Magnetic resonance (MR)
  - 3. Nuclear medicine
    - a. Breast-specific gamma imaging (BSGI)/Molecular breast imaging (MBI)
    - b. Positron emission mammography (PEM)
  - 4. Tomosynthesis
- D. Interventional procedures
  - 1. Localization procedures
  - 2. Biopsy procedures
  - 3. Fine needle aspiration procedures
- E. Other

### **IV. National Guidelines and Standards**

- A. FDA
  - 1. Approves accrediting and certification agencies for mammography
    - a. Private, nonprofit organizations (ACR, MQSA)

- b. States that have approved accrediting bodies
    - 2. Responsibilities of accrediting or certification agencies
      - a. Facility standards
        - 1) Physician standards
        - 2) Mammographer standards
        - 3) Medical physicist standards
        - 4) X-ray equipment characteristics
        - 5) QA and QC programs
        - 6) Phantom image quality testing
        - 7) Radiation dose limits
        - 8) Information update provisions
        - 9) Medical records
          - a) Film retention
          - b) Physician notification
            - (1) Timeline
            - (2) Breast imaging reporting and data system (BIRADS)
        - 10) Patient notification requirements
          - a) Lay report to be used with BIRADS
          - b) Breast density
          - c) Timeline
        - 11) Clinical image review
- B. MQSA requirements for compliance
  - 1. Certification of mammography facilities by approved accrediting bodies
  - 2. Annual mammography facility physics survey, consultation and evaluation performed by a certified or state-licensed medical physicist
  - 3. Annual inspection of mammography facilities, performed by federally certified or state-certified inspectors
  - 4. Qualification standards for interpreting physicians, mammographers, medical physicists and mammography facility inspectors
  - 5. Specified boards or organizations eligible to certify the training and experience of mammography personnel
  - 6. Quality standards for mammography equipment and practices, including QA and QC programs
  - 7. Standards governing record-keeping for patient files and requirements concerning mammography reporting and patient notification by physicians
  - 8. Review of outcome data, including disposition of all positive mammograms, and correlation of pathology results
- C. ACR Guidelines for Accreditation
  - 1. Accreditation of mammography facilities by appropriate state or federal agencies
  - 2. Annual mammography facility physics survey, consultation and evaluation performed by a certified or state-licensed medical physicist
  - 3. Annual inspection of mammography facilities, performed by federally certified or state-certified inspectors

4. Qualification standards for interpreting physicians, mammographers, medical physicists and mammography facility inspectors
5. Specified boards or organizations eligible to certify the training and experience of mammography personnel
6. Quality standards for mammography equipment and practices, including QA and QC programs
7. Standards governing record-keeping for patient files and requirements concerning mammography reporting and patient notification by physicians

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# Equipment

## Description

Content gives the student a foundation of the concepts of new and emerging mammography equipment. The types and function of mammographic and QC equipment, along with the mandated requirements governing their use, are described and discussed.

## Objectives

1. Label the components of the mammographic unit.
2. Demonstrate and properly operate mammography equipment and demonstrate the correct use of compression devices, filtration devices, the magnification setup, use of grids and automatic exposure controls.
3. Label the components of the dedicated mammography tube.
4. State the specifications of the various components in a mammography unit (half-value layer, focal spot size, source-to-image distance and the minimum requirements based on MQSA guidelines).
5. Explain the significance of target/filter combinations.
6. Define heel effect.
7. Describe the geometry and purpose of the mammography primary beam.
8. Define reciprocity law failure.
9. Differentiate between the various types of x-ray generators used in mammography.
10. Discuss and define digital mammography.
11. Discuss image processing and the effect it has on digital mammography images.
12. Explain the additional functions available with digital imaging: measuring the area of interest, filtration of image, magnification, contrast, density, subtraction of image.
13. Define compression, its usefulness and minimum and maximum requirements, based on MQSA guidelines.
14. State the purpose of magnification.
15. Accessorize equipment according to the procedure being performed.
16. Set appropriate kVp, mA and time or automatic exposure control (AEC) and the correct position of the photosensor.
17. Process digital images.
18. Describe a picture archiving and communications system (PACS) and its function.
19. Identify components of a PACS.
20. Identify modality types that may be incorporated into a PACS.
21. Define accession number.
22. Describe worklist and correct use.
23. Define digital imaging and communications in medicine (DICOM).
24. Describe data flow for a DICOM image from an imaging modality to a PACS.
25. Identify common problems associated with retrieving/viewing images within a PACS.
26. Identify the primary uses of the diagnostic display workstation.
27. Produce hard copy images of digital images.
28. Discuss the image storage and viewing capabilities related to digital mammography.

## Content

### I. Dedicated Mammography Equipment

- A. C-arm x-ray tube stand
- B. Mammography tube
  - 1. Rotating vs. stationary anodes
  - 2. Tube design
    - a. Tube configuration
    - b. Anode configuration
    - c. Biangular targets
  - 3. Focal spot
    - a. Standard sizes
    - b. Magnification size
    - c. Effective target angle
    - d. Reference axis target angle
    - e. Bias focusing
  - 4. Target materials
    - a. Molybdenum
    - b. Specialized tungsten
    - c. Rhodium
    - d. Dual targets (rhodium or molybdenum choice)
- C. Filtration
  - 1. Exit window filtration
    - a. Glass
    - b. Beryllium
  - 2. Tube filtration
    - a. Molybdenum
    - b. Rhodium
    - c. Aluminum
- D. Beam geometry
  - 1. Primary beam
    - a. Central ray geometry
    - b. Reference axis
    - c. Photon energies
  - 2. Heel effect
    - a. Effects on intensity
    - b. Effects on apparent focal spot size
  - 3. Beam limiting devices
    - a. Purpose
    - b. Collimation
      - 1) Three-sided
  - 4. Source-to-image distance (SID)
  - 5. Object-to-image distance (OID)
    - a. Effects on dose

- b. Effects on contrast
- E. Generator
  - 1. Types
    - a. Three-phase
    - b. High-frequency
    - c. Constant potential
  - 2. Homogenous x-ray beam
  - 3. Ripple factor
  - 4. Tube capacity (mA output)
- F. Automatic exposure control (AEC)
  - 1. Purpose
  - 2. Types
    - a. Ionization chamber
    - b. Solid state
    - c. Functions
    - d. Design
    - e. Placement in system
- G. Grids
  - 1. Types
    - a. Reciprocating
    - b. Stationary
  - 2. Ratio
  - 3. Design
    - a. Conventional
    - b. Honeycomb
- H. Compression devices
  - 1. Purpose
  - 2. Compression testing
  - 3. Types
    - a. Manual
    - b. Motorized
  - 4. Paddle shapes, sizes and purposes
- I. Magnification
  - 1. Purpose
  - 2. Focal spot size
  - 3. Air gap technique
  - 4. Effect of dose
  - 5. Magnification factor

## **II. Digital Mammography**

- A. Type of detectors

1. CR imaging plates
2. Phosphor screens
3. Charged coupled device (CCD)
4. Matrix/pixels
5. Field sizes
6. Resolution
7. Optical density vs. noise ratio – signal to noise ratio (SNR)
8. Contrast to noise ratio (CNR)

B. Approaches of digital mammography

1. Single-exposure approach
2. Multiple-exposure approach

C. Pre and postprocessing of digital image

D. Advantages

1. Radiation dose reductions
2. Image enhancement
3. Time
4. Telemammography
5. Productivity

E. Disadvantages

1. Expense
2. Additional equipment
  - a. Review workstation
  - b. PACS
  - c. Laser printer
3. Connectivity
4. Compatibility
5. Computer literacy of technologist

### III. PACS

A. Terminology

B. System components and function

C. Digital imaging and communications in medicine (DICOM)

1. Components of a DICOM record
2. DICOM conformance statements
3. DICOM coded terminology pertinent to digital mammography

D. Teleradiography

E. Mammographer

1. Access work order (worklist)



2. Postprocessing – image manipulation
3. Annotation issues
4. Transmitting images to PACS
5. Health Insurance Portability and Accountability Act (HIPAA)
6. Workflow
7. Processing other vendor (OV) images

F. Image Output

1. Retention
2. Transfer of images
  - a. Final interpretation quality
    - 1) Laser images
    - 2) CD

**IV. FDA/MQSA Requirements**

- A. Mammography equipment
1. Dedicated
  2. Gantry assembly motion
    - a. Rigidly fixed
    - b. Rotation requirements
    - c. Visual indication of gantry angle
  3. Image receptors
    - a. Classification of sizes
    - b. Film-screen receptors (moving grids)
    - c. Magnification devices (removable grids)
    - d. Grid motion impedance
  4. Compression
  5. Technical factor display
  6. Focal spot selection
  7. Beam limitation and light fields
    - a. Alignment of light field to x-ray field
    - b. Illumination requirements
    - c. Exposure interlock systems
  8. Source-to-image receptor distance
    - a. Minimum requirements
    - b. Visual indication of selected SID
  9. Dose limitations
  10. Infection control

**V. Quality Assurance of Equipment**

- A. Facility QA program
- B. Maintenance of logbooks
- C. Phantom images

- D. Clinical image monitoring
- E. Clinical image interpretation
- F. Physicist surveys
- G. Medical records

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# Interventional Procedures

## Description

Content establishes a knowledge base in the type and application of interventional procedures involving breast imaging modalities.

## Objectives

1. Illustrate the sterile technique.
2. Describe localization techniques.
3. Describe biopsy techniques.
4. Delineate galactography.
5. Describe specimen imaging guidelines.
6. Describe specimen handling and record keeping for pathologic analysis.
7. Describe continuous patient care from prebiopsy to postbiopsy.

ASRT

## **Content**

### **I. General Information**

- A. Sterile technique
  - 1. Spread of infection
    - a. Exogenous
    - b. Endogenous
    - c. Iatrogenic
    - d. Nosocomial
  - 2. Preparation of local anesthetics, contrast media, etc.
  - 3. Proper glove use
  - 4. Skin preparation
  - 5. Sterile tray preparation
  - 6. Disposal of items
- B. Localization terms
  - 1. Clock
  - 2. Quadrant
  - 3. Distance from nipple

### **II. Localization Modalities**

- A. Mammography localization
  - 1. Definition
  - 2. Application
  - 3. Technique
- B. Stereotactic lesion localization
  - 1. Definition
  - 2. Application
  - 3. Technique
- C. Ultrasound localization
  - 1. Definition
  - 2. Application
  - 3. Technique
- D. MR localization
  - 1. Definition
  - 2. Application
  - 3. Technique
  - 4. MR safety issues for personnel
  - 5. MR appropriate equipment

### **III. Interventional Procedures**

- A. Cyst aspirations
  - 1. Definition
  - 2. Application

- 3. Technique
- B. Fine-needle aspiration biopsies
  - 1. Definition
  - 2. Application
  - 3. Technique
- C. Core biopsy
  - 1. Definition
  - 2. Application
  - 3. Technique
- D. Wire localization
  - 1. Definition
  - 2. Application
  - 3. Technique
- E. Vacuum-assisted breast biopsy
  - 1. Definition
  - 2. Application
  - 3. Technique
- F. Galactography
  - 1. Definition
  - 2. Application
  - 3. Technique
- G. Specimen Imaging
  - 1. Imaging guidelines
    - a. Core specimens
    - b. Surgical specimens
- IV. Pathologic Analysis**
  - A. Specimen handling
    - 1. Universal precautions
    - 2. Solutions
      - a. Saline
      - b. Formaldehyde
    - 3. Preparation of slides
    - 4. Specimen labeling
  - B. Record keeping
- V. Patient Care**
  - A. Prebiopsy
    - 1. Knowledge of informed consent procedures

2. Vital signs
  - a. Explanation of procedure
- B. During procedure
  1. Patient awareness
  2. Signs of vasovagal reaction and syncope
  3. Signs of allergic reactions to anesthesia
  4. Anxiety
- C. Postbiopsy
  1. Postbiopsy imaging for clip placement
  2. Postbiopsy pressure and wound dressing
  3. Knowledge of postbiopsy care instructions
  4. Follow-up with patient

ASRT

# Mammography Quality Management

## Description

Content establishes a minimum standard set forth by regulatory agencies that closely monitor a facility's QA and QC program. It is important to incorporate all patient services and procedures conducted within the mammography department or facility's quality management program. The individual testing requirements and procedures are demonstrated and discussed.

## Objectives

1. Identify and perform recommended QA and QC testing procedures according to ACR and MQSA guidelines based on analog or digital equipment.
2. Document test results and make appropriate adjustments or recommendations to maintain patient safety.
3. Implement appropriate corrective measures when established QC standards are not within recommended guidelines.
4. Perform routine safety checks on mammography equipment and accessories.
5. Discuss the role of the physician, mammographer and medical physicist within a quality management program.

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## **Content**

### **I. Quality Management Program for Digital Equipment**

- A. Mammography equipment
  - 1. Laser imager QC
  - 2. Workstation QC (including test pattern)
    - a. Radiologist workstation
    - b. Acquisition workstation
  - 3. Monitor
    - a. Cleanliness
    - b. Calibration
    - c. SMPTE pattern
  - 4. Phantom images
  - 5. Detector calibration
  - 6. Flat field and artifacts
  - 7. Viewboxes and viewing conditions
  - 8. SNR, CNR, modulation transfer function (MTF)
  - 9. Compression force
  - 10. Repeat analysis
  - 11. Visual checklist
  - 12. Review medical physicists annual survey report
- B. Reporting system
- C. PACS

### **II. Additional Quality Assurance Procedures**

- A. Medical physicist's annual survey
  - 1. Analysis and follow-up
  - 2. General QC tests
    - a. Unit assembly
    - b. Collimation assessment
    - c. System resolution
    - d. AEC performance
    - e. Uniformity of screen speed
    - f. Artifact evaluation
    - g. Image quality evaluation
    - h. kVp accuracy and reproducibility
    - i. Beam quality assessment (HVL)
    - j. Breast entrance exposure, glandular dose, radiation output
    - k. Viewbox luminance
      - l. Compression paddle alignment
    - m. Assessing QC program
- B. Qualification standards
  - 1. Physicians
    - a. Lead interpreting physician



2. Mammographers
    - a. QC technologist
  3. Medical physicists
- C. MQSA inspection by federally-certified or state-certified inspectors
1. On-site testing of equipment
  2. Analysis of QA program
    - a. State inspection

### **III. Image Quality Standards**

- A. Proper identification
- B. Proper placement of markers

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## New Technologies

### Description

Content includes emerging technologies in the breast imaging field. Students should have knowledge of the theory and potential clinical applications of these technologies.

This is not to say they must have clinical experience as many newer technologies are not abundantly available for several years following initial FDA clearance.

### Objectives

1. Describe the uses of computer-aided detection for mammography images.
2. Describe the basic theory of digital breast tomosynthesis including appropriate use.
3. Identify the value of biomarkers and those specific to breast imaging modalities.
4. Discuss dual energy contrast digital mammography and its appropriate use.
5. Describe the potential benefits and use of breast elastography.

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## **Content**

### **I. Computer-Aided Detection**

- A. Define
- B. Proper protocol for use
- C. Influence on mammography interpretation

### **II. Digital Breast Tomosynthesis (DBT)**

- A. Define
- B. Theory of DBT
- C. Personnel training requirements (MQSA)
- D. Potential benefits
- E. Types of images
  - 1. Projection images
  - 2. Reconstruction images

### **III. Breast Imaging Biomarkers**

- A. Breast density assessment
  - 1. Define
  - 2. Breast density as it relates to risk of breast cancer
- B. Breast arterial calcification scoring
  - 1. Define
  - 2. Related medical conditions to arterial calcification

### **IV. Dual Energy Contrast-enhanced Mammography**

- A. Define
- B. Theory
- C. Potential benefits

### **V. Breast Elastography Ultrasound Imaging**

- A. Define
- B. Theory
- C. Potential benefits

### **VI. Nuclear Medicine Studies**

- A. Scintimammography

B. Breast-specific gamma imaging

**VII. Positron Emission Tomography**

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# Positioning

## Description

Content provides a knowledge base of the various positioning techniques and projections used to perform screening and diagnostic mammography. Content consists of discussions about resolving imaging problems, significance of patient's personal and clinical history, selection of technical factors, and implemented national standards involved in breast imaging.

## Objectives

1. Identify the significance of effective patient education and communication skills.
2. Document detailed patient personal and clinical histories and data.
3. Observe any outstanding physical characteristics and document the findings on patient history sheet.
4. Respond to patient questions; explain the procedure and the reasons for compression before proceeding with the mammogram.
5. Select proper exposure factors according to patient's breast composition and/or placement of AEC.
6. Describe the critical role of breast compression.
7. Evaluate resulting mammogram image quality for good diagnostic interpretation.
8. Identify common problems of poor positioning, and make appropriate corrections.
9. Identify anatomical structures or pathological findings.
10. Identify supplemental positions/projections used for diagnostic mammography.
11. Maintain a professional, competent, confident and nonjudgmental attitude.
12. Recognize key terms and phrases used in breast imaging mammography.
13. Explain the basic ACR and MQSA guidelines required for all mammograms.
14. Identify FDA regulations regarding image identification, record and report results.
15. Describe screening and diagnostic positions/projections utilized to image the breast.
16. Demonstrate the craniocaudal (CC) and mediolateral oblique (MLO) projections, the two standardized mammographic projections for screening.
17. Describe breast-imaging techniques for breast implants.
18. Describe the positioning technique for specimen imaging.
19. Modify positions/projections for the physically nonconforming patient.

## **Content**

### **I. Clinical Data of Patient**

- A. History and documentation of details
  - 1. Gender
  - 2. Age
  - 3. Age at onset of menses
  - 4. Parity
    - a. Nulliparity
    - b. Multiparity
    - c. Age at primiparity
  - 5. Menstrual status
    - a. Last menstrual cycle
    - b. Age at menopause
    - c. Hysterectomy
    - d. Oophorectomy
  - 6. Medications
    - a. Estrogen
    - b. Progesterone
    - c. Prolactin
    - d. Steroids – males
    - e. Estrogen inhibitors
  - 7. Previous breast biopsies
    - a. Surgical biopsy and pathologic results
    - b. Core biopsy and pathologic results
    - c. Cyst aspirations
  - 8. Previous breast surgery
    - a. Augmentation
    - b. Reduction
    - c. Other
  - 9. Family history of breast cancer
  - 10. Other
    - a. Previous chest surgery (open heart, etc.)
    - b. Port-a-caths, pacemakers
    - c. Moles
    - d. Accessory nipple
    - e. Unusual landmarks
    - f. Date of most recent clinical breast exam (CBE) by a qualified health care provider

### **II. Description of Examination**

- A. Explain procedure
  - 1. Pre-exam instruction
  - 2. Establish rapport
  - 3. Psychological and emotional support
  - 4. Address patient limitation

- B. Explain compression
- C. Answer questions

### **III. Screening Mammography**

- A. Craniocaudal (CC) projection
  - 1. Purpose
  - 2. Anatomical structures demonstrated
  - 3. Part position (x-ray tube assembly and image receptor)
  - 4. Patient position
- B. Mediolateral oblique (MLO) projection
  - 1. Purpose
  - 2. Anatomical structures demonstrated
  - 3. Part position (x-ray tube assembly and image receptor)
  - 4. Patient position

### **IV. Diagnostic and Additional Projections**

- A. Exaggerated craniocaudal (XCCL) projection
  - 1. Purpose
  - 2. Anatomical structures demonstrated
  - 3. Part position (x-ray tube assembly and image receptor)
  - 4. Patient position
  - 5. Other
- B. Ninety degree or true lateral projection
  - 1. Mediolateral (ML) projection
    - a. Purpose
    - b. Anatomical structures demonstrated
    - c. Part position (x-ray tube assembly and image receptor)
    - d. Patient position
    - e. Other
  - 2. Lateromedial (LM) projection
    - a. Purpose
    - b. Anatomical structures demonstrated
    - c. Part position (x-ray tube assembly and image receptor)
    - d. Patient position
    - e. Other
- C. Spot compression projection and view
  - 1. Purpose
  - 2. Anatomical structures demonstrated
  - 3. Part position (x-ray tube assembly and image receptor)
  - 4. Patient position
  - 5. Other

- D. Cleavage (CV) projection
  - 1. Purpose
  - 2. Anatomical structures demonstrated
  - 3. Part position (x-ray tube assembly and image receptor)
  - 4. Patient position
  - 5. Other
  
- E. Tangential (TAN) projection
  - 1. Purpose
  - 2. Anatomical structures demonstrated
  - 3. Part position (x-ray tube assembly and image receptor)
  - 4. Patient position
  - 5. Other
  
- F. Axillary tail (AT) projection
  - 1. Purpose
  - 2. Anatomical structures demonstrated
  - 3. Part position (x-ray tube assembly and image receptor)
  - 4. Patient position
  - 5. Other
  
- G. Rolled projections (RL, RM, RS and RI)
  - 1. Purpose
  - 2. Anatomical structures demonstrated
  - 3. Part position (x-ray tube assembly and image receptor)
  - 4. Patient position
  - 5. Other
  
- H. Superolateral to inferomedial oblique (SIO) projection
  - 1. Purpose
  - 2. Anatomical structures demonstrated
  - 3. Part position (x-ray tube assembly and image receptor)
  - 4. Patient position
  - 5. Other
  
- I. Inferomedial to superolateral oblique (ISO) projection
  - 1. Purpose
  - 2. Anatomical structures demonstrated
  - 3. Part position (x-ray tube assembly and image receptor)
  - 4. Patient position
  - 5. Other
  
- J. Caudocranial (FB) projection
  - 1. Purpose
  - 2. Anatomical structures demonstrated
  - 3. Part position (x-ray tube assembly and image receptor)



4. Patient position
  5. Other
- K. Implant displaced (ID) projection (Eklund)
1. Purpose
  2. Anatomical structures demonstrated
  3. Part position (x-ray tube assembly and image receptor)
  4. Patient position
  5. Other
- L. Magnification (M) projection
1. Purpose
  2. Anatomical structures demonstrated
  3. Part position (x-ray tube assembly and image receptor)
  4. Patient position
  5. Other
- M. Lateromedial oblique (LMO)
1. Purpose
  2. Anatomical structures demonstrated
  3. Part position (x-ray tube assembly and image receptor)
  4. Patient position
  5. Other
- N. Other view modifiers
1. Nipple in profile (NP)
  2. Anterior compression (AC)
  3. Inframammary fold (IMF)
  4. Axillary tissue (AX)
- O. Triangulation
- P. Patients requiring modification of positioning techniques
1. Males
  2. Kyphotic patients
  3. Large breasts
  4. Small breasts
  5. Encapsulated implants
  6. Pectus excavatum
  7. Pectus carinatum
  8. Protruding abdomens
  9. Pacemaker
  10. Stretcher
  11. Wheelchair
  12. Infuse-port (Port-A-Cath)
  13. Physically handicapped

14. Mentally handicapped
15. Frozen shoulder
16. Barrel chest
17. Thick axilla
18. Irradiated breast
19. Reduction mammoplasty
20. Postsurgical breast

## **V. Evaluation of Images**

### **A. Positioning**

### **B. Compression**

### **C. Exposure**

### **D. Contrast**

### **E. Sharpness**

### **F. Noise**

### **G. Artifacts**

### **H. Motion**

### **I. Annotations**

### **J. Collimation**

## **VI. Correct Image Labeling**

### **A. Required**

1. Two patient identifiers
2. View and laterality
  - a. Placement of marker
3. Name, city, state and zip of facility
4. Performing technologist ID
5. Date of exam
6. Detector or room ID

### **B. Strongly recommended**

1. Street address of facility
2. Technical factors

### **C. Recommended**

1. Separate date sticker

## **VII. Image Quality Problems**

- A. Nipple not in profile
- B. Skin folds or wrinkling
- C. Difficulty compressing due to patient body habitus
- D. Incorrect or uneven compression
- E. Superimposition of extra anatomy
- F. Drooping of breast
- G. Motion
- H. Other

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# Sonomammography

## Description

Content develops a basic understanding of breast ultrasound imaging and the indications and use of ultrasound with emphasis on mammographic correlation. It develops a basic understanding of the equipment, importance of patient positioning and image labeling. It develops an understanding of the bioeffects of ultrasound.

## Objectives

1. Identify the uses and indications of breast ultrasound imaging.
2. Describe the basic components of sonography equipment and display of image.
3. Describe the sonographic appearance of breast anatomy.
4. Describe correct patient positioning.
5. Describe the importance of image labeling and components of precise location.
6. Correlate mammographic finding with ultrasound.
7. Identify basic bioeffects and patient safety concerns associated with sonography.

ASRT

## **Content**

### **I. Ultrasound**

A. Definition

B. Indications

### **II. Breast Imaging With Ultrasound**

A. Equipment

1. Monitor

2. Transducer image display

a. Orientation to patient

b. Characteristics

1) Anterior vs. posterior

2) Lateral vs. medial

3) Depth

B. Image characteristics

1. Sonographic appearance of breast anatomy

a. Skin line

b. Cooper's ligaments

c. Fibroglandular tissue

d. Fat

e. Fascia

f. Pectoralis muscle

g. Ribs

h. Nipple

i. Ducts

j. Vessels

C. Sonographic appearance of abnormalities

1. Benign findings

2. Malignant findings

### **III. Patient Positioning**

A. Degree of obliquity

1. Size of breast

2. Lesion location

B. Arm placement

C. Patient comfort

### **IV. Image Labeling**

A. Importance

B. Descriptive components for precise location

1. Side
2. Clockface ordination
3. Distance from the nipple
4. Depth
  - a. A – anterior or superficial
  - b. B – middle
  - c. C – posterior or chest
5. Scan planes
  - a. Radial
  - b. Antiradial
  - c. Longitudinal
  - d. Transverse
6. Measurement of lesion

## **V. Mammographic Correlation**

- A. Triangulation
- B. Image concordance

## **VI. Bioeffects and Safety**

ASRT

# Technical Applications

## Description

Content establishes a knowledge base of factors that govern and influence producing and recording mammographic images.

## Objectives

1. Perceive the purpose for AEC and relate it to an automatic kVp system.
2. Describe how kVp, mA, time and compression affect the mammographic image.
3. Identify the maximum permissible dose per mammography exam based on MQSA standards.
4. Identify the average dose per mammographic exposure.
5. Describe how kVp, mA, time and compression affect the radiation dose to the patient.
6. Select the correct technical variable based on variations in breast anatomy.
7. Identify imaging artifacts on digital mammography images.

ASRT

## Content

### I. Technical Variables

- A. Density
- B. Contrast
- C. kVp
  - 1. Range
  - 2. Rationale
  - 3. Effect on image quality
  - 4. Relationship to exposure time/reciprocity law failure and optimum optical density
  - 5. Effect on contrast
  - 6. Effect on digital images
- D. mAs
  - 1. Range
  - 2. Relationship to mR
  - 3. Relationship to exposure time/reciprocity law failure
  - 4. Effect on density
  - 5. Effect on digital images
- E. Compression
  - 1. Density
  - 2. Contrast
  - 3. Detail
  - 4. Radiation dose
- F. Automatic exposure control (AEC)
  - 1. Definition
  - 2. Effect of kVp
  - 3. Effect of consistent image quality
  - 4. Backup timing
  - 5. Photocell placement
  - 6. Tracking
  - 7. Reproducibility
  - 8. MQSA requirements
- G. Manual technique
  - 1. Uses
- H. Density setting
- I. Tube/filter combination
- J. Half-value layer (HVL)
  - 1. Heterogeneous and homogeneous radiation



2. MQSA requirements

K. Reciprocity law failure

1. Definition
2. Correlation to generator type and mR/mAs
3. Correlation to exposure time
4. Correlation to digital imaging

## **II. Exposure range – Standard Deviation**

A. Collimation

1. Purpose and importance
2. Field size
3. MQSA requirements

B. Artifacts

C. Laser imaging systems

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## Clinical Experience Requirements

The most current information regarding the eligibility requirements for a postprimary certification examination in mammography can be found in the ARRT Clinical Experience Requirements document. The document is located at [www.arrt.org/pdfs/Disciplines/Clinical-Experience/MAM-Clinical-Experience.pdf](http://www.arrt.org/pdfs/Disciplines/Clinical-Experience/MAM-Clinical-Experience.pdf).

ARRT

## Optional Content

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

ASRT

# Film-Screen Image Acquisition and Processing

## Description

Content establishes a knowledge base in factors that govern the image production process. Film imaging with related accessories is emphasized.

## Objectives

- ◆ Describe the effects of storage on image quality.
- ◆ Discuss safelight illumination appropriate for specific image receptor systems.
- ◆ Discuss darkroom-related Occupational Safety & Health Administration (OSHA) standards for health and safety.
- ◆ Discuss the possible causes and health implications of “darkroom chemical sensitivity.”
- ◆ Describe the function of each component of radiographic film.
- ◆ Explain latent image formation.
- ◆ Describe the features of the characteristic curve and explain its purpose.
- ◆ Select the most appropriate image receptor to be used for given clinical situations.
- ◆ Describe various types of image receptor holders.
- ◆ Describe the function of each component of an intensifying screen.
- ◆ Select the most appropriate intensifying screen for given clinical situations.
- ◆ Identify procedures that ensure a long screen life devoid of artifacts and distortion.
- ◆ Analyze the effects of processing on image quality.
- ◆ Identify key components of an automatic film processor.
- ◆ Demonstrate how various film sizes are fed into the film processor.
- ◆ Analyze the steps of the processing cycle by providing the specific action and duration of time for each step.
- ◆ Identify the purpose of a daily quality control program for processors.
- ◆ Identify types of image artifacts and analyze them to determine the cause.
- ◆ Identify common silver recovery methods.

## **Content**

### **I. Darkroom/Storage Environment**

- A. Location/construction/function
  - B. Darkroom environment
    - 1. Temperature
    - 2. Humidity
    - 3. Ventilation
    - 4. Lighting
      - a. Safelight
        - 1) Filter colors – spectral emission vs. film sensitivity
        - 2) Mounting distance and direction
        - 3) Bulb size/wattage
        - 4) Safelight testing
      - a. Overhead light
    - 5. Radiation shielding
    - 6. Film handling considerations
  - C. Film storage considerations
    - 1. Temperature
    - 2. Humidity
    - 3. Light
    - 4. Radiation
    - 5. Pressure
    - 6. Inventory control
  - D. Safety
    - 1. Occupational Safety & Health Administration (OSHA)
    - 2. Material safety data sheet (MSDS)
    - 3. Darkroom chemical sensitivity
- ### **II. Characteristics of Film**
- A. Properties
    - 1. Contrast
    - 2. Exposure response – speed sensitivity
    - 3. Recorded detail – spatial resolution
  - B. Latent image formation
  - C. Response curves – D-LogE, Hurter and Driffield (H&D) or characteristic
    - 1. Speed
    - 2. Control contrast – average gradient
    - 3. Exposure latitude
  - D. Reciprocity law failure
    - 1. Definition

2. Correlation to generator type and mR/mAs
3. Correlation to exposure time
4. Correlation to film-screen combination
5. Correlation to digital imaging

### **III. Image Receptor Holders and Intensifying Screens**

- A. Cassettes
  1. Purpose
  2. Construction
  3. Loading/unloading
  4. Maintenance
  
- B. Intensifying screens
  1. Purpose
  2. Construction/composition
  3. Principles of function
  4. Classification
    - a. Phosphor spectral emission
    - b. Absorption efficiency
    - c. Speed
  5. Maintenance
    - a. Handling
    - b. Cleaning
    - c. Evaluating

### **IV. Automatic Processing**

- A. Purpose
  
- B. Components
  1. Developer
  2. Fixer
  3. Wash
  4. Dryer
  
- C. Systems
  1. Transport
  2. Replenishment
  3. Recirculation
  4. Temperature control
  5. Dryer
  
- D. Film feed
  
- E. Maintenance/cleaning
  
- F. Quality control and documentation

## **V. Artifacts**

- A. Types
- B. Causes
- C. Effects
- D. Preventive/corrective maintenance

## **VI. Silver Recovery**

- A. Rationale
- B. Methods
  - 1. Electrolytic
  - 2. Metallic replacement/ion exchange
  - 3. Discarded film
- C. Security

## **VII. Quality Management Program for Analog Equipment**

- A. Mammography equipment
  - 1. Processor QC
  - 2. Screen/film contact (8 cassettes)
  - 3. Darkroom cleanliness
  - 4. Phantom images
  - 5. Screen cleanliness
  - 6. Viewboxes and viewing conditions
  - 7. Darkroom fog
  - 8. Compression force
  - 9. Repeat analysis
  - 10. Analysis of fixer retention in film
  - 11. Visual checklist
  - 12. Review medical physicists annual survey report
- B. Darkroom
  - 1. Purpose of quality assurance
  - 2. Regulations and recommendations
- C. Processor
  - 1. Purpose of quality assurance
  - 2. Control film
  - 3. Data plotted
    - a. Film medium density
    - b. Film density difference
    - c. Film base and fog

4. Corrective measures
  - a. Chemistry
    - 1) Developer
    - 2) Fixer
    - 3) Water (rinse)
  - b. Temperature
    - 1) Developer
    - 2) Fixer
    - 3) Water (rinse)
    - 4) Dryer
  - c. Time
  - d. Film
  - e. Ventilation

### **VIII. Weekly Quality Assurance Procedures**

- A. Screen cleanliness
  1. Purpose
  2. Procedure
  3. Documentation
- B. Viewbox maintenance
  1. Purpose
  2. Procedure
  3. Magnifying glasses
  4. Documentation
- C. Phantom images
  1. Purpose
  2. Congruity of image
    - a. Cassette
    - b. Phototimer
    - c. Viewbox
  3. Documentation
    - a. Exposure time
    - b. Optical density
    - c. Density difference
    - d. Fibers
    - e. Speck groups
    - f. Masses
  4. Problem-solving steps

### **IX. Monthly Quality Assurance Procedures**

- A. Visual checklist
  1. Purpose
  2. Documentation



## **X. Quarterly Quality Assurance Procedures**

- A. Repeat analysis
  - 1. Purpose
  - 2. Analyze data
  - 3. Document data
  - 4. Problem-solving steps
  
- B. Fixer retention test
  - 1. Purpose
  - 2. Procedure
  - 3. Documentation
  - 4. Problem-solving steps

## **XI. Semiannual Quality Assurance Procedures**

- A. Darkroom fog test
  - 1. Purpose
  - 2. Procedure
  - 3. Documentation
  - 4. Problem-solving steps
  
- B. Film-screen contact test
  - 1. Purpose
  - 2. Procedure
  - 3. Documentation
  - 4. Problem-solving steps
  
- C. Compression test
  - 1. Purpose
  - 2. Procedure
  - 3. Documentation
  
- D. Problem-solving steps

# Film-Screen Imaging Technical Factors

## Description

Content establishes a knowledge base of film-screen technical factors that govern the recording of mammographic images.

## Objectives

1. Describe different film-screen combinations, their functions within the imaging system and their effect on the mammographic image.
2. Describe different types of processing and their importance in the mammographic imaging chain.
3. Identify processing artifacts on the mammography film.

## Content

### I. Technical Variables

- A. Density
- B. Contrast
- C. kVp
  1. Range
  2. Rationale
  3. Effect on image quality
  4. Relationship to exposure time/reciprocity law failure and optimum optical density
  5. Effect on contrast
- D. mAs
  1. Range
  2. Relationship to mR
  3. Relationship to exposure time/reciprocity law failure
  4. Effect on density
- E. Reciprocity law failure
  1. Definition
  2. Correlation to generator type and mR/mAs
  3. Correlation to exposure time
  4. Correlation to film-screen combination

### II. Screen and Film Variables

- A. Screens
  1. Intensifying differences
    - a. Slow
    - b. Medium
    - c. Fast

- d. Rare earth
- 2. Single screens
  - a. Advantages
  - b. Disadvantages
- 3. Double screens
  - a. Advantages
  - b. Disadvantages
- 4. Cassettes
- 5. Care and maintenance of screens
- 6. MQSA requirements and tests
- 7. Artifacts

**B. Image receptors (film systems)**

- 1. Single emulsion
- 2. Double emulsion
- 3. Speed
- 4. Contrast
- 5. H&D curves
- 6. Artifacts

**III. Processing**

**A. Darkroom**

- 1. Safelight standard
- 2. Airflow (ventilation)
- 3. Humidity
- 4. Design
- 5. MQSA requirements

**B. Dedicated and nondedicated processing**

**C. Standard and extended processing**

- 1. Chemistry
- 2. Temperature
- 3. Replenishment rates
- 4. Roller transport
- 5. Guideshoes
- 6. Airflow

**D. Artifacts**

- 1. Before exposure artifacts
- 2. After exposure artifacts
- 3. Artifacts associated with film processing

## Appendix

This section provides an inventory of pre-existing knowledge and skills gained through entry-level radiography education and reinforced by professional practice. The content in this section aids technologists in career planning and provides preassessment tools for program managers to use in developing candidate selection criteria.

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 the appropriate medical asepsis and sterile technique.

- 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.

ASRT

## Digital Image Acquisition and Display

### Description

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

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

### Objectives

- Define terminology associated with digital imaging systems.
- Describe the various types of digital receptors.
- Describe the response of digital detectors to exposure variations.
- Compare the advantages and limits of each receptor type.
- Evaluate the spatial resolution and dose effectiveness for digital radiography detectors.
- Describe the histogram and the process or histogram analysis as it relates to automatic rescaling and determining an exposure indicator.
- Relate the receptor exposure indicator values to technical factors, system calibration, part/beam/plate alignment and patient exposure.
- Describe the response of PSP systems to background and scatter radiation.
- Use appropriate means of scatter control.
- Avoid grid use errors associated with grid cutoff and Moiré effect.
- Identify common limitations and technical problems encountered when using PSP systems.
- Employ appropriate beam/part/receptor alignment to avoid histogram analysis errors.
- Associate impact of image processing parameters to the image appearance.
- Apply the fundamental principles to digital detectors.
- Evaluate the effect of a given exposure change on histogram shape, data width and image appearance.
- Describe the conditions that cause quantum mottle in a digital image.
- Formulate a procedure or process to minimize histogram analysis and rescaling errors.
- Examine the potential impact of digital radiographic systems on patient exposure and methods of practicing the as low as reasonably achievable (ALARA) concept with digital systems.
- Describe picture archival and communications system (PACS) and its function.
- Identify components of a PACS.
- Define digital imaging and communications in medicine (DICOM).
- Describe HIPAA concerns with electronic information.
- Identify common problems associated with retrieving/viewing images within a PACS.

## 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 (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 and 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.
- Differentiate between civil and criminal liability.
- Define tort and explain the differences between intentional and unintentional torts.



## 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.
- 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 Radiologic Science and Health Care

### Description

Content provides an overview of the foundations of radiography and the practitioner's role in the health care delivery system. Principles, practices and policies of health care organizations are examined and discussed in addition to the professional responsibilities of the radiographer.

### Objectives

- Identify other health science professions that participate in the patient's total health care.
- Identify various settings involved in the delivery of health care.
- Discuss the reimbursement/payment options for health care services.
- Discuss the role and value of a mission statement to the operation of an institution.
- Describe relationships and interdependencies of departments within a health care institution.
- Discuss the responsibilities and relationships of all personnel in the radiology department.
- Differentiate between quality improvement/management, quality assurance and quality control.
- Differentiate among accreditation types.
- Define credentialing, certification, registration, licensure and regulations.
- Discuss career opportunities and advancement for the radiographer.
- Identify the benefits of continuing education as related to improved patient care and professional enhancement.

## Medical Terminology

### Description

Content provides an introduction to the origins of medical terminology. A word-building system is introduced and abbreviations and symbols are discussed. Also introduced is an orientation to understanding radiographic orders and diagnostic report interpretation. Related terminology is addressed.

### Objectives

- Apply the word-building process.
- Interpret medical abbreviations and symbols.
- Critique orders, requests and diagnostic reports.
- Define medical imaging and radiation oncology terms.
- Translate medical terms, abbreviations and symbols into common language from a medical report.

ASRT

## 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.

- 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

## Pharmacology and Venipuncture

### Description

Content provides basic concepts of pharmacology, venipuncture and administration of diagnostic contrast agents and intravenous medications. The appropriate delivery of patient care during these procedures is emphasized.

### Considerations

Students should successfully complete patient care objectives (including CPR and basic life support (BLS) certification), as well as objectives related to the anatomy and physiology of the circulatory and excretory systems, prior to introducing this educational content.

Though regulations regarding the administration of contrast media and intravenous medications vary between states and institutions, the official position of the American Society of Radiologic Technologists is that venipuncture falls within the radiologic technology profession's general scope of practice and practice standards. Therefore, it should be included in the didactic and clinical curriculum included with demonstrated competencies in all appropriate disciplines regardless of the state or institution where the curriculum is taught.

In states or institutions where students are permitted to perform intravenous injections, the program has specific ethical and legal responsibilities to the patient and the student. The student shall be assured that:

- Legal statutes allow student radiographers to perform venipuncture.
- Professional liability coverage is adequate.
- Adequate supervision is provided.
- Appropriate, structured laboratory objectives are identified.
- Evaluation and demonstration of competency occur before venipuncture is performed unsupervised.

### Objectives

- Distinguish among the chemical, generic and trade names for drugs in general.
- Describe pharmacokinetic and pharmacodynamic principles of drugs.
- Explain the uses and impact of drug categories on the patient.
- Define the categories of contrast agents and give specific examples for each category.
- Explain the pharmacology of contrast agents.
- Describe methods and techniques for administering various types of contrast agents.
- Identify and describe the routes of drug administration.
- Demonstrate appropriate venipuncture technique.
- Differentiate between the two major sites of intravenous drug administration.
- Identify, describe and document complications associated with venipuncture and appropriate actions to resolve these complications.
- Discuss the various elements of initiating and discontinuing intravenous access.
- Differentiate and document dose calculations for adult and pediatric patients.

- Prepare for injection of contrast agents/intravenous medications using aseptic technique.
- Explain the current legal status and professional liability issues of the radiographer's role in contrast and/or drug administration.

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 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.

# Radiation Physics

## Description

Content is designed to establish a basic knowledge of physics pertinent to developing an understanding of radiations used in the clinical setting. Fundamental physical units, measurements, principles, atomic structure and types of radiation are emphasized. Also presented are the fundamentals of x-ray generating equipment, x-ray production and its interaction with matter.

## Objectives

- Define the fundamental units of the English, metric and Système International d'Unités (SI) systems.
- Calculate various unit conversions.
- Demonstrate applications of the general principles that relate to inertia, work, energy and momentum.
- Describe Bohr's theory of atomic structure.
- Compare the characteristics and functions of a proton, neutron and electron.
- Discuss the energy levels of the atom.
- Define the terms relating to atomic nomenclature.
- Compare covalent bonding and ionic bonding.
- Describe the process of ionization.
- Differentiate between the characteristics of a mixture, substance and element.
- Classify the characteristics of an element using the periodic table.
- Compare the characteristics of a molecule and compound.
- Describe the nature of light.
- Explain the relationship between wavelength, frequency and velocity.
- Differentiate between the radiations of the electromagnetic (EM) spectrum.
- Explain the relationship of energy and frequency to Planck's constant.
- Distinguish between electrical charge and electrical field.
- Describe the methods of electrification.
- Explain the laws of electrostatics and their application.
- Describe the properties and laws of magnetism.
- Explain the electronic spin of an element to its potential magnetic properties.
- Describe the principle of magnetic induction.
- Define potential difference, current, resistance, circuit and electric power.
- Compare the characteristics of direct and alternating currents.
- Compare electrical measuring devices.
- Discuss electrical protective devices.
- Discuss the interaction between electric and magnetic fields.
- Describe the characteristics and functions of a cathode and rotating anode.
- Describe the construction and function of tube housing.
- Identify the parts of an x-ray tube.
- Determine heat units and cooling characteristics of x-ray tube housings.

- Propose methods to extend tube life.
- Discuss application and components of automatic exposure devices.
- State the principles of x-ray production.
- Compare the production of bremsstrahlung with the production of characteristic radiations.
- Compare various photon interactions in terms of description of interaction, relation to atomic number and applications.
- Discuss relationships of wavelength and frequency to beam characteristics.
- Define units of radiation measurement and provide an example of its application.

ASRT

## 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.

## 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.

- 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.

## Radiographic Pathology

### Description

Content introduces concepts related to disease and etiological considerations with emphasis on radiographic appearance of disease and impact on exposure factor selection.

### Objectives

- Define basic terms related to pathology.
- Describe the basic manifestations of pathological conditions and their relevance to radiologic procedures.
- Discuss the classifications of trauma.
- Describe imaging procedures used in diagnosing disease.
- List the causes of tissue disruption.
- Describe the healing process.
- Identify complications connected with the repair and replacement of tissue.
- Describe the various systemic classifications of disease in terms of etiology, types, common sites, complications and prognosis.
- Describe the radiographic appearance of diseases.
- Identify imaging procedures and interventional techniques appropriate for diseases common to each body system.
- Identify diseases caused by or connected to genetic factors.

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