

Table 1. Breast imaging residency training curriculum

By means of clinical experience, lectures, conferences, textbooks, syllabi, journal reprints, online references, teaching files, and other teaching materials, the resident should become familiar with and understand the following topics in breast disease:

I. Breast anatomy, physiology, and pathology

- A. Breast development
- B. Normal breast anatomy and histology; alteration with age, pregnancy, menstrual cycle, and hormonal effects; male breast anatomy
- C. Regional lymph node anatomy and drainage patterns
- D. Pathologic appearance and clinical significance of:
 1. Benign breast processes including fibrocystic changes, usual duct hyperplasia, columnar cell lesions without atypia, fibroadenomas, and fat necrosis
 2. Atypical ductal hyperplasia, flat epithelial atypia, lobular neoplasia (atypical lobular hyperplasia and lobular carcinoma in situ), papillary lesions, radial scar/complex sclerosing lesions, and other high risk lesions
 3. Ductal carcinoma in situ, including its histologic subtypes
 4. Invasive ductal carcinoma
 - a. not otherwise specified
 - b. variants or subtypes (mucinous, medullary, papillary, tubular)
 5. Invasive lobular carcinoma
 6. Multifocal and multicentric carcinoma
 7. Less commonly encountered cancers, such as Paget's disease and inflammatory carcinoma
 8. Other malignancies involving the breast, including phyllodes tumor, lymphoma, leukemia, sarcomas, metaplastic carcinomas, and metastases
- E. Radiologic-pathologic considerations
 1. Histologic grading
 2. Tumor cell receptor and molecular profile
 3. Genetic mapping
 4. Pathologic staging
 5. Multifocal and multicentric carcinoma
 6. Margin analysis for specimens containing malignancy
 7. Assessment for targeted microcalcifications within biopsy specimen

II. Epidemiology

- A. Risk factors for developing breast cancer
 1. Indications for genetic counseling/testing
 2. Risk assessment methods/tools
 3. Breast density as a risk factor and its effect on mammographic sensitivity
- B. Breast cancer incidence and mortality, including longitudinal trends
- C. Breast cancer staging and survival rates by stage
- D. Prevalence and incidence screening; evidence-based rationale for screening mammography
- E. Evidence, indications, and limitations for supplemental screening

III. Mammographic equipment and technique

- A. For screen-film and full-field digital mammography
 1. Features of dedicated mammographic units, including target, filtration, automatic exposure control, and grids
 2. Factors affecting optical density, contrast, sharpness, and noise
 3. Selection of technique factors, including effects of milliamp-seconds, kilovolt peak, target and filter material choice, and density settings on image quality and radiation dose
 4. Effect of breast thickness and composition on technique, image quality, and radiation dose
 5. Mammographic positioning for craniocaudal and mediolateral oblique views
 6. Mammographic positioning for women with breast implants
 7. Rationale for breast compression
 8. Image quality assessment for proper breast positioning, compression, exposure, contrast, sharpness, noise, and image labeling
- B. For FFDM
 1. Optimal viewing conditions
 2. Characteristics of FFDM systems, including advantages and limitations
 3. Effects of postprocessing on the digital mammographic image
 4. Effect of signal-to-noise ratio on radiation dose
 5. Dedicated high-luminance, high-resolution viewing monitors
 6. ACR Practice Guideline for the Performance of Whole Breast Digital Mammography [3]
- C. SF mammography
 1. Characteristics of mammographic SF systems
 2. Film processing
 3. Effect of screen-film speed, optical density, and film processing on radiation dose
 4. High-intensity viewboxes, viewbox masking

Table 1. Continued**IV. Mammography quality assurance**

- A. Familiarity with content in the ACR Mammography Quality Control Manual [4] and/or ACR Digital Mammography Quality Control Manual [5]
- B. Purpose and frequency of performance of quality control tests performed by the technologist and physicist
- C. Demonstrate proficiency in recognizing the mammographic appearance of artifacts for both screen-film and digital mammography
- D. Regulation
 - 1. Equipment, quality control, and personnel (radiologist, technologist, physicist) requirements for ACR accreditation and MQSA certification
 - 2. Responsibilities of the lead interpreting physician
- E. Medical audit
 - 1. Audit definitions as provided by BI-RADS [6,7]
 - 2. Desirable goals and benchmarks for standard outcome parameters, for both screening and diagnostic mammography [8-10]
 - 3. Auditing requirements for MQSA certification [11]
 - 4. Knowledge of National Mammography Database (NMD)

V. Mammographic interpretation

- A. Optimal viewing conditions for both analog and digital images, including a low ambient light environment
- B. Demonstrate proficiency in:
 - 1. Recognizing normal mammographic anatomy
 - 2. Recognizing the mammographic features of characteristically benign and suspicious breast calcifications
 - 3. Recognizing the mammographic features of characteristically benign and suspicious breast masses
 - 4. Recognizing the mammographic appearance of indirect signs of malignancy (architectural distortion, asymmetries, etc)
 - 5. Familiarity with BI-RADS descriptors [6,7]
 - 6. Recognizing the mammographic features of the surgically altered breast, including augmentation, reduction mammoplasty, and the reconstructed breast
 - 7. Recognizing the mammographic features of probably benign (BI-RADS category 3) lesions
 - 8. Principles, methods, strengths, and pitfalls of computer-aided detection and double reading
 - 9. Principles, methods, strengths, and pitfalls of digital breast tomosynthesis

VI. Screening mammography

- A. Randomized clinical trials, case-control studies, service-screening studies: purpose, methods, results
- B. Pitfalls in evaluating screening results: lead-time bias, length-bias sampling, selection bias, prevalence versus incidence screening, interval cancer rate, survival rates
- C. Relative screening efficacy of clinical breast examination, breast self-examination, and mammography
- D. Benefit-risk assessment, including radiation risk and false positives
- E. Cost-effectiveness
- F. Controversies regarding screening women aged 40-49 years; younger than age 40
- G. Screening guidelines of ACR, American Cancer Society, National Cancer Institute, US Preventative Services Task Force, etc
- H. Logistics and throughput issues in the performance and interpretation of screening mammography examinations
 - I. ACR Practice Guideline for the Performance of Screening Mammography [3]

VII. Diagnostic (problem-solving) mammography

- A. Techniques and indications for and value of supplementary mammographic views
- B. Familiarity with mammography BI-RADS descriptors [6,7]
- C. Demonstrate proficiency in:
 - 1. Performing the work-up of lesions seen on only one standard (mediolateral oblique or craniocaudal) screening view
 - 2. Three-dimensional lesion localization
 - 3. Correlation of palpable with imaging findings
 - 4. Evaluation and management of a palpable mass (or other focal symptoms) when there are no associated mammographic findings
 - 5. Assessment of extent of disease for suspicious and for known-malignant lesions
 - 6. Evaluation of the postoperative breast (including reduction, breast conservation, reconstruction and augmentation)
 - 7. Evaluation of the male breast
 - 8. ACR Practice Guideline for the Performance of Diagnostic Mammography [3]

VIII. Breast ultrasound

- A. Equipment and physical principles, including the role of harmonic and color Doppler imaging
- B. Techniques, including assessment of image quality, image labeling
- C. Indications
- D. Demonstrate proficiency in:
 - 1. Scanning the breast
 - 2. Recognizing normal sonographic anatomy
 - 3. Recognizing features of simple cysts, complicated cysts, and complex cystic and solid masses
 - 4. Recognizing differential features of benign and malignant solid masses
 - 5. Familiarity with breast US BI-RADS descriptors [6,7]
 - 6. Correlation with findings at mammography and clinical breast examination

Table 1. Continued

7. Evaluation and management of young women with symptoms
 8. Assessment of extent of disease for known malignancy or highly suspicious lesions, including evaluation of the axilla
 9. Evaluation and management of the patient with mastitis/abscess symptoms
 10. Limitations in the detection and assessment of microcalcifications
 11. Controversies regarding the role of screening whole-breast ultrasound examination
 12. ACR Practice Guideline for the Performance of a Breast Ultrasound Examination [3]
 13. ACR Breast Ultrasound Accreditation Program
- E. Auditing—Familiarity with definitions and procedures as provided in BI-RADS [6,7]
- IX. Breast MRI**
- A. Equipment and physical principles
 - B. Techniques
 - C. Indications
 - D. Strengths and limitations of kinetic and morphologic analysis
 - E. Demonstrate proficiency in:
 1. Recognizing normal MRI anatomy
 2. Categorization of enhancing lesions as mass, nonmass, or focus (foci)
 3. Recognizing differential features of benign and malignant masses
 4. Recognizing differential features of benign and malignant nonmass enhancement
 5. Evaluation of background parenchymal enhancement and tissue composition
 6. Familiarity with breast MRI BI-RADS descriptors [6,7]
 7. Evaluating implant integrity and pulse sequences specific to this evaluation
 8. Correlation with findings at mammography, ultrasound, and clinical breast examination
 9. Use of targeted ultrasound for MRI detected lesions
 10. Evaluation of need for and approach to MRI guided biopsy
 11. Post MR biopsy evaluation, pathology correlation, and follow-up
 12. Limitations in the detection and assessment of lesions presenting as microcalcifications
 13. Controversies regarding the role breast MRI examination for screening and extent of disease evaluation
 14. ACR Practice Guideline for the Performance of MRI of the Breast [3]
 15. Knowledge of ACR Breast MRI Accreditation program
 - F. Auditing—Familiarity with definitions and procedures as provided in BI-RADS [6,7]
- X. Reporting and medicolegal aspects of breast imaging**
- A. Demonstrate proficiency in producing breast imaging reports, including:
 1. ACR BI-RADS lexicon terms for mammography, ultrasound, and MRI [6,7]
 2. Lesion location
 3. Categorization of breast composition (BI-RADS breast density descriptors) [6,7]
 4. Final assessment categories (ACR BI-RADS; MQSA regulatory requirements) [6,7,11]
 5. Management recommendations
 6. Concordance between lesion descriptors and assessment categories
 7. Concordance between assessment categories and management recommendations
 8. Reporting of assessment-management discordance scenarios as provided in BI-RADS [6,7]
 - B. MQSA regulatory requirements for reporting mammography results to referring clinician and patient [11]
 - C. Medicolegal aspects of all breast imaging and interventional procedures
 1. Understanding the supervisory responsibility for approving the technical quality of a given examination
 2. Communication issues and follow-up of abnormal findings
 3. Informed consent as appropriate
 4. Determining radiologic-pathologic concordance and reporting of further management and follow up recommendations
- XI. Interventional procedures**
- A. Principles, indications and contraindications, equipment, preparation, technique, advantages, disadvantages, accuracy, and auditing for:
 1. Needle-wire localization (and other localization methods as applicable) guided by mammography, ultrasound and MRI
 2. Core needle biopsy by stereotactic, ultrasound, and MRI guidance
 3. Fine needle aspiration, if available, with ultrasound guidance
 4. Cyst aspiration with ultrasound guidance
 5. Targeted ultrasound to substitute ultrasound guidance for MRI guidance where possible
 6. Seroma and other fluid-collection aspirations with ultrasound guidance
 7. Use and limitations of using markers to indicate the site of percutaneous biopsy
 7. Specimen radiography, including paraffin block radiography
 8. Galactography, if available
 - B. Assessment of imaging-pathologic concordance
 - C. Postprocedure follow-up imaging
 - D. ACR Guideline for the Performance of Ultrasound-Guided Breast Interventional Procedures [3]
 - E. ACR Guideline for the Performance of Stereotactically Guided Breast Interventional Procedures [3]
 - F. ACR Ultrasound-Guided Breast Biopsy Accreditation Module (part of the ACR Breast Ultrasound Accreditation Program)
 - G. ACR Stereotactic Breast Biopsy Accreditation Program
 - H. ACR Breast MRI Accreditation Program

Table 1. Continued**XII. Therapeutic and management considerations**

- A. Basic understanding of breast cancer treatment options
- B. Understand the key role of each member of the multidisciplinary team needed to care for a breast cancer patient, including the radiation oncologist, surgeon, medical oncologist, pathologist, radiologist, and the patient
- C. Role of breast imaging in planning and monitoring of breast cancer treatment and posttreatment follow-up
- D. ACR Practice Guideline for the Management of Ductal Carcinoma In-Situ of the Breast (DCIS) [3]
- E. ACR Practice Guideline for Breast Conservation Therapy in the Management of Invasive Breast Carcinoma [3]
- F. ACR Appropriateness Criteria for: Breast Microcalcifications; Nonpalpable Breast Masses; Palpable Breast Masses; Stage I Breast Carcinoma [12]

XIII. Economics of breast imaging practice

- A. Basic understanding of coding and billing
- B. Revenue positive, revenue neutral, and revenue negative breast imaging examinations

XIV. Other recommendations

- A. Minimum of 12 full-time equivalent weeks of clinical training in breast imaging during 4-year residency. It is recommended that the initial month of breast imaging training be given in the first or second year of residency. It is strongly suggested that all 3 months be completed within the first three (3) years of residency training with an additional 1-2 weeks in the last 6 months of training to include the interpretation of 240 screening examinations to meet current FDA requirements. Alternatively, 10 weeks could be completed in the first 36 months with 2 weeks reserved to include screening interpretation in the final 6 months of training.
- B. Active participation in screening and diagnostic mammography interpretation
- C. Hands-on performance of breast ultrasound examinations
- D. Exposure to all types of interventional breast imaging procedures, but especially needle-wire localization and ultrasound-guided core biopsy
- E. Active participation in breast MRI interpretation
- F. Formal teaching conferences (lectures, case presentations)
- G. Imaging-pathologic correlation conferences and multidisciplinary breast cancer case conferences, if practical
- H. Direct observation or video image review of mammographic positioning for routine and supplementary views
 - I. Review of teaching file materials (film or digital images), especially using computer-based interactive formats
- J. Breast imaging textbooks available in department and/or breast imaging section library
- K. Reprint file or reference library including breast imaging materials
- L. Log of numbers of mammograms, sonograms, and MRI examinations interpreted and of procedures performed by each resident, as appropriate

XV. Breast Imaging Fellowship Training Curriculum

- A. Minimum of 6 full-time equivalent months training after completion of residency; 12 months is recommended.
- B. The fellow should acquire much deeper knowledge of all topics for which the resident should have familiarity and understanding (as listed in the Breast Imaging Residency Training Curriculum)
- C. Fellows should interpret many more examinations and perform many more interventional procedures than residents
- D. Demonstrate proficiency in performing all types of interventional breast imaging procedures performed at the training institution; when the number of a given interventional procedure is severely limited, these procedures should be performed by the fellow and observed by residents; if a particular interventional procedure listed above is not performed at all at the training institution, hands-on experience with this procedure should be arranged at a nearby institution, if practical
- E. Demonstrate proficiency in interacting with patients, including how to recommend biopsy, how to explain a cancer diagnosis, and how to develop sensitivity to patients' emotional needs
- F. Experience interacting with members of the multidisciplinary team involved in patient care
- G. Familiarity with breast molecular imaging
- H. Familiarity with performing a medial audit
 - I. Teaching medical students and residents
- J. Encourage participation in research projects
- K. Familiarity with performing breast positioning and setting techniques for mammographic examination
- L. Familiarity with performing technologists' quality control tests for screen-film and digital mammography
- M. Knowledge of quality control tests performed by medical physicist
- N. Knowledge of MRI artifacts and safety issues, including contrast administration
- O. Familiarity with emerging technologies, including contrast enhanced mammography
- P. Knowledge of nonconventional breast imaging techniques, such as thermography or optical imaging, and the limitations of such methods
- Q. Familiarity with emerging US techniques, such as elastography and automated breast US
- R. Observation of pathology, breast surgery, and radiation therapy practice
- S. Familiarity with risk assessment, high risk clinics, and genetic counseling