

Mammography Curriculum

Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE, Albuquerque, NM 87123-3909.

©2022 American Society of Radiologic Technologists. All rights reserved. Schools and educational programs have the ASRT's permission to use the objectives sections of the curriculum as written. The remaining sections of the curriculum can be used with attribution for the purposes of course development, program promotion or course and program documentation. For other uses, contact the ASRT for reprint permission at education@asrt.org.

Core Content

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

Objectives

- Recognize breast anatomy and development.
- Identify internal and external breast anatomy as well as its mammographic appearance.
- List tissue layers and cellular components of the breast.
- Describe the sequence of a mammographic examination procedure.
- Conduct a patient assessment.
- List types of mammographic procedures.
- Discuss the Breast Imaging Reporting and Data System (BI-RADS®)
- Recognize breast pathology and cancer classification systems.
- Explain breast cancer treatment options.
- List the components of a mammography machine.
- Describe the digital imaging workflow.
- Explain quality assurance and quality control procedures and regulations.
- Identify the indications and equipment used for breast sonography.
- Discuss the positioning and imaging factors associated with breast sonography.

Breast Anatomy and Mammographic Correlation

- I. The Breast**
 - A. Developmental stages
 - B. Life cycle
 - C. Female
 - D. Male
 - E. Hormonal and surgical changes
- II. External Anatomy and Mammographic Appearance**
 - A. Nipple and areola
 - B. Skin
 - C. Breast margins and axillary tail
 - D. Anatomical reference terminology
- III. Internal Anatomy and Mammographic Appearance**
 - A. Fascial layers
 - B. Retromammary fat space
 - C. Tissue types (i.e., supporting, fibrous, glandular and adipose)
 - D. Systems (i.e., lymphatic and vascular)
 - E. Pectoral muscle

- IV. Cellular Components (i.e., epithelial cells, myoepithelial cells and basement membrane)
- V. Breast Anomalies

Patient Examination

- I. Communication (e.g., patient education)
- II. Assessment
 - A. Documentation
 - 1. Medical history
 - 2. Clinical findings
 - 3. Radiopaque markings
 - B. Patient limitations
 - C. Clinical breast examination
- III. Positioning
 - A. Standard projections
 - B. Replacing or problem-solving projections
 - C. Modifications and technical adjustments
- IV. Breast Procedures
 - A. Screening
 - B. Diagnostic
 - C. Digital breast tomosynthesis (DBT)
 - D. Interventional
 - 1. Biopsy procedures
 - 2. Localization
 - 3. Pre- and post-procedure care
 - E. Other modalities
 - 1. Ultrasound (US)
 - 2. Magnetic resonance imaging (MRI)
 - 3. Contrast enhanced mammography (CEM)
 - 4. Cone beam breast computed tomography (CBBCT)
 - 5. Computerized tomographic laser mammography (CTLTM)
 - 6. Nuclear medicine (i.e., BSGI, PEM and MBI)
- V. Image Evaluation and Quality Control

Breast Reporting, Pathology and Treatment

- I. Breast Imaging Reporting and Data System (BI-RADS®)
 - A. Imaging terminology
 - B. Report organization

- C. Assessment structure
- D. Classification system

II. Pathology

- A. Benign
- B. High risk
- C. Malignant
- D. Breast cancer classifications
 - 1. TNM staging and grading
 - 2. Multifocal or multicentric
 - 3. Receptors and HER2 +/-

III. Treatment Options

- A. Surgery
- B. Radiation therapy
- C. Systemic therapy (e.g., chemo, hormone, immuno therapy)
- D. Prophylaxis

Equipment and Technical Applications

I. Dedicated Mammography Equipment

- A. Components
 - 1. C-arm
 - 2. X-ray tube
 - 3. Image detector
 - 4. Compression devices
- B. Beam geometry effects (e.g., heel effect, magnification)
- C. Technical factors

II. Digital Workflow

- A. Acquisition workstation
- B. Radiologist workstation
- C. Computer-aided detection systems (CAD)
- D. Image management (PACS/MIMPS)
- E. Tele mammography

III. Quality Assurance and Quality Control

- A. Personnel requirements and responsibilities
 - 1. Interpreting physicians
 - 2. Mammographers
 - 3. Medical physicists
 - 4. Re-establishing qualifications for personnel
 - 5. Modality specific training (Mammography Quality Standards Act [MQSA])
- B. Facility quality control programs
 - 1. Technologist tests

2. Medical Physicist tests
 3. Lead interpreting physician (LIP) review
 4. Quality standards (Enhancing Quality Using the Inspection Program [EQUIP])
- C. Guidelines and standards
1. Certification
 2. Accreditation
 3. MQSA Inspection requirements

Breast Sonography

- I.** Indications
- II.** Equipment
 - A. Monitor
 - B. Transducers
- III.** Positioning (i.e., arm placement and degree of obliquity)
- IV.** Imaging
 - A. Appearance (i.e., normal, benign and malignant)
 - B. Labeling
 1. Laterality
 2. Clockface ordination
 3. Distance from nipple
 4. Region localization
 5. Scan planes and measurements
 - C. Mammographic correlation
- V.** Bioeffects and Safety

Resources

This list of resources is designed to help educators sample the pool of available references and study materials in medical imaging. The resources list should be viewed as a snapshot of available materials. Omission of any one title is not intentional. Because the body of literature and media related to the field is dynamic, educators are encouraged to find additional sources for recent updates, revisions, and additions to this collection.

2018 ACR Digital Mammography QC Manual Resources. American College of Radiology website. <https://www.acraccreditation.org/Resources/Digital-Mammography-QC-Manual-Resources>

2022 *Comprehensive Accreditation Manual for Hospitals*. Oak Brook, IL: Joint Commission Resources; 2016. ISBN 1599409498

Adler A, Carlton R. *Introduction to Radiologic Science and Patient Care*. 7th ed. St. Louis, MO: Elsevier Saunders; 2016. ISBN 0323315798

Andolina VF, Lille SL. *Mammographic Imaging: A Practical Guide*. 4th ed. Baltimore, MD: Lippincott-Raven Publishers; 2010. ISBN 1605470317

Bassett LW. Imaging of breast masses: Breast imaging. *Radiol Clin North Am*. 2000;38(4):669–690.

Bassett LW, Jackson V, Fu K, et al. *Diagnosis of Diseases of the Breast*. 2nd ed. Philadelphia, PA: Saunders; 2004. ISBN 0721695639

Berns EA, Pfeiffer DE, Butler PF, et al. *Digital Mammography Quality Control Manual*. 2nd ed. Reston, VA: American College of Radiology; 2020.

Bontrager KL, Lampignano JP. *Textbook of Radiographic Positioning and Related Anatomy*. 10th ed. St Louis, MO: Mosby-Year Book Inc; 2013. ISBN 0323083889

Practice Parameters and Technical Standards. American College of Radiology website. <https://www.acr.org/Clinical-Resources/Practice-Parameters-and-Technical-Standards>

Bushong SC. *Radiologic Science for Technologists: Physics, Biology, and Protection*. 12th ed. St Louis, MO: Mosby/Elsevier; 2017. ISBN 0323353770

Cardeñosa G. *Breast Imaging Companion*. 4th ed. Philadelphia, PA: Wolters Kluwer; 2017. ISBN 1496314964

Cardeñosa G. *Clinical Breast Imaging: The Essentials*. 1st ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2015. ISBN 1451151772

Carlton RR, Adler AM. *Principles of Radiographic Imaging: An Art and a Science*. 56th ed. Clifton Park, NY: Delmar, Cengage Learning; 2013. ISBN 1439058725

Carroll QB. *Radiography in the Digital Age: Physics, Exposure, Radiation Biology*. 3rd ed. Springfield, IL: Charles C. Thomas; 2018. ISBN 0398080968

Carter C, Vealé B. *Digital Radiography and PACS*. 4th ed. St. Louis, MO: Mosby/Elsevier; 2022. ISBN 0323086446

Chen SC, Carton AK, Albert M, Conant EF, Schnall MD, Maidment AD. Initial Clinical Experience with Contrast-Enhanced Digital Breast Tomosynthesis. *Acad Radiol*. 2007;14(2):229-238.

Chung H, Parikh J. Telemammography: Technical Advances Improve Patient Access in Breast Care. *J Breast Imaging*. 2020; 2(2): 152-156.

Cook DM, Young TA. *Ethical and Legal Issues for Imaging Professionals*. 2nd ed. St. Louis, MO: Mosby; 2007. ISBN 0323045995

Dabbs DJ. *Breast Pathology*. 2nd ed. Philadelphia, PA: Elsevier; 2017. ISBN 0323389619

Dixon A. *Breast Ultrasound: How, Why and When*. 1st ed. Edinburgh, NY: Churchill Livingstone/Elsevier; 2008. ISBN 0443100764

D'Orsi CJ. *ACR BI-RADS Atlas: Breast Imaging Reporting and Data System*. 5th ed. Reston, VA: American College of Radiology; 2014. ISBN 155903016X

Durand MA, Haas BM, Yao X, et al. Early Clinical Experience with Digital Breast Tomosynthesis for Screening Mammography. *Radiology*. 2015;274(1): 85-92.

Edge SB, et al. *AJCC Cancer Staging Handbook*. 78th ed. New York, NY: Springer; 2010. ISBN 0387884424

Evans A, et al. Quantitative Shear Wave Ultrasound Elastography: Initial Experience in Solid Breast Masses. *Breast Cancer Research*. 2010;12(6):R104.

Gao Y, Moy L, Heller S. Digital Breast Tomosynthesis: Update on Technology, Evidence, and Clinical Practice. *RadioGraphics*. 2021; 41(2): 321-337.

Gater L. Digital Mammography: State of The Art. *Radiol Technol*. 2002; 173(5):446–457.

Gheonea IA, Donoiu L, Camen D, Popescu FC, Bondari S. Sonoelastography of Breast Lesions: A Prospective Study Of 215 Cases with Histopathological Correlation. *Rom J Morphol Embryol*. 2011;52(4):1209-1214.

Gilbert FJ, Astley SM, Gillan MG, et al. Single Reading with Computer-Aided Detection for Screening Mammography. *N Engl J Med*. 2008;359(16):1675-1684.

Gromet M. Comparison of Computer-Aided Detection to Double Reading of Screening Mammograms: Review Of 231,221 Mammograms. *AJR Am J Roentgenol*. 2008;19(4):854-859.

Gurley LT, Callaway WJ, eds. *Introduction to Radiologic Technology*. 78th ed. Maryland Heights, MO: Mosby; 2011. ISBN 0323073514

Harris JR, Lippman ME, Morrow M, Osborne CK. *Diseases of the Breast*. 5th ed. Philadelphia, PA: Wolters Kluwer/Lippincott Williams & Wilkins; 2014. ISBN 1451186274

Heywang-Köbrunner SH, Schreer I, Barter S. *Diagnostic Breast Imaging: Mammography, Sonography, MRI and Interventional Procedures*. 3rd ed. New York, NY: Thieme Medical Publishers; 2014. ISBN 3131028939

Huang HK. *PACS and Imaging Informatics: Basic Principles and Applications*. 2nd ed. Hoboken, NJ: Wiley-Liss; 2010. ISBN 0470373725

Huppe AI, Overman KL, Gatewood JB, Hill JD, Miller LC, Inciardi MF. Mammography Positioning Standards in the Digital Era: Is the Status Quo Acceptable? *AJR Am J Roentgenol*. 2017 Dec;209(6):1419-1425. doi:10.2214/AJR.16.17522.

Ikeda D, Miyake KK. *Mammography: The Requisites*. 3rd ed. St Louis, MO: Mosby; 2017. ISBN 0323329047

Johnston J, Fauber TL. *Essentials of Radiographic Physics and Imaging*. 3rd ed. St Louis, MO: Mosby; 2019. ISBN 0323339662

Ko JM, Nicholas MJ, Mendel JB, et al. Prospective Assessment of Computer-Aided Detection in Interpretation of Screening Mammography. *Am J Roentgenol*. 2006; 187(6): 1483-1491.

Kopans DB. *Breast Imaging*. 3rd ed. Baltimore, MD: Lippincott Williams & Wilkins; 2007. ISBN 0781747686

Long BW, Rollins JH, Smith BJ. *Merrill's Atlas of Radiographic Positions and Radiologic Procedures*. 15th ed. St Louis, MO: Mosby-Year Book Inc; 2016. ISBN 0323263410

Long SM, Miller LC, Botsco MA, Martin LL. *Handbook of Mammography*. 5th ed. Alberta, Canada: Mammography Consulting Services; 2010. ISBN 0986521701

Madjar H, Mendelson EB. *The Practice of Breast Ultrasound: Techniques, Findings, Differential Diagnosis*. 2nd ed. New York, NY: George Thieme Verlag; 2008. ISBN 3131243422

Mello-Thoms C. The Problem of Image Interpretation in Mammography: Effects of Lesion Conspicuity on the Visual Search Strategy of Radiologists. *Br J Radiol*. 2006; 79(2):S111-6.

Orth D. *Essentials of Radiologic Science*. 2nd ed. Philadelphia, PA: Wolters Kluwer Health/Lippincott, Williams & Wilkins; 2017. ISBN 1496317270

Pearl O. Breast Intervention and Breast Cancer Treatment Options. *Radiol Technol*. 2015; 86(5): 535-562.

Pearl O. *Mammography and Breast Imaging PREP: Program Review and Exam Prep*. 3rd ed. McGraw-Hill; 2022.

Pearl O. Positioning Challenges in Mammography. *Radiol Technol*. 2014; 85(4):417–443.

Pianykh OS. *Digital Imaging and Communications in Medicine (DICOM): A Practical Introduction and Survival Guide*. 2nd ed. NY, NY: Springer; 2012. ISBN 3642108490

Price J. *Handbook of Breast MRI*. New York, NY: Cambridge University Press; 2011. ISBN 052113966X

Raza S, Birdwell RL, Ritner JA, et al. *Specialty Imaging: Breast MRI: A Comprehensive Imaging Guide*. Salt Lake City, UT: Amirsys; 2010. ISBN 193188417X

Seeram E. *Digital Radiography: An Introduction*. Clifton Park, NY: Delmar; 2011. ISBN 1401889999

Sencha AN, Evseeva EV, Mogitov MS, et al. *Breast Ultrasound*. New York, NY: Springer; 2013. ISBN 366251074

Shepard GT. *Radiographic Image Production and Manipulation*. New York, NY: McGraw-Hill; 2003. ISBN 0071375775

Shiffman, MA. *Breast Augmentation*. Springer; 2009. eBook. ISBN 978-3540789482

Smith A. Breast Tomosynthesis: The use of breast tomosynthesis in a clinical setting. Hologic website. http://www.hologic.ca/sites/default/files/WP-00060_Tomo%20White%20Paper_Rev5.pdf

Smith A. Design Considerations in Optimizing a Breast Tomosynthesis System. Hologic website. http://breasttomo.co.uk/sites/breasttomo.co.uk/files/008-%20Design_Considerations_Optimizing_Breast_Tomo.pdf

Stavros T. *Breast Ultrasound*. 1st ed. Lippincott Williams & Wilkins. 2004.

Tabár L, Dean PB. *Teaching Atlas of Mammography*. 4th ed. New York, NY: Thieme Stuttgart; 2012. ISBN 3136408049

Appendix

Curriculum Revision Workgroup

We would like to extend special recognition to the outstanding professionals who volunteered their time as members of the curriculum revision project:

Susan Cazaux, M.B.A., R.T.(R)(M)

Stephanie Johnston, M.S.R.S., R.T.(R)(M)(BD)(BS), FASRT

Wanda McNeil Johnson, B.S.R.S., R.T.(R)(M)(CT)

Jeannean Rollins, M.R.C., R.T.(R)(CV)(M)

Erin Zubia, R.T.(R)(M)(QM)

We also wish to express our sincere appreciation for the many contributions and suggestions from the professional community over the course of this project.