

# Table of Contents

## I Methods 1

### 1 Patient History and Communication with the Patient 3

|   |   |   |    |
|---|---|---|----|
| Scheduling .....                                      | 4 | Interventions .....   | 5  |
| Patient Information .....                             | 4 | <b>Patient History</b> .....                                | 5  |
| Mammography .....                                     | 4 | Risk Factors .....  | 5  |
| Sonography .....                                      | 4 | Medical History Data Helpful for Image Interpretation ..... | 11 |
| Magnetic Resonance Imaging with Contrast Medium ..... | 5 | <b>References and Recommended Reading</b> .....             | 11 |

### 2 Clinical Findings 15

|                         |    |   |    |
|-------------------------|----|---|----|
| Purpose .....           | 16 | Palpation .....                                 | 17 |
| Techniques .....        | 16 | Assessment of Clinical Abnormalities .....      | 19 |
| Visual Inspection ..... | 16 | <b>References and Recommended Reading</b> ..... | 20 |

### 3 Mammography 21

|  |    |  |    |
|--|----|--|----|
| <b>Purpose, Accuracy, Possibilities, and Limitations</b> ..... | 22 | Film Labeling .....  | 62 |
| Indications .....  | 22 | Spot Compression .....   | 62 |
| Accuracy .....   | 22 | Magnification Technique .....  | 64 |
| Screening .....  | 24 | Positioning of Breasts with Implants .....                                     | 71 |
| Problem Solving .....  | 24 | <b>Imaging of the Specimen</b> .....   | 72 |
| <b>Mammographic Technique</b> .....                            | 25 | <b>Quality Factors</b> .....   | 74 |
| Components of the Mammographic Imaging Technique .....         | 25 | Hardware Factors that Influence Image Quality .....                            | 74 |
| Picture Archiving and Communications Systems (PACSs) .....     | 39 | Influence of the Screen–Film System and Film Processing on Image Quality ..... | 75 |
| Computer-Aided Diagnosis (CAD) .....                           | 40 | Additional Factors .....   | 76 |
| <b>Specific Requirements and Solutions</b> .....               | 40 | Quality Assurance in Mammography .....   | 76 |
| Image Sharpness .....  | 40 | <b>Reporting and Documentation of Findings</b> ..                              | 78 |
| Contrast .....   | 41 | Clinical Findings .....  | 78 |
| Noise .....  | 49 | Mammographic Report .....  | 79 |
| Radiation Dose .....   | 50 | <b>Galactography</b> .....   | 85 |
| <b>Positioning and Compression</b> .....                       | 52 | Duct Sonography and MRI .....  | 91 |
| Compression .....  | 52 | Histopathologic Assessment of Ductal Abnormalities .....                       | 91 |
| Positioning for Standard Views .....                           | 54 | <b>Pneumocystography</b> .....   | 92 |
| Positioning for Additional Views .....                         | 57 | <b>References and Recommended Reading</b> .....                                | 93 |

### 4 Sonography 97

|  |     |  |     |
|--|-----|--|-----|
| <b>Purpose, Accuracy, Possibilities, and Limitations</b> ..... | 98  | <b>Examination Technique</b> .....                             | 103 |
| Diagnosing Cysts .....   | 98  | Time-Gain Compensation .....                                   | 104 |
| Differentiating Solid Lesions .....                            | 98  | Focusing .....   | 105 |
| Diagnosing Carcinoma .....                                     | 98  | Examination Technique and Documentation .....                  | 105 |
| Imaging Assessment of Younger Women .....                      | 99  | <b>Interpreting and Documenting Sonographic Findings</b> ..... | 112 |
| Screening with Sonography .....                                | 99  | Normal Sonographic Findings .....                              | 112 |
| Ultrasonography of the Axilla .....                            | 99  | Sonographic Lesions .....                                      | 113 |
| <b>Equipment Requirements</b> .....                            | 100 | <b>References and Recommended Reading</b> .....                | 124 |
| Transducer .....   | 100 |  |     |
| Image Quality .....  | 101 |  |     |



|   |            |
|---|------------|
| <b>5 Magnetic Resonance Imaging</b>                                 | <b>127</b> |
| Purpose, Accuracy, Possibilities, and Limitations .....             | 128        |
| MR Technique .....  | 129        |
| Dynamic Contrast-Enhanced MRI (DCE-MRI)                             | 129        |
| Unenhanced MRI .....  | 131        |
| Diffusion-Weighted Imaging and MR Spectroscopy .....                | 132        |
| Scheduling and Performing Breast MRI .....                          | 132        |
| <b>6 Emerging Technologies in Breast Imaging</b>                    | <b>177</b> |
| Introduction .....  | 178        |
| Mammography .....   | 178        |
| Digital Breast Tomosynthesis .....                                  | 178        |
| Dual Energy Mammography (Spectral Mammography) .....                | 180        |
| Contrast-Enhanced Digital Mammography ...                           | 180        |
| Ultrasound .....  | 180        |
| Sonoelastography .....  | 181        |
| Automated Whole Breast and 3D Ultrasound .....                      | 181        |
| <b>7 Imaging Assessment and Percutaneous Breast Biopsy</b>          | <b>185</b> |
| Purpose, Accuracy, Possibilities, and Limitations .....             | 186        |
| Purpose .....   | 186        |
| Measures Before Histopathologic Assessment                          | 186        |
| Definitions .....   | 187        |
| Accuracy .....  | 187        |
| Possibilities, Limitations, Choice of Biopsy Method .....           | 189        |
| Patient Information, Patient Preparation, and Postbiopsy Care ..... | 192        |
| Techniques for Biopsy and Biopsy Guidance .....                     | 193        |
| Fine Needle Aspiration .....  | 193        |
| Core Needle Biopsy .....  | 194        |
| Vacuum-Assisted Breast Biopsy .....                                 | 195        |
| Biopsy Under Ultrasound Guidance .....                              | 197        |
| Stereotactic Biopsy .....   | 203        |
| MR-Guided Percutaneous Biopsy .....                                 | 207        |
| Handling the Biopsy Specimen .....                                  | 210        |
| Interpreting the Histopathologic Results .....                      | 210        |
| References and Recommended Reading .....                            | 213        |
| <b>8 Preoperative Localization</b>                                  | <b>215</b> |
| Purpose, Definition, Indications, and Side Effects .....            | 216        |
| Purpose .....   | 216        |
| Definition .....  | 216        |
| Indication .....  | 216        |
| Side Effects .....  | 216        |
| Methods and Technique .....   | 217        |
| Mammographically Guided Localization Techniques .....               | 217        |
| Ultrasound-Guided Localization .....                                | 221        |
| MR-Guided Localization .....  | 222        |
| CT-Guided Localization .....  | 222        |
| Galactographically Guided Localization .....                        | 222        |
| Materials for Lesion Localization .....                             | 222        |
| Problems and Their Solutions .....                                  | 227        |
| References and Recommended Reading .....                            | 228        |
| <b>II Appearance</b>  | <b>231</b> |
| <b>9 The Normal Breast</b>  | <b>233</b> |
| Anatomy .....   | 234        |
| The Adolescent Female Breast .....                                  | 235        |
| Histology .....   | 235        |
| Clinical Examination .....  | 235        |



|   |            |   |     |
|---|------------|---|-----|
| Mammography .....   | 235        | Macromastia .....   | 242 |
| Sonography .....  | 235        | Accessory Breast Tissue (Polymastia) .....                    | 244 |
| <b>The Mature Female Breast</b> .....   | 235        | Inverted Nipple .....   | 244 |
| Histology .....   | 235        | <b>Pregnancy and Lactation</b> .....                          | 246 |
| Clinical Examination .....  | 235        | Histology .....   | 246 |
| Mammography .....   | 236        | Clinical Examination .....                                    | 246 |
| Sonography .....  | 237        | Mammography .....   | 246 |
| Magnetic Resonance Imaging .....  | 237        | Sonography .....  | 246 |
| <b>Breast Density and Changes with Age</b> .....  | 241        | Magnetic Resonance Imaging .....                              | 246 |
| Histology .....   | 241        | <b>Breast Response with Hormone Replacement Therapy</b> ..... | 248 |
| Clinical Examination .....  | 241        | Mammography .....   | 248 |
| Mammography .....   | 241        | Sonography .....  | 248 |
| Sonography .....  | 241        | Magnetic Resonance Imaging .....                              | 248 |
| Magnetic Resonance Imaging .....  | 242        | Percutaneous Biopsy .....                                     | 248 |
| <b>Variants of Normal Findings</b> .....  | 242        | <b>References and Recommended Reading</b> ....                | 252 |
| Definition .....  | 242        |   |     |
| Anisomastia .....   | 242        |   |     |
| <b>10 Benign Breast Disorders</b> .....   | <b>255</b> |   |     |
| Definition .....  | 256        | Diagnostic Strategy and Objectives .....                      | 260 |
| Pathogenesis .....  | 256        | Mammography .....   | 261 |
| Incidence .....   | 256        | Sonography .....  | 266 |
| Histopathology .....  | 256        | Magnetic Resonance Imaging .....                              | 268 |
| Clinical Findings .....   | 258        | Percutaneous Biopsy .....                                     | 272 |
| Mammographic Density and Risk .....   | 258        | <b>References and Recommended Reading</b> ....                | 273 |
|   |            |   |     |
| <b>11 Cysts</b> .....   | <b>275</b> |   |     |
| Histology .....   | 276        | Aspiration of the Cyst .....                                  | 281 |
| Definition .....  | 276        | Pneumocystography .....                                       | 282 |
| <b>Medical History and Clinical Findings</b> .....  | 276        | Mammography .....   | 282 |
| <b>Breast Examination</b> .....   | 276        | Magnetic Resonance Imaging .....                              | 283 |
| <b>Objectives of Diagnostic Studies</b> .....   | 276        | <b>Galactocele and Oil Cysts</b> .....                        | 284 |
| <b>Diagnostic Strategy</b> .....  | 278        | Definitions .....   | 284 |
| Sonography .....  | 278        | <b>References and Recommended Reading</b> ....                | 286 |
|   |            |   |     |
| <b>12 Benign Tumors and Tumorlike Masses</b> .....  | <b>290</b> |   |     |
| <b>Hamartoma or Adenofibrolipoma</b> .....  | 290        | Angiomas .....  | 308 |
| <b>Cowden Syndrome</b> .....  | 292        | Granular Cell Tumor (Myoblastoma) .....                       | 309 |
| <b>Fibroepithelial Mixed Tumors</b> .....   | 292        | Pseudoangiomatous Stromal Hyperplasia ....                    | 309 |
| <b>Fibroadenoma, Adenofibroma, Juvenile or Giant Fibroadenoma</b> .....                                       | 292        | <b>Benign Fibroses</b> .....                                  | 310 |
| Fibroadenoma .....  | 292        | Focal Fibrous Disease or Fibrosis Mammarum ...                | 310 |
| Papilloma .....   | 306        | Amyloidosis of the Breast .....                               | 310 |
| Lipoma .....  | 306        | Steatocystoma Multiplex .....                                 | 310 |
| <b>Rare Benign Tumors</b> .....   | 306        | Intramammary Lymph Nodes .....                                | 310 |
| Leiomyoma, Neurofibroma, Neurilemmoma, Benign Spindle Cell Tumor (Myofibroblastoma), Chondroma, Osteoma ..... | 306        | <b>References and Recommended Reading</b> ....                | 312 |
|   |            |   |     |
| <b>13 Inflammatory Conditions</b> .....   | <b>316</b> |   |     |
| <b>Mastitis</b> .....   | 316        | <b>Abscesses and Fistulas</b> .....                           | 321 |
| Etiology .....  | 316        | Histology .....   | 321 |
| Clinical Findings .....   | 316        | Clinical Findings .....                                       | 321 |
| Diagnostic Strategy and Goals .....   | 317        | Diagnostic Strategy .....                                     | 321 |



|   |     |  |            |
|---|-----|--|------------|
| <b>Granulomatous Conditions</b> .....                           | 327 | Clinical Findings .....                        | 327        |
| Histologic and Microbiological                                  |     | Diagnostic Strategy .....                      | 328        |
| Confirmation .....  | 327 | <b>References and Recommended Reading</b> .... | 335        |
| <b>14 Lesions of Uncertain Malignant Potential (B3 Lesions)</b> |     |  | <b>337</b> |
| Definition .....  | 338 | Atypical Lobular Hyperplasia, Lobular          |            |
| Rationale for Diagnostic Strategy and                           |     | Carcinoma in Situ/                             |            |
| Therapeutic Recommendations for                                 |     | (and Pleomorphic-Type LCIS) .....              | 345        |
| B3 Lesions .....  | 338 | <b>Radial Scars</b> .....                      | 346        |
| Diagnostic Strategy and Management .....                        | 339 | <b>Papillary Lesions</b> .....                 | 348        |
| Prevalence of Lesions of Uncertain Malignant                    |     | <b>Fibroepithelial Lesions of Uncertain</b>    |            |
| Potential, Imaging and Overall Risk .....                       | 339 | <b>Malignant Potential</b> .....               | 356        |
| <b>Atypical Intraductal Epithelial Proliferations</b>           | 340 | Other B3 Lesions .....                         | 360        |
| Atypical Ductal Hyperplasia .....                               | 340 | <b>References and Recommended Reading</b> .... | 361        |
| Flat Epithelial Atypia and Columnar                             |     |  |            |
| Cell Lesions with Atypia .....                                  | 341 |  |            |
| <b>15 Carcinoma in Situ</b>                                     |     |  | <b>365</b> |
| Definition, Terminology, and Biological                         |     | <b>Ductal Carcinoma in Situ (DCIS)</b> .....   | 370        |
| Context .....   | 366 | Definition .....                               | 370        |
| <b>Lobular Carcinoma in Situ, Pleomorphic</b>                   |     | Incidence .....                                | 370        |
| <b>Subtypes (Pleomorphic LCIS)</b> .....                        | 366 | Histopathology .....                           | 370        |
| Incidence .....   | 366 | Importance and Natural History .....           | 371        |
| Importance .....  | 367 | Therapeutic Decisions .....                    | 372        |
| Histology .....   | 368 | Clinical Findings and History .....            | 372        |
| Clinical Presentation and History .....                         | 368 | Diagnostic Methods: Value and Goals .....      | 372        |
| Diagnostic Strategy .....                                       | 368 | <b>References and Recommended Reading</b> .... | 386        |
| <b>16 Invasive Carcinoma</b>                                    |     |  | <b>391</b> |
| Epidemiology and Etiology .....                                 | 392 | Sensitivity and Specificity of                 |            |
| Definition and Problems Posed .....                             | 392 | Mammography .....                              | 431        |
| Spectrum and Detectability .....                                | 393 | Differential Diagnostic Considerations .....   | 431        |
| Diagnostic Strategy and Goals .....                             | 394 | <b>Sonography</b> .....                        | 432        |
| Histology .....   | 400 | Diagnostic Role .....                          | 432        |
| Breast Cancer and Prognosis .....                               | 402 | Indications .....                              | 432        |
| Clinical Examination .....                                      | 403 | Image Presentation of Breast Carcinoma .....   | 433        |
| <b>Mammography</b> .....  | 405 | Correlation between Sonographic Image          |            |
| Radiographic Density of Breast                                  |     | Presentation and Histology .....               | 440        |
| Carcinomas .....  | 405 | Accuracy and Differential Diagnosis .....      | 440        |
| Direct Signs of Focally Invasive                                |     | <b>Magnetic Resonance Imaging</b> .....        | 441        |
| Breast Carcinoma .....  | 407 | Diagnostic Role .....                          | 441        |
| Indirect Signs (Secondary Criteria of                           |     | Imaging Presentation of Carcinomas .....       | 441        |
| Malignancy) of Focally Growing Invasive                         |     | Indications .....                              | 445        |
| Carcinomas .....  | 417 | <b>Percutaneous Biopsy Methods</b> .....       | 448        |
| Signs of Diffusely Growing Carcinomas .....                     | 420 | Diagnostic Role .....                          | 448        |
| Value of Follow-up and Prior Studies .....                      | 420 | Indications .....                              | 450        |
| The Influence of Histology on Mammographic                      |     | Disposition after Percutaneous Biopsy .....    | 450        |
| Presentation .....  | 428 | <b>References and Recommended Reading</b> .... | 450        |
| <b>17 Lymph Nodes</b>   |     |  | <b>457</b> |
| Sentinel Lymph Node Biopsy .....                                | 458 | <b>Normal Lymph Nodes</b> .....                | 459        |
| The Role of Imaging .....                                       | 459 | <b>Pathologic Changes in Lymph Nodes</b> ..... | 464        |
| Anatomy .....   | 459 | Metastatic Adenopathy .....                    | 464        |



|   |     |  |            |
|---|-----|--|------------|
| Other Causes of Adenopathy .....                                      | 469 | <b>Further Techniques in Nodal Imaging:</b>      |            |
| Nodal Calcifications .....  | 469 | MRI and PET .....                                | 471        |
| Percutaneous Biopsy .....   | 471 | References and Recommended Reading ....          | 473        |
| <b>18 Other Semi-Malignant and Malignant Tumors</b>                   |     |  | <b>475</b> |
| <b>Phyllodes Tumor (Cystosarcoma</b>                                  |     | Clinical Findings .....                          | 480        |
| <b>Phyllodes)</b> .....   | 476 | Diagnostic Strategy and Goals .....              | 480        |
| Histology .....   | 476 | <b>Malignancies of the Breast of Hematologic</b> |            |
| Clinical Findings .....   | 476 | <b>Origin</b> .....                              | 484        |
| Diagnostic Strategy and Goals .....                                   | 476 | Histopathology .....                             | 484        |
| <b>Fibromatosis</b>   |     | Clinical Findings .....                          | 484        |
| (= Extra-abdominal Desmoid) .....                                     | 479 | Diagnostic Strategy and Goals .....              | 485        |
| <b>Hemangiopericytoma and</b>   |     | <b>Metastases</b> .....                          | 487        |
| <b>Hemangi endothelioma</b> .....                                     | 479 | Histology .....                                  | 487        |
| <b>Adenomyoepithelioma</b> .....                                      | 480 | Clinical Findings .....                          | 487        |
| <b>Sarcomas</b> .....   | 480 | Diagnostic Strategy and Goals .....              | 487        |
| Histology .....   | 480 | References and Recommended Reading ....          | 489        |
| <b>19 Post-Traumatic, Post-Surgical, and Post-Therapeutic Changes</b> |     |  | <b>493</b> |
| <b>Post-Traumatic and Post-Surgical Changes</b> ..                    | 494 | <b>Changes Following Breast-Conserving</b>       |            |
| Histology .....   | 494 | <b>Therapy without Irradiation</b> .....         | 512        |
| Clinical History and Findings .....                                   | 494 | Definition .....                                 | 512        |
| Diagnostic Strategy and Goals .....                                   | 494 | Clinical and Imaging Findings .....              | 512        |
| <b>Reduction Mammoplasty</b> .....                                    | 507 | Differential Diagnosis and Diagnostic            |            |
| Definition .....  | 507 | Strategy .....                                   | 512        |
| Surgical Procedures .....   | 507 | <b>Changes Following Breast-Conserving</b>       |            |
| Diagnostic Strategy .....   | 507 | <b>Therapy with Irradiation</b> .....            | 512        |
| <b>Changes Following Reconstruction</b> .....                         | 509 | Definition .....                                 | 512        |
| Definition .....  | 509 | Clinical Findings .....                          | 513        |
| Surgical Procedures .....   | 509 | Diagnostic Strategy and Goals .....              | 513        |
| Diagnostic Strategy .....   | 509 | References and Recommended Reading ....          | 529        |
| <b>20 Radiologic Assessment of Women with Breast Implants</b>         |     |  | <b>533</b> |
| <b>Types of Implants</b> .....  | 534 | Surveillance of Women with an Implant            |            |
| Structure .....   | 534 | Following Oncoplastic Surgery .....              | 544        |
| <b>Anatomy</b> .....  | 535 | Screening of Asymptomatic Women who have         |            |
| <b>Imaging</b> .....  | 535 | had Breast Augmentation .....                    | 547        |
| Mammography .....   | 535 | Imaging Assessment of Women with Implants        |            |
| Ultrasound .....  | 539 | after Oncoplastic Surgery .....                  | 547        |
| Magnetic Resonance Imaging .....                                      | 540 | Imaging Assessment of Women after                |            |
| Histopathologic Assessment in Women with                              |     | Augmentation Implant .....                       | 547        |
| Implants .....  | 540 | Histopathologic Assessment in Women with         |            |
| <b>Complications of Breast Implants</b> .....                         | 541 | Implants .....                                   | 547        |
|   |     | References and Recommended Reading ....          | 552        |
| <b>21 Skin Changes</b>  |     |  | <b>553</b> |
| <b>Nodular Changes of the Skin and</b>                                |     | Definition .....                                 | 554        |
| <b>Subcutaneous Tissue</b> .....                                      | 554 | Incidence .....                                  | 554        |
| Clinical Findings .....   | 554 | Diagnostic Strategy .....                        | 555        |
| Diagnostic Strategy .....   | 554 | Clinical Findings .....                          | 561        |
| <b>Skin Thickening</b> .....  | 554 | References and Recommended Reading ....          | 562        |



|                                  |     |  |     |
|----------------------------------|-----|--|-----|
| <b>22 The Male Breast</b>        |     | <b>563</b>                                     |     |
| Anatomy .....                    | 564 | Diagnostic Strategy .....                      | 565 |
| Clinical Examination .....       | 564 | <b>Breast Cancer</b> .....                     | 567 |
| Mammography .....                | 564 | Definition .....                               | 567 |
| Ultrasound .....                 | 564 | Histology .....                                | 567 |
| Magnetic Resonance Imaging ..... | 564 | Clinical Findings .....                        | 569 |
| <b>Gynecomastia</b> .....        | 565 | Diagnostic Strategy .....                      | 569 |
| Definition .....                 | 565 | <b>Miscellaneous</b> .....                     | 571 |
| Histology .....                  | 565 | <b>References and Recommended Reading</b> .... | 573 |
| Clinical Findings .....          | 565 |  |     |

**III Application of Diagnostic Imaging of the Breast 575**

|  |     |  |     |
|--|-----|--|-----|
| <b>23 Screening</b>                        |     | <b>577</b>                                     |     |
| Definition .....                           | 578 | Other Tests for Breast Cancer Screening .....  | 582 |
| Quality Assurance .....                    | 578 | Absolute Numbers .....                         | 582 |
| <b>The Special Task of Screening</b> ..... | 578 | Potential Risks and Limitations .....          | 583 |
| <b>The Data and Discussions</b> .....      | 579 | Expected Advantages .....                      | 586 |
| Other Age Groups .....                     | 581 | <b>References and Recommended Reading</b> .... | 589 |

**24 Additional Diagnostic Evaluation of Screening Findings and Solving of Problems in Symptomatic Patients 593**

|  |     |  |     |
|--|-----|--|-----|
| <b>Pathognomonic Findings</b> .....                | 594 | Asymmetry .....                                | 626 |
| Imaging Assessment .....                           | 595 | The Mammographically Dense Breast .....        | 631 |
| Histopathologic Assessment .....                   | 596 | Other Clinical Abnormalities .....             | 639 |
| <b>Differential Diagnosis and Assessment</b> ..... | 597 | Microcalcifications .....                      | 641 |
| Smoothly Outlined Density .....                    | 597 | Nipple Discharge .....                         | 656 |
| Mass Not Smoothly Outlined,                        |     | Inflammatory Changes .....                     | 660 |
| Focal Asymmetry .....                              | 604 | The Young Patient .....                        | 662 |
| Architectural Distortion .....                     | 615 | <b>References and Recommended Reading</b> .... | 672 |