The Thoracic Radiologist's Guide to the Breast

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Learning Objectives

- To recognize normal CT appearance of breast tissue as CT may often provide the first images of the breast
- To identify CT cross-sectional imaging appearance of benign and malignant breast processes in females and males
- To become familiar with expected cross-sectional imaging appearance of the post-operative breast and recognize post-operative complications
- To discuss the potential advantages of CT evaluation of the breast and encourage accurate description of findings for more valuable reporting

Disclosures

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Introduction

- Increased utilization of CT imaging has led to increased detection of incidental breast lesions
  - CT may be the first evaluation of the breast
  - Breast findings may easily be missed or not appropriately managed
- 2003 study evaluating MDCT perform on 149 women with 173 breast lesions (Inoue et al)
  - Features predictive of malignancy: irregular margins, irregular shape, and rim enhancement
- 2010 study with 78 incidental breast lesions on CT (Moyle et al)
  - Best morphological predictors of malignancy: spiculation and irregularity
  - Calcification patterns were found to be “diagnostically unhelpful”
- Limited literature regarding imaging features for benign breast findings on CT.
  - Therefore, in the absence of long-term stability, correlative evaluation with mammography and/or sonography is generally warranted.
Breast findings on CT should be described using the BI-RADS lexicon set forth by the ACR
• Maintains consistency; more accurate and more valuable reporting of findings
• CT descriptions should also include
  • CT attenuation and enhancement patterns if relevant
  • Location to a quadrant (relative to the nipple) and distribution
  • Presence of skin thickening, nipple retraction, breast edema, architectural distortion, axillary disease, and/or local invasive disease
• Breast density: mammographic descriptor set forth by the BI-RADS lexicon
  • Decreased sensitivity of the traditional mammographic work-up in denser breast tissue
  • Breast density in general provides little utility when evaluating the breast by CT
  • CT may have an increased role for detection of enhancing masses for more dense breasts in particular

Almost entirely fatty
Heterogeneously dense
Scattered areas of fibroglandular density
Extremely dense
## Case Outline

### Benign Breast Disease
- Benign macrocalcifications
- Macroscopic Fat-containing lesions
  - Fat Necrosis
  - Lipoma
  - Hamartoma
- Multiple circumscribed bilateral masses
  - Cysts and Fibroadenomas
- Hematoma/Seroma
- Abscess/Mastitis
- Neurofibromas (Neurofibromatosis)
- Hemangiomas (Maffucci’s Syndrome)

### Malignant Breast Disease
- Invasive ductal carcinoma
- Invasive lobular carcinoma
- Inflammatory breast carcinoma
- Papillary cancer
- Local recurrence of breast cancer
- Radiation-induced angiosarcoma
- Breast lymphoma
- Multiple myeloma metastases
- Melanoma metastases with biopsy tract seeding

### The Post-operative Breast
- Post-biopsy change and clip placement
- Implant Reconstruction: Rupture
- Implant Reconstruction: Contracture
- Myocutaneous Flap Reconstruction
- Silicone Granulomas

### Male Breast Disease
- Gynecomastia
- Invasive ductal carcinoma
- Ductal carcinoma in-situ
Benign Breast Disease: Macrocalcifications

Background:
- Macro and microcalcifications are common breast findings
- Macrocalcifications generally considered benign
- Microcalcifications are considered suspicious for malignancy
  - Unlikely to be resolved by CT spatial resolution limitations

Imaging Features:
- High attenuation calcifications within the breast tissue
- Variable appearance but relatively large in size if visible on CT
- Uniform, large, round calcifications are more likely benign
- Features of benign calcifications include:
  - Coarse
  - Rod like
  - Lucent centered
  - Rim-like
- Fine pleomorphic calcifications (<0.5 mm) have an increased probability of indicating malignancy
  - Due to small size are unlikely to be identified by CT

Management:
- Given the spatial resolution limitations of CT, calcifications identified within the breast on CT are likely macrocalcifications and overwhelmingly benign.
- However if there is any concern, dedicated mammographic evaluation could be recommended.

64 year old female with benign breast calcification. Noncontrast CT shows coarse macrocalcification in the upper outer quadrant of the right breast (arrow). This correlated with benign coarse dystrophic calcification on mammographic evaluation.
Background:
- On mammography a *circumscribed fat-containing* mass is considered benign (BI-RADS 2).
- Caveats do exist, for example: malignancy within a hamartoma or pathologic lymph node with relatively preserved fatty hilum
- Fat containing circumscribed masses include:
  - *Fat necrosis*: Saponification of fat with varying degrees of surrounding fibrotic reaction (if none, then “oil cyst” appearance)
    - May be related to trauma, surgery, or radiation therapy
  - *Lipoma*: benign tumor of mature adipocytes
  - *Hamartoma*: aka fibroadenolipoma; benign proliferation of fibrous, glandular, and fatty tissue with thin capsule

Presentation:
- May be incidental or painless breast lumps
- Fat necrosis: may present as indurated or with erythema and/or ecchymosis

Imaging Features:
- *Fat Necrosis*: look for central areas of macroscopic fat.
  - May also be associated with surrounding fibrosis (soft tissue density)
  - If present, calcifications are characteristically located peripherally
  - May not be visible by the spatial-resolution limitations of CT
- *Lipoma*: mass-like area of macroscopic fat often with regional mass effect.
- *Hamartoma*: Well circumscribed mass-like soft tissue density containing macroscopic fat.

Management:
- Macroscopic fat within an incidental lesion identified on CT is a benign finding.
- If there is concern for alternate diagnosis dedicated mammographic evaluation could be obtained to confirm the presence of internal macroscopic fat.
Fat-Containing Lesions: Additional Cases

45 year old female s/p right mastectomy with TRAM flap reconstruction. Abnormal masses on CT containing macroscopic fat density and associated foci of macroscopic calcification within the upper outer and lower inner quadrants (arrows). Patient underwent mammographic evaluation and were compatible with areas of fat necrosis based on their mammographic appearance.

52 y/o female with incidentally detected left breast mass on CT referred for mammographic work-up. Axial and sagittal CT images demonstrate a rounded, mass-like area of soft tissue mass in the upper outer left breast with stippled low attenuation fat (arrows). Mammographic evaluation demonstrated fat within this lesion consistent with a benign hamartoma.

Axial CT image demonstrates a right chest wall lipoma displacing breast tissue (arrow).
Multiple Bilateral Circumscribed Masses

Background:
- Multiple bilateral circumscribed masses are generally considered benign on mammographic evaluation (BI-RADS 2) as they overwhelmingly represent cysts (most commonly) or fibroadenomas.
  - However, papillomas (which portend an increased risk of breast cancer) and even papillary carcinoma may uncommonly present as multiple round or oval masses
  - Consideration may also be given to metastatic disease (melanoma is most common), but margins are often irregular
  - Cysts and fibroadenomas generally located within breast tissue whereas metastatic masses are typically located throughout the breast, including fatty tissue, inframammary fold and axilla
- Fibroadenoma is the most common benign breast tumor
  - Most commonly found in women ages 15-40
  - May involute and calcify, especially in postmenopausal females
  - Multiple fibroadenomas reported in 20% of cases

Presentation:
- May be incidental on CT or mammographic evaluation, however also often present with palpable breast lump to mammography

Imaging Features:
- Multiple bilateral soft tissue density circumscribed masses
  - Ensure smooth margins and to indicate if any one lesion does not appear similarly to the others
  - Solitary fibroadenomas are circumscribed, round or oval masses which may or may not contain coarse calcifications.
  - Cysts typically appear circumscribed round or oval
    - May have variable attenuation due to complex contents

Management:
- Multiple bilateral similar appearing circumscribed masses are overwhelmingly considered benign on screening mammogram
  - However, if the finding is made on CT, referral for dedicated mammographic evaluation is prudent
    - There is currently a lack of literature regarding benign breast mass features on CT, including accuracy of margin assessment on CT for definitive diagnosis
  - Characteristic “popcorn” calcification associated with a fibroadenoma is benign

53 year old asymptomatic female with bilateral breast cysts incidentally identified on CT (arrows). CT shows bilateral circumscribed, ovoid, soft tissue attenuation masses. Dedicated mammographic evaluation confirms multiple bilateral circumscribed masses predominantly within the upper outer quadrants (boxes). Ultrasound image shows thin-walled hypoechoic cysts with increased through transmission, low level internal echoes without internal vascular flow.
Hematoma/Seroma

Background:
- CT often performed after surgery or biopsy for staging and/or evaluation of disease progression.
- Resolution of hematomas may often result in seromas (serous fluid collection)

Presentation:
- Breast hematomas and seromas may often be present after surgical intervention, biopsy or trauma.

Imaging Features:
- Often rounded mass-like density within the breast tissue which may contain central hyperdense circumscribed mass. Mammography shows a hyperdense circumscribed mass. Sonographic evaluation demonstrates a complex fluid collection without internal vascular flow.
- Peripheral enhancement may be present
- Associated findings may include metallic clips, air fluid levels and additional signs of trauma (adjacent rib fractures)
- May leave residual fibrous scars which may appear as an irregular or spiculated soft tissue density.
  - Prior studies and/or correlation with surgical history or biopsy markers may be of value in differentiating scar at a surgical site from a concerning mass
  - Size and density of an area of scar should improve with time, not worsen.

Management:
- Hematomas should resorb over time differentiating them from other potential masses.
- Correlative surgical or trauma history likely present
- Consider immediate or short term follow up with dedicated mammographic and/or sonographic evaluation if there is any concern for alternate diagnosis.
Mastitis/Abscess

Background:
- Mastitis is inflammation of the breast parenchyma
  - Develops in 1%–24% of breast-feeding women (especially primiparous)
  - 5-11% complicated by breast abscess
- Breast abscesses subtypes
  - Puerperal (Associated with lactation, younger females)
    - Often caused by S. aureus infiltrating stagnant lactiferous ducts
  - Nonpuerperal are further classified by location
    - Central (periareolar): more common, often affects young female smokers; most difficult type to treat (chronic clinical course)
    - Peripheral: generally older females with chronic underlying medical conditions (e.g. diabetes); may also be seen in women taking steroids or s/p recent breast intervention
- In males, most often involve the periareolar region

Presentation:
- Breast pain, redness, warmth and/or palpable lump
- Fever is infrequently encountered but may be present

Imaging Features:
- CT: Often rounded mass-like density within the breast tissue which may contain central fluid attenuation.
- Surrounding soft tissue edema and skin thickening in cases of mastitis.
- Peripheral enhancement may be present
- US: hypoechoic, often multiloculated, fluid collection with thick echogenic periphery with increased peripheral vascular flow (no internal vascular flow)

Management:
- Abscesses should respond to antibiotic treatment (often including percutaneous drainage)
  - Puerperal and peripheral nonpuerperal respond better to treatment than central puerperal
- Consider immediate or short term follow up with dedicated mammographic/sonographic evaluation to ensure resolution and exclude any alternate diagnosis such as inflammatory breast carcinoma

36 y/o female with hidradenitis presents with 3 day history of left breast induration and tenderness. Axial and sagittal CT images demonstrate asymmetric left breast skin thickening and fat stranding. An intradermal abscess (arrows) is present. The patient was treated with incision and drainage and antibiotics without complication during an ER visit.
Neurofibroma

**Background:**
- Neurofibromas are benign peripheral nerve sheath tumors (Schwann cell origin)
- Lesions grow along and inseparable from peripheral nerves and are often fusiform in shape
- Most often skin or subcutaneous
- Rarely seen in the breast, but most often in association with Neurofibromatosis type 1 (NF-1)
  - NF-1 is a multisystem neurocutaneous disorder
  - Subcutaneous in location, most often periareolar
  - Variable size (up to 1 cm)
  - Although often larger and multiple when associated with NF-1

**Presentation:**
- May present in the setting of known neurofibromatosis
  - Often diagnosed in childhood
  - May be sporadic and incidental

**Imaging Features:**
- CT: well circumscribed, often multiple, soft tissue masses predominantly in the skin or subcutaneous soft tissues
- Associated findings of NF-1 may include multiple organ systems, including skeletal and CNS.
- Mammography: Circumscribed round/ovoid masses which may demonstrate a rim of air density suggestive of their superficial (dermal) location.
- Sonography: Superficially located circumscribed hypoechoic mass with posterior acoustic enhancement

**Management:**
- Local excision if cosmetically desired
Hemangioma

Background:
- Hemangiomas constitute approximately 7% of all benign tumors
- The most frequent tumor of infancy and childhood
- Maffucci’s Syndrome
  - Nonhereditary, congenital, syndrome of unknown origin defined by multiple enchondromas and soft tissue cavernous hemangiomas
  - Sometimes also lymphangiomas
  - The overall prevalence of associated malignancies is reported between 23%–100%
  - Most commonly chondrosarcoma: malignant transformation rate from enchondromas generally described to be 15-30%
  - Malignant transformation of hemangiomas to vascular sarcomas is 3-5%
  - Other associated malignancies include pancreatic, ovarian and gliomas

Presentation:
- Hemangiomas may intermittently change in size and can be painful
  - Occasionally the overlying skin may have a characteristic bluish discoloration, especially in Maffucci’s where the majority of hemangiomas are subcutaneous
- Hemangiomas are more common in women and may increase in size during pregnancy
- Maffucci’s Syndrome
  - Majority present before puberty age
  - May present with painless swelling of a digit or a pathological fracture
    - An enchondroma presenting with pain without an underlying fracture is concerning for underlying malignancy

Imaging Features on CT:
- Calcium-density phleboliths are often identified within soft tissue density hemangiomas on CT

Management:
- Symptom relief
- Early detection of associated malignancies in Maffucci’s syndrome

70 y/o male with Maffucci’s syndrome and multiple hemangiomas. Axial CT images demonstrate multiple bilateral soft tissue rounded breast masses. A few have central coarse calcification indicative of phleboliths (arrows). Additional hemangioma is present in the anterior mediastinum.
Malignant Disease: Invasive Ductal Carcinoma

Background:
- Most common type of breast cancer
  - Accounts for 80-90% of all invasive cancers
- Cellular origin from ductal epithelium, with invasion through the basement membrane
- Etiology unknown, but increased risk in patients with prior radiation exposure and BRCA mutations

Presentation:
- Palpable mass
- Nipple inversion/retraction
- Skin dimpling or retraction if close to skin surface

Imaging Features:
- CT findings:
  - Dense, irregular mass with spiculated margins
  - Early or peripheral enhancement
  - Can have internal enhancing septations
  - Associated findings can include invasion of pectoralis muscle, overlying skin thickening, pleural effusion,
  - Important to evaluate for lymphadenopathy which may not be detected on mammography
    - axillary, internal mammary, infra or supraclavicular nodes
- PET/CT: 93% sensitivity; can be helpful in evaluating treatment response

Management:
- Breast conserving surgery with adjuvant radiation (tumor less than 5 cm, involving 1 quadrant of the breast)
- Mastectomy for larger tumors or multicentric disease; adjuvant radiation therapy usually with tumors >5 cm, positive margins, or lymph nodes
- Adjuvant or neoadjuvant chemotherapy for lymph node involvement and higher grade tumors

68 y/o female with incidental breast cancer detected on CT done for pulmonary embolism evaluation. Axial and coronal CT images demonstrate circumscribed lobulated mass in upper outer quadrant of left breast (arrow). Dedicated mammographic evaluation demonstrates multiple lobulated masses within the upper outer left breast. Dedicated ultrasound suggested cystic appearance of these hypoechoic masses without internal vascular flow. Attempted cyst aspiration with subsequent core needle biopsy revealed high grade ductal carcinoma with anaplastic features.
Invasive Ductal Carcinoma: Additional Cases

54 y/o female with axial CT image demonstrating irregular mass-like soft tissue density within the left breast. Mammographic evaluation demonstrated invasive ductal carcinoma.

50 year old female with invasive ductal carcinoma involving the upper outer left breast at posterior depth. Axial CT demonstrates an irregular soft tissue density mass (arrow). Correlative mammogram also demonstrates this dense, irregular mass.

63 y/o female with large left breast mass extending to the skin surface consistent with ulcerating invasive ductal breast. Multiple enlarged left axillary nodal metastases with obliteration of the sinus fat are also evident.

36 y/o female diagnosed with infiltrating ductal carcinoma. Serial axial CT images demonstrate multiple enhancing irregular masses within the right breast (arrows) with right axillary nodal disease.
Invasive Lobular Carcinoma

**Background:**
- Accounts for 10-15% of invasive breast cancers
- Typically spreads through breast parenchyma via diffuse infiltration
- Increased likelihood of multifocality and bilaterality compared to invasive ductal carcinoma

**Presentation:**
- Atypical imaging and clinical presentation due to its unique histopathology and failure to elicit a desmoplastic response
- May not present as a palpable mass

**Imaging Features:**
- CT findings are often vague and easily missed
  - Asymmetric soft tissue density with or without associated skin thickening
  - May manifest as a discrete mass or masses
- Typically subtle mammographically (false negative rates up to 19%) and may present as an ill-defined mass, architectural distortion, or asymmetry;
- A discrete mass and microcalcifications are less common than with other breast malignancies
- Adjunct imaging with ultrasound and magnetic resonance imaging can aid in detection
- Compared with ductal carcinoma, lobular carcinoma is more likely to metastasize to peritoneum-retroperitoneum, GI/GU tract, leptomeninges, and myocardium
  - Similar rates of metastatic disease to liver, bone, and pleura

**Management:**
- Overall survival rate for those with a given size and stage of invasive lobular carcinoma is typically slightly higher than those patients with invasive ductal carcinoma
- Surgical excision (more likely to require mastectomy) and radiation therapy
- Chemotherapy for higher stages

68 y/o female with invasive lobular carcinoma who presented with a palpable right axillary mass for 2 weeks. Axial contrast enhanced CT images show a cluster of enhancing small masses in the upper outer quadrant of the right breast (arrow) and pathologic right axillary adenopathy. Right breast mammography demonstrate partially obscured small mass in lateral breast (arrow) and axillary lymphadenopathy. In cases of unilateral axillary adenopathy, a primary breast malignancy should be suspected even when not evident by CT.
75 y/o female with invasive lobular carcinoma who initially presented with a right axillary palpable lump. Axial CT image demonstrates irregular enhancing mass in central right breast (arrow) and abnormal enhancing right axillary lymphadenopathy. Sagittal f3D post contrast fat saturation MRI image demonstrating abnormal enlarged right axillary and subpectoral lymph nodes, as well as irregular enhancing breast mass at mid to anterior depth (arrow) with adjacent clumped non-mass enhancement extending both anteriorly and posteriorly from the mass. Axial post contrast fat saturation MRI image of the breasts demonstrating the irregular enhancing mass within the right breast (arrow). Axial image from PET-CT demonstrates mild FDG uptake in right breast mass (arrow).
Inflammatory Breast Carcinoma

**Background:**
- Highly aggressive breast carcinoma accounting for 2-5% of all breast cancers
- Dermal lymphatic involvement by carcinoma resulting in inflammatory-like changes
- Predilection for early metastasis
- Worse prognosis compared with other types of breast cancer

**Presentation:**
- Rapid onset of symptoms; <3 months
- May mimic mastitis
- Breast erythema and edema involving at least 1/3 of breast
- *Peau d'orange*: “skin of an orange” dimpling due to obstructed dermal lymphatics

**Imaging Features:**
- Increased breast density; focal mass and/or diffuse infiltration
- Skin thickening: 0.7-3.0 cm
- Diffuse breast enlargement
- Regional adenopathy very common
- Nodal involvement: axillary, subpectoral, infraclavicular, internal mammary and supraclavicular regions
- 20-40% have distant metastasis at presentation
- Bone most common site of distant metastasis
- PET/CT useful to detect distant metastasis and for monitoring response to treatment

**Management:**
- Skin punch biopsy shows tumor emboli in dermal lymphatics
- Preoperative chemotherapy followed by mastectomy and radiation therapy
- 25-50% 5-year survival

67 year old female with inflammatory breast carcinoma and right breast erythema. Axial images from contrast enhanced CT show asymmetric right skin thickening (arrow), irregular right breast soft tissue masses and axillary adenopathy with surrounding fat stranding. Staging PET/CT confirms FDG activity within skin thickening (arrow) and shows site of primary breast malignancy.
Papillary Carcinoma

Background:
- Constitutes approximately 1-2% of breast cancers in women
- Invasive and in situ forms can either be intraductal or intracystic
- Generally occur in older women (average 7th decade)
- Better survival rate compared with other types of breast cancer

Presentation:
- Slow growing tumor
- Nipple discharge; bloody in 22-34% of cases
- Nipple retraction or deviation
- Palpable, usually large masses in subareolar region

Imaging Features:
- Oval, round, or lobulated circumscribed mass
  - Typical central subareolar location
- Can present as multiple round/oval circumscribed masses
  - Often peripherally located in breast
- Axillary node metastases infrequent, though enlarged lymph nodes with sinus histiocytosis often encountered
- On US often see mixed solid and cystic masses
- Can undergo spontaneous hemorrhage (fluid-fluid levels, high signal intensity on both T1 and T2 weighted images)
- Can have solid variant where cystic component is absent

Management:
- Surgical excision, which may be mastectomy or lumpectomy
- Axillary lymph node dissection for those tumors with suspected invasive components
- No clear role for neoadjuvant therapy unless there is a coincident adjacent focus of DCIS or microinvasion
- 10 yr survival rate approaching 100%
Local Breast Cancer Recurrence

Background:
- Local recurrence: in surgical bed
- Regional recurrence: in draining lymph nodes
- 5-27% risk of locoregional recurrence
- Risk factors
  - No postoperative radiation therapy
  - Large primary tumors
  - Positive margins
  - Multiple cancers at presentation
  - Positive lymph nodes

Presentation:
- Palpable abnormality in mastectomy bed

Imaging Features:
- CT findings:
  - Focal skin thickening > 1 cm
  - Dense soft tissue in subcutaneous fat
  - Focal mass or irregularity in chest wall musculature
- PET/CT: sensitivity 97%; accuracy 95%

Management:
- Portends increased risk for distant metastasis and breast cancer related mortality
- Mammography standard for post operative imaging surveillance
- Early detection allows for curative intervention and increased survival

54 y/o female with local recurrence of invasive ductal breast carcinoma status post radical right mastectomy. Axial CT image shows a focal parasternal soft tissue mass in the mastectomy bed (arrow). The mass shows increased T2 signal intensity and abnormal FDG activity on PET/CT.
Radiation-Induced Angiosarcoma

Background:
- Malignant tumor arising from neoplastic transformation of endothelial cells lining blood vessels
- Represents less than 1% of breast neoplasms
- Primary angiosarcoma occurs in 3-4th decades vs secondary angiosarcoma occurs in patients >65 years old
- Risk factors for secondary breast angiosarcoma:
  - After breast radiation therapy at levels between 25-80 Gy; rarely with conservation therapy without associated radiation
  - Chronic lymphedema (Stewart-Treves syndrome)

Presentation:
- Primary cases typically present with an enlarging breast or palpable mass; may show blue discoloration of overlying skin
- Secondary cases may present as:
  - Palpable mass - small nodules or larger mass
  - Alteration in skin color (ie: blue/red/purple discoloration, ecchymosis, violaceous erythematous plaques)
  - Bimodal frequency - can occur a few years after or many years after radiation therapy
  - Often delayed diagnosis as may mimic bruising and appears similar to post-surgical change on imaging

Imaging Features:
- CT findings: skin thickening, with or without associated mass
  - Mass typically not found in lumpectomy bed, which would be more suggestive of recurrent breast cancer
  - Metastases spread homogeneously; lungs most common
- PET/CT: Can be used for staging (FDG avid tumor)

Management:
- Surgical resection with mastectomy; with or without chemotherapy
- Poor prognosis, especially with higher grade tumors
- CT important for follow-up in monitoring treatment response, local recurrence, distal metastases
Lymphoma

Background:
- Comprises approximately 0.4-0.7% of breast cancers
- About 1-2% of all lymphomas involve the breast
- Breast may be the primary site or involved with disseminated disease
  - Secondary involvement is slightly more common
- Typically affects postmenopausal women
  - B cell more common than T cell lineage
  - Burkitt’s lymphoma more frequently occurs in pregnant or lactating women and African Americans

Presentation:
- May manifest as a palpable mass
- Can be unilateral or bilateral
- Skin changes such as retraction and erythema occur less frequently than other types of breast cancer

Imaging Features:
- Breast tissue swelling with either well-defined or ill-defined mass or masses
- Intrathoracic or extrathoracic lymph node and chest wall involvement can also be assessed by CT
- Indistinct margins may be due to lymphomatous infiltration of adjacent glandular tissue
- On mammography, typically seen as a relatively well circumscribed mass without associated calcifications or spiculation
- PET/CT: Generally used for initial staging, to monitor response to therapy, and to detect local recurrence

Management:
- Primarily managed with systemic chemotherapy
- Radiotherapy can be used as an adjunct therapy
- Surgical management is not typically indicated

71 y/o male with primary diffuse large B cell lymphoma of the breast presenting with a palpable breast lump. Axial CT image demonstrates mostly well circumscribed, lobular mass within the left breast. PET-CT demonstrates FDG avidity of the mass. Mammographic images demonstrate large mass in the region of the palpable marker. Ultrasound demonstrates a mixed cystic and solid hyperechoic mass.
Multiple Myeloma Metastases

Background:
- Plasmacytoma is a malignant plasma cell proliferative disorder derived from B cells
  - Primary
  - Secondary: due to disseminated multiple myeloma
- Extramedullary plasmacytoma most commonly occurs in patients with a history of multiple myeloma
  - Breast involvement is very rare; head and neck involvement is more common
- Isolated primary breast plasmacytoma can occur, though approximately 20% of these patients later develop multiple myeloma
  - Age group affected: 50-60s

Presentation:
- May present as unilateral or bilateral, typically painless palpable breast masses
- Skin erythema and axillary lymphadenopathy are rare

Imaging Features:
- CT findings:
  - Round or lobulated homogenous soft tissue mass or masses
  - Not typically associated with calcifications
- PET/CT: (FDG avid tumor)
  - Can detect initial presentation of breast plasmacytomas in patients with multiple myeloma
  - Can be used to monitor response to treatment

Management:
- Case dependent, though usually involves a combination of radiotherapy and chemotherapy
- Primary involvement usually has a better prognosis than secondary involvement from multiple myeloma

68 y/o female with remote history of right breast invasive ductal carcinoma status post lumpectomy and radiation therapy 3 years prior. The patient presented with numerous new bilateral palpable breast masses over 2 months. Axial CT images show multiple bilateral enhancing masses. Right breast skin thickening is due to previous radiation therapy. Biopsy of the dominant mass in each breast revealed plasma cell neoplasms.
Melanoma Metastasis with Biopsy Tract Seeding

Background:
- Breast metastasis accounts for 0.5-2.0% of breast malignancies
- Most frequent source of metastatic breast disease is contralateral breast cancer
- Other common primary malignancies:
  - Lymphoma
  - Melanoma
  - Sarcoma
  - Lung
  - Gastric
  - Ovarian
  - Renal
  - Prostate: most common primary in males
- Biopsy tract seeding is exceedingly uncommon
- Lower reported incidence with vacuum assisted biopsy devices

Presentation:
- Palpable breast mass
- Metastasis do not cause skin or nipple retraction unlike primary malignancies

Imaging Features:
- Breast metastasis often found in fatty tissue rather than glandular tissue
- Typically a solitary rounded and well-defined mass
- More often multiple and bilateral compared with primary breast cancers
- Associated with disseminated metastatic disease

Management:
- Important to distinguish primary from secondary malignancy as treatment and prognosis significantly differs
Male Breast Disease: Gynecomastia

Background:
- Benign proliferation of male breast glandular tissue
- Most common abnormality of male breast occurring in up to 55% at autopsy
- Defined as > 2 cm of subareolar tissue in a non-obese male
- Due to increased estrogen levels, decreased testosterone and several medications
- Biphasic (acute florid ~ <1 yr and chronic fibrotic phase ~ >1yr) which correspond to two distinctly different imaging patterns
- Additional imaging pattern due to high estrogen
- Typically bilateral but can be unilateral (up to 40%)
- Pseudogynecomastia is excess breast fat deposition without breast tissue seen in obesity and neurofibromatosis

Presentation:
- Vast majority of patients are asymptomatic
- Clinically it must be soft, mobile, tender and subareolar
- Tender in the acute phase, but asymptomatic in the chronic phase
- Radiologically relevant causes include: cirrhosis, testicular trauma/infection, carcinomas (adrenal, gastric, lung, renal, pituitary, and testicular), hyperthyroidism and chronic renal insufficiency

Imaging Features:
- CT findings: must be subareolar
  - Nodular glandular (acute florid phase)
    - Long axis that is parallel to the skin
    - Indistinct borders blending into surrounding fat
  - Dendritic (chronic fibrotic phase)
    - Triangular with extensions that radiate into the subareolar fat
    - Flame, fanned, or spiculated shape
  - Diffuse glandular (due to very high estrogen levels)
    - Resembles a female breast

Management:
- Benign and typically self limited
- Evaluation for the causative condition or medication
- Any mass that is not subareolar is not gynecomastia; If it is not typical gynecomastia it deserves mammographic work-up and potentially biopsy

73 year old male with palpable left breast mass found to have bilateral gynecomastia, left greater than right. Axial CT shows subareolar flame-shaped distribution of breast tissue confirmed on mammographic images.

57 y/o male on hormone therapy for prostate cancer. Axial CT shows asymmetric flame-shaped subareolar gynecomastia.
Invasive Ductal Carcinoma

Background:
- Male breast cancer accounts for 1% of all breast cancer
- Invasive ductal carcinoma accounts for 93.7% of breast cancer in men
- Risk factors that are the same as in women include age, family history, Jewish heritage, chest wall irradiation, hyperestrogenism, hyperthyroidism, exposure to hepatotoxins, and BRCA2 gene mutation (4-16% of male breast cancer patients)
- Additional risk factors in males include undescended testes, orchiectomy and orchitis, and Klinefelter’s syndrome (3% lifetime risk)

Presentation:
- Presentation of disease will be the same as in women
- Symptoms include a palpable lump, nipple pain, nipple inversion, clear or bloody nipple discharge, skin thickening, rash or axillary adenopathy

Imaging Features:
- Irregular margins, irregular shape, and rim enhancement are features most predictive of malignancy in one study
- Spiculated margin was seen in 72% of low grade tumors and only 24% of high grade tumors in another study
- Some cancers may be oval, well-circumscribed or lobulated.
- Enhancement and washout are also predictive of malignancy

Management:
- Gold standard is mammographic workup and biopsy
- Mastectomy rather than lumpectomy given volume
- Men have a 25% higher mortality rate than women
  - Diagnosed at a later stage of disease compared with women

79 y/o male with invasive ductal carcinoma. Axial CT image shows an irregular subareolar left breast mass with associated skin thickening and nipple retraction (arrow). There is associated lymphedema and left axillary nodal metastasis (arrow).
Ductal Carcinoma In Situ

Background:
- Stage 0 breast cancer; confers a 100% 5 year survival
- By definition no spread to the lymph nodes or distant sites
- Rare diagnosis as men are not routinely screened

Presentation:
- DCIS generally has no signs or symptoms
- A small number of people may have a lump in the breast or some discharge coming out of the nipple
- According to the National Cancer Institute, about 80% of DCIS cases are found by mammography in women. There are no such available statistics in men as no general screening occurs

Imaging Features:
- Calcifications may be more coarse than in women
- There may be an underlying density representing another associated disease such as a papilloma in the example case
- Pleomorphic calcifications are concerning
- Nearly all calcifications seen on CT are macroscopic and likely benign, however, as spatial resolution continues to improve more fine pleomorphic calcifications may be seen

Management:
- Generally lumpectomy is performed +/- hormonal therapy as most male breast cancers are hormone receptor positive
- Higher risk of a second breast cancer than the general population
- Most recurrences happen within the 5 to 10 years after initial diagnosis
- The chance of a recurrence is under 30%

62 y/o male with incidental left breast DCIS within a papilloma identified on CT lung cancer screening study. Axial CT images show unilateral left gynecomastia and a separate irregular left breast mass and macrocalcification (arrow). Mammographic work-up demonstrates the benign coarse calcification identified on CT. However, mammography identified microcalcifications (circle) which are beyond the resolution of CT which represent DCIS.
Postprocedural Breast: Post-biopsy Change and Clips

**Background:**
- Biopsy clips: Extremely variable in composition and shape depending on institution and vendor
- Titanium most common, some embedded in polymer, collagen or gel
- Placed in all biopsies (benign and malignant) by most institutions for localization after biopsy
- Purpose is to uniquely identify site of biopsy for potential future intervention
- In one retrospective study of 111 biopsies and clip deployments 31 clips (28%) were more than a centimeter from the target on at least one post-biopsy image

**Imaging Features:**
- All clips will be radiopaque, some containing polymer for avid visualization on ultrasound
- May be associated with a seroma, hematoma, abscess, mass, calcification or may have migrated
- May mimic calcifications within a mass

**Management:**
- No need to report clip presence on CT or placement unless suspected migration
- A clip within a mass conveys that it has been biopsied and does not need specific recommendations on CT.
- Presence may be helpful to detect location of a known primary breast malignancy which may not be otherwise evident on CT.

85 y/o female with post biopsy changes. The patient presented with a palpable lump in the right breast and US-guided and stereotactic biopsy with placement of tissue markers was performed 5 weeks prior to CT. Axial CT images demonstrate radiopaque tissue markers with associated soft tissue density at 3 right breast biopsy sites and right axilla (arrows). CT appearance after biopsy appears similar for all biopsy sites with irregular associated soft tissue density and increased density at biopsy sites (arrows) due to post biopsy change/hematoma. Pathologies of the three right breast biopsy sites demonstrated benign fibrocystic change (yellow arrow), Invasive ductal carcinoma (red arrow) metastatic to the right axilla (white arrow) and DCIS (green arrow).
Implants and Complications

Background:
- Numerous types of implants including: single lumen silicone or saline, double lumen, adjustable single or double lumen, and triple lumen
- Capsule: fibrous tissue formed by body around implant
- Complications such as capsular retraction/contracture, herniation, intracapsular rupture and extracapsular rupture are common

Presentation:
- Most ruptures are asymptomatic
- Intracapsular Rupture - Breast pain, firmness, distortion
- Extracapsular Rupture - migration of free floating silicone may result in palpable nodules, adenopathy or skin breakdown

Imaging Features:
- Radial folds: normal in-foldings of the shell extending to the periphery of the implant with no implant material centrally are a normal finding
- Intracapsular Rupture: contained by fibrous capsule
  - Subcapsular lines: gel bleeds
  - Keyhole sign: implant material on both sides of radial fold
  - Linguine sign: multiple grouped curvilinear intracapsular lines upon one another with interposed implant material
- Extracapsular Rupture: gross rupture beyond capsule
  - Free silicone extends into the breast or axilla. Some peri-implant fluid can be normal so MRI with silicone/water suppression sequences is recommended for specificity

Management:
- Intracapsular Rupture - 10% will progress to extracapsular rupture within 2 years. Close follow up with plastic surgery and MRI every 2 years or less
- Extracapsular Rupture - Surgical removal/replacement

71 y/o female with intact right and ruptured left breast implants. Axial CT and MRI images show normal radial folds of the right implant. A linear filling defect (arrows) with implant material on both sides is compatible with the linguine sign indicating left intracapsular rupture.
Implant Contracture

Background:
- Multifactorial thickening, tightening, fibrosis and hardening of the capsule resulting in implant rounding
  - Most common breast implant complication
- Contracture rate: wide range of reported incidence (0-45%)
- Silicone implants have a 2.25 fold increased risk
- Contracture alone does not cause rupture if it is an even force circumferentially. However herniation may progress to rupture

Presentation:
- Initially presents with mild breast induration
- As the capsule thickens the breast will become more firm
- With further progression the breast will shrink and become distorted
- There can be a range of symptoms varying from localized tenderness to very severe diffuse pain

Imaging Features:
- Contracture is a clinical diagnosis but may be suggested by implant deformity or a calcified capsule
  - Notably peri-implant calcifications may be of no clinical significance if they do not create distortion or pain
  - Calcifications may also mimic malignancy on mammography
  - Distortion in the setting of pain is most diagnostic

Management:
- Capsulectomy or implant replacement is standard in symptomatic cases
- Asymptomatic cases are generally monitored clinically or with breast MRI every two years
Myocutaneous Flap Reconstruction

Background:
- Transverse rectus abdominis musculocutaneous flap reconstruction: Most utilized form of breast reconstruction
- Creation of a neobreast after total mastectomy utilizing a rectus pedicle, superior epigastric vasculature, and an ellipsoid portion of lower abdominal fat and skin from the abdomen sparing the umbilicus
- Alternatively the latissimus dorsi or deep inferior epigastric perforator flap methods may be used

Imaging Features:
- Homogeneous, fatty appearance with lack of ductal/glandular elements, supporting ligaments and paucity of vasculature
- Outline of the contact zone between flap and native tissue
- Medial and lateral scars, muscular pedicle can be followed from the epigastrium to the neobreast in an oblique orientation
- Absent rectus muscle in expected location in ventral abdomen
- Skin thickening, fat necrosis, seroma, and hematoma can simulate breast cancer recurrence
  - Recurrence rate is 2-4% after 2 years
- Deep inferior epigastric perforator CTA exams may be performed preoperatively to select the best artery to use for the flap
  - Understanding of the location and selecting the best artery will shorten OR times and decrease patient morbidity
- Perforator with a short intramuscular course of <4cm through the rectus muscle are the easiest and safest to dissect whereas vessels with a long intramuscular course are more prone to injury

Management:
- Mammographic follow up for chest wall recurrence is variably recommended
- Difficult to assess for recurrence on CT- variable appearance of rectus flap which may be misinterpreted creating a false positive

64 year old female with TRAM reconstruction. Axial CT images show myocutaneous pedicle and outline of the contact zone between flap and native tissue (arrows) in now adipose of the neobreast. Mammogram displays deep vertical rectus muscle (arrow). MRI of the same patient demonstrates the myocutaneous pedicle and contact zone in homogenous fatty reconstructed breasts (arrow). This patient previously presented with postoperative intramuscular rectus hematoma and seroma after TRAM reconstruction (bottom right B)
Silicone Granulomas/Mastopatathy

Background:
- Free silicone injection was commonly used for cosmetic augmentation until it was banned by the FDA in 1992
- Complications of free silicone injection include silicone granulomas, fibrosis, and lymphadenopathy

Presentation:
- Diffuse nodularity that is clinically palpable and limits physical exam for breast cancer screening
- May become painful although most are asymptomatic

Imaging Features:
- On mammography, multiple dense nodular masses are usually seen. Distortion may also occur
- On CT, silicone granulomas appear as soft-tissue nodules with associated fat infiltration +/- rim calcification
- On MRI, these nodules are hypointense on T1-weighted images, hyperintense on T2-weighted images, and hyperintense on silicone-sensitive sequences

Management:
- Mammography is still recommended but is extremely limited.
  - Digital breast tomosynthesis may be helpful.
- Surgical removal is recommended if localized
- If symptoms are minimal no treatment is advised
- Muscle relaxant medications may improve pain if present

59 y/o female with free silicone injections. Axial CT images show multiple soft-tissue rounded breast nodules some with high attenuation, right greater than left. Mammogram shows bilateral high density masses compatible with free silicone injection.

64 y/o female with history of free silicone injections. Mammogram shows innumerable diffuse bilateral high attenuation masses in both breasts with coalescing calcifications.
Take Home Points

• CT features highly predictive of malignancy: Margin irregularity and spiculation
  • Malignancy may also present as round masses including: papillary, mucinous, and medullary cancers.

• CT findings with breast malignancy: skin thickening, nipple retraction, local invasion, axillary disease,
  • Should always be described as CT may better these additional findings than mammography

• In males, any breast mass or tissue asymmetry that is not subareolar or does not appear “typical” for gynecomastia should be have dedicated mammographic evaluation.
  • Male breast cancer is diagnosed at later stages and portends a 25% higher mortality rate than in women.

• Calcifications resolved on CT are likely macroscopic and overwhelmingly benign.
  • If concern for small pleomorphic calcifications mammographic evaluation should be recommended.

• Macroscopic fat definitively within a lesion is a benign finding: lipoma, hamartoma, fat necrosis

• Limited literature regarding CT features which represent high positive predictive value for benign findings
  • Therefore, in the absence of long-term stability, evaluation with mammography is generally warranted.

• CT findings of breast implant contracture: Capsule calcification, implant distortion and rounding

• CT findings of breast implant rupture: linear filling defects with implant material on both sides. Implant material extending beyond capsule.
  • Radial folds have implant material only on one side and are a normal finding
References


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Thank You

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