Breast Cancer Workup and Surgical Planning

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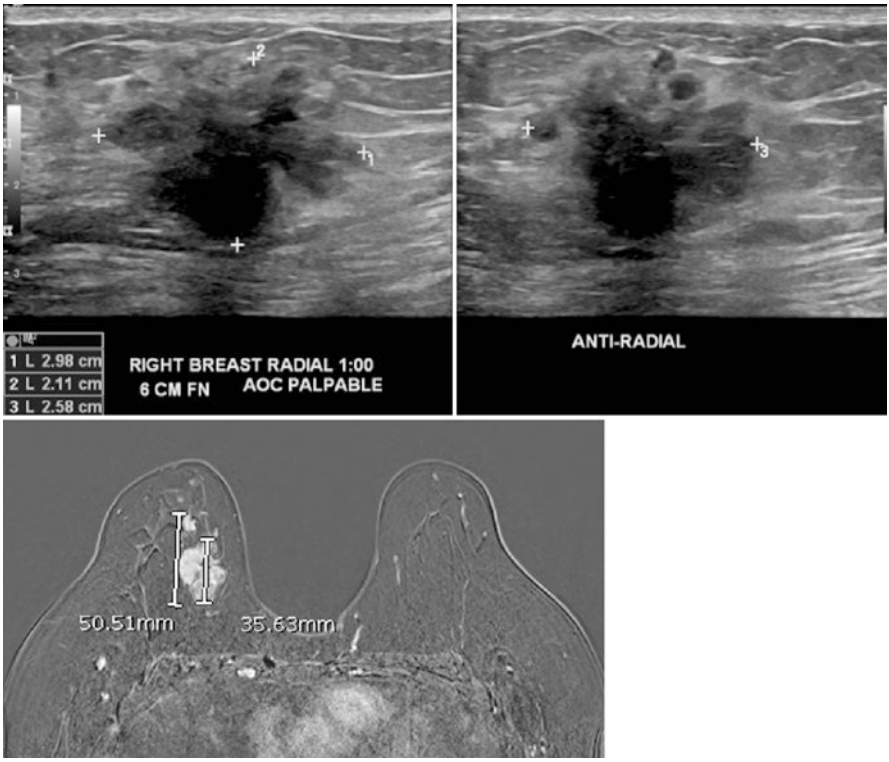
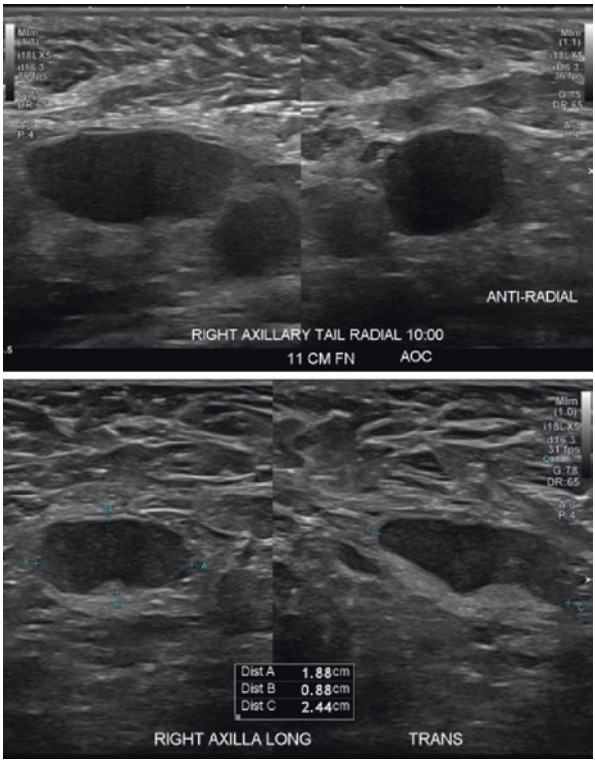
1. 57-year-old woman with biopsy-proven invasive ductal carcinoma of the right breast. Ultrasound shows an irregular, hypoechoic mass with angular and indistinct margins. MRI shows an enhancing mass containing biopsy microclip artifact and adjacent enhancing foci. What is the size of the mass for TNM staging?



(a) 30 mm.
(b) 36 mm.
(c) 51 mm.
(d) The size of the mass by ultrasound and of the mass by MRI should be averaged.

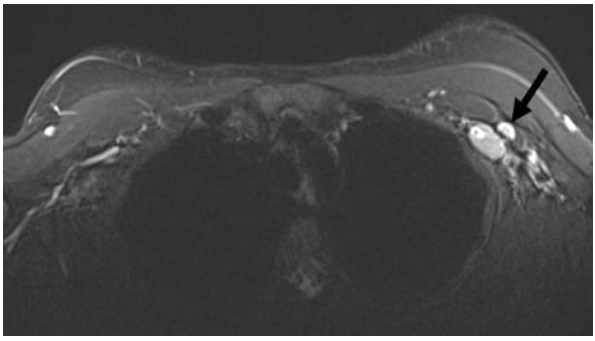
2. A 49-year-old woman presents with a palpable lump in the right axilla. The ultrasound is shown below. A biopsy of the lymph node was performed, and the biopsy result is metastatic invasive ductal carcinoma from a breast primary. Other than showing abnormal axillary lymph nodes, her mammogram was normal. What is the next step?



(a) Contrast-enhanced mammography.
(b) Breast MRI.
(c) Molecular breast imaging.
(d) Surgical excision of the biopsy-proven metastatic axillary lymph node.
(e) PET examination.

3. Which statement below is incorrect regarding axillary lymph nodes?
(a) To evaluate axillary lymph nodes, the patient should be positioned supine oblique with the hand above the head, and with the arm abducted and externally rotated.
(b) Ultrasound is preferred over MRI as the initial exam. Ultrasound is more cost effective and is better at evaluating morphology.
(c) Sentinel node is usually found at the inferior/lower part of the axilla.
(d) Tumor infiltration starts at the center of the lymph node.

4. Which axillary lymph node level is marked with the black arrow on the image below?
   (a) I.
   (b) II.
   (c) III.
   (d) The arrow is not in the axillary region.

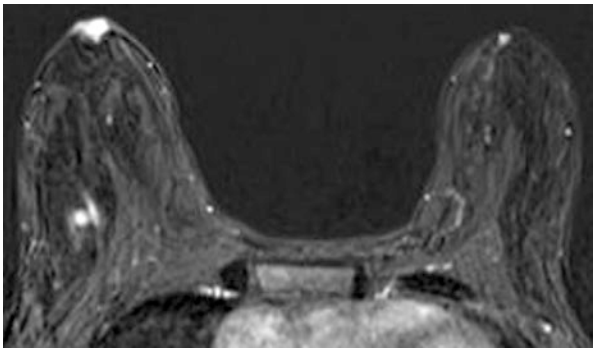


5. Metastases to the cervical, contralateral internal mammary, or contralateral axillary lymph nodes are considered:
   (a) N2 disease.
   (b) N3 disease.
   (c) M0 disease.
   (d) M1 disease.

6. Isolated metastasis to the internal mammary lymph node occurs in what percent of breast cancers?
   (a) Up to 5%.
   (b) Up to 25%.
   (c) Up to 75%.
   (d) Up to 90%.

7a. A 32-year-old woman presents with right nipple erythema and discharge. On physical examination, there is no evidence of skin thickening or ulceration. Her diagnostic mammogram and ultrasound were unrevealing. What is the next best step?
   (a) Contrast-enhanced mammography (CEM).
   (b) MRI.
   (c) PET examination.
   (d) No additional imaging is indicated.

7b. Her MRI is shown below. What is the diagnosis?

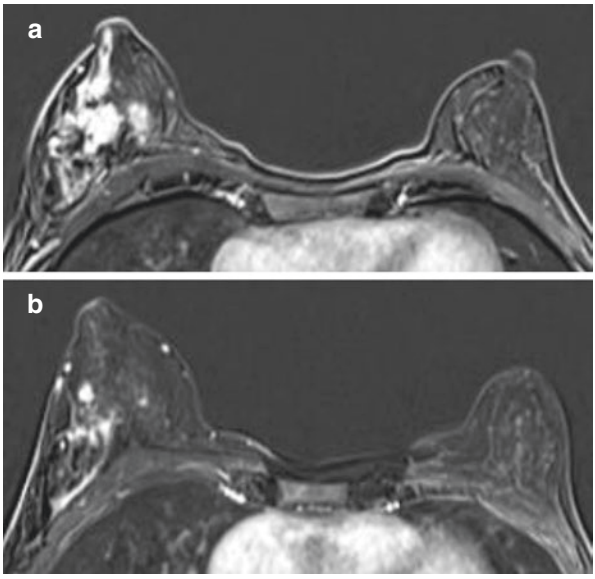


(a) Paget's disease.
(b) Eczema.
(c) Fat necrosis.
(d) Inflammatory breast cancer.

7c. Her nipple biopsy showed Paget's disease. Her focused ultrasound after the MRI was negative. What is the next step?
(a) PET.
(b) Lumpectomy.
(c) Surgical excision of the nipple.
(d) MRI-guided biopsy.

8. Paget's disease of the nipple is associated with what other malignancy?
(a) Phyllodes tumor.
(b) Lymphoma.
(c) DCIS.
(d) Sarcoma.
(e) Squamous cell carcinoma.

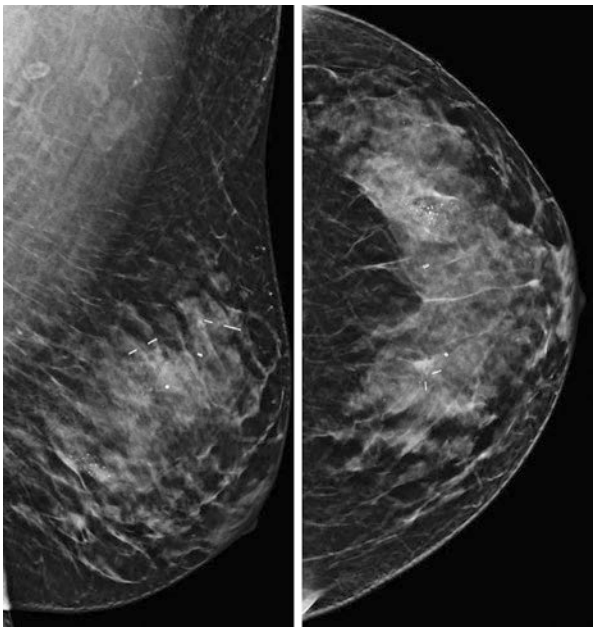
9. 57-year-old woman diagnosed with triple negative invasive ductal carcinoma of the right breast. Fig. A is her breast MRI prior to treatment. Fig. B is her breast MRI after neoadjuvant chemotherapy. What was her response to chemotherapy?



(a) Partial response.
(b) Complete response.
(c) Unable to determine response, need ultrasound images.
(d) Stable disease.

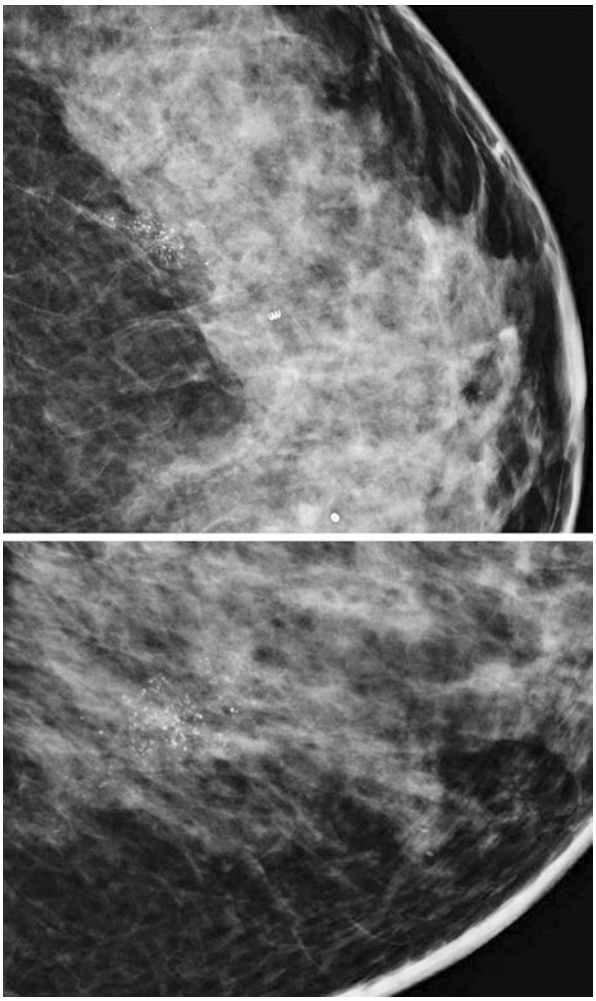
10. Which imaging modality is the most accurate to assess response after neoadjuvant chemotherapy?
(a) Mammogram.
(b) Contrast-enhanced mammogram.
(c) Ultrasound.
(d) MRI.
(e) PET.

11a. A 46-year-old woman presents for screening mammogram. The left screening views are shown. The patient has a history of prior benign surgical excision and core needle biopsy of the left breast. What is the correct BI-RADS assessment for the screening mammogram?



(a) BI-RADS 2. Benign. The surgical scar marker and biopsy clip show that all findings have been evaluated in the past.
(b) BI-RADS 0. Incomplete. Recall the patient.
(c) BI-RADS 4. Suspicious. Recommend stereotactic biopsy.
(d) BI-RADS 1. Negative examination. Return to annual screening.

11b. The patient was recalled, and magnification views of the groups of calcifications were performed. What is the next step?



(a) Stereotactic biopsy.
(b) Wait for prior films.
(c) MRI.
(d) Ultrasound.

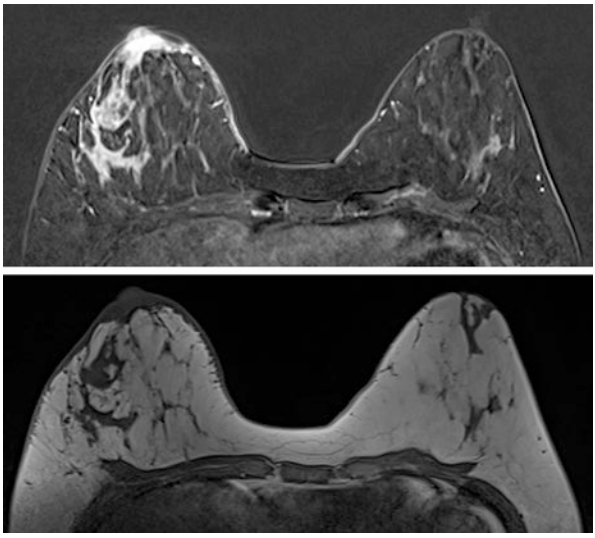
11c. Subsequent ultrasound was performed. What is the next step?

(a) Stereotactic core biopsy.
(b) Ultrasound-guided core biopsy.
(c) MRI to delineate extent of disease.
(d) Await prior films as the patient had a prior benign biopsy.

11d. There were additional calcifications in the same quadrant and both groups were malignant. What is the correct term for disease?
(a) Multicentric disease.
(b) Multiquadrant disease.
(c) Multifocal disease.
(d) Multipart disease.

12. An incidentally detected FDG-avid breast lesion greater than 1 cm is identified on FDG PET/CT. What is the likelihood of malignancy?
(a) 1–5%
(b) 10–20%
(c) 30–40%
(d) 80–90%.

13. 29-year-old BRCA1 positive woman with biopsy-proven invasive ductal carcinoma of the right breast with axillary nodal metastases. Her MRI for initial local staging is shown below. There is non-mass enhancement in the outer right breast. What additional finding on the MRI is important to communicate to the breast surgeon prior to surgery?

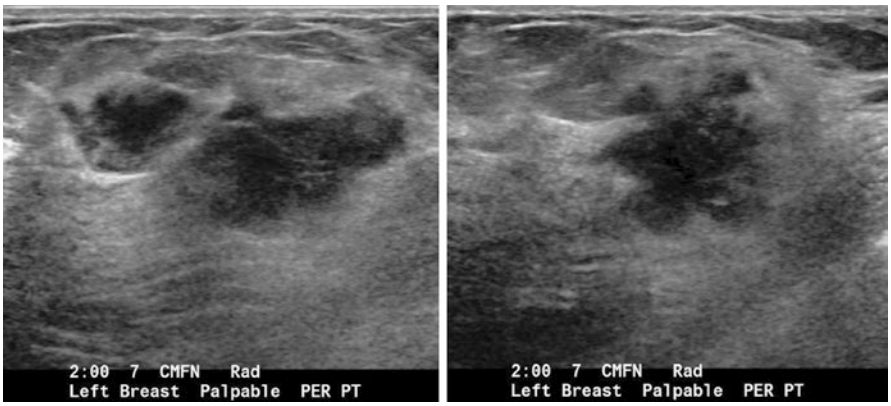


(a) There is pectoralis muscle involvement.
(b) There is chest wall involvement.
(c) There is nipple involvement.
(d) There are suspicious internal mammary lymph nodes.

14. Which molecular subtype of breast cancer is most likely in a woman with BRCA1 mutation?
(a) Triple negative.
(b) Luminal A.
(c) Luminal B.
(d) HER2-enriched.

15a. A 38-year-old pregnant woman presents with a palpable breast lump. What is the first-choice imaging modality to work up a palpable breast mass in a pregnant or lactating woman?
(a) Mammogram.
(b) MRI.
(c) Ultrasound.
(d) The patient should be imaged after she is no longer pregnant or has stopped lactating.

15b. The ultrasound for this woman's palpable lump is shown below. What is the most appropriate next step?

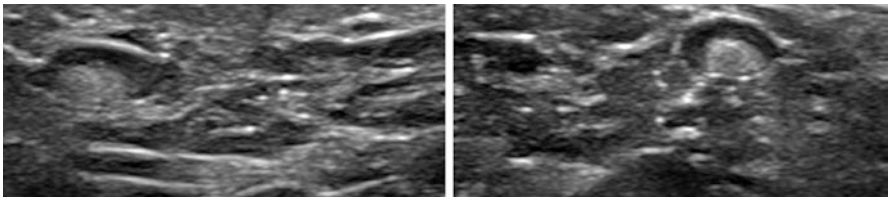


(a) Close interval ultrasound follow-up in 6 months.
(b) MRI.
(c) Biopsy.
(d) Return after the patient has delivered and stopped breast feeding.

15c. What is the most common presentation of pregnancy-associated breast cancer?
(a) Nipple discharge.
(b) Painless breast lump.
(c) Unilateral breast engorgement.
(d) Skin thickening and erythema.

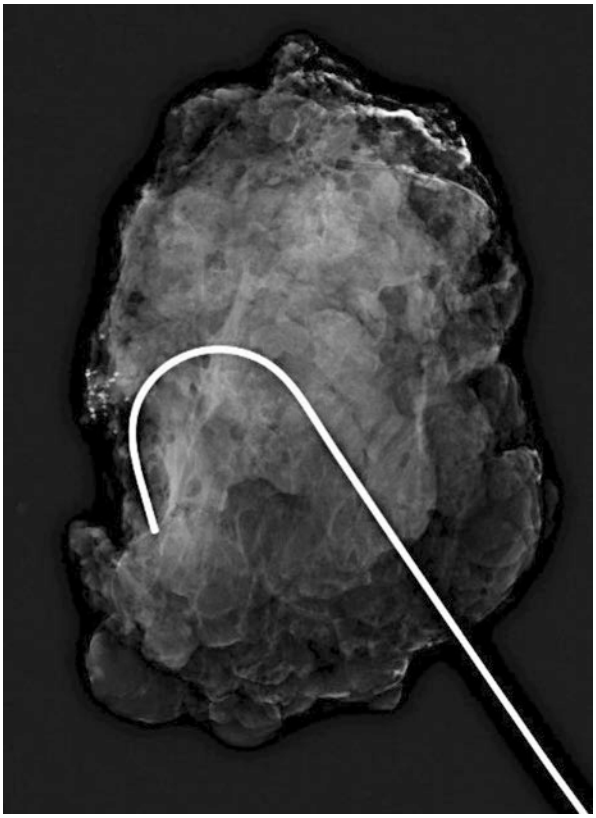
16. A type 5 lymph node has what positive predictive value for malignancy?
(a) 4%
(b) 29%
(c) 80%
(d) 98%.

17. 52-year-old woman with a known invasive ductal carcinoma in the left breast. Ultrasound of the axilla was performed. What is the next step?



(a) Ultrasound-guided core needle biopsy of the lymph node.
(b) Treatment of the primary breast cancer.
(c) MRI.
(d) Complete axillary lymph node dissection.

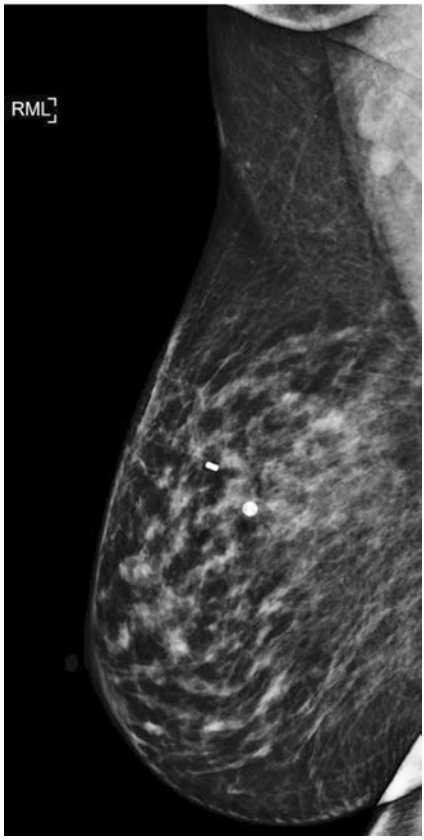
18a. An 88-year-old woman with biopsy-proven DCIS presenting as calcifications underwent surgical resection. The specimen radiograph is shown below. What findings regarding the specimen should be communicated to the surgeon?



(a) The specimen is adequate.
(b) No calcifications are identified in the specimen.
(c) Measurements of the size of the specimen.
(d) There are round faint calcifications along the margin.

18b. The surgeon removed additional margins. Due to the presence of extensive calcifications prior to surgery, what is the most appropriate next step prior to starting radiation therapy?
(a) No additional step is necessary prior to radiation.
(b) Ultrasound.
(c) MRI.
(d) Diagnostic mammogram.

19. The breast radiologist plans to perform mammographically guided seed bracketing in the area of the two biopsy clips that were placed after biopsy of calcifications. What is the optimal distance the seeds should be placed from one another?



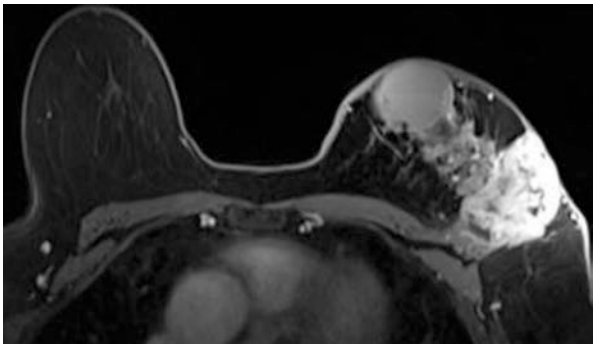
(a) At most 1 cm.
(b) 2–3 cm
(c) The distance between the seeds does not matter; it is important to place the seeds as accurately as possible in every case.
(d) At least 5 cm.

20. Another patient undergoing radioactive seed placement has a biopsy microclip at the site of microcalcifications that needs to be targeted for surgical removal. What is the optimal placement of the radioactive seed in respect to the microclip?
(a) Within the prior microclip.
(b) Adjacent to the site of the prior microclip.
(c) Do not place the radioactive seed; it is contraindicated in lesions with prior biopsy microclip.
(d) Anywhere in the lesion of interest; the spatial relationship of the radioactive seed to the biopsy microclip is not important.

21. A 47-year-old woman with infiltrating ductal carcinoma is undergoing right breast lumpectomy with sentinel lymph node biopsy and is referred to you for radioactive seed placement both in the right breast mass and in a suspicious axillary node. What is the best order of seed placement?
    (a) The order of placement does not matter.
    (b) Place a seed in the breast mass first and then the axillary lymph node.
    (c) Place a seed in the axillary lymph node first and then the breast mass.
    (d) Place a seed in the breast mass only; there is no data to support radioactive seed placement in a suspicious axillary lymph node.

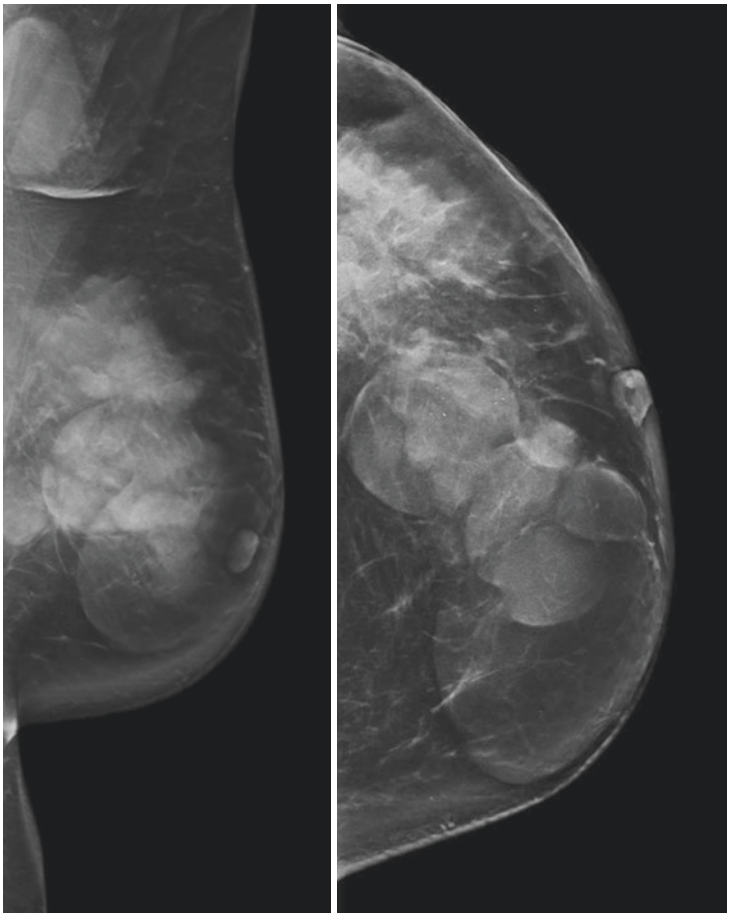
22. Another woman is undergoing right breast lumpectomy and sentinel lymph node biopsy for breast cancer. If she is planned for preoperative sentinel node Technetium-99 injection and radioactive seed placement in a suspicious axillary node, which procedure should be done first?
    (a) Radioactive seed placement.
    (b) Sentinel node injection.
    (c) The order does not matter.
    (d) The procedures should be done at the same time.

23a. 58-year-old woman with recently diagnosed invasive ductal carcinoma of the left breast and positive axillary lymph nodes. The image below demonstrates what findings in the left breast?



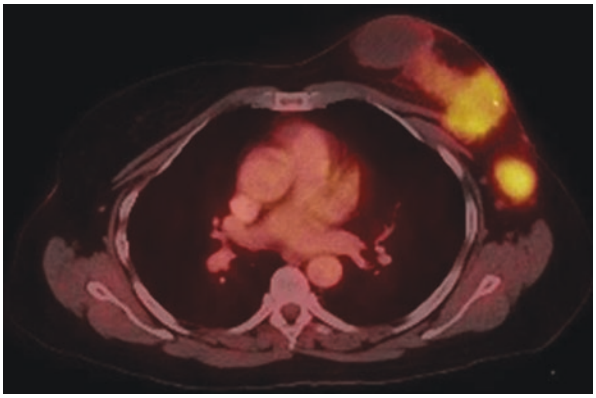
    (a) Irregular masses with a fat plane separating it from the pectoralis muscle.
    (b) Enhancement of the pectoralis muscle, which indicates muscular invasion.
    (c) Irregular masses with involvement of the chest wall.
    (d) Pectoralis muscle involvement, which is considered metastatic disease.

23b. The patient's mammogram is shown below. How would you best characterize her disease?



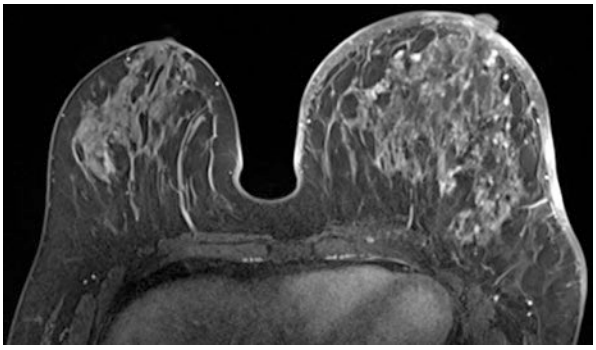
(a) Multilobulated.
(b) Multifocal.
(c) Multicentric.
(d) Multinodular.
(e) Multigeographic.

24. A woman with newly diagnosed left breast cancer underwent FDG PET-CT. The tumor showed avid FDG uptake with high SUV. The tumor most likely has which of the following characteristics?



(a) Triple negative.
(b) Estrogen receptor positive.
(c) Lobular cancer.
(d) Less than 1 cm in size.

25a. A 53-year-old woman with no significant past medical history presents with enlargement and redness of the left breast for the past 2 months, which did not improve after a course of antibiotics. Her MRI is shown below. What is the most likely diagnosis?



(a) Infectious mastitis.
(b) Prior radiation therapy to the region.
(c) Paget's disease.
(d) Inflammatory breast cancer.

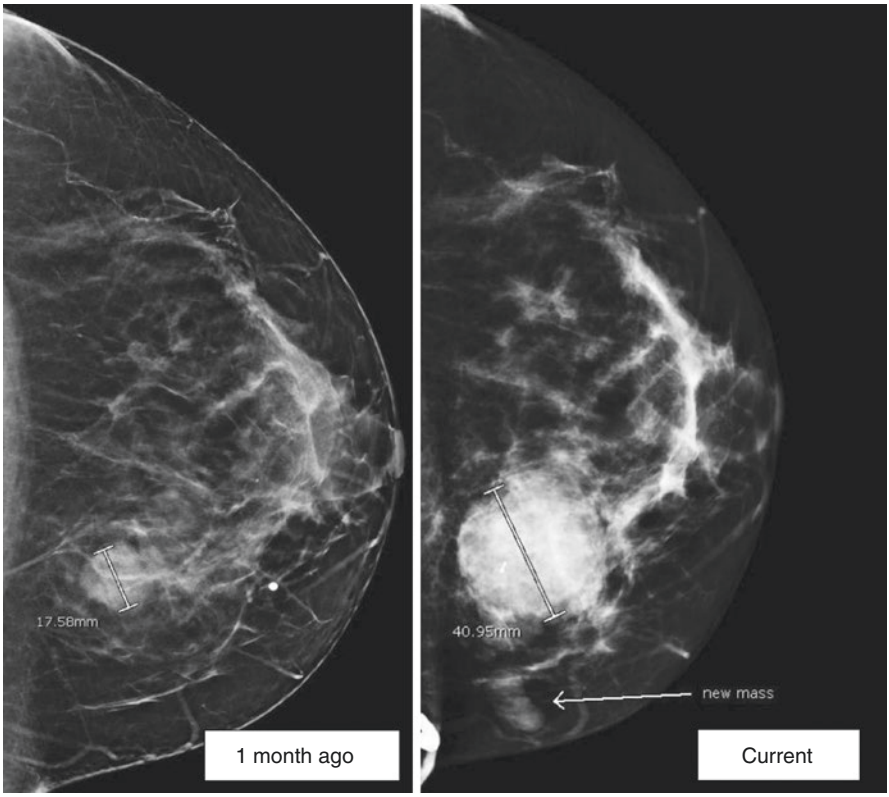
25b. The patient above had workup and was not found to have any suspicious lymph nodes nor evidence of metastatic disease. What is her TNM stage?
(a) IIb.
(b) IIIa.
(c) IIIb.
(d) IIIc.

26. For DCIS, what is the TNM stage according to the AJCC staging system eighth edition?
(a) T1a.
(b) T1b.
(c) T1c.
(d) Tis.

27. Which of the following breast pathologies is included in the current AJCC staging system for breast cancer?
(a) LCIS.
(b) Phyllodes tumor.
(c) Lymphoma.
(d) Paget's disease of the breast.

28. For which clinical stage of breast cancer should CT chest, abdomen, and pelvis, bone scan, or PET-CT be considered?
(a) Stage I and above.
(b) Stage II and above.
(c) Stage III and above.
(d) Stage IV and above.

29. A 40-year-old woman presents with a palpable breast lump. Diagnostic mammogram demonstrated a mass. Biopsy was performed and came back as invasive ductal carcinoma. Follow-up mammogram 1 month later was performed (current).



What is the best estimate of the Ki-67 for this patient?
(a) Zero.
(b) Low.
(c) High.
(d) Ki-67 estimation cannot be determined based on these images.

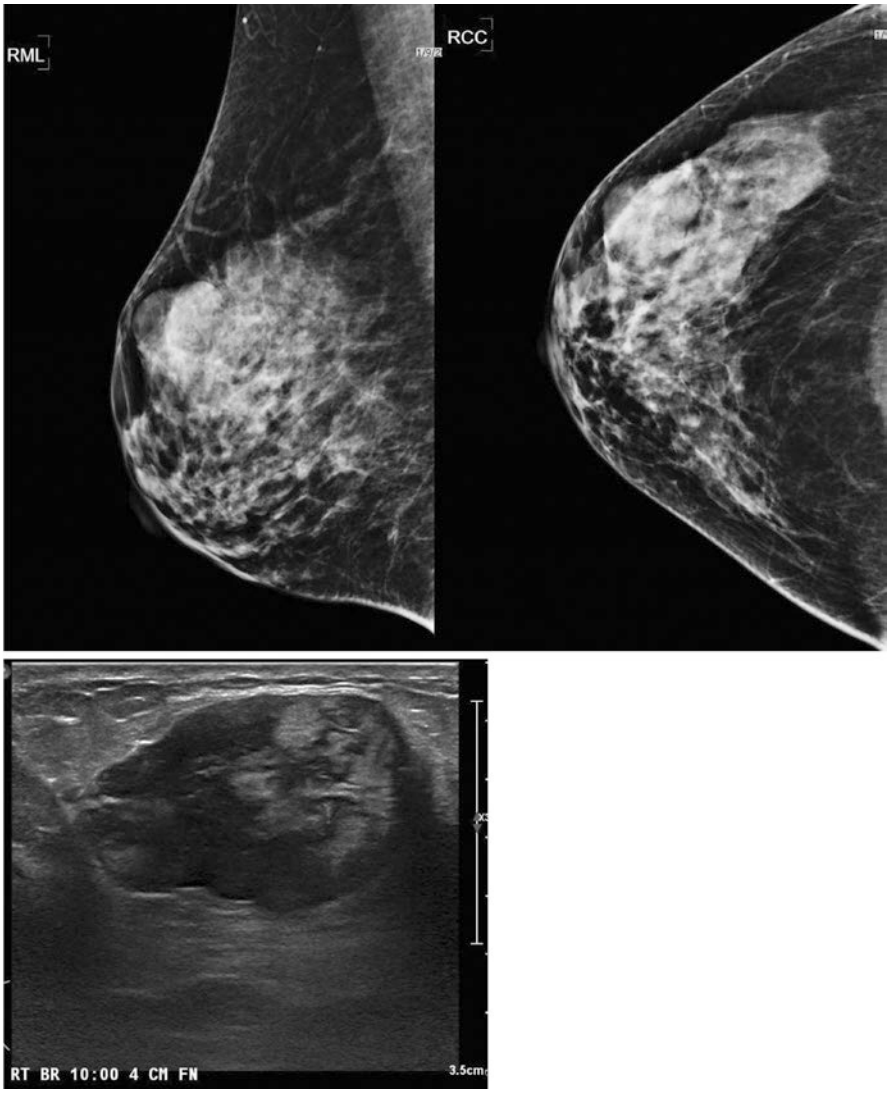
30. For patients with T1 and T2 hormone receptor positive, HER2-negative, and lymph node-negative tumors, what Oncotype DX recurrence score places them in the same AJCC prognostic category as stage I breast cancer?
    (a) Less than 11.
    (b) Less than 21.
    (c) Less than 35.
    (d) Less than 50.

31. Which of the following regarding invasive lobular carcinoma is false?
    (a) It is difficult to determine extent of disease due to its diminished fibrotic reaction.
    (b) It is more often bilateral than invasive ductal carcinoma.
    (c) Preoperative MRI decreases the chances of repeat surgery.
    (d) It accounts for approximately 35% of all breast cancer.

32. Among women with N1 breast cancer receiving neoadjuvant chemotherapy who had two or more sentinel lymph nodes examined in the American College of Surgeons Oncology Group (ACOSOG) Z1071 clinical trial, the false-negative rate of sentinel lymph node biopsy was which of the following?
    (a) 1%
    (b) 4%
    (c) 12.6%
    (d) 74.6%.

33. Which of the following is not an absolute or relative contraindication to whole breast radiation?
    (a) Pregnancy.
    (b) Multicentric disease.
    (c) Prior breast radiation.
    (d) Multifocal disease.

34a. A 33-year-old woman with a history of phyllodes tumor presents with a lump in the right breast. She underwent a diagnostic mammogram and ultrasound.



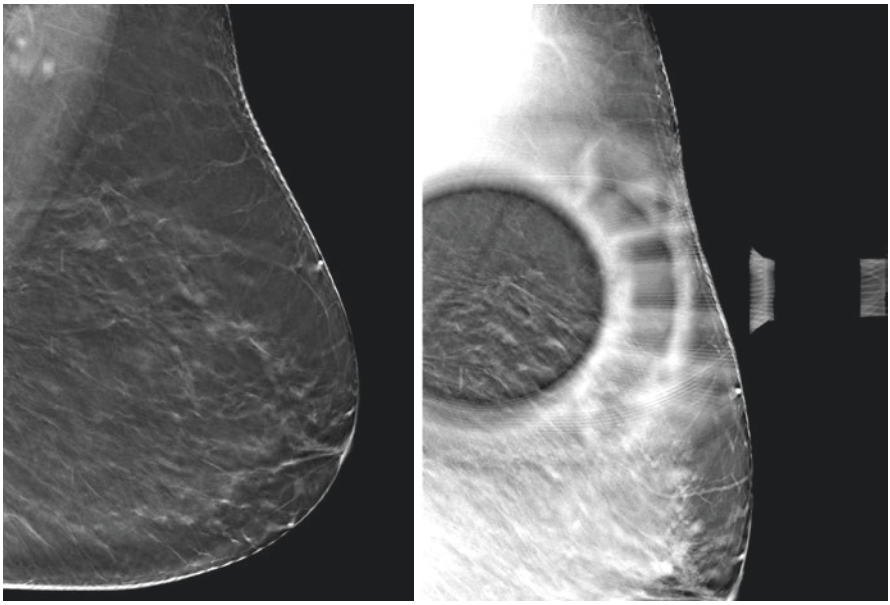
What is the typical treatment for benign phyllodes tumor?

(a) Complete surgical excision with wide margins and chemotherapy.
(b) Complete surgical excision with wide margins.
(c) Complete surgical excision with wide margins, axillary node dissection, chemotherapy, and radiation therapy.
(d) Neoadjuvant chemotherapy followed by wide surgical excision.

34b. What syndrome is associated with the development of phyllodes tumor?
(a) Li–Fraumeni syndrome.
(b) Cowdens.
(c) Von Hippel-Lindau.
(d) Neurofibromatosis.

35. A 52-year-old woman was recently diagnosed with invasive ductal carcinoma in the left breast. She was found to have an Oncotype DX score of 8. What is the significance of this score?
(a) The patient has an increased risk of recurrence and should be treated with chemotherapy.
(b) She has a lower risk of recurrence and may not need chemotherapy.
(c) She has metastatic disease.
(d) She has an increased risk of metastatic disease.

36a. A 74-year-old woman was recalled from screening mammogram with tomosynthesis. Spot compression images were performed at the time of diagnostic imaging and an area of architectural distortion was identified. No ultrasound correlate was identified. What is the next step?

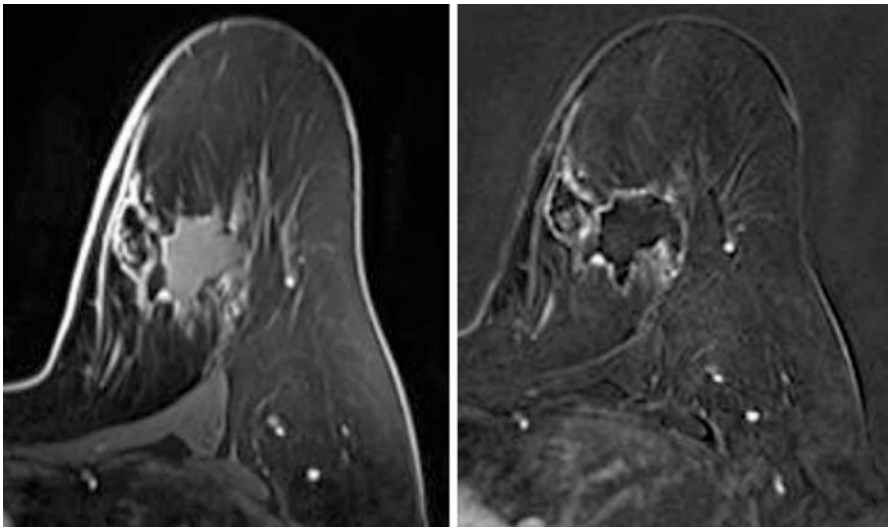


(a) MRI.
(b) Contrast-enhanced mammogram.
(c) Ultrasound-guided biopsy.
(d) Stereotactic-guided biopsy.
(e) 6-month follow-up.

36b. What is the malignancy rate of tomosynthesis stereotactic-guided core needle biopsy of architectural distortion without a sonographic correlate?
(a) 2%
(b) 19%
(c) 79%
(d) 99%.

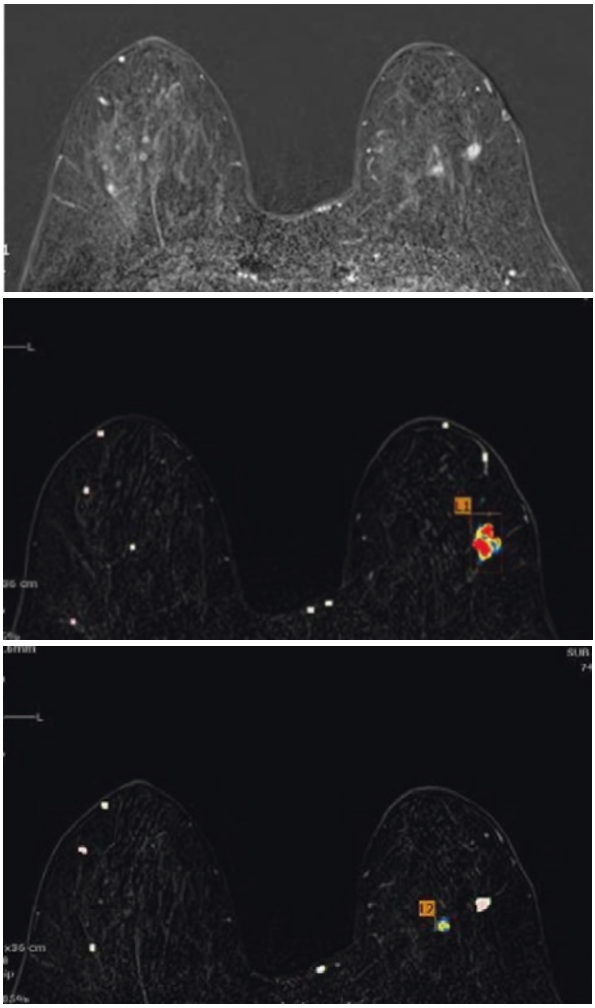
36c. Surgical excision was performed, and surgical pathology was 2 cm of invasive lobular carcinoma in a background of LCIS. The invasive carcinoma was less than 1 mm from the lateral margin. Which imaging modality would best help evaluate for residual disease prior to re-excision?
(a) PET-CT.
(b) Contrast-enhanced mammogram.
(c) Diagnostic mammogram.
(d) MRI.
(e) Ultrasound.

36d. The MRI is shown below. Based on the MRI and the pathology findings, what is the next step?



(a) Re-excision.
(b) 6-month follow-up MRI
(c) PET-CT exam.
(d) Ultrasound.

37. A 66-year-old woman presents with the MRI below. Both lesions were biopsied and showed invasive ductal carcinoma. The primary tumor measures 18 mm, and the satellite lesion measures 7 mm. What is the T of the TNM staging of this patient's breast cancer?

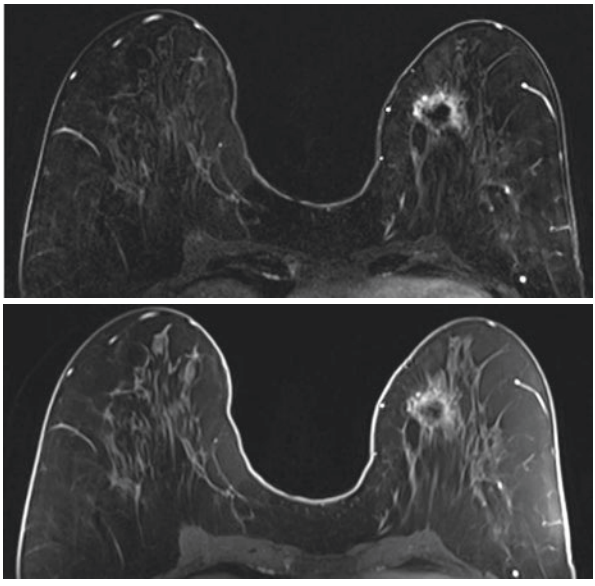


(a) T1.
(b) T2.
(c) T3.
(d) T4.

38. A mass measures 15 mm on ultrasound but 21 mm on MRI. What is the correct measurement of the mass for TNM staging?
    (a) MRI measurement.
    (b) Ultrasound measurement.
    (c) Both measurements should be averaged.
    (d) The patient should be recalled, and a repeat ultrasound should be performed to obtain a new measurement.

39. Excellent tumor response to neoadjuvant chemotherapy is best seen in which molecular subtypes of breast cancer?
    (a) Triple negative and HER2 positive breast cancer.
    (b) Hormone receptor positive and HER2 negative breast cancer.
    (c) Hormone receptor positive and HER2 positive breast cancer.
    (d) There is no difference among the molecular subtypes of breast cancer for response to neoadjuvant chemotherapy.

40. A 53-year-old woman underwent surgery for DCIS and subsequent MRI images are shown following surgery. What is the most appropriate next step?



    (a) Radiation.
    (b) Re-excision.
    (c) Routine follow-up.
    (d) PET/CT scan.

41a. 61-year-old woman with a history of right breast cancer. Screening mammogram is shown with comparison images from 2 years prior. What is the most appropriate BI-RADS assessment?

(a) BI-RADS 0 additional imaging.
(b) BI-RADS 3 probably benign post-surgical changes.
(c) BI-RADS 2 benign post-surgical changes.
(d) BI-RADS 4 suspicious.

41b. The patient was recalled, and additional imaging was performed. What is the most appropriate assessment and management plan?

(a) The finding represents benign post-surgical changes; return in 1 year.
(b) The finding represents benign post-surgical changes; return in 6 months.
(c) Ultrasound.
(d) MRI.

41c. An ultrasound was performed, and biopsy showed invasive ductal carcinoma. The patient has already undergone radiation in the past as part of initial breast conserving treatment. What is the traditional treatment for the recurrent cancer at the lumpectomy site?

(a) Radiation therapy.
(b) Re-excision with radiation.
(c) Mastectomy.
(d) No surgical management.

Answers

1. b. 36 mm.

   By ultrasound, the index cancer measures 30 mm. By MR, the index cancer measures 36 mm. Including adjacent enhancing foci, the span of suspicious enhancements measures 51 mm in conglomerate.

   For TNM staging, the maximum dimension of the dominant mass measured to the nearest millimeter is used. Associated satellites of non-contiguous tumor should not be included in the T measurement but should be reported for surgical planning [1, 2].

   Although size measurements vary between ultrasound and MRI, that by MRI is considered more accurate and should therefore be used [1, 2]. In this case, the answer is 36 mm. If a substantial discrepancy between measurements on different imaging modalities exists such that T staging is affected, additional imaging workup and/or biopsy should be performed to better delineate the extent of disease [1, 2].

2. b. Breast MRI.

   Breast MRI should be performed for unilateral metastatic axillary adenopathy to assess for underlying breast disease. MRI has been shown to identify the occult primary breast malignancy in 62–86% of women presenting with axillary lymph node metastasis [3]. Better delineation of the extent of disease is important for treatment planning.

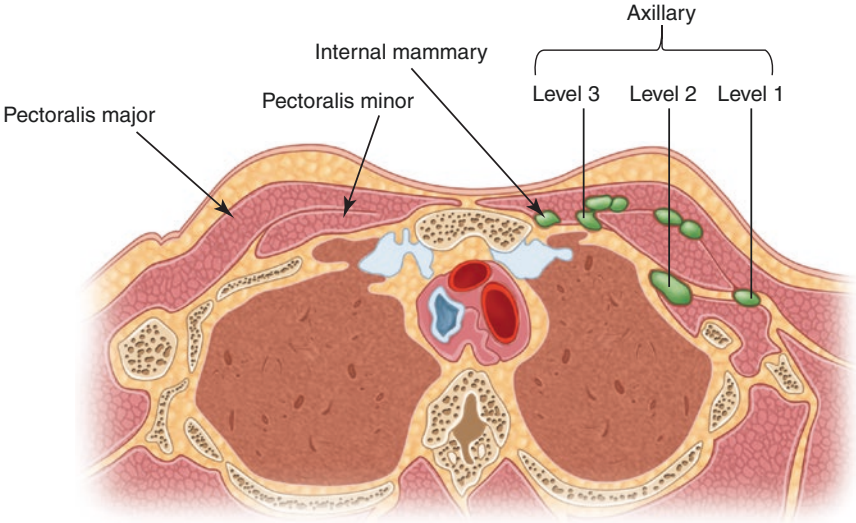
3. d. Tumor infiltration begins at the periphery, not the center, of the axillary lymph node.

   All other answer choices are true [4].

4. a. I.

   The three major sites of lymphatic drainage of the breast are the axillary, interpectoral, and internal mammary lymph nodes. The regional lymph nodes in the breast for staging breast cancer include the axillary, interpectoral, internal mammary, and supraclavicular lymph nodes. Although intramammary lymph nodes are located within the breast, they are considered axillary lymph nodes for staging purposes [2] Please see question 14 in Chap. 5 for additional anatomic details.

   The axillary lymph nodes can be classified as level I (low axilla) nodes, which are located lateral to the lateral border of the pectoralis minor muscle. Level II (mid-axilla) nodes are located between the medial and lateral borders of the pectoralis minor muscle and include interpectoral nodes (Rotter's nodes). Level III (apical axilla or infraclavicular) nodes are located medial to the medial margin of the pectoralis minor muscle and inferior to the clavicle. The level III nodes designate a worse prognosis. The internal mammary lymph nodes are located in the intercostal spaces along the edge of the sternum. The supraclavicular lymph nodes are located in the supraclavicular fossa, which is bounded laterally and superiorly by the omohyoid muscle and tendon, medially by the internal jugular vein, and inferiorly by the clavicle and subclavian vein [1, 2]. Please see question 14 in chapter 5 for additional anatomic details.



5. d. M1.

Metastasis to cervical lymph nodes, contralateral internal mammary lymph nodes, or contralateral axillary lymph nodes are considered distant metastases, classified as M1 disease [1, 2]. The clinical anatomic nodal staging and the pathological anatomical nodal staging are different, designated as c for clinical and p for pathological. The clinical anatomical nodal staging is more relevant for the radiologist as this is based on imaging findings [1, 2]. Refer to the tables below for an overview of the clinical anatomical nodal and metastasis criteria.

Clinical Regional Lymph nodes (cN)

cN Category	cN Criteria
cNX	Regional lymph nodes cannot be assessed
cN0	No regional lymph node metastasis by clinical exam or imaging
cN1	Metastasis to movable ipsilateral level I or II axillary
cN2	Fixed or matted ipsilateral level I or II axillary nodes (cN2a) or ipsilateral internal mammary nodes in the absence of axillary node metastasis (cN2b)
cN3	Metastases in ipsilateral level III (cN3a) or ipsilateral internal mammary nodes with level I, II axillary nodes (cN3b) or metastases in ipsilateral supraclavicular nodes (cN3c)

Metastasis

M category	M criteria
M0	No clinical or imaging evidence of metastases
cM1	Clinical or imaging evidence of metastases

6. a. Up to 5%.

Normal internal mammary nodes are less than 6 mm in short-axis dimension [2, 4]. Isolated metastases to the internal mammary nodes occur in 1–5% of breast cancers [4]. The metastases usually come from medial or deep lesions. Usually, metastases to the internal mammary nodes occur after a tumor has metastasized to the axilla, which is considered N3b disease [2, 4]. When there are isolated metastases to the internal mammary nodes, it is considered N2b disease [2, 4].

Surgical dissection is not performed for internal mammary nodal metastases because there is no survival benefit and there is increased morbidity [4]. In such cases, radiation treatment planning is tailored to include the internal mammary nodes. Standard tangential external beam radiation therapy of the breast does not typically include these nodes [4].

7a. b. MRI.

Paget's disease of the breast is a rare malignancy of the breast and accounts for approximately 1–3% of all breast cancers [5]. The clinical presentation of Paget's disease of the nipple includes itching, eczema, and erythema of the nipple and areola, nipple erosion, ulceration, or retraction, scaly or flaky skin, or isolated bloody discharge from the nipple. Mammography may be unrevealing in 50% of cases [5]. If the mammogram and ultrasound are negative, MRI is recommended as a next step because 90% of cases of Paget's disease of the nipple are associated with an additional underlying breast malignancy [5].

7b. a. Paget's disease.

The MRI image shows asymmetric enhancement of the right nipple and an enhancing mass in the outer right breast. The MR findings of the right nipple in conjunction with the history are consistent with Paget's disease. If the mammogram and ultrasound are negative, MRI is recommended as a next step [5].

7c. d. MRI-guided biopsy.

In addition to the asymmetric enhancement of the right nipple, there is an enhancing mass in the outer right breast on MRI. This finding is suspicious and should undergo biopsy. Over 90% of Paget's disease cases are associated with either ductal carcinoma in situ (DCIS) or invasive carcinoma [5]. This woman underwent mastectomy with surgical pathology showing both Paget's disease and invasive ductal carcinoma.

8. c. DCIS.

Ninety percent of cases of Paget's disease of the nipple are associated with an additional underlying breast malignancy, most frequently DCIS in the lactiferous ducts of the nipple-areolar complex [5]. Paget's disease can also be associated with DCIS or invasive cancer elsewhere in the breast [5].

9. a. Partial response.

Based on Response Evaluation Criteria in Solid Tumors (RECIST), the resolution of all lesions indicates complete response [6]. A decrease in the maximum diameter of target lesions by greater than or equal to 30% compared with baseline indicates partial response. An increase in diameter of greater than or equal to 20% is consistent with progression of disease. When the criteria for neither partial response nor progression of disease is met, it is considered stable disease [6]. On the initial MRI (Fig. A), there is extensive non-mass enhancement throughout the right breast. On her subsequent MRI (Fig. B), the non-mass enhancement has decreased by greater than 30%, consistent with partial response.

10. d. MRI.

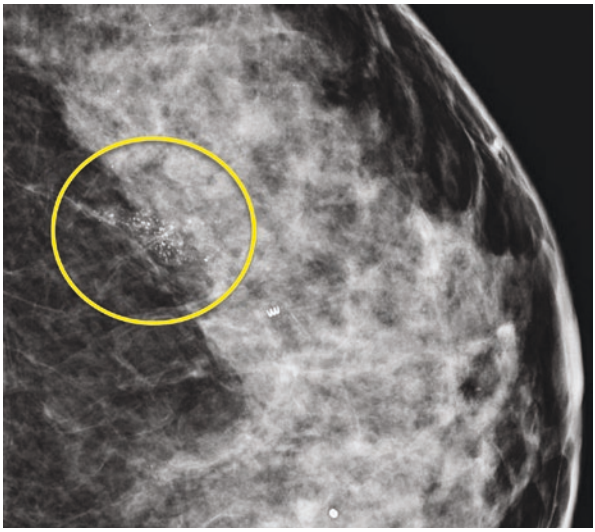
MRI is the most accurate imaging modality for assessing tumor response to neoadjuvant therapy after treatment [7–9]. A meta-analysis that compared MRI and FDG PET/CT for evaluation of pathologic response to neoadjuvant chemotherapy in patients with breast cancer found that when performed after completion of neoadjuvant therapy, MRI outperformed FDG PET/CT through its higher sensitivity (0.88 vs 0.57) [7].

11a. b. BI-RADS 0. Incomplete. Recall the patient.

Although the patient has undergone prior benign surgical excision and prior benign biopsy, there are calcifications that require further evaluation. The patient should be recalled for magnification views of the calcifications.

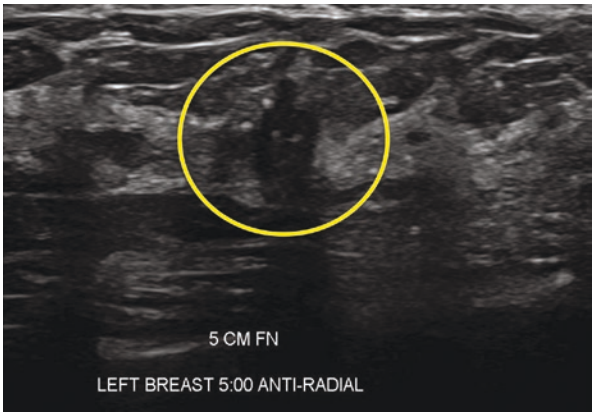
11b. d. Ultrasound.

There are suspicious grouped fine pleomorphic calcifications in the lower outer left breast. There is an additional smaller group of suspicious calcifications seen in the medial left breast (magnification views not shown). Although the suspicious calcifications can be biopsied by stereotactic guidance, an ultrasound should first be performed to evaluate for an underlying sonographic mass representing a potential invasive component, which can be targeted by ultrasound for biopsy.



11c. b. Ultrasound-guided core biopsy.

The ultrasound shows an irregular hypoechoic mass with calcifications within and adjacent to the mass. The constellation of findings is worrisome for malignancy, and an ultrasound-guided core needle biopsy should be performed. Although the calcifications can be targeted by stereotactic guidance, the mass seen on ultrasound is worrisome for an invasive component and should be targeted by ultrasound guidance. Specimen radiograph of the tissue obtained from ultrasound-guided biopsy can be obtained to confirm sampling of calcifications.



11d. c. Multifocal disease.

Multifocal disease involves one quadrant of the breast, while multicentric disease involves two or more quadrants of the breast or lesions that are greater than 5 cm apart [10]. Multicentric breast cancer typically is not amenable to breast conservation therapy due to distance of lesions and resultant distortion of the breast; mastectomy is the standard of care in these cases [10]. MRI is more sensitive than mammography for the detection of multifocal or multicentric disease in dense breasts [11]. If the patient desires breast conservation therapy, an additional area in another quadrant should be biopsied to document extent of disease [11].

12. c. 30–40%.

Incidentally detected FDG-avid breast soft tissue lesions have a 30–40% chance of malignancy, including unsuspected primary breast cancer, metastases to the breast, and breast lymphoma [12]. These lesions should be further evaluated with dedicated mammography and/or ultrasound. Lesions with suspicious characteristics on subsequent workup warrant targeted biopsy [12].

13. c. There is nipple involvement.

The MRI shows extensive non-mass enhancement in the outer right breast, which extends to the nipple. There is suspicious enhancement of the nipple itself. Breast cancer invasion of the nipple-areolar complex is considered skin involvement, T4 disease, and precludes nipple-sparing mastectomy [13]. The MRI does not show pectoralis muscle, chest wall, or internal mammary lymph node involvement.

14. a. Triple negative.

Breast cancers in BRCA1 positive women are associated with the triple negative molecular subtype, whereas those in BRCA2 positive women are associated with the luminal B molecular subtype [14–16]. BRCA1 carriers are more likely to present with breast cancer at a younger age, have higher nuclear grade, worse histologic grade, earlier development of metastasis, and decreased survival compared to BRCA2 carriers [14].

Molecular subtype	ER/PR	HER2	Associations
Luminal A	ER (+) and/or PR (+)	(−)	Favorable prognosis, low Ki-67 (<14%), responds to endocrine therapy
Luminal B	ER (+) and/or PR (+)	(−) or (+)	BRCA2, high Ki-67 (>14%), endocrine therapy not reliable
HER2-enriched	(−)	(+)	Responds to trastuzumab (Herceptin) and responds to anthracycline-based chemotherapy
Basal like	(−)	(−)	Most often triple negative, often seen in BRCA1, common in African American women, sensitive to platinum-based chemotherapy and PARP inhibitors

15a. c. Ultrasound.

Ultrasound is the first-choice imaging modality in a pregnant or lactating woman with a palpable breast mass [17]. Ultrasound does not utilize ionizing radiation and has a high sensitivity for detecting breast cancer [17]. Ultrasound has a reported sensitivity and negative predictive value of 100% in these women [17].

If suspicious findings are seen on ultrasound, a full workup with mammography is warranted to help identify calcifications and to delineate extent of disease [17].

15b. c. Biopsy.

The ultrasound shows suspicious irregular hypoechoic masses with angular, microlobulated, and indistinct margins. Ultrasound-guided biopsy is the most appropriate next step. In this case, the biopsy result was triple negative invasive ductal carcinoma with DCIS.

Pregnancy-associated breast cancer is the most common malignancy in pregnancy and is the most common cause of cancer-related death in pregnant and lactating women [17]. The imaging features have been reported to be similar to those of non-gestational breast cancers [17]. Biopsy of any new solid mass detected on ultrasound during pregnancy should be considered to avoid a delay in diagnosis [17].

15c. b. Painless breast lump.

The most common presentation of pregnancy-associated breast cancer is a painless, palpable breast lump [17]. Other less common clinical presentations include unilateral breast enlargement with skin thickening, focal pain, and nipple discharge associated with a mass. The "milk rejection" sign has been described, in which the infant refuses to nurse from the affected breast [17].

16. b. 29%.

Axillary lymph nodes can be classified according to cortical morphologic features. Usually types 1–3 can be considered benign. Type 1 lymph nodes are hyperechoic with almost no discernible cortex. Type 2 lymph nodes have a uniformly thin hypoechoic cortex of <3 mm, while type 3 lymph nodes have a uniformly thick cortex of >3 mm and may have minor surface lobulations. Type 4 lymph nodes are hypoechoic with generalized cortical lobulation [18]. Type 5 lymph nodes demonstrate asymmetric focal hypoechoic cortical lobulation and have a positive predictive value of 29% [18]. Type 6 are completely hypoechoic with no hilum, and its positive predictive value for malignancy is 58% [18].

17. b. Treatment of the primary breast cancer.

The images show an axillary lymph node with normal morphology, including reniform shape and central echogenic hilum. Although normal-appearing lymph nodes can still harbor micrometastases, there are no suspicious imaging findings to warrant biopsy or dissection.

Evaluation of axillary lymph node involvement in breast cancer is an integral part of determining extent of disease for treatment planning [19]. Based on the American College of Surgeons Oncology Group (ACSOG) Z0011 trial, current recommendations are to offer sentinel lymph node biopsy in lieu of complete axillary lymph node dissection to select women with stage T1 or T2 tumors without palpable lymphadenopathy [19]. In this trial, complete axillary lymph node dissection did not improve survival and resulted in increased morbidity [19].

18a. d. There are round faint calcifications along the margin.

Prior to localization, all prior breast imaging should be reviewed carefully [20]. This patient had biopsy-proven DCIS presenting as extensive calcifications. At the time of specimen review, the radiologist should inform the surgeon whether the targeted lesion and/or biopsy microclip(s) are seen in the specimen and whether the specimen margins appear adequate by imaging [20]. The faint calcifications along the margin of the specimen should be communicated to the surgeon, as these appear suspicious and warrant wider excision. The final pathology on this specimen did have positive surgical margins.

18b. d. Diagnostic mammogram.

Due to the large extent of calcifications that were biopsy-proven as DCIS, the treatment team should obtain a post-surgical, pre-radiation diagnostic mammogram with magnification views to assess for any residual calcifications. Although MRI can be performed to assess for residual disease, the area of calcifications may not enhance on MRI.

19. b. 2–3 cm.

A separation of at least 2–3 cm between radioactive seeds enables the surgeon to better detect each site and to remove both seeds in one specimen [21]. Close proximity of seeds can limit intraoperative detection of separate radioactive sites, leading to an unrecovered seed [21].

20. b. Adjacent to the site of the prior microclip.

A preoperative radioactive seed should be placed adjacent to a prior biopsy microclip. Placing a seed at the site of the prior microclip can result in it residing in the gelatinous substance of the microclip, making intraoperative recovery of the seed more difficult due to the slippery nature of the bioabsorbable polymer surrounding the metallic microclip [21]. Intraoperatively, the microclip, seed, or both can be expelled from the surgical bed or suctioned out without the surgeon's knowledge [21].

21. c. Place a seed in the axillary lymph node first and then the breast mass,

A radioactive seed should be placed first in the axillary lymph node, with confirmation of placement using a Geiger counter, before any additional seeds are placed in the breast, since its location in the axilla may be beyond the field of view of the post-procedure mammogram [21].

22. a. Radioactive seed placement.

A radioactive seed should be placed in the suspicious axillary lymph node before sentinel node injection of Technetium-99 [21]. Since the seed may be beyond the field of view of the post-procedure mammogram, its placement can be confirmed with a Geiger counter [21]. However, if the seed is placed after Technetium-99 injection, the Geiger counter cannot distinguish between radioactivity from the seed and radioactivity from the Technitium-99 injection [21].

23a. b. Enhancement of the pectoralis muscle, which indicates muscular invasion.

The MRI shows invasion of the pectoralis muscle, which is not considered chest wall and does not affect TNM staging [2]. Pectoralis muscle involvement may be seen as direct muscle enhancement with loss of the fat plane between tumor and muscle [2, 22]. Obliteration of the fat plane without associated muscle enhancement does not necessarily indicate pectoralis muscle involvement [2, 22]. Pectoralis muscle involvement is important to describe because it may affect surgical approach [2, 22]. In contrast, chest wall invasion is involvement of ribs, intercostal muscles, and/or serratus anterior muscle, and upgrades the stage to T4 [2].

23b. c. Multicentric disease.

Multicentric disease involves two or more quadrants of the breast or consists of lesions that are more than 5 cm apart, as seen in this case [10, 11]. Multifocal disease involves multiple masses involving one quadrant of the breast [10, 11]. MRI is more sensitive than mammography for the detection of multifocal or multicentric disease in dense breasts [11]. Multilobulated, multinodular, and multigeographic are not standardized descriptors for breast cancer tumor distribution.

24. a. Triple negative.

Higher FDG uptake and SUV can be seen in more aggressive disease, including high grade and estrogen receptor negative cancer such as triple negative cancer [23]. False-negative PET-CT results can be seen in tumors that are less than 1 cm due to small size and in lobular cancers [23]. False-positive uptake can be seen in infectious and inflammatory processes, post-surgical changes, radiation necrosis, and proliferative changes such as gynecomastia and lactation, and uncommonly fibroadenomas [23].

25a. d. Inflammatory breast cancer.

The main differential diagnosis for inflammatory breast cancer (IBC) is mastitis with or without associated abscess [24]. If the patient fails appropriate antibiotic treatment or has an incomplete response to antibiotics, then IBC should be considered [24]. Both clinical evidence of inflammatory disease and tissue diagnosis of malignancy are required to confirm the diagnosis of IBC [1, 24]. On this MRI, there is marked diffuse skin thickening of the enlarged left breast with diffuse asymmetric enhancement.

25b. c. IIIb.

The AJCC defines inflammatory breast cancer (IBC) as a clinical-pathologic entity with diffuse skin erythema and edema (peau d'orange) involving at least one-third of the skin of the breast with symptoms occurring for less than 6 months [1, 22]. IBC typically progresses rapidly over weeks to months due to tumor emboli obstructing flow in the dermal lymphatic vessels [22]. T4d staging is reserved for disease that meets criteria for IBC regardless of tumor size [1, 22].

The staging system for breast cancer is shown in the chart below.

Anatomic staging is utilized when biomarker tests are not available [1, 2]. If favorable, biomarker tests can decrease the staging by one level [1].

Tumor Stage by TNM Grade

Stage	TNM
0	Tis, N0, M0
IA	T1, N0, M0
IB	T0, N1mi, M0 T1, N1mi, M0
IIA	T0, N1, M0 T1, N1, M0 T2, N0, M0
IIB	T2, N1, M0 T3, N0, M0
IIIA	T0, N2, M0 T1, N2, M0 T2, N2, M0 T3, N1, M0 T3, N2, M0
IIIB	T4, N0, M0 T4, N1, M0 T4, N2, M0
IIIC	Any T, N3, M0
IV	Any T, any N with M1

Definition of Primary Tumor (T) for Clinical and Pathological Staging. All measurements should be taken of the greatest dimension of the tumor.

T category	T criteria
TX	Primary tumor unable to be assessed
T0	No evidence of primary tumor
Tis	DCIS Paget disease of the nipple (not associated with invasive carcinoma or DCIS in the ipsilateral breast)
T1	Tumor less than or equal to 20 mm
T1mi	Tumor less than or equal to 1 mm

T category	T criteria
T1a	Tumor greater than 1 mm but less than or equal to 5 mm (please note that any measurement greater than 1–1.9 mm should be rounded up to 2 mm)
T1b	Tumor greater than 5 mm but less than or equal to 10 mm
T1c	Tumor greater than 10 mm but less than or equal to 20 mm
T2	Tumor greater than 20 mm but less than or equal to 50 mm
T3	Tumor greater than 50 mm
T4	Tumor extension to the chest wall
T4a	Extension to the chest wall only
T4b	Ulceration and/or ipsilateral macroscopic satellite nodules and/or edema of the skin that does not meet the criteria for inflammatory cancer
T4c	Both T4a and T4b
T4d	Inflammatory breast cancer

Clinical Regional Lymph nodes (cN)

cN Category	cN Criteria
cNX	Regional lymph nodes cannot be assessed
cN0	No regional lymph node metastasis by clinical exam or imaging
cN1	Metastasis to movable ipsilateral level I or II axillary
cN2	Fixed or matted ipsilateral level I or II axillary nodes (cN2a) or ipsilateral internal mammary nodes in the absence of axillary node metastasis (cN2b)
cN3	Metastases in ipsilateral level III (cN3a) or ipsilateral internal mammary nodes with level I, II axillary nodes (cN3b) or metastases in ipsilateral supraclavicular nodes (cN3c)

Metastasis

M category	M criteria
M0	No clinical or imaging evidence of metastases
cM1	Clinical or imaging evidence of metastases

26. d. Tis.

DCIS and Paget's disease (without associated invasive carcinoma or DCIS) are categorized as Tis [1, 2]. T1 disease is invasive carcinomas subcategorized as T1mi (tumor size ≤1 mm), T1a (tumor size >1 mm but ≤5 mm), T1b (tumor size >5 mm but ≤10 mm), and T1c (tumor size >10 mm but ≤20 mm) [1, 2]. Previous editions included LCIS in the Tis category, but in the AJCC eighth edition update, LCIS is excluded [1, 2].

27. d. Paget's disease of the breast.

Paget's disease without associated invasive carcinoma or DCIS is classified as Tis in the current AJCC staging system for breast cancer [1, 2]. LCIS is no longer included in the Tis category but rather is considered a benign entity that confers a higher lifetime risk of future breast cancer [1, 2]. Phyllodes tumor and lymphoma are not included in the AJCC staging system for breast cancer [1, 2].

28. c. Stage III and above.

    According to the guidelines of the National Comprehensive Cancer Network, for patients with clinical stage I to stage IIB disease, imaging studies should be directed by signs or symptoms (i.e., bone scan should be performed if the patient reports bone pain or has an elevated serum alkaline phosphatase) [2]. For patients with clinical stage IIIA disease, CT or MRI chest, abdomen, and pelvis, bone scan, or PET-CT using fluorine 18 fluorodeoxyglucose or radioactive sodium fluoride should be considered [2].

29. c. High.

    The rapid progression of disease over 1 month manifesting as increase in size of the index cancer and development of an adjacent new mass is consistent with a high Ki-67 level. The Ki-67 corresponds to the tumor proliferation status [25]. A higher Ki-67 is associated with a worse clinical outcome and changes in Ki-67 during neoadjuvant chemotherapy are used to assess treatment response [25].

    Ki-67 plays a role in differentiating luminal A and luminal B molecular subtypes of breast cancer [25]. Both luminal types are hormone receptor positive, but type A has a lower Ki-67 less than 14, and type B has a higher Ki-67 greater than or equal to 14 [25]. Luminal A tends to be less responsive to chemotherapy but is responsive to endocrine therapy [25]. Luminal B treatment may involve both endocrine therapy and chemotherapy, as well as molecular targeted drugs [25].

30. a. Less than 11.

    The Oncotype DX recurrence score is a validated multigene panel used for hormone-positive, node-negative tumors to evaluate the benefit of implementing adjuvant chemotherapy in addition to endocrine therapy [2]. It evaluates 16 genes and 5 reference genes to predict the likelihood of recurrence in patients undergoing endocrine therapy alone, categorizing each patient into low, intermediate, or high-risk categories for recurrence [2]. An Oncotype DX recurrence score of less than 18 denotes a patient with a low risk of recurrence, predicting no additional benefit of chemotherapy. In the eighth edition of the AJCC staging system for breast cancer, the incorporation of the Oncotype DX recurrence score can potentially downstage tumors, as in this case [2].

31. d.

    Invasive lobular carcinoma accounts for approximately 5-15% of all breast cancer [26].

32. c. 12.6%.

    Sentinel lymph node surgery provides reliable nodal staging information with less morbidity than axillary lymph node dissection for patients with clinically node-negative breast cancer (N0) [27]. However, the ACOSOG Z1071 clinical

trial demonstrated a false-negative rate of 12.6% in those initially presenting with biopsy-proven N1 breast cancer receiving neoadjuvant chemotherapy [28]. The increased false-negative threshold greater than 10% in this patient population shows that sentinel lymph node surgery alone is not appropriate in N1 breast cancer receiving neoadjuvant chemotherapy [28]. For these patients, preoperative localization of the biopsy-proven metastatic axillary lymph node with targeted axillary dissection is an option [28].

33. d. Multifocal disease.

Relative contraindications for breast radiation include pregnancy, extensive multicentric disease, collagen vascular disease, prior breast radiation, or anticipated poor cosmetic result [29].

34a. b. Complete surgical excision with wide margins.

Phyllodes tumors account for approximately 1% of all breast neoplasms [30]. Classically, they occur in women in their fifth decade and can be quite large, up to 5 cm, when first detected. Phyllodes tumors usually present as a dense round or oval, non-calcified mass and can mimic a fibroadenoma. Occasionally, they can contain cystic spaces [31]. Phyllodes tumors are fibroepithelial neoplasms with both stromal and epithelial elements. They have a characteristic leaf-like architecture with abundant cellular stroma [30, 31].
Phyllodes tumors are subclassified as benign, borderline, or malignant. Approximately 25% of phyllodes tumors are malignant, and approximately 13–40% of the malignant subtype can metastasize [32]. Metastasis is usually via hematogenous spread for the borderline and malignant types [30].

All phyllodes tumors should be completely excised, with negative surgical margins greater than or equal to 1 cm [30]. Axillary lymph node dissection is not necessary. Local recurrence ranges from 5% to 30% in benign phyllodes and up to 65% in borderline and malignant phyllodes if there is incomplete excision [30].

Adjuvant radiation therapy may treat borderline or malignant tumors, but not usually used in cases of benign phyllodes tumors. Chemotherapy is used for certain patients with large, high-risk, or recurrent malignant phyllodes tumors [32].

34b. a. Li–Fraumeni Syndrome [32].

35. b. She has a lower risk of recurrence and may not need chemotherapy.

The Oncotype DX recurrence score is a validated multigene panel used for hormone-positive, node-negative tumors to evaluate the benefit of adjuvant chemotherapy in addition to endocrine therapy [2, 23]. The large randomized prospective trials showed recurrence of less than 10% at 10 years in patients with a score of 18 or less [23]. Data suggest that patients with a score of 10 or less, as in this patient's case, have an overall survival of 98%, with 99.3% metastasis-free disease at 5 years [23].

36a. d. Stereotactic-guided biopsy.

On the provided mammograms, an area of architectural distortion is identified in the upper left breast. Although a sonographic correlate was not identified, this persisted on the spot compression images and therefore is still suspicious and should be categorized as BI-RADS 4. The lack of sonographic correlate should not preclude biopsy of a suspicious mammographic finding [33]. Since the distortion is identified mammographically, this can be biopsied by stereotactic guidance.

36b. b. 19%.

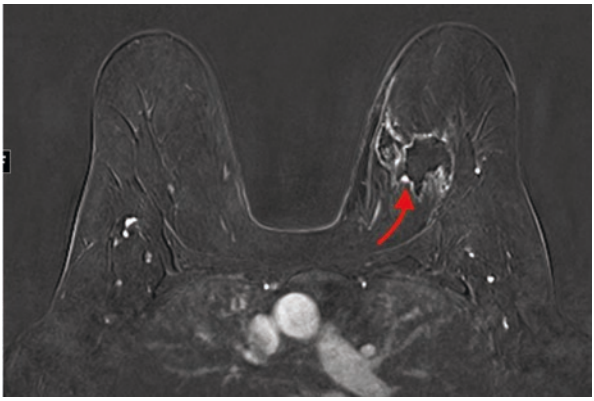
In a study of tomosynthesis-guided biopsy of architectural distortion without a sonographic correlate, the cancer yield was 19% [32]. This study suggests that a high index of suspicion should be maintained for distortions, and biopsy is warranted [33].

36c. d. MRI.

Breast MRI is a sensitive tool in the detection of residual disease in a patient with positive or close surgical margins [34]. The other imaging modalities listed are not as sensitive.

36d. a. Re-excision.

There is suspicious nodular enhancement along the periphery of the lumpectomy bed (curved red arrow). The patient should undergo re-excision, especially in the context of close surgical margin on the surgical specimen. Re-excision was performed, and atypical lobular carcinoma and lobular carcinoma in situ were seen. No residual invasive carcinoma was identified on re-excision in this case.



37. a. T1.

The index tumor defines the T in TNM staging [1, 2]. The satellite lesion is not included in the measurement [1, 2]. A T1 tumor measures less than or equal to

20 mm. A T2 lesion is greater than 20 mm but less than 50 mm. A T3 tumor is greater than 50 mm. A T4 tumor has direct extension to the chest wall and/or the skin with macroscopic changes [1, 2].

38. a. MRI measurement.

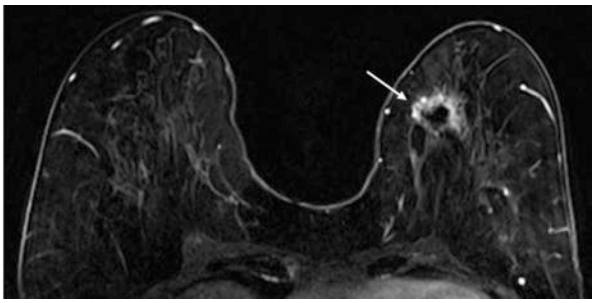
The largest tumor dimension should be measured on all imaging modalities [1]. If there is a discrepancy between the ultrasound and the MRI measurements, the MRI measurement should be used as it is considered more accurate [1]. If there is a large variation in measurements, such as due to additional disease revealed by one imaging modality, additional biopsies should be considered to document the true extent of disease [1].

39. a. Triple negative and HER2 positive breast cancer.

Tumor response to neoadjuvant chemotherapy can provide prognostic information as pathologic complete response after neoadjuvant chemotherapy and surgical resection is associated with improved disease-free survival [9]. This correlation is strongest for patients with triple negative and HER2 positive breast cancers [9].

40. b. Re-excision.

The MRI shows suspicious nodular enhancement at the periphery of the lumpectomy site and is suspicious for residual disease. Mass like enhancement, nodularity greater than 5 mm around a seroma cavity or segmental or clumped non-mass enhancement around a seroma cavity is suspicious [34]. However, minimal or focal area of enhancement or thin non-mass enhancement may be seen up to 18 months post-surgery [34]. If it is not associated with a mass or nodularity, it can be considered probably benign and a 6 month follow-up can be performed [34]. In this case, re-excision showed dense fibrosis and signs of prior surgical site without evidence of recurrence.



41a. a. BI-RADS 0 additional imaging.

A radiopaque scar marker is present denoting the area of prior surgery and there are post-surgical changes consistent with the history of lumpectomy. However, there is a new asymmetry in the retroareolar right breast with distortion. Although distortion can be seen in the setting of surgery, the distortion

and asymmetry are new and associated with nipple retraction. The constellation of findings is highly worrisome, and the patient should be called back (BI-RADS 0) for further workup.

41b. c. Ultrasound.

The finding is a new mass in the subareolar region with associated nipple retraction. Ultrasound is the most appropriate next step for further evaluation.

41c. c. Mastectomy.

Imaging of patients previously treated for breast cancer can be challenging. Any new areas of asymmetry, breast edema, distortion, or suspicious calcifications should be viewed with a high level of suspicion and warrants further evaluation to assess for the presence of tumor recurrence [35]. This was subsequently biopsied and was invasive ductal carcinoma. Mastectomy is the traditional treatment of a breast cancer in a previously irradiated breast; although in some cases, breast radiation after a second breast conserving surgery is a viable option to mastectomy [36].

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