

A semi-transparent anatomical illustration of a human torso. On the left, a cross-section of the breast shows pink glandular tissue and yellow fatty tissue. On the right, a side view of the chest wall is shown with a large red muscle, ribs, and a blue ribcage. Green dots on the muscle represent metastatic deposits.

# *Beyond Breast Cancer: Chest Wall Masses on Breast Imaging*

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# **OBJECTIVES**

***Review*** normal breast chest wall anatomy and lymph node stations

***Understand*** imaging findings which suggest lesion origin and chest wall invasion

***Discuss*** the background and multimodality breast imaging features of various benign and malignant chest wall masses, recognizing that not all breast masses found on breast imaging are breast cancer

# OUTLINE

## Chest Wall Anatomy

Review chest wall anatomy, including on MG, US, and MRI.

## Imaging Tips

Discuss techniques to optimize evaluation of the chest wall on breast imaging.

## Chest Wall Pathology

Outline chest wall pathology, including location and classification.

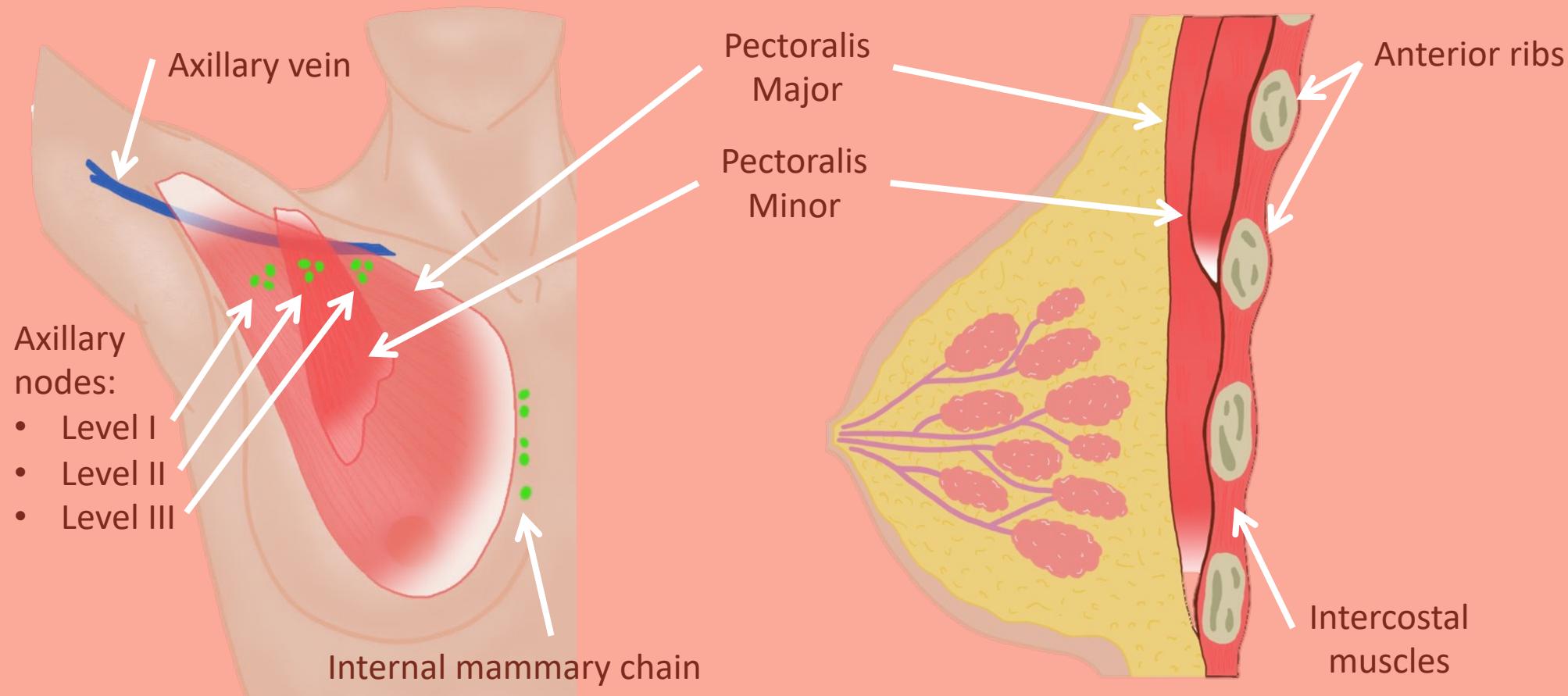
## Cases

Case-based review of chest wall pathology on breast imaging.

## Summary

Review chest wall pathology and where to find it.

# CHEST WALL ANATOMY



On breast imaging, it is important to evaluate the chest wall anatomy, particularly for hidden pathology or chest wall invasion! Most posterior is the rib cage – look at the ribs and intercostal muscles. Overlying the rib cage are two muscles: the pectoralis minor and the pectoralis major. The ***pectoralis minor is an important landmark*** for axillary lymph node levels.

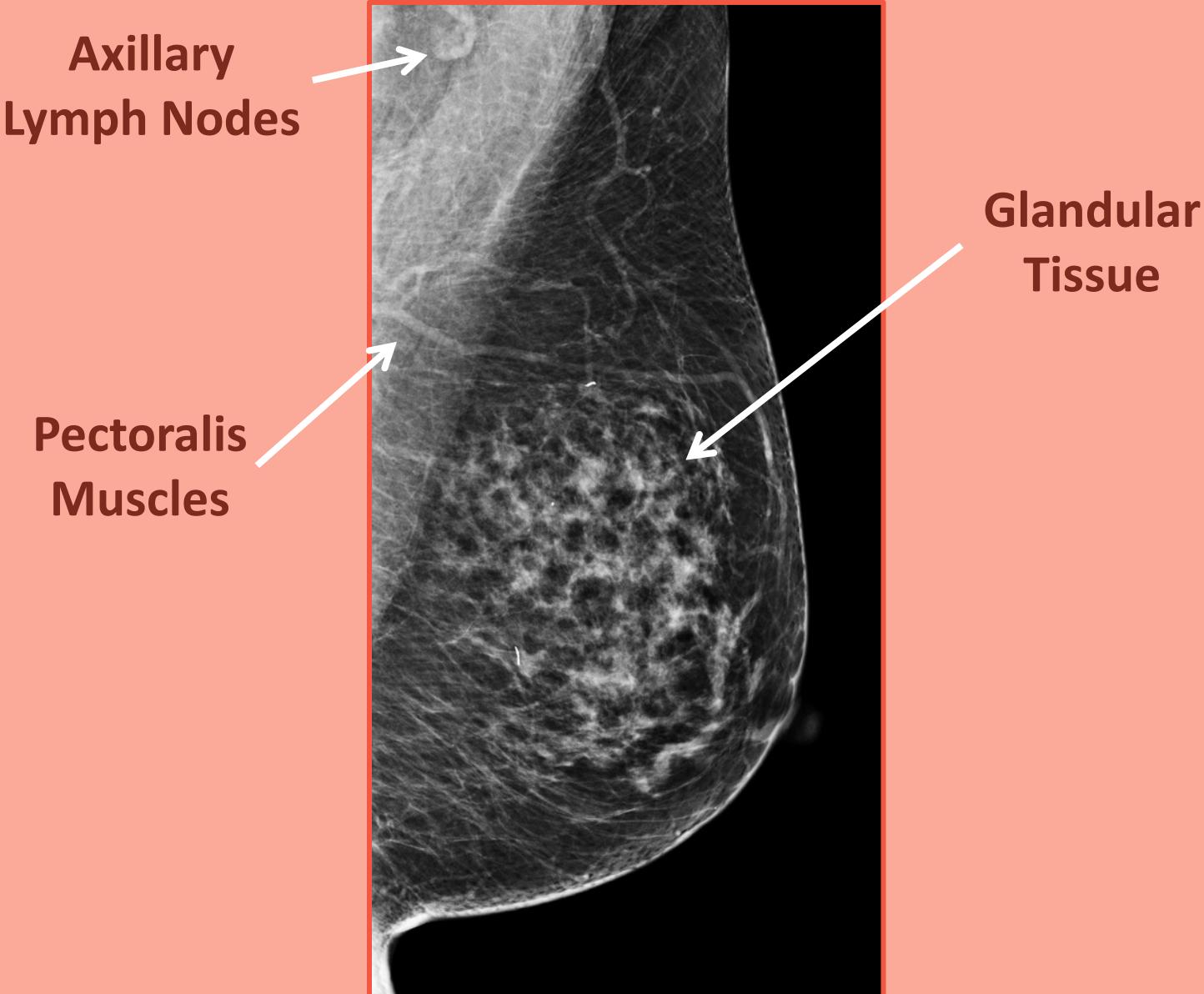
***Level I*** nodes lie inferior/lateral to the lateral edge of the pectoralis minor.

***Level II*** nodes are between the medial and lateral margins of the pectoralis minor.

***Level III*** nodes lie superior/medial to the medial edge of the pectoralis minor.

***Internal mammary lymph node chain*** lies parasagittal to the sternum.

# CHEST WALL ANATOMY - MG

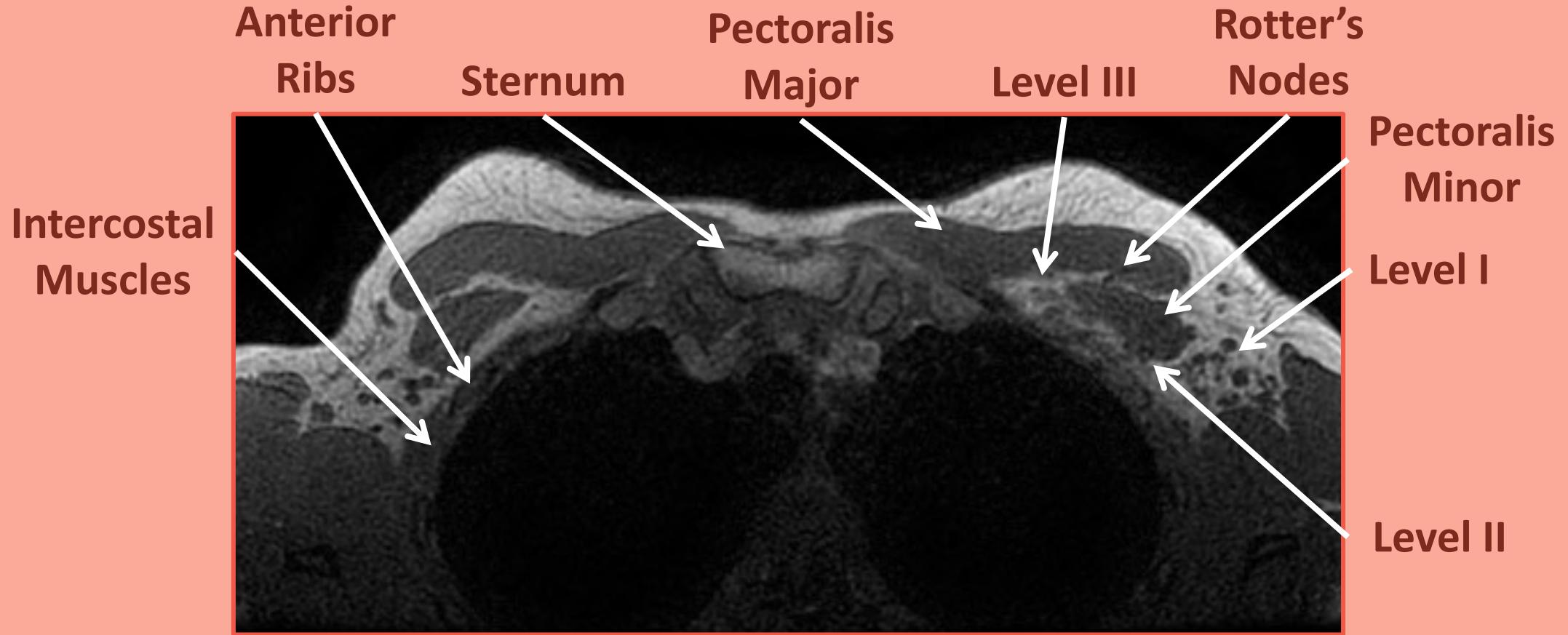


# CHEST WALL ANATOMY - US



Don't forget to evaluate all landmarks on ultrasound. The ***pectoralis muscles*** and ribs are often easily identifiable and can be ***used as landmarks*** to look for axillary lymph nodes as well as evaluate for pectoralis or chest wall lesions or invasion.

# CHEST WALL ANATOMY - MRI



***Rotter's nodes*** lie in an ***interpectoral*** location between the pectoralis major and minor muscles, and are ***considered level II nodes*** for staging purposes.

***MRI*** is a great tool for problem solving lesion location and potential chest wall invasion.

***Chest wall invasion*** is defined by a process/mass extending ***through and posterior to the pectoralis muscles***. Involvement of the pectoralis muscles alone does not constitute chest wall invasion.

# TIPS FOR IMAGING THE CHEST WALL

When evaluating the chest wall, it is important to visualize the *pectoralis muscles, thoracic cage, and axillary lymph nodes.*

There is limited evaluation of the pectoralis muscle, axillary tail, and axillae on *mammography* using the *MLO view*. A supplementary *XCCL view* can aid in evaluating more lateral tissue.

Depending on breast size, the chest wall can often be visualized on *US*, and *axillary lymphadenopathy* is better evaluated for morphology.

*MRI* is the best imaging modality when evaluating for extent of *chest wall invasion*.

# CHEST WALL PATHOLOGY

Chest wall pathology can be **categorized in many ways**: by location, cell origin, and whether benign vs malignant. Here, we will break down chest wall pathology predominantly by cell origin, following WHO classification when possible. Note, this list is not exhaustive!

## INFECTIOUS/ INFLAMMATORY

- Abscess

## ADIPOCYTIC

- Lipoma
- Liposarcoma

## MUSCULAR

- Leiomyosarcoma
- Rhabdomyosarcoma
- Spindle cell sarcoma

## FIBROUS

- Fibromatosis
- Stomal fibrosis
- Malignant fibrous histiocytoma

## VASCULAR

- Hemangioma
- Lymphatic malformation
- Vascular malformation
- Angiosarcoma

## PLASMA CELL

- Plasmacytoma
- Multiple myeloma

## PERIPHERAL NERVE SHEATH

- Schwannoma
- Neurofibroma
- Ganglioneuroma
- Paraganglioma
- Malignant peripheral nerve sheath tumor

## OSSEOUS

- Enostosis
- Aneurysmal bone cyst
- Giant cell tumor
- Fibrous dysplasia
- Osteochondroma
- Chondrosarcoma
- Osteosarcoma

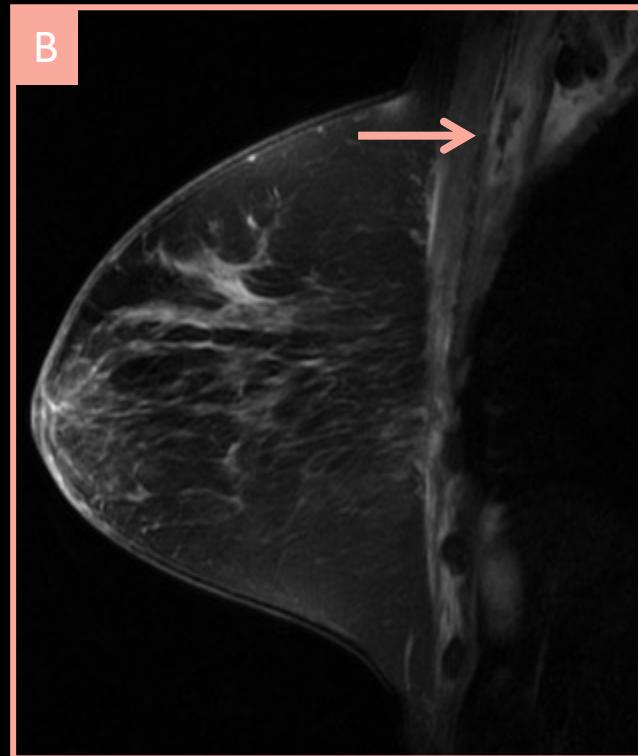
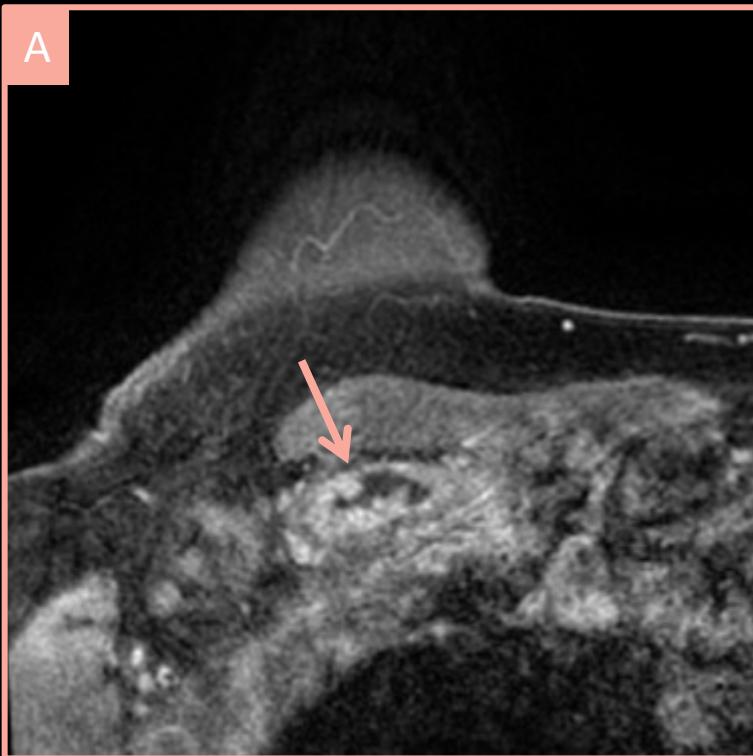
While you may not come across all of these pathologies on breast imaging, it is important to **understand what alternate lesions may appear in the breast**, besides mammary lesions!

We will review several of these pathologies found on breast imaging on the upcoming slides!

We will also discuss breast cancer invading into the chest wall, as well as non-tumor bonus cases for a full spectrum of chest wall pathology on breast imaging!

# INTRAMUSCULAR ABSCESS

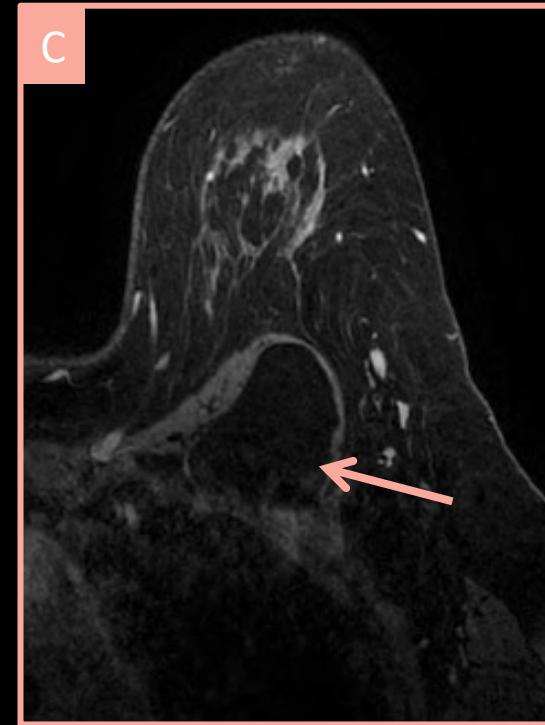
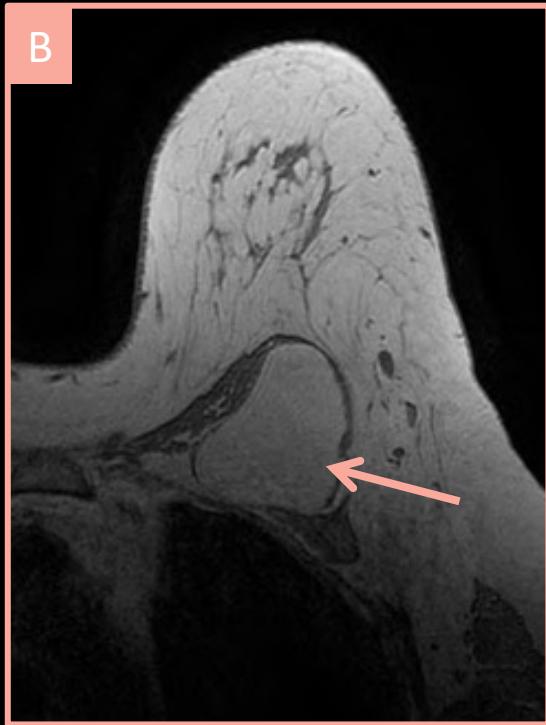
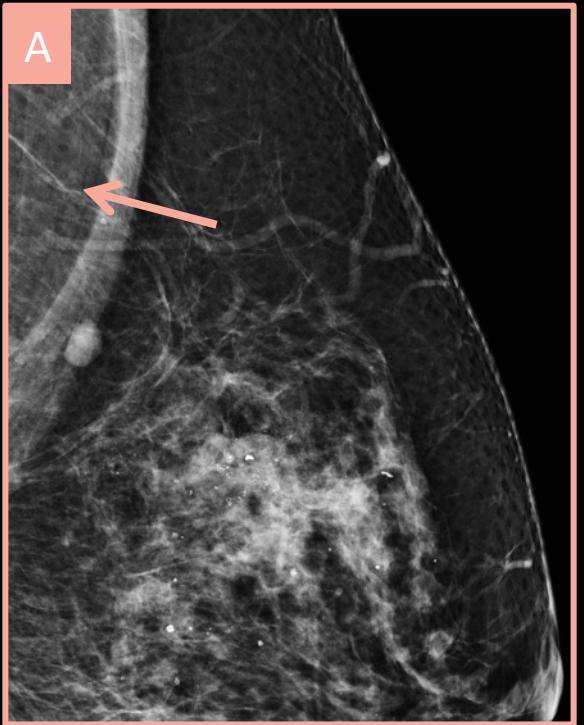
58-year-old female with history of left breast invasive ductal carcinoma and recent MRSA bacteraemia on antibiotics found to have right pectoralis minor abscess on routine follow-up breast MRI. Post-contrast MRI image (A) shows a **peripherally enhancing collection**, which is T1 and T2 (B) **hypointense centrally**, consistent with abscess within the pectoralis minor muscle.



## Teaching Points

- Look out for a history of bacteraemia or immunocompromise.
- MRI: + **Peripheral enhancement, centrally T1/T2 hypointense**.
- If accessible, treatment involves percutaneous aspiration and IV antibiotics, +/- incision and drainage.

# INTRAMUSCULAR LIPOMA



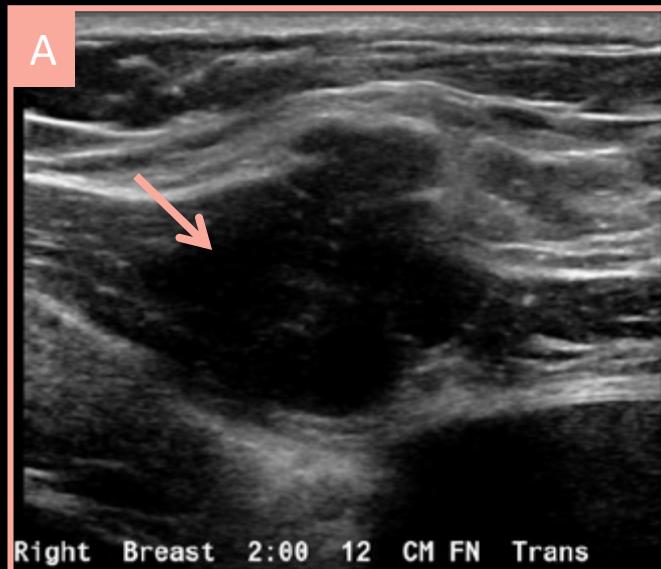
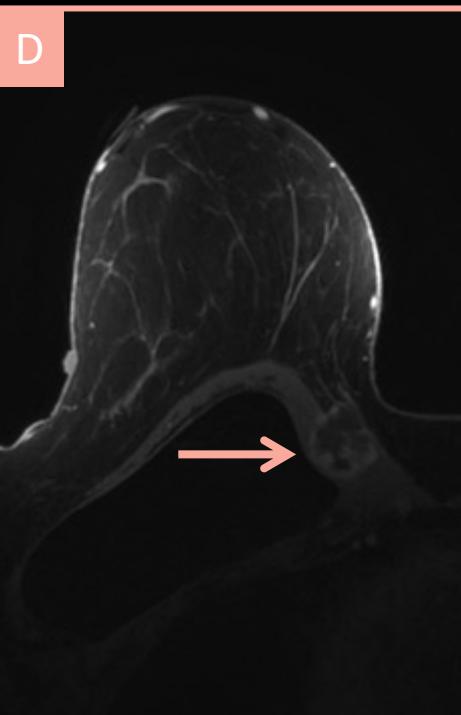
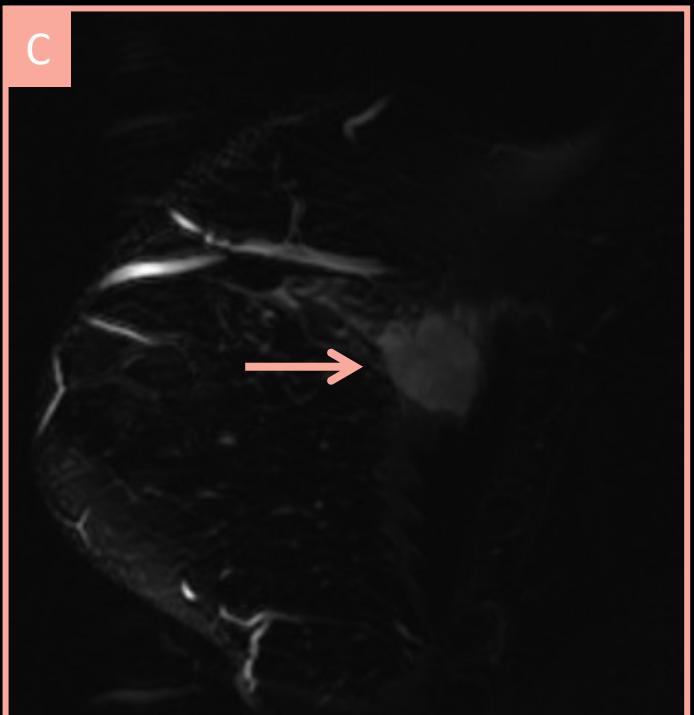
61-year-old female with incidental note of an intramuscular lipoma. MG (A) shows a **fat containing lesion within the left pectoralis major muscle**. MRI also demonstrates a **well-circumscribed, encapsulated lesion within the left pectoralis major muscle following fat signal**: T1 hyperintense (B), and hypointense on fat saturation (C).

## Teaching Points

- Lipomas can be found in the skin, breast tissue, muscles, and even osseous structures.
- Deep chest wall lipomas can appear infiltrative, rather than encapsulated (as seen here).
- Appreciate the predominantly **fatty contents** of the tumor on all imaging. When there is lesion complexity, tissue sampling may be required to rule out well-differentiated liposarcoma.
- Imaging findings which may **suggest malignancy** include size **> 10 cm** and **thick nodular septae**. MRI can be obtained to assess for enhancement of the septae.

# SPINDLE CELL SARCOMA

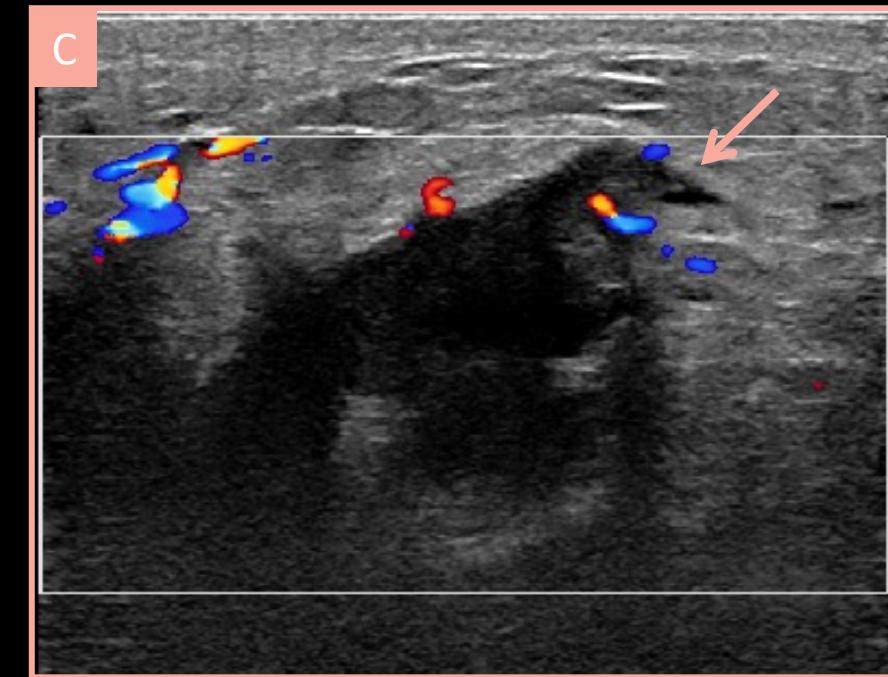
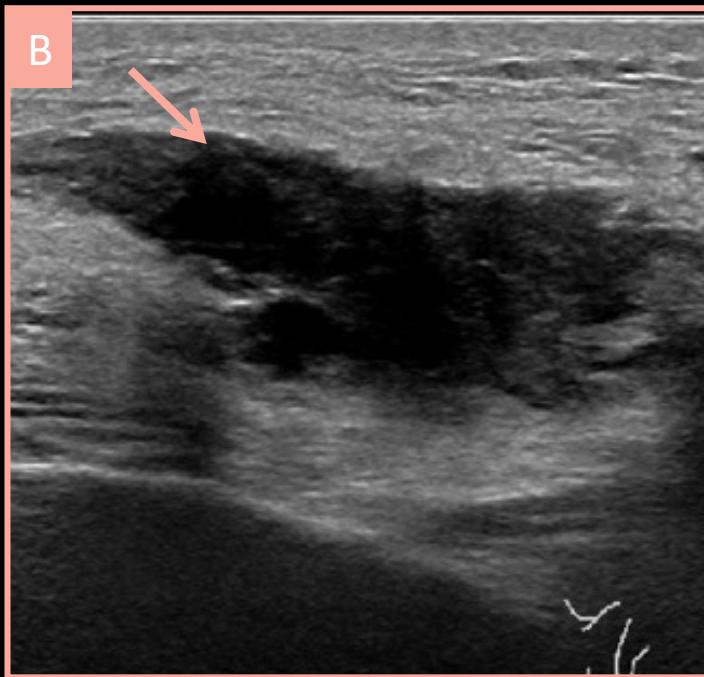
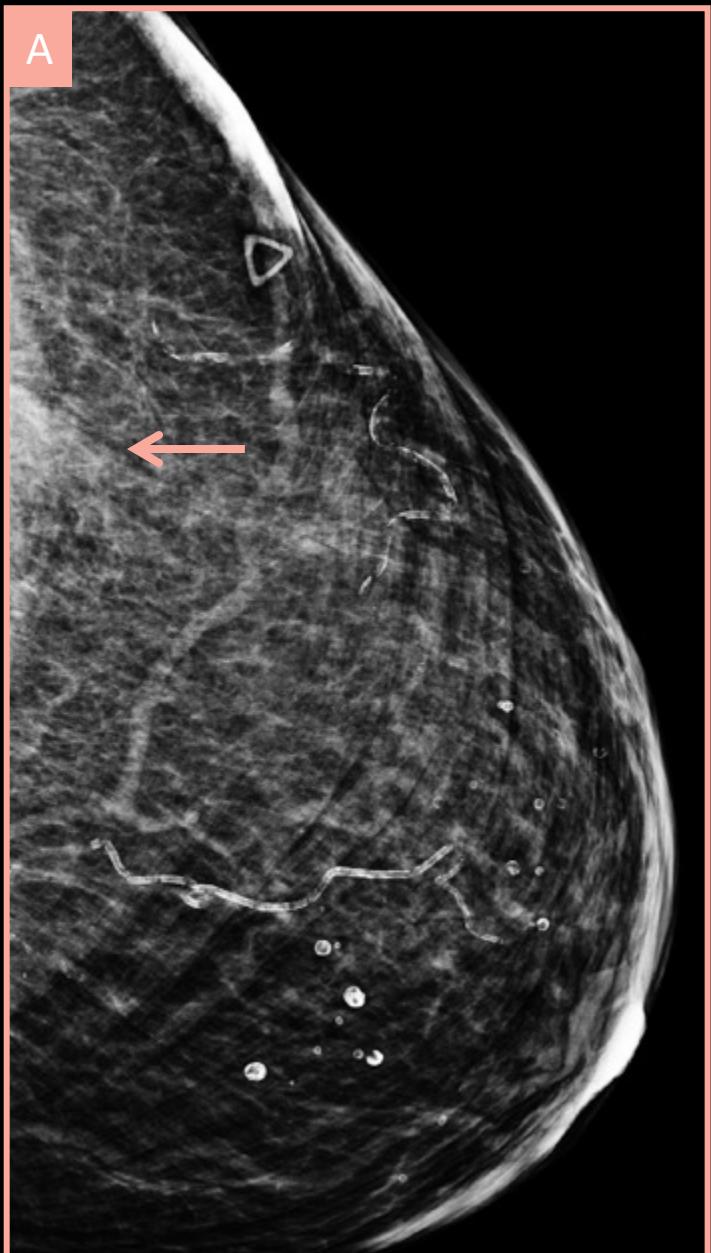
54-year-old female with bilateral breast implants presents with right breast palpable mass. US (A) shows an irregular heterogeneously hypoechoic mass with **expansion of the muscle**. MRI shows a **T2 hyperintense** (C), **rim-enhancing** (D) mass arising from the inner aspect of the right pectoralis muscle. Chest CT (B) for staging redemonstrates the intramuscular mass in the right pectoralis muscle.



## Teaching Points

- Primary malignant spindle cell tumors are < 1% of breast malignancies.
- Mean age in 60s.
- Predilection for African American/Hispanic women
- US may show **cystic areas**; calcifications and axillary lymph node involvement are uncommon.
- MRI appearance is typically **T2 hyperintense** + variable enhancement.
- Surgery + XRT; Chemo often ineffective.

# FIBROMATOSIS



61-year-old female presents with a left breast painless palpable mass. Mammogram (A) partially shows a mass overlying the pectoralis muscle. US (B) identifies an **irregular hypoechoic mass** with angular margins invading the pectoralis major. Color Doppler (C) demonstrates **internal vascular flow**.

## Teaching Points

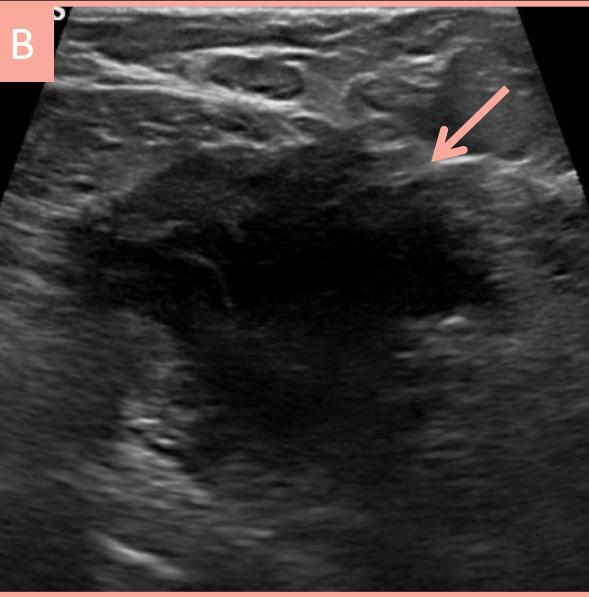
- Also known as desmoid tumors.
- Develop slowly and may exhibit ***local invasion*** close to pectoralis muscle.
- Typically sporadic, but has association with **Gardner syndrome**, prior breast reduction, and breast implants.
- Can see **recurrence** after surgical excision.

# IMPLANT-ASSOCIATED FIBROMATOSIS

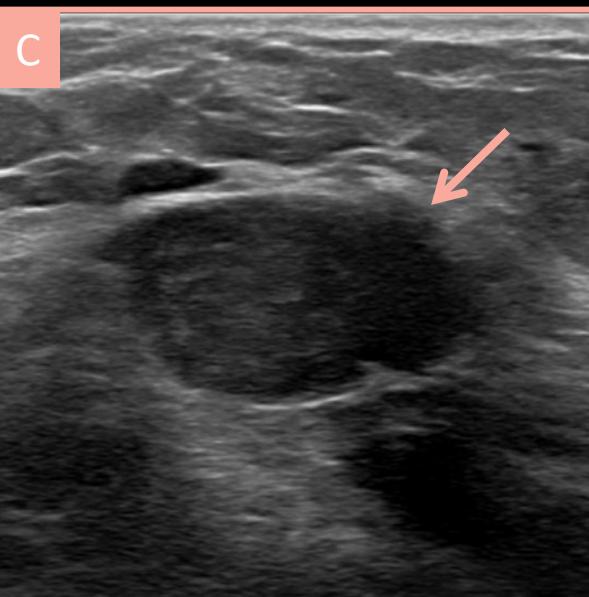
A



B



C

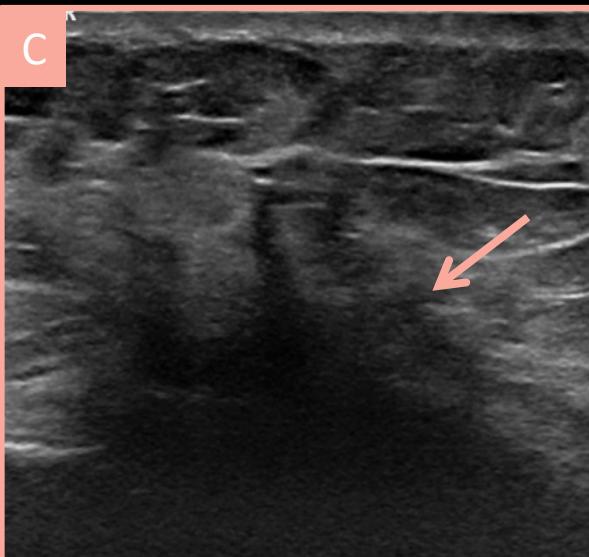


36-year-old female with history of right breast implant with new tender lumps of the right breast. Diagnostic MG (A) shows a **dense focal asymmetry with architectural distortion** corresponding with the patient's palpable concern as indicated by the triangle marker. US shows a corresponding **heterogeneous mass, portions of which have irregular (B) and circumscribed (C) margins**. Biopsy revealed fibromatosis.

## Teaching Points

- Fibromatosis can mimic malignancy due to **tethering of Cooper's ligaments** resulting in a spiculated appearance.
- **Wide local excision** is recommended to reduce risk for recurrence.

# STROMAL FIBROSIS



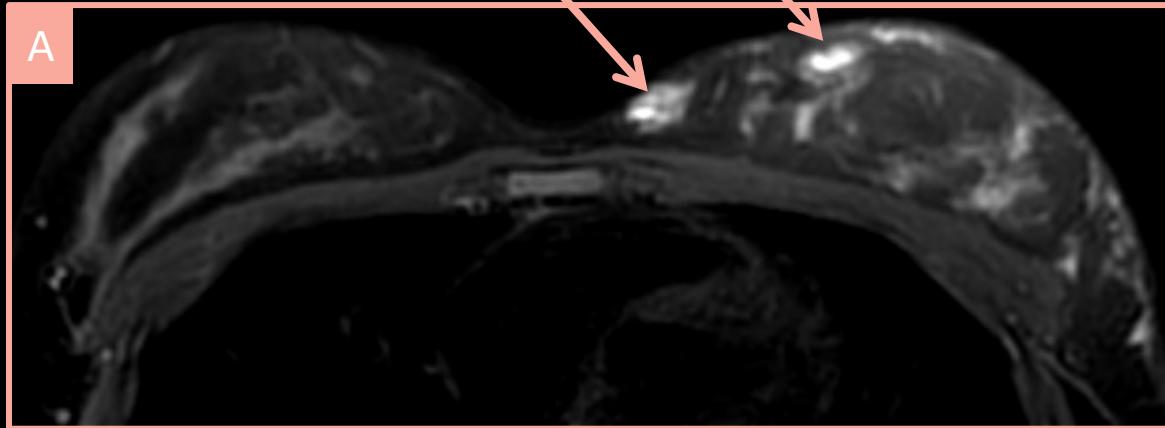
46-year-old BRCA2+ female with history of left breast cancer s/p bilateral mastectomy and reconstruction with a new **FDG avid parasternal mass** on PET (A, B). US (C) demonstrates an **irregular hypoechoic mass with angular margins**. Pathology revealed stromal fibrosis.

## Teaching Points

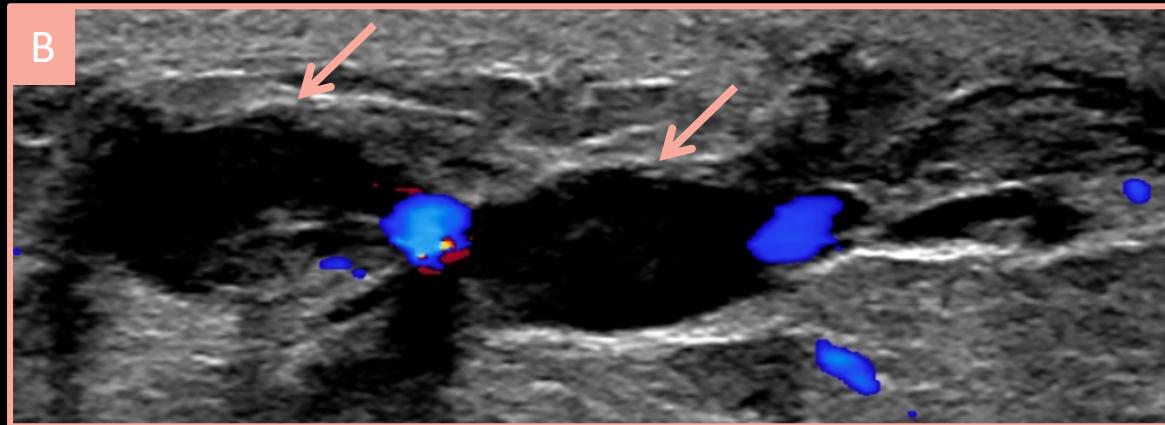
- The cause of stromal fibrosis is unclear. These lesions are often found incidentally, though can present with tenderness or palpable abnormality.
- On pathology, it is characterized by ***proliferation of fibrous stroma and obliteration of normal glandular tissue***.
- Imaging varies and can appear benign with a well-circumscribed mass or mimic malignancy. As such, tissue sampling is necessary to make this diagnosis.

# LYMPHATIC MALFORMATION

A



B

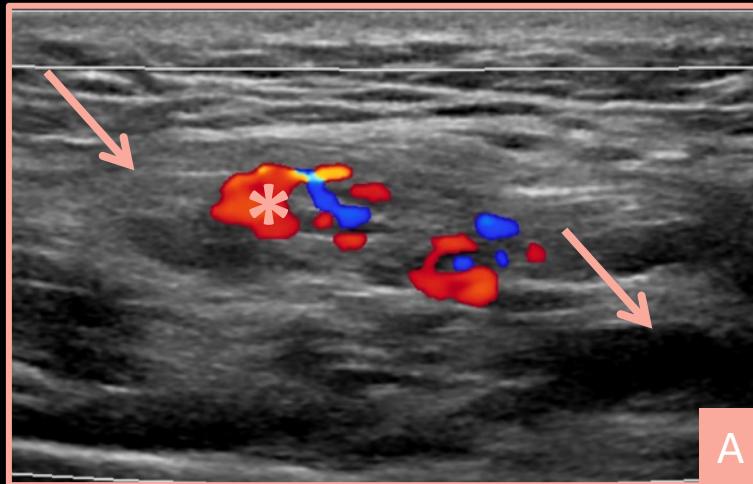


16-year-old patient with history of left chest wall/upper extremity lymphatic malformation and free fat injection of the underdeveloped left breast for symmetry. MRI (A) shows **T2 bright cystic spaces** consistent with known lymphatic malformation. Doppler US (B) shows **anechoic cystic and tubular spaces with some debris and flow in intervening septae**, a classic look for lymphatic malformations.

## Teaching Points

- Lymphatic malformations are vascular malformations which can occur throughout the body, including solid organs and the head and neck region (where they are often referred to as cystic hygromas).
- On MRI and US, they appear as ***multiple cystic spaces***.
- Treatment varies, usually surgical excision or sclerotherapy.

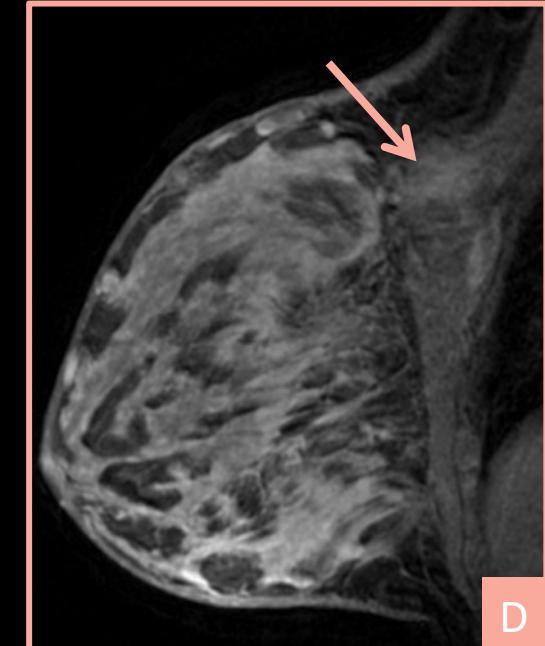
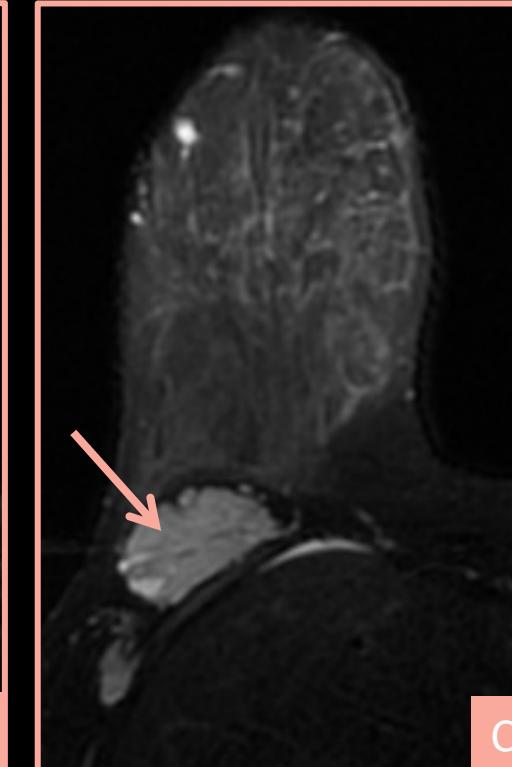
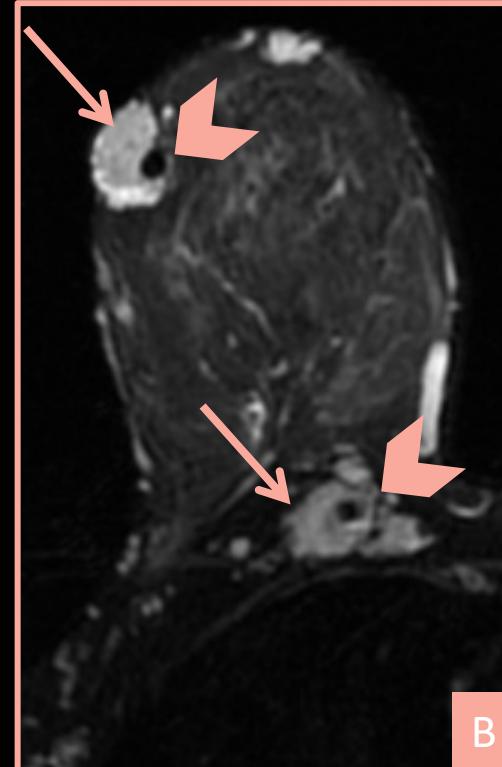
# VENOUS MALFORMATION



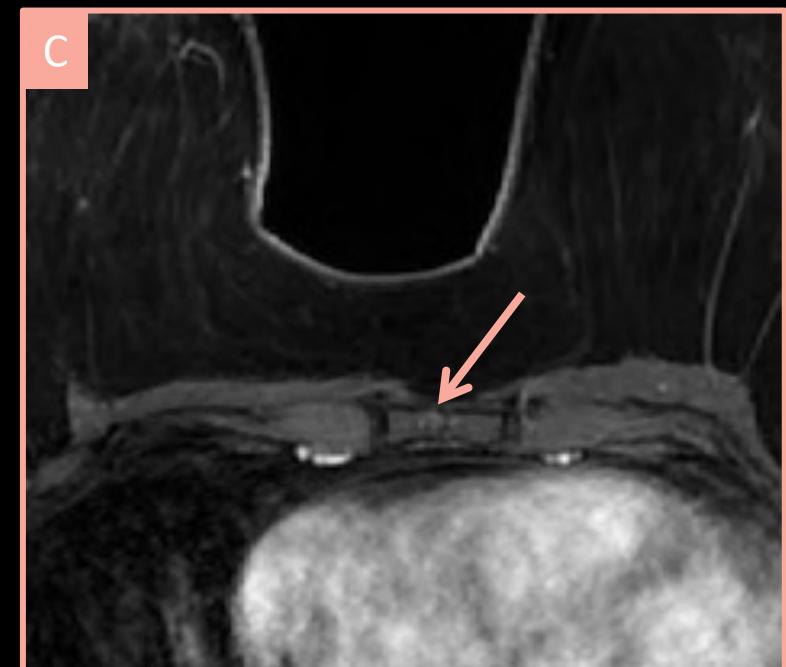
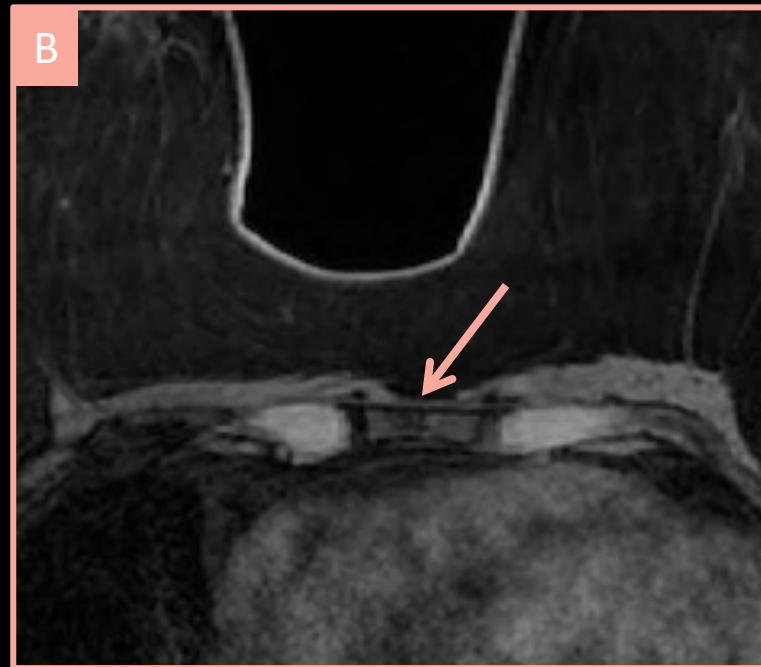
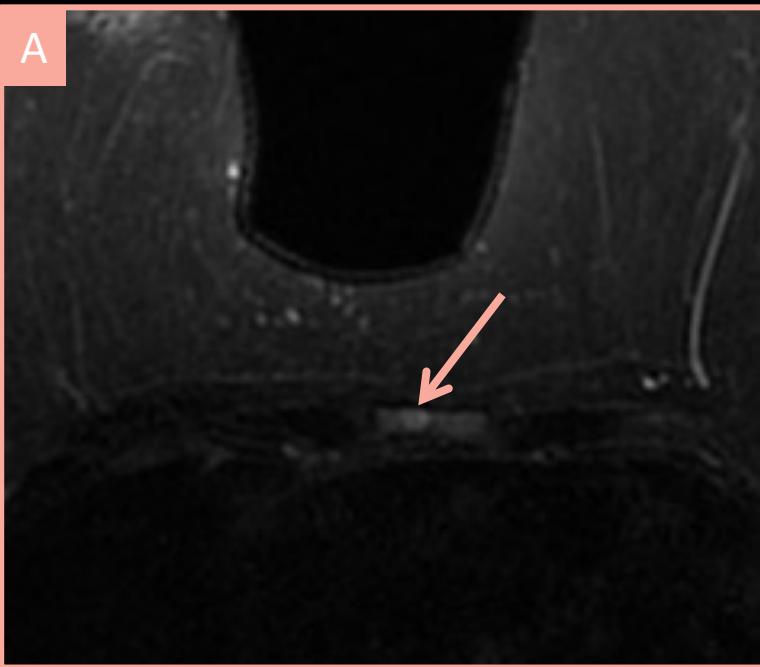
25-year-old patient with mass-like area of the upper inner right breast, more pronounced when she engages her pectoral muscles. US (A) shows **hyperechogenicity and anechoic spaces (arrows) within the right pectoralis muscle, and numerous blood vessels (asterisk)**. MRI shows a network of dilated vessels interconnecting **multiple lobulated T2 hyperintense masses** (B, C), as well as **rounded foci of susceptibility artifact** (arrowhead) consistent with phleboliths. One of these lesions involves the right pectoralis muscle (B, C). These lesions demonstrate **incomplete delayed contrast enhancement** (D).

## Teaching Points

- Soft tissue venous malformations are low-flow vascular malformations (commonly called hemangiomas).
- **Phleboliths**, if seen, strongly support the diagnosis and are sequelae of the slow flow.
- Intramuscular venous malformations may result in atrophy of the involved muscle.
- Size affected by valsalva, position.



# INTRAOSSEOUS HEMANGIOMA



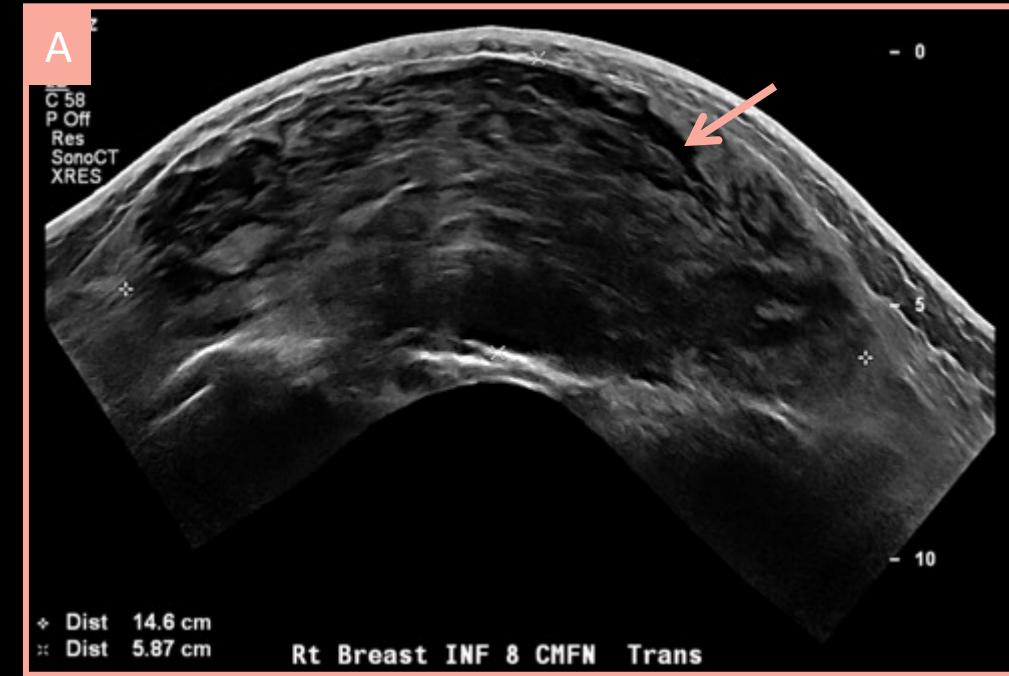
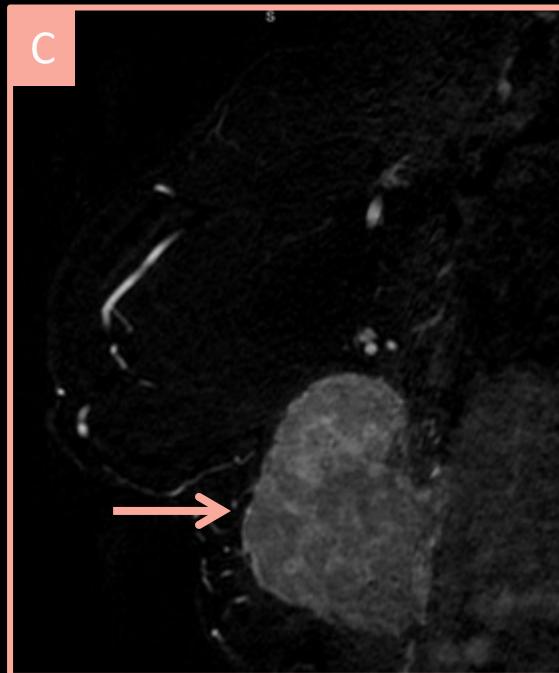
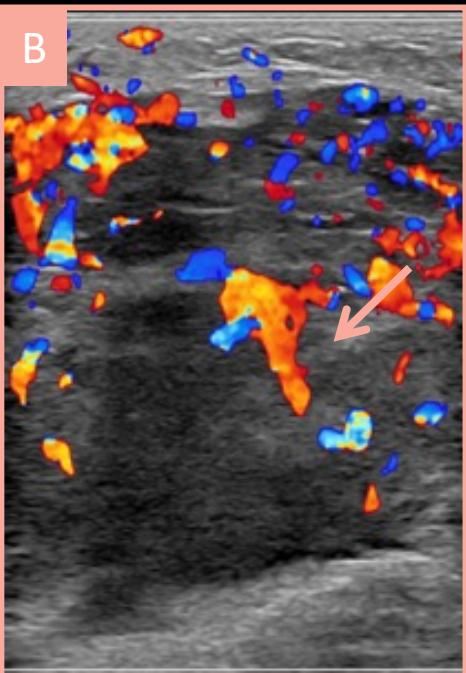
69-year-old female with recently diagnosed left breast IDC undergoing staging breast MRI. Incidental note of a small **T2 hyperintense (A), enhancing (C) lesion in the sternum, with intralesional fat suppressed on T1 fat-sat pre-contrast (B)**. This is compatible with a benign intraosseous hemangioma.

## Teaching Point

- If present, intralesional fat can be identified on fat suppression sequences, supportive of the diagnosis.

# PLASMACYTOMA

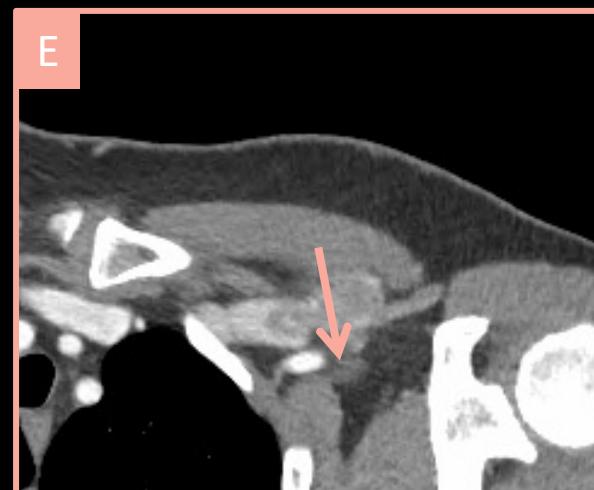
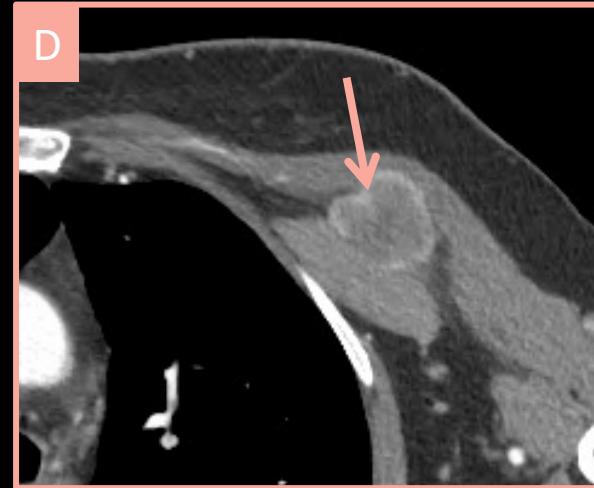
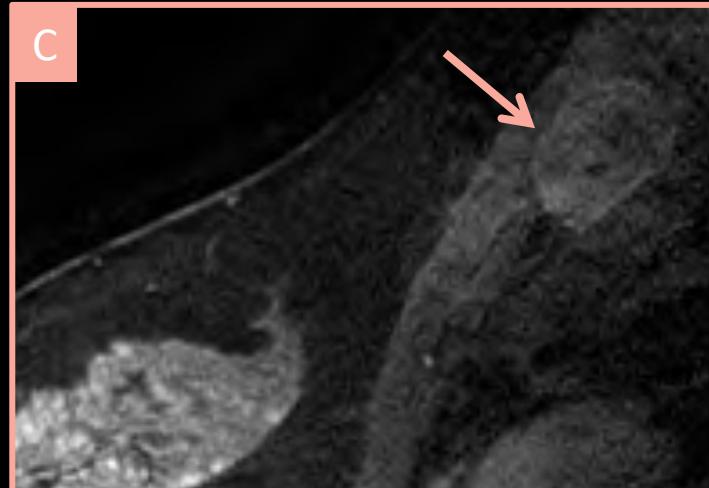
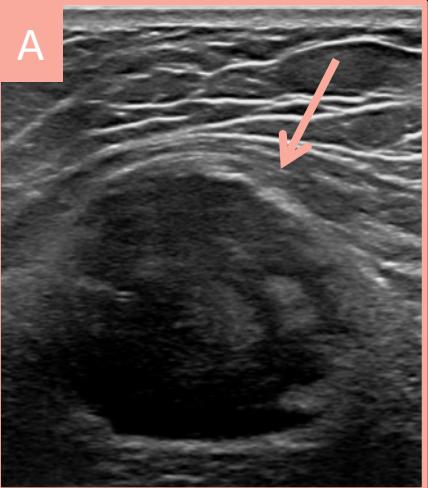
78-year-old female with history of left breast cancer s/p left mastectomy, multiple myeloma with right breast lump, found to have plasma cell myeloma of the right chest wall. Initial US (A) shows a **large heterogeneous, predominantly hypoechoic mass** which was difficult to evaluate due to size. Color Doppler (B) demonstrates **internal vascular flow**. T2-weighted MRI (C) shows a **hyperintense mass** with loss of fat planes and **chest wall invasion** involving the intercostal muscles and adjacent ribs. This mass was heterogeneously enhancing (not pictured).



## Teaching Points

- Extramedullary plasma cell tumors are a rare form of solitary plasmacytoma.
- Can occur in patients with known **Multiple Myeloma** or as solitary tumor.
- 4<sup>th</sup>-7<sup>th</sup> decades of life.
- Commonly **invade nearby structures**.
- Treatment: XRT, surgery, or both.

# ROTTER'S NODES

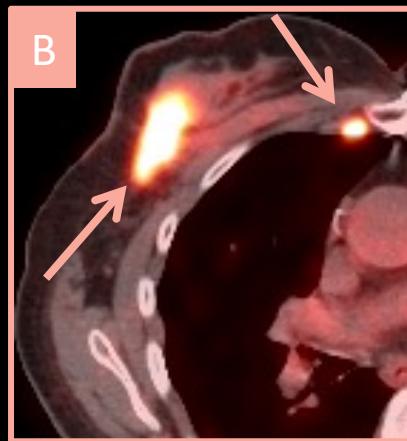
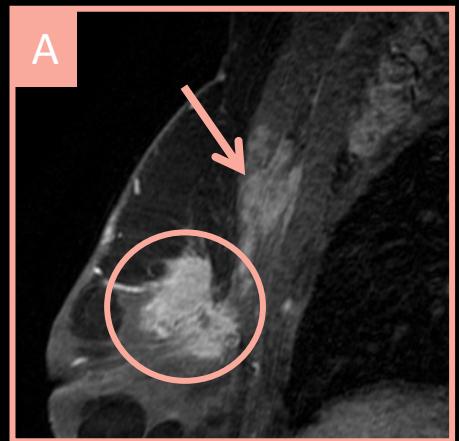


45-year-old female with a history of left IDC s/p lumpectomy and sentinel lymph node biopsy with positive nodes. Less than one year later, she presented with a left axillary palpable concern, determined to be breast cancer recurrence in Rotter's nodes. US (A) shows an **irregular heterogeneous hypoechoic mass** (asterisk) deep to the pectoralis muscle (arrow). MRI (B - T1, C - T1 FS p/c) shows two (one shown) **irregular enhancing masses** deep to the pectoralis major and likely superficial to the pectoralis minor muscles. CT (D, E) again shows **two enhancing masses**, confirming **interpectoral** location, consistent with Rotter's nodes. The superior node appears **contiguous with a left axillary vein filling defect** (arrow) concerning for intravascular tumor extension.

## Teaching Points

- Located **between the pectoralis major and minor muscles**, Rotter's nodes are an uncommon site for breast cancer recurrence.
- Rotter's nodes are **considered level II lymph nodes** for staging purposes.

# PECTORALIS INVOLVEMENT BY BREAST CA

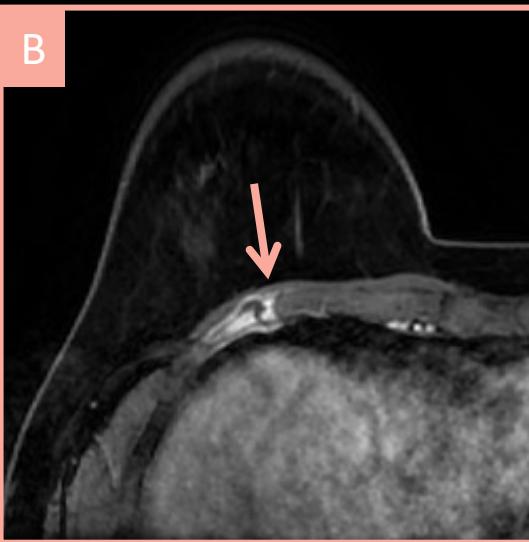
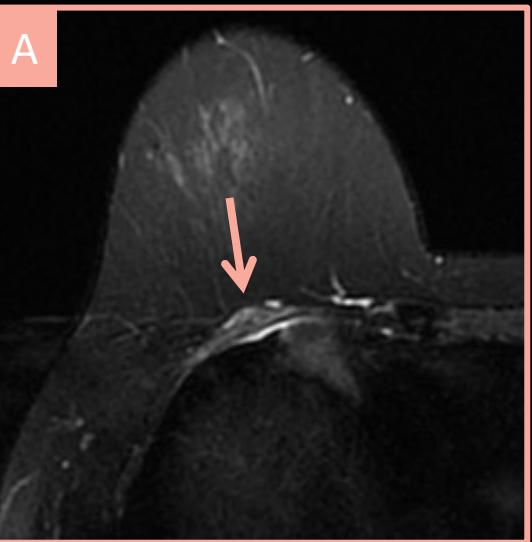


56-year-old female with palpable right breast lump found to have suspicious mass on MG, subsequent biopsy revealed IDC. Post-contrast MRI (A) shows an **enhancing irregular, spiculated mass (circle)**, and **enhancement within the right pectoralis muscle (arrow)**, though no chest wall invasion is identified. Subsequent PET/CT shows **FDG-avid right breast mass (B)**, **right pectoralis muscle metastasis (C)**, and **metastasis to all three axillary levels (D, E)** in addition to the **internal mammary chain (B)**.

## Teaching Points

- Enhancement of the pectoralis muscle should raise suspicion for chest wall invasion.
- Chest wall invasion*** is defined by extension of mass ***through the pectoralis muscle into the thoracic cage***, which ***upgrades staging to T4a***. Invasion into the muscle alone does not upgrade staging.

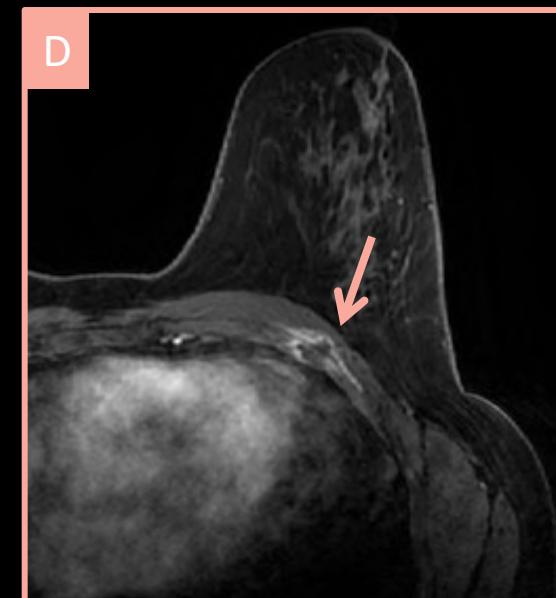
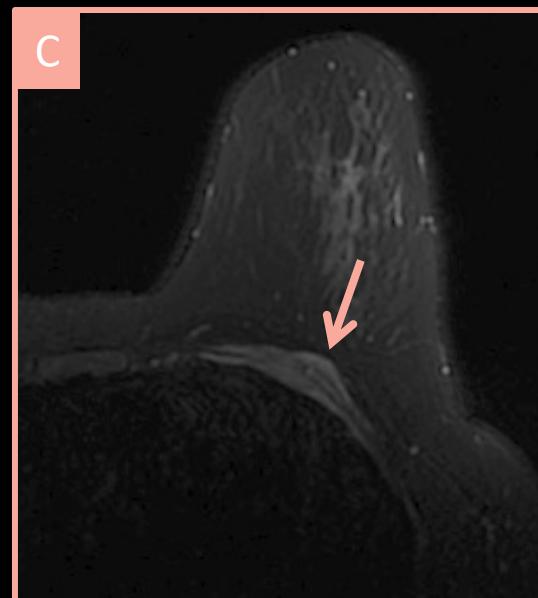
# RIB FRACTURE



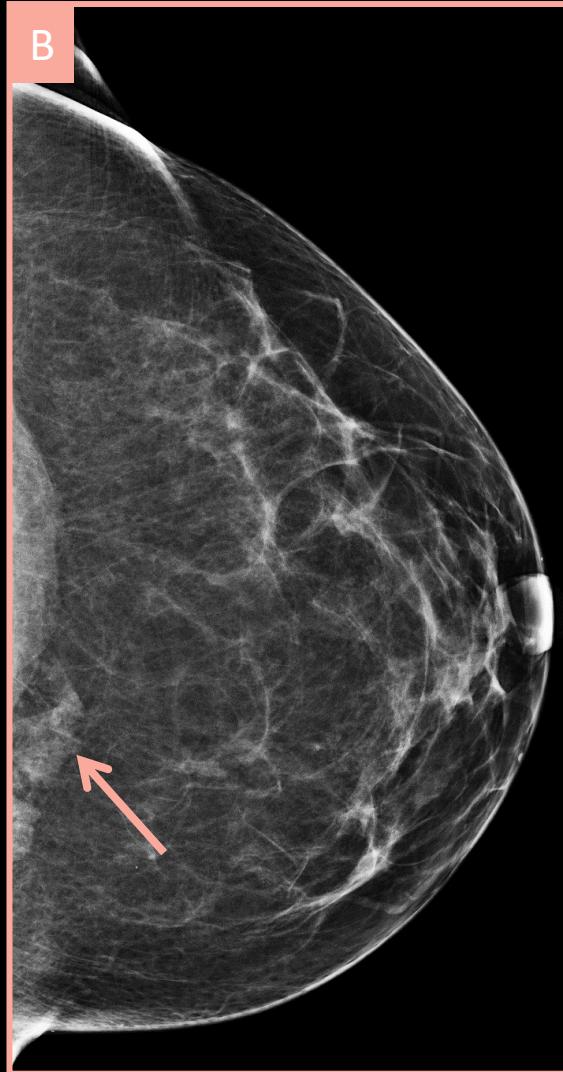
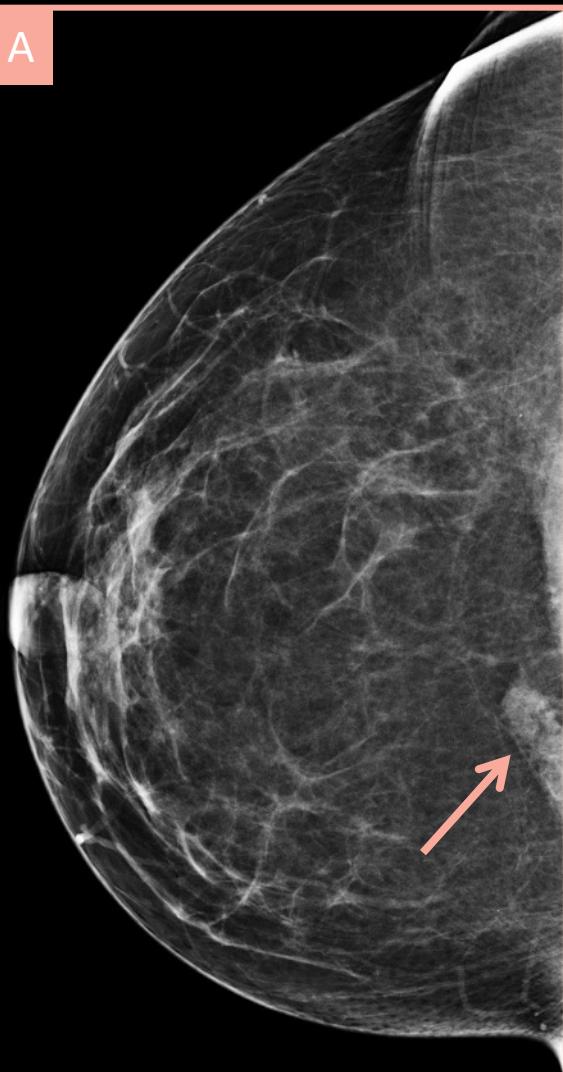
Two different breast MRIs with incidental note of right (A, B) and left (C, D) **rib fractures (arrows)**, which demonstrate **T2 hyperintense edema and periosteal reaction** (A, C), with associated **contrast enhancement** (B, D).

## Teaching Points

- Make sure to look at all extramammary structures!
- Fracture can be identified by a ***T1 dark fracture line***, benign appearing periosteal reaction, and no significant soft tissue component.
- Benign pathology, such as rib fractures, should be differentiated from primary bone malignancy or secondary metastasis using imaging findings, clinically history, and tissue sampling when necessary.



# STERNALIS MUSCLE



Incidental note of bilateral sternalis muscles. MG (A, B) shows partially visualized **irregular equal density masses in the slightly inner posterior breasts (arrows)** consistent with bilateral sternalis muscles. These were verified on a prior CT chest (C).

## Teaching Points

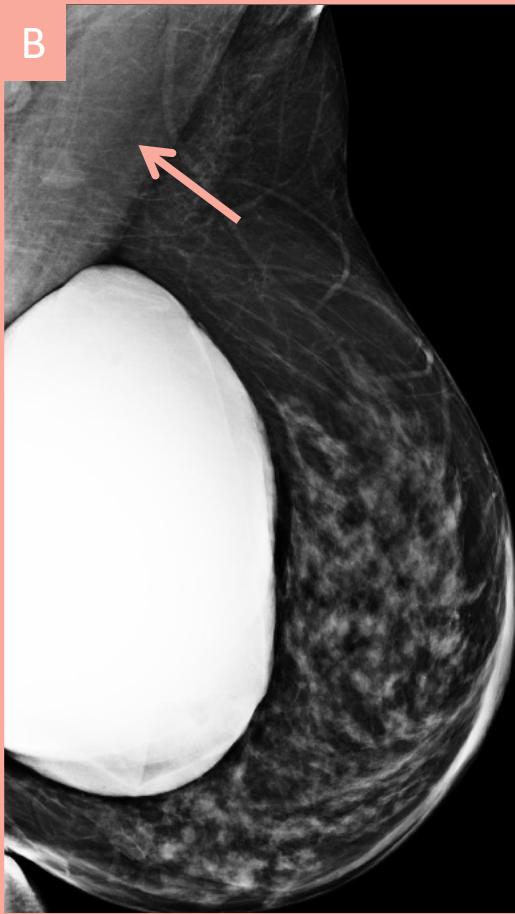
- Accessory muscle which is **parasternal** in location.
- Occurs in ~5% of patients and is more often unilateral than bilateral.

# POLAND SYNDROME

A



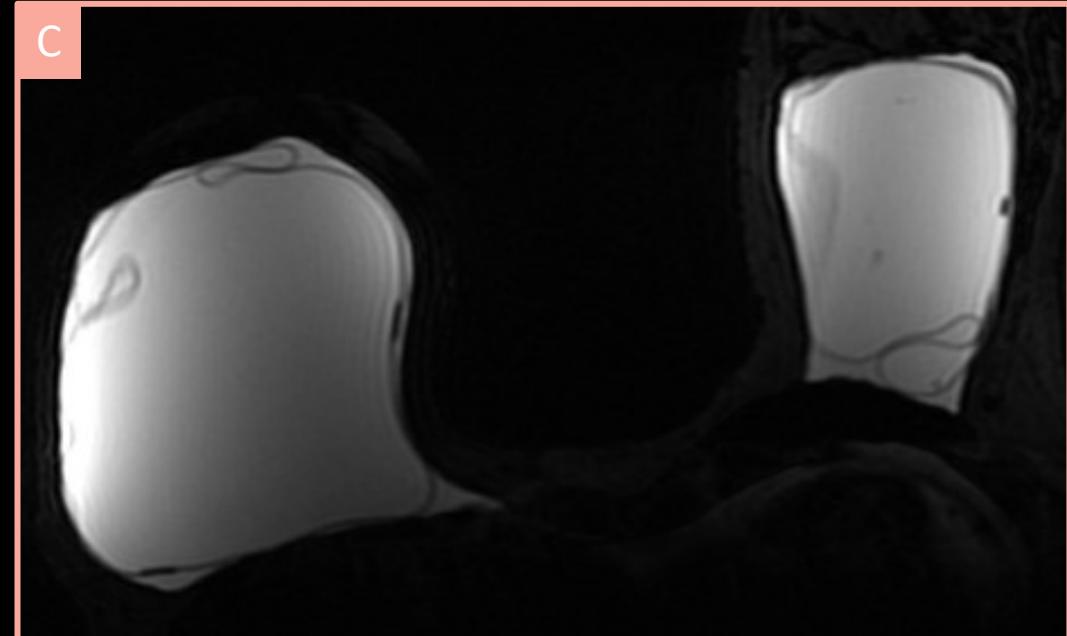
B



## Teaching Points

- Defined as congenital unilateral absence of the ***pectoralis major and minor muscles***.
- May be associated with other ipsilateral abnormalities:
  - Amazia – absence of breast parenchyma.
  - Amastia – absence of breast tissue.
- Patients may undergo breast augmentation for symmetry of the breasts.

C



62-year-old patient with Poland syndrome and history of bilateral breast augmentation. MG demonstrates **absence of the right pectoralis muscle** (A), present on the left (B). MRI (C) highlights the asymmetric chest wall due to Poland syndrome, and bilateral intracapsular implant rupture.

# *SUMMARY OF CHEST WALL MASSES*

## SOFT TISSUES (INCL MUSCLES)

### BENIGN

- Lipoma
- Schwannoma
- Neurofibroma
- Ganglioneuroma
- Paraganglioma
- Hemangioma
- Fibromatosis
- Stromal fibrosis
- Vascular and lymphatic malformations

### MALIGNANT

- Liposarcoma
- Spindle cell sarcoma
- Leiomyosarcoma
- Rhabdomyosarcoma
- Malignant fibrous histiocytoma
- Malignant peripheral nerve sheath tumor
- Angiosarcoma
- Plasmacytoma

## BONES

### BENIGN

- Enostosis
- Hemangioma
- Aneurysmal bone cyst
- Giant cell tumor
- Fibrous dysplasia
- Osteochondroma

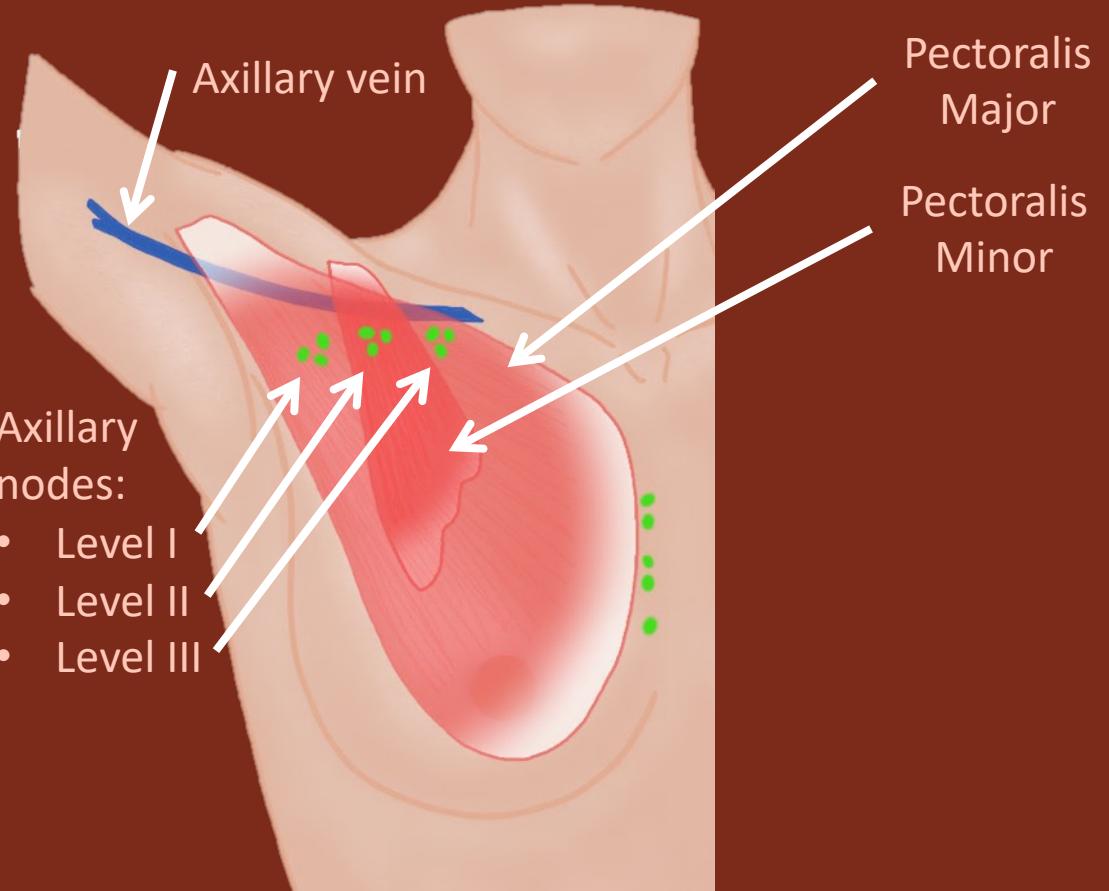
### MALIGNANT

- Chondrosarcoma
- Osteosarcoma
- Plasmacytoma
- Multiple Myeloma

# REVIEW QUESTION 1

What anatomic landmark is key to differentiating level I, II, and III axillary lymph nodes?

- A. Sternum
- B. Axillary vein
- C. Pectoralis major
- D. Pectoralis minor



# ***REVIEW QUESTION 2***

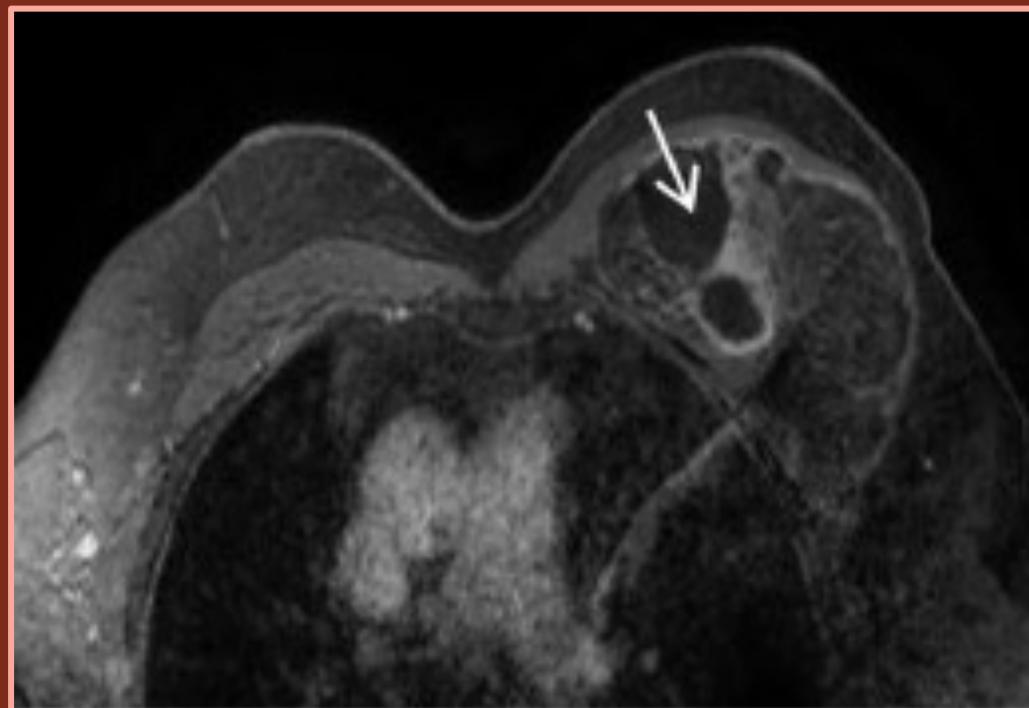
What features may suggest a diagnosis of well-differentiated liposarcoma over lipoma? Choose all that apply:

A. Lesion size > 10 cm

B. T1 hyperintensity

C. Thick nodular septae

D. Enhancing septae



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# ***REVIEW QUESTION 3***

What is the cause of fibromatosis' spiculated appearance?

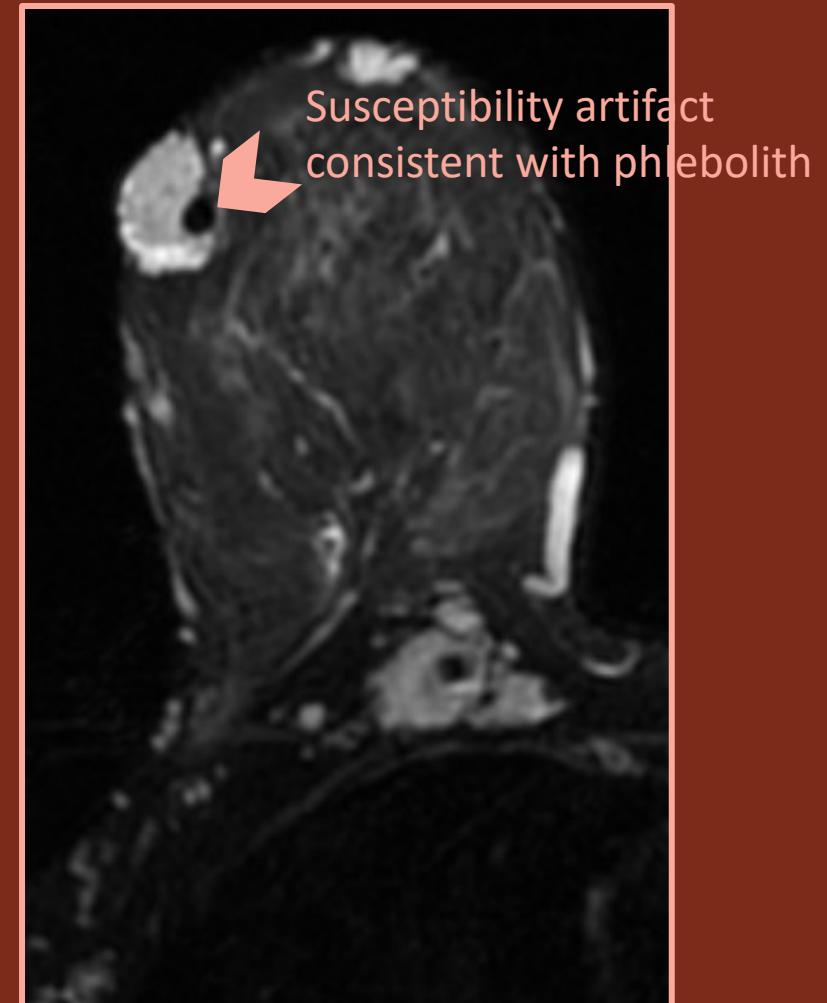
- A. Spread along mammary ducts
- B. Tethering of Cooper's ligaments
- C. Malignant desmoplastic reaction



# ***REVIEW QUESTION 4***

Which feature is not characteristic of a venous malformation?

- A. Foci of susceptibility artifact
- B. Enhancement
- C. T2 hyperintensity
- D. T2 hypointensity



# ***REVIEW QUESTION 5***

True or False?

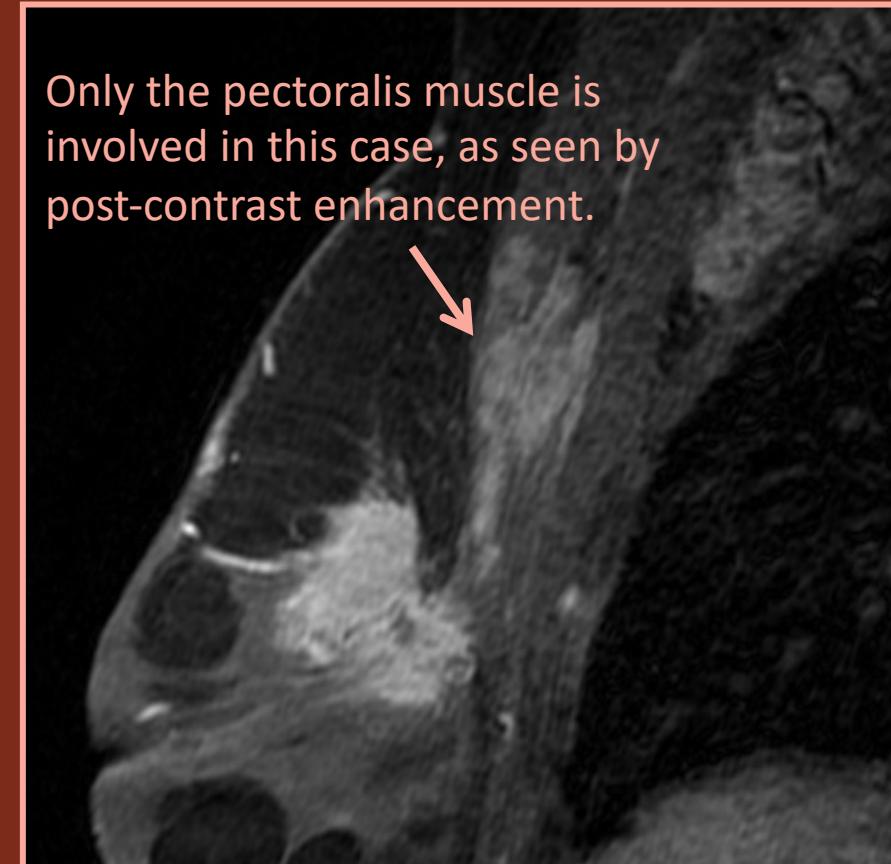
When staging breast cancer, involvement of the pectoralis muscles only, without involvement of the thoracic cage, is considered chest wall invasion.

# ***REVIEW QUESTION 5***

**False!**

There must be involvement of the thoracic cage for it to be considered chest wall invasion.

Only the pectoralis muscle is involved in this case, as seen by post-contrast enhancement.



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