Imaging Findings of Chest Wall Lesions on Breast Sonography

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Objective. The purpose of this presentation is to illustrate the sonographic findings of chest wall lesions that were depicted on breast sonography. ***Methods.*** Chest wall lesions detected during breast sonography were collected and reviewed retrospectively. ***Results.*** The sonographic findings of normal chest walls and various pathologic chest wall lesions, including inflammatory lesions, benign neoplasms, and malignant neoplasms, are discussed. ***Conclusions.*** Familiarity with normal sonographic anatomy and chest wall lesions could be helpful in differentiating a chest wall lesion from a breast lesion and in showing whether the origin of any palpable breast lump is in the breast parenchyma or the chest wall on breast sonography. ***Key words:*** breast; chest wall; sonography.

In performing a sonographic examination of the breast, abnormal chest wall findings can be found incidentally or can appear as breast lumps because of the anatomic relationship between the chest wall and the breast. In such situations, it is important to clarify whether the origin of such an abnormality is from the breast parenchyma or the chest wall.[1] The chest wall is composed of fat and soft tissue, including nerves, blood vessels, lymphatic vessels, muscle, bone, cartilage, and fibrous connective tissue. Therefore, chest wall lesions can arise from any of these component tissues, and various pathologic conditions such as infections or inflammations, benign or malignant neoplasms, and other benign lesions can exist. In this presentation, several chest wall lesions on breast sonography are illustrated to help differentiate them from breast lesions.

Abbreviations
CT, computed tomography; MRI, magnetic resonance imaging

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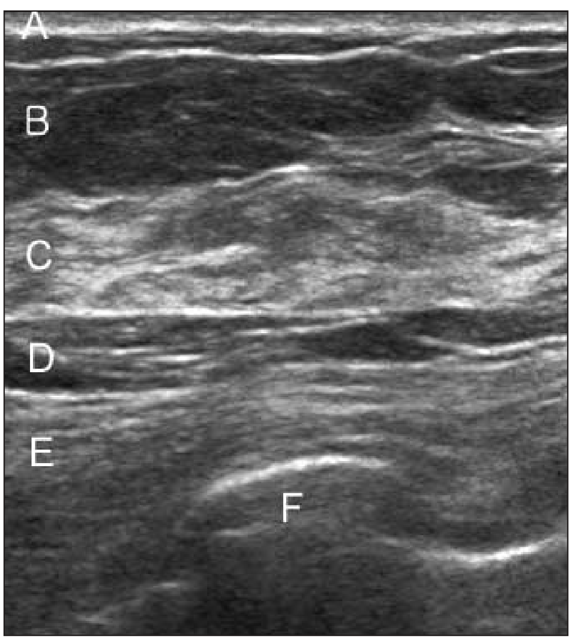
Anatomic Relationship Between the Chest Wall and Breast on Sonography

The chest wall usually consists of 4 layers: the skin, subcutaneous fat, pectoral muscles, and rib and intercostal muscles (Figure 1).[2] The skin appears sonographically as a thin hyperechoic layer. The subcutaneous fat is an isoechoic layer, which consists of oval fat lobules separated by echogenic septa. Its thickness varies according to the patient's body habitus. Several muscles compose the middle layer of the chest wall. The pectoralis, serratus, latissimus dorsi, and trapezius muscles are the larger ones. The sonographic appearance of skeletal muscles is uniform, with multiple echogenic striae over a hypoechoic background on longitudinal scans and multiple echogenic dots over the hypoechoic background on transverse scans because of the multiple horizontal fanlike linear reflections of the fascial planes. Of the ribs on sonography, only the anterior cortex appears as a continuous smooth bright interface with marked posterior acoustic shadowing, but costal cartilage is visible. Costal cartilage is homogeneous and less echogenic than the adjacent muscle. It appears round or ovoid on a longitudinal image and tubular on a transverse image (Figure 2). Between the second and sixth ribs, the breast is contained in a fascial envelope, the superficial pectoral fascia, whose deep layer lies anterior to the pectoral muscle and whose superficial layer is just deep to the subcutaneous fat. A retromammary fat layer is located between the breast parenchyma and the pectoral muscle.

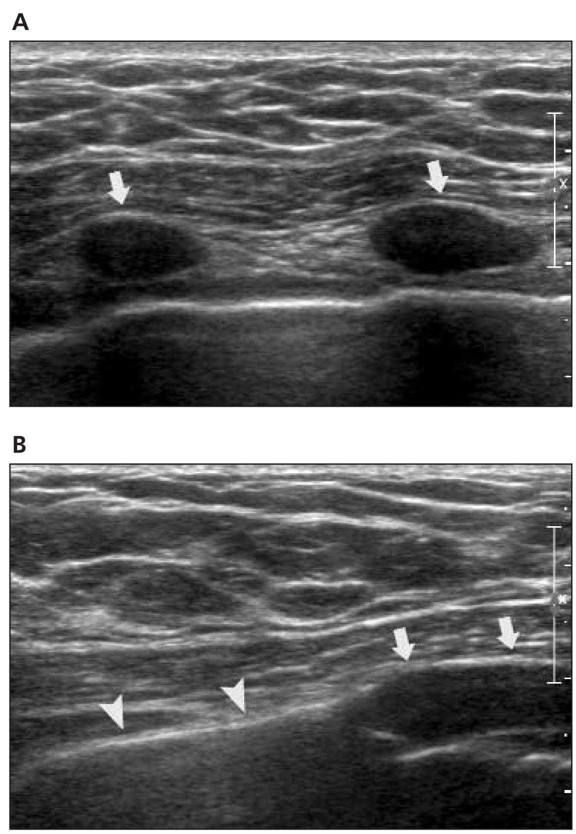
Figure 1. Sonographic anatomy of the chest wall and breast (transverse image). A, Skin; B, subcutaneous fat; C, breast parenchyma; D, retromammary fat; E, pectoral muscles; F, rib.



Differentiation of Chest Wall Lesions From Breast Lesions

Lesions located in the lateral and posterior portions of the chest wall originate solely from the chest wall and do not involve the breast parenchyma. It can be difficult to differentiate the source of lesions in the anterior chest wall on sonography. Because such lesions can be seen on deep portions of soft tissues, detection and characterization of them on sonography may be limited. Therefore, sonographic techniques that optimize visualization of the lesions are essential. Adjustments to a deep portion in the field of view, focal zones, time gain compensation, dynamic range, and postprocessing gray scale imaging can improve image quality, and the lesions can be more clarified. Transducers of a lower frequency, such as 5 MHz, may be helpful for evaluation of a deeper area, but the lower resolution may diminish the accuracy of lesion analysis. On sonography,

Figure 2. Sonographic findings of costal cartilage. **A**, Longitudinal image; **B**, transverse image. Arrowheads indicate the rib; and arrows, costal cartilage.



a few findings may be helpful. Lesions originating from the chest wall displace the breast tissue anteriorly as they expand into the breast and can be at an obtuse angle to the chest wall. If a retromammary fat layer is shown anterior to the lesion, it can be expected to be of chest wall origin (Figure 3). Computed tomography (CT) or magnetic resonance imaging (MRI) can be performed, especially for large or deeply located lesions.

Inflammation: Tuberculosis

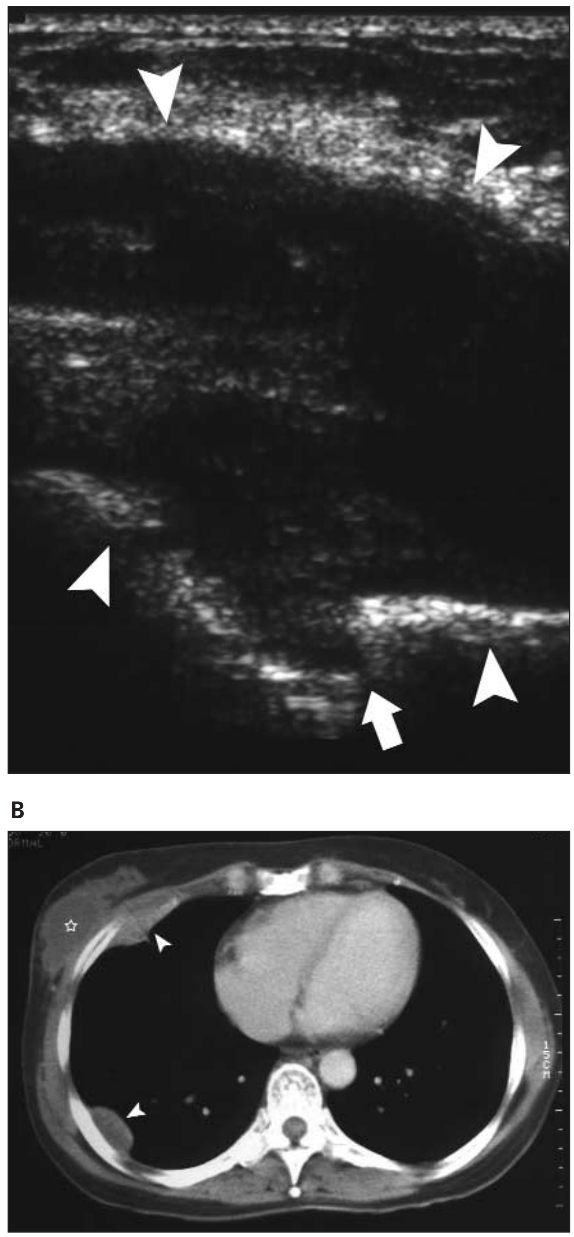
Chest wall involvement is an uncommon manifestation of tuberculosis that may be due to contiguous spread from underlying pleural or pulmonary lesions, although hematogenous seeding without active pulmonary disease is more common.[3] Chest wall abscesses and sinus tract formation occur in about 25% of cases.[4] The presentation may be similar to that of a pyogenic abscess or simply an enlarging mass.[5] When an abscess develops, sonographically, a heterogeneous hypoechoic mass with irregular borders appears in the chest wall (Figure 4). Sonography is of particular value for detecting fluid collections. The periphery of an abscess is usually hypervascular, as shown on Doppler imaging. In the case of percutaneous interventions such as aspiration or drainage of an abscess, sonography provides good guidance. A tuberculous abscess in the retromammary region usually appears as a focal smoothly marginated inhomogeneous hypodense lesion with a surrounding enhancing rim on CT. A direct fistulous connection with the pleura or a destroyed rib fragment in the abscess revealed by CT can be helpful in the differential diagnosis of other infectious types of retromammary abscesses.[6] Treatment is by either percutaneous drainage or resection and prolonged antituberculosis therapy.[5]

Figure 3. Sonography of a chest wall lesion posterior to the breast shows a few clues to the origin. This lesion was diagnosed as a benign lipoma sonographically. The mass (star) is at an obtuse angle to the chest wall (arrows), and retromammary fat (arrowheads) is lifted anteriorly by the mass.

Figure 4. Tuberculous abscess in a 50-year-old woman who had a palpable mass in her right breast for 1 month. **A**, Sonography shows an anechoic cystic mass with a hypoechoic irregular thick wall in the retromammary area (arrowheads) and breakdown of the pleural echogenic line, suggesting intrathoracic extension (arrow). **B**, Contrast-enhanced CT shows an abscess cavity in the retromammary area of the right breast with internal necrosis and peripheral enhancement (star). Multiple abscesses are also seen in the ipsilateral pleura (arrowheads).

A

B



Benign Neoplasms

Hemangiomas

Hemangiomas are occasionally found in the soft tissue of the chest wall. Histologically, soft tissue hemangiomas are subdivided into 5 categories depending on the predominant type of vascular channel: capillary, cavernous, arteriovenous, venous, and mixed variations.[7] A hemangioma in the chest wall is usually cavernous and may contain a substantial amount of fat. Phleboliths are associated with cavernous hemangiomas in approximately 50% of cases.[3,8] Cavernous hemangiomas consist of dilated tortuous thin-walled vessels, which are larger and deeper and occur later in life than other variations. Sonography can reveal a complex mass containing dilated vascular channels (Figure 5). If phleboliths are abundant, acoustic shadowing may also be documented (Figure 6). Doppler evaluation may show hypervascularity and low-resistance arterial flow with forward flow during both systole and diastole (Figure 5).[8] Plain chest radiographs may show a soft tissue mass, which occasionally is associated with pressure erosion on adjacent bone and phleboliths. Computed tomography shows a poorly defined mass with attenuation approximating that of skeletal muscle and heterogeneous contrast uptake and "filling in" of the lesion on delayed scanning, along with phleboliths and underlying bone remodeling (Figure 6). Magnetic resonance imaging characteristically shows intermediate signal intensity on T1-weighted images and marked hyperintensity on T2-weighted images, indicating the central angiomatous core of the neoplasm. Signal intensity voids caused by rapidly flowing blood can also be seen.[3,8] Cavernous hemangiomas do not spontaneously involute and therefore may require surgical intervention.[7]

Lymphangiomas

Lymphangiomas are congenital disorders of the lymphatic channels, which may affect any organ or tissue throughout the body. They may be localized or diffuse and can occasionally contain smooth muscle elements.[5] A localized lymphangioma (cystic hygroma) has the appearance of a well-demarcated cystic mass with lobulations and septations. On sonography, the lesions

Figure 5. Intramuscular hemangioma in a 23-year-old woman with a palpable mass in the outer portion of the right breast. **A**, Sonography shows an ovoid circumscribed mass in the pectoral muscle with anechoic foci corresponding to a dilated vascular channel. **B**, Corresponding power Doppler imaging shows increased vascularity within the mass. **C**, From the periphery of the mass (star), the diverged pectoral muscle (arrows) can be seen.

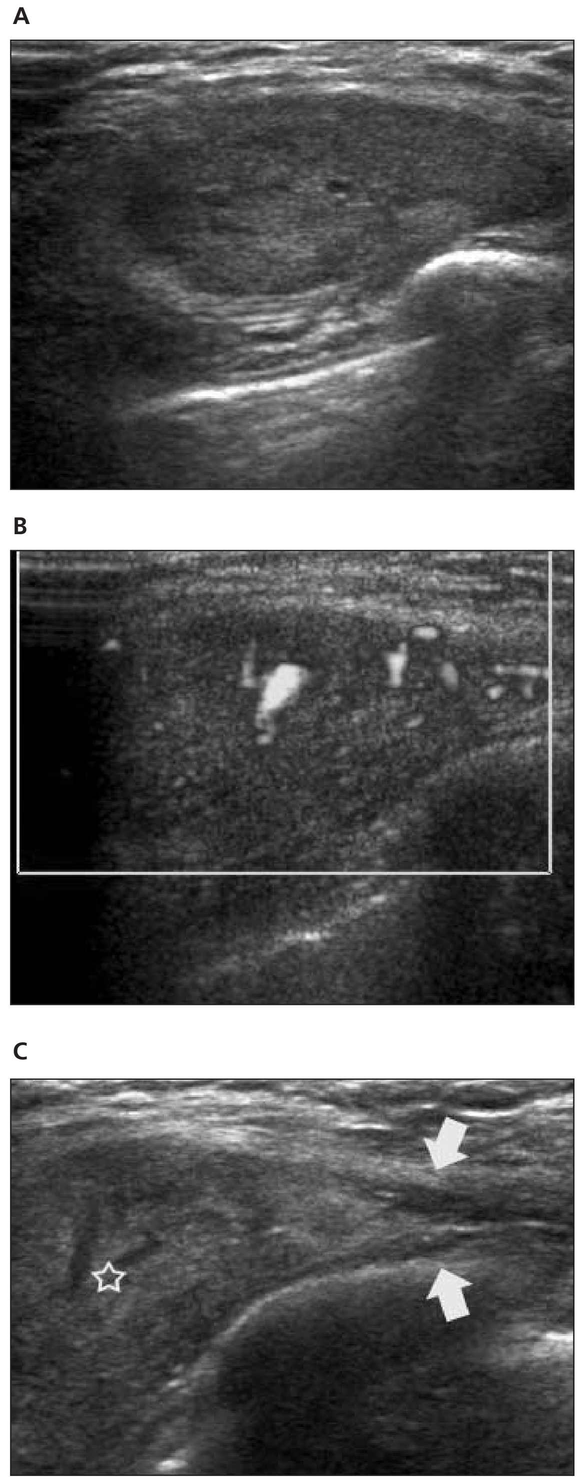
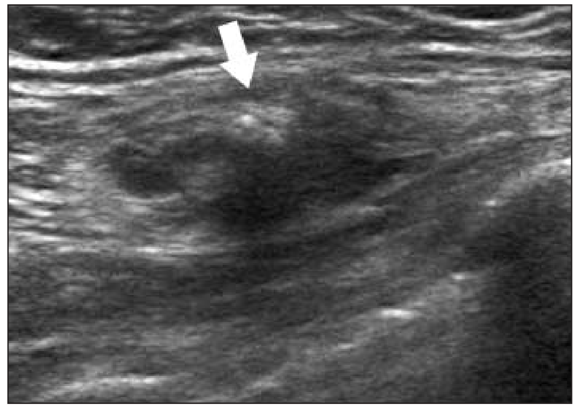


Figure 6. Cavernous hemangioma in a 54-year-old woman with a palpable mass in the left breast. **A**, Sonography shows a poorly defined hypoechoic mass within the pectoral muscle. The arrow indicates hyperechoic phleboliths within the mass. **B**, Mammography shows a hyperdense mass with coarse calcifications (phleboliths) in the pectoral muscle (arrow). **C**, A cone compression magnification view shows the location of the mass within the pectoral muscle. Arrows indicate the anterior margin of the pectoral muscle. **D** and **E**, Computed tomography shows a well-defined isoattenuated mass with phleboliths in the pectoral muscle. Its enhancement approximates that of skeletal muscle after administration of contrast media (arrows).

A



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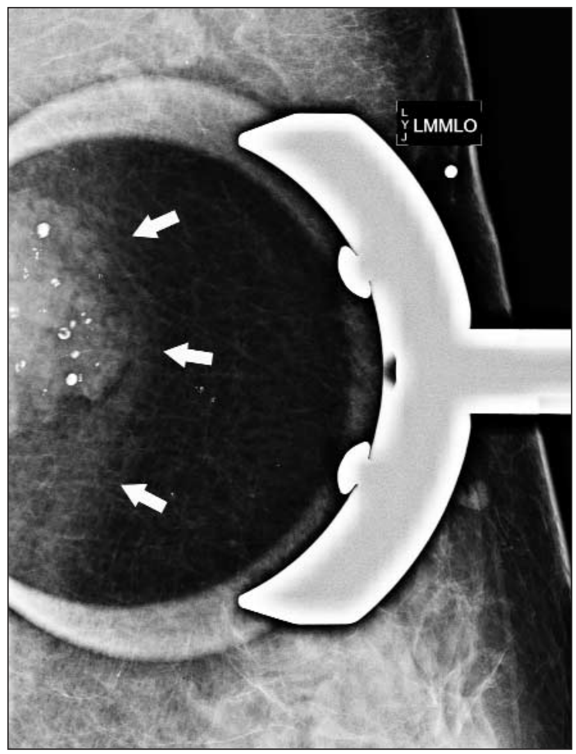
C



D

E

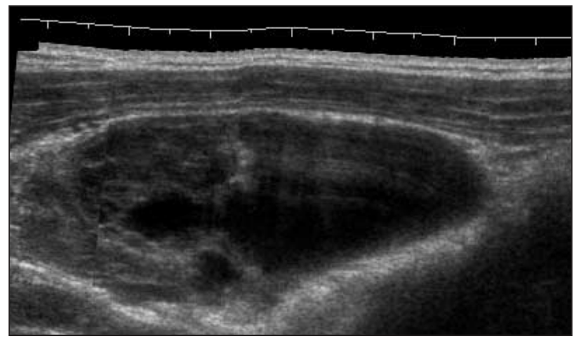
appear as multilocular cystic masses containing septa of variable thickness. The fluid inside can appear completely anechoic, hypoechoic, or hyperechoic because of infections, hemorrhage, or a high lipid content (Figure 7). Sonography is particularly helpful in differentiating cystic and solid masses, whereas MRI is more useful in determining a mass' extent and the involvement of contiguous structures and in allowing for accurate preoperative staging, which is essential for defining and "mapping" the individual cystic loci (Figure 7).[9] T2-weighted imaging with fat suppression and short-tau inversion recovery sequences highlight the water content of lymphangiomas and are excellent for delineating the full extent of these lesions.[10]

Neurogenic Tumors: Neurofibromas and Schwannomas

Classically, neurogenic tumors include 2 major benign histotypes: schwannoma (also referred to as neurilemmoma or neurinoma) and neurofibroma.[11] In the chest wall, neurogenic tumors originate from the intercostal nerves of the thoracic cage. Neurogenic tumors have a nonspecific appearance on sonography because they usually are fusiform hypoechoic masses with well-defined margins (Figure 8).[12] A presumptive diagnosis of a neurogenic tumor can be made reliably with sonography only if a soft tissue mass is found to be connected to a nerve bundle at its proximal and distal poles. However, a tumor that originates from small nerve branches is difficult to visualize, especially in the chest wall. This determination requires a careful scanning technique.[11] The extreme pain that often accompanies percutaneous biopsy is further evidence of the neural origins of the tumor. In most cases, sonography (as well as CT and MRI) has many shortcomings with regard to determining the histopathologic characteristics of nerve tumors.[11] Most schwannomas appear as eccentric masses with a homogeneous texture, posterior acoustic enhancement, intratumoral cystic changes, and hypervascularity on color Doppler imaging. Neurofibromas, on the other hand, commonly have a coarse echogenic hypovascular pattern. However, these differences are not reliable for histopathologic differentiation based on sonographic findings.

Figure 7. Lymphangioma in a 33-year-old woman with a palpable mass in the upper portion of the right breast. **A**, Sonography shows a well-defined cystic mass with a septal and solid component. **B**, T2-weighted MRI shows a circumscribed markedly hyperintense cystic mass with a thin hypointense wall and septa posterior to the pectoral muscle (arrows). **C**, Contrast-enhanced T1-weighted MRI with fat suppression shows enhancements in the peripheral wall and internal septa of the mass (arrows).

A



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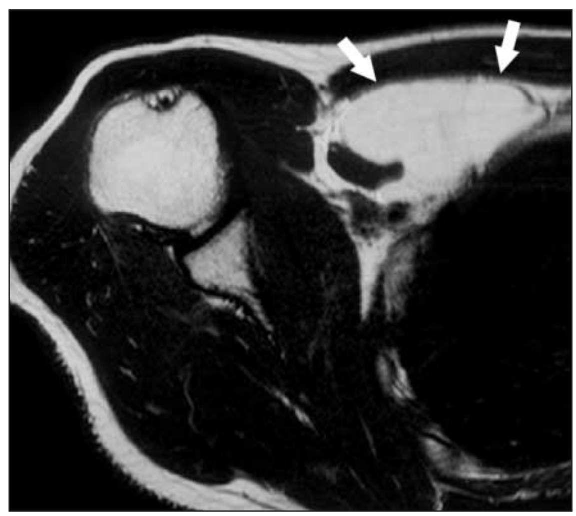

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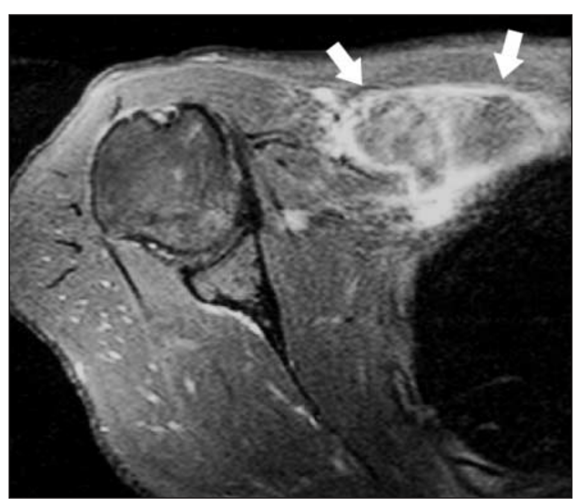
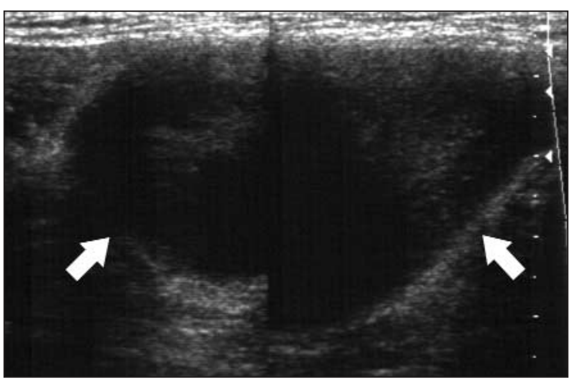


Epidermal Inclusion Cysts

Epidermal inclusion cysts are benign cutaneous or subcutaneous lesions formed by the inclusion of keratinizing squamous epithelium within the dermis, which becomes cystic and filled with laminated keratin. Clinically, they arise most commonly in the hair-bearing areas of the body, including the scalp, face, neck, face, trunk, and back. They can be caused by surgery, needle biopsy, or penetrating trauma but can also arise in preexisting sebaceous cysts when a squamous epithelium grows down into the fundus of the gland.[13–15] On sonography, epidermal inclusion cysts have been described as circumscribed hypoechoic solid- or complex-appearing masses containing variable echogenic foci without color Doppler signals (Figure 9).[14] The squamous epithelium continuously forms layers of keratin that slough off into the cavity of the cyst, resulting in characteristic multilaminar echogenicity on sonography, creating an onion-like appearance. When the sloughed keratin forms a denser nodule within the cyst, it may have a pearl-like appearance similar to the appearance of sebum within an ovarian dermoid, which may cause acoustic shadowing, even when not calcified. The keratin nodule may also calcify.[16] The treatment of choice is surgical excision.

Figure 8. Neurogenic tumors. **A**, Neurofibroma in a 24-year-old woman with a palpable mass in the left breast. Sonography shows a circumscribed hypoechoic mass in the chest wall (arrows). **B**, Schwannoma in a 29-year-old woman with a palpable mass in the left breast. Sonography shows a circumscribed hypoechoic mass in the subcutaneous fat layer of the chest wall.

A



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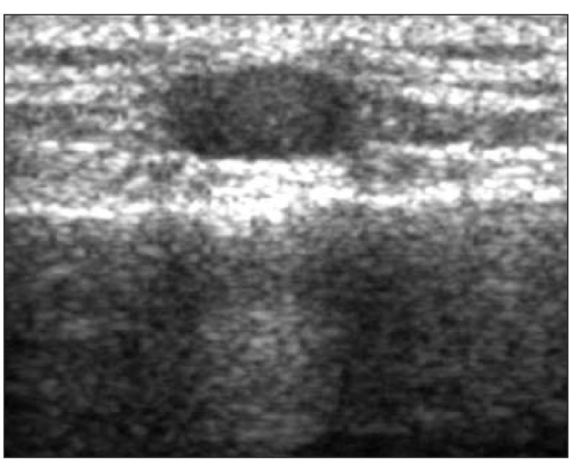
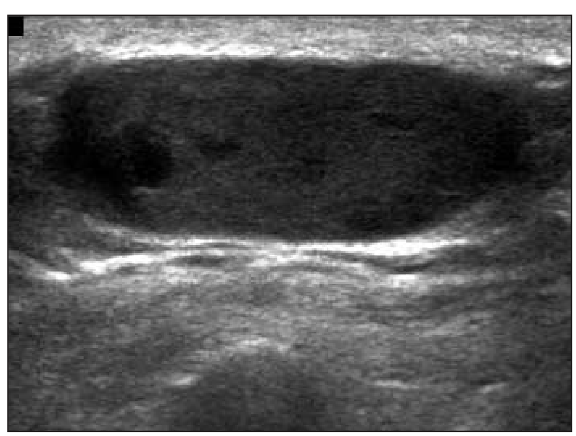


Malignant Neoplasms

Recurrence of Breast Cancer

Modified radical mastectomy is one of the treatment methods for breast cancer. The reported failure rate of this treatment method varies from less than 5% to greater than 30%. Local and regional sites constitute the most common sites of soft tissue recurrence of breast cancer. Chest wall invasion may occur either by direct local extension of the tumor through the pectoral fascia and into the pectoral muscles (Figure 10) or by indirect extension via interpectoral nodes (Figure 11). Most recurrent cancers appear on sonography as hypoechoic lesions; however, recurrent cancer may manifest as hyperechoic lesions (Figure 12).[17] Accurate diagnosis may be achieved with sonographically guided fine-needle aspiration biopsy even in a shallowly located or small lesion.[17–19] Recommendations

Figure 9. Epidermal inclusion cyst in a 41-year-old woman with a palpable mass in the right breast. Sonography shows a well-defined hypoechoic mass in the subcutaneous fat layer of the chest wall with internal anechoic foci and posterior acoustic enhancement.



for treatment of local and regional recurrences vary widely but frequently include surgical resection, external radiation therapy, systemic hormone therapy, and chemotherapy.

Metastases

Metastatic tumors are the most common chest wall malignancies. They are the result of hematogenous or lymphatic dissemination from other organs. The most common sources are lung, breast, kidney, and prostate carcinomas. The most common radiologic manifestation of these tumors is a lytic lesion on one of the ribs.[20]

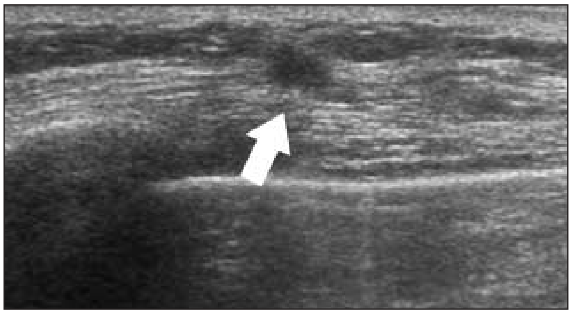
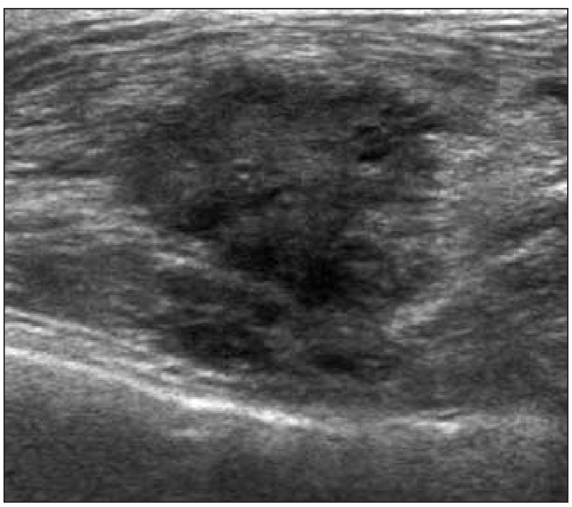


Figure 10. Recurrence of breast cancer in a 53-year-old woman who underwent a right modified radical mastectomy 5 years previously. Sonography for routine follow-up shows a poorly defined hypoechoic nodule within the muscle of the right chest wall (arrow).

Figure 11. Recurrence of breast cancer in a 62-year-old woman with a palpable mass in the left chest wall. She underwent a modified radical mastectomy of the ipsilateral breast 19 years previously because of breast cancer. **A**, Sonography shows a poorly defined hypoechoic mass in the interpectoral area. **B**, Medial to the mass, another hypoechoic nodule is shown within the pectoral muscle (arrow). Both lesions indicated the recurrence of breast cancer.

A



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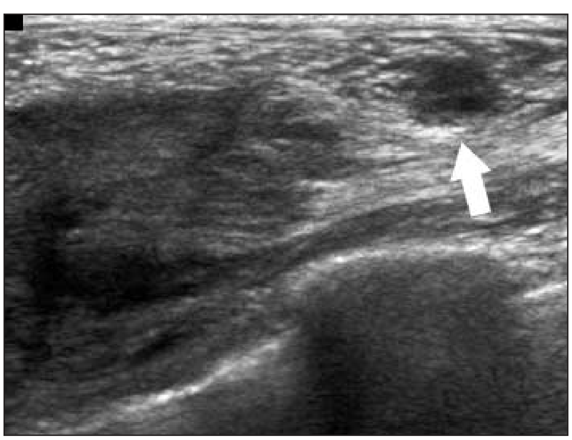
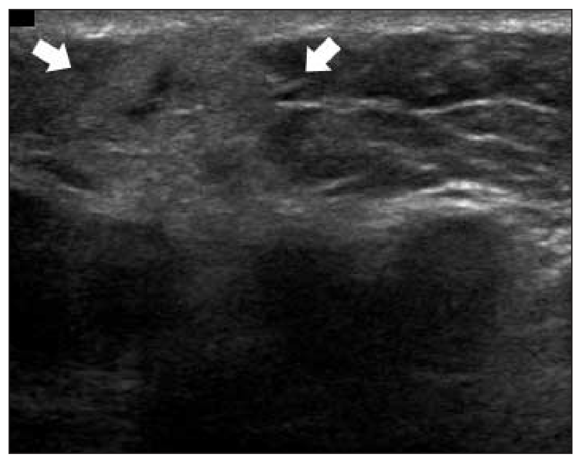


Figure 12. Recurrence of breast cancer in a 30-year-old woman with a palpable mass in the left anterior chest wall. She underwent a modified radical mastectomy of the contralateral breast 1 year previously because of breast cancer. **A**, Sonography shows a poorly defined hyperechoic mass in the subcutaneous fat layer of the chest wall (arrows). **B**, Contrast-enhanced CT shows a poorly defined enhancing lesion (arrow) anterior to the xyphoid process of the sternum.

A



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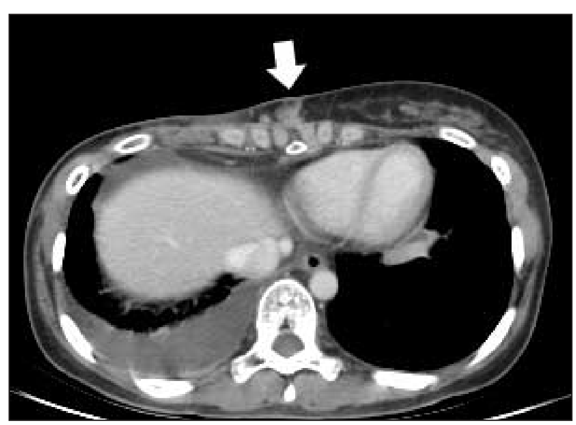


Bony metastases to the ribs can sometimes be visualized more easily than expected on sonography, although bone scintigraphy and positron emission tomography with fluorodeoxyglucose are more sensitive than sonography for detecting bony metastases. On sonography, the cortex of the normal rib shows a relatively uniform thickness of echogenicity. In cases of osteolytic metastatic rib lesions in which the cortical bone structure has been completely destroyed, sonography can show the irregular, thickened, or disrupted echogenic cortical line, which may be associated with abnormal acoustic transmission. Infiltration of the bone appears as a hypoechoic mass, replacing the normal echogenicity of the rib (Figure 13).[21,22]

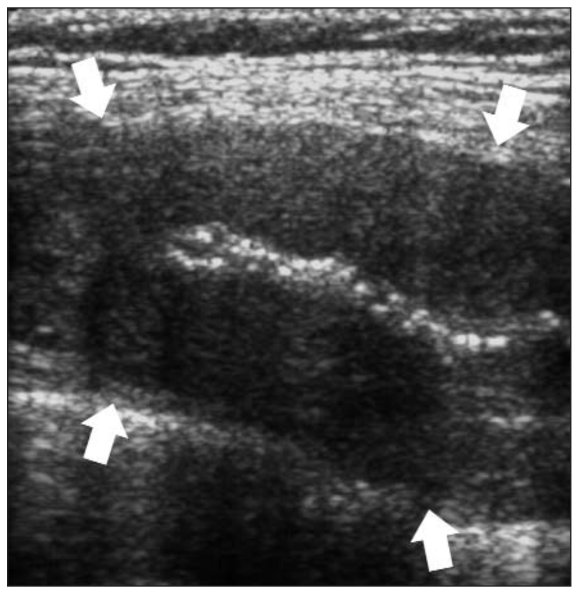
Metastatic lesions to the soft tissue of the chest wall are uncommon. Such metastases are usually seen in patients with extensive metastases elsewhere and portend a poor prognosis. The most common metastasis is from a melanoma.[2,23] On sonography, superficial metastases are evident as nodules with smooth or lobulated contours, hypoechogenicity compared with muscle, and a heterogeneous echo texture including small hypoechoic areas in some cases.[24] Superficial melanoma metastases typically are well-defined hypoechoic lesions with smooth or lobulated contours, mild to moderate heterogeneity, and enhanced acoustic through-transmission on sonography. Internal flow revealed by color Doppler sonography is present in many but not all superficial melanoma metastases (Figure 14).[25] In malignant lymphomas, secondary involvement of the musculoskeletal system is common in soft tissue tumors and usually occurs in the trunk and lower limb. Hodgkin and non-Hodgkin lymphomas may occasionally involve the chest wall with or without mediastinal or lung parenchymal disease.[3,26] Most superficial soft tissue lymphomas are the nodal or mass type and hypoechoic, similar to soft tissue sarcomas, on sonography (Figure 15).[27] Determining the anatomic extent of the disease affects initial staging and treatment planning in patients with malignant lymphomas. If malignancy is found, CT or MRI should be performed for staging before treatment.

Soft Tissue Sarcomas

Primary soft tissue sarcomas of the chest wall are uncommon. A fibrosarcoma is the most common histologic type of tumor.[28] All of these tumors have a similar radiologic appearance. On radiography, CT, and MRI, they appear as areas of soft tissue density or attenuation, often associ-

Figure 13. Metastasis to the rib from breast cancer in a 55-year-old woman who underwent a right modified radical mastectomy 3 years previously. **A**, Sonography shows a hypoechoic mass with internal irregular linear hyperechogenicity, which has destroyed the bony cortex in the left second rib (arrows). **B**, Contrast-enhanced CT shows a heterogeneously enhanced soft tissue mass destroying the second rib in the anterior chest wall (arrows).

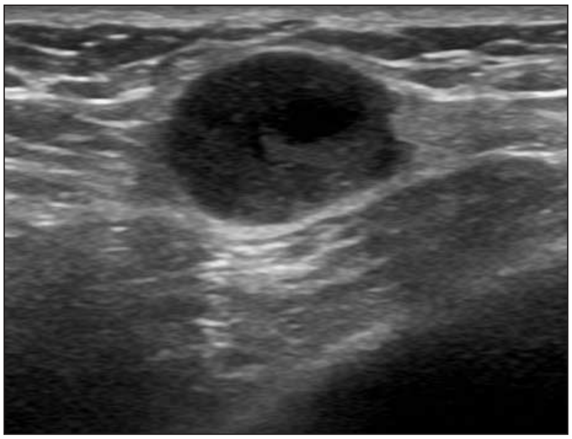
A



B

Figure 14. Metastatic malignant melanoma in a 38-year-old man with a palpable mass in the lateral area of the right breast. He had a diagnosis of malignant melanoma of the back 1 year previously. **A**, Sonography shows a circumscribed hypoechoic nodule with an internal anechoic portion and posterior acoustic enhancement in the right lateral chest wall. **B**, Positron emission tomography with fluorodeoxyglucose shows multiple areas of fluorodeoxyglucose uptake in the right axilla, chest wall, and inguinal area (arrows).

A



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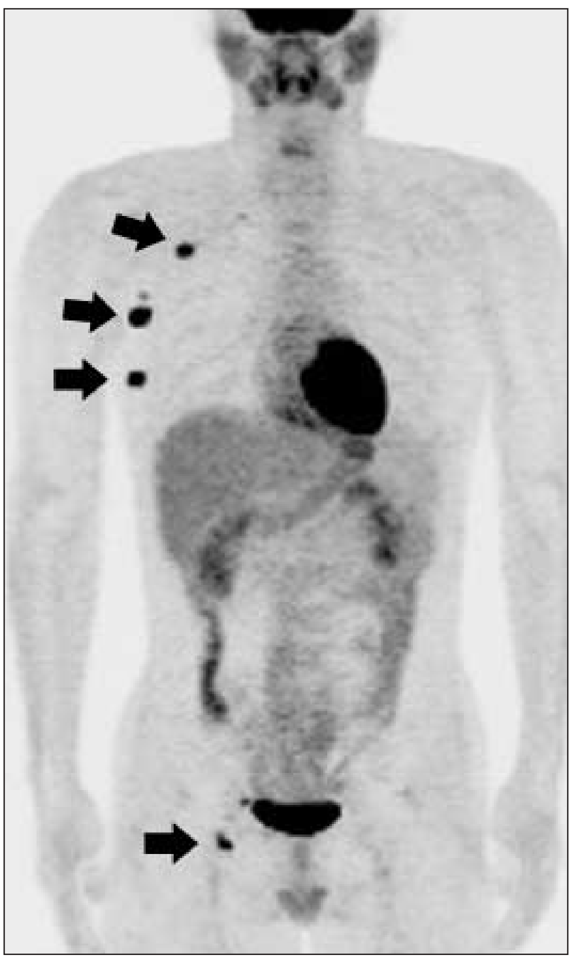


ated with necrotic areas of low density or attenuation. Calcification within the tumor may also be seen.[3] Soft tissue sarcomas have a poor prognosis, and the tumor grade and differentiation are the most important factors affecting survival. Wide resection is the treatment of choice, and adjuvant therapy is considered for high-grade sarcomas.[29] A primary leiomyosarcoma of the chest wall is a rare neoplasm that shows smooth muscle differentiation. It is reported to occur in approximately 1% to 4% of patients with primary soft tissue sarcomas of the chest wall and generally has a poor prognosis, with high percentages of recurrence and hematogenous metastasis.[30,31] The small lesions tend to be homogeneously hypoechoic on sonography and homogeneously contrast enhanced on CT scans. However, CT scans usually show a large mass that frequently includes areas of necrotic or cystic changes, with central hypoattenuation and peripheral contrast enhancement.[30] Typical MRI features of the mass include a spindle shape and relatively low signal intensity on T1-weighted images and high signal intensity on T2-weighted images. After intravenous administration of contrast material, tumors typically show an enhanced rim on the periphery and a central area of low signal intensity (Figure 16).[26] Because there is no pathognomonic radiologic finding for this disease, the diagnosis can only be achieved by biopsy.[30] Malignant peripheral nerve sheath tumors (also called neurofibrosarcomas or malignant schwannomas) are neoplasms of nerve sheath origin that infiltrate locally and metastasize. They usually arise in preexisting neurofibromas of the

Figure 15. Lymphoma in a 60-year-old woman with a palpable mass below the left breast. Sonography shows a poorly defined heterogeneous hypoechoic mass with posterior acoustic enhancement in the anterior chest wall.

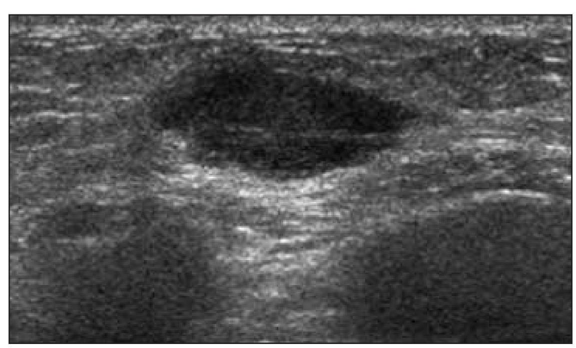
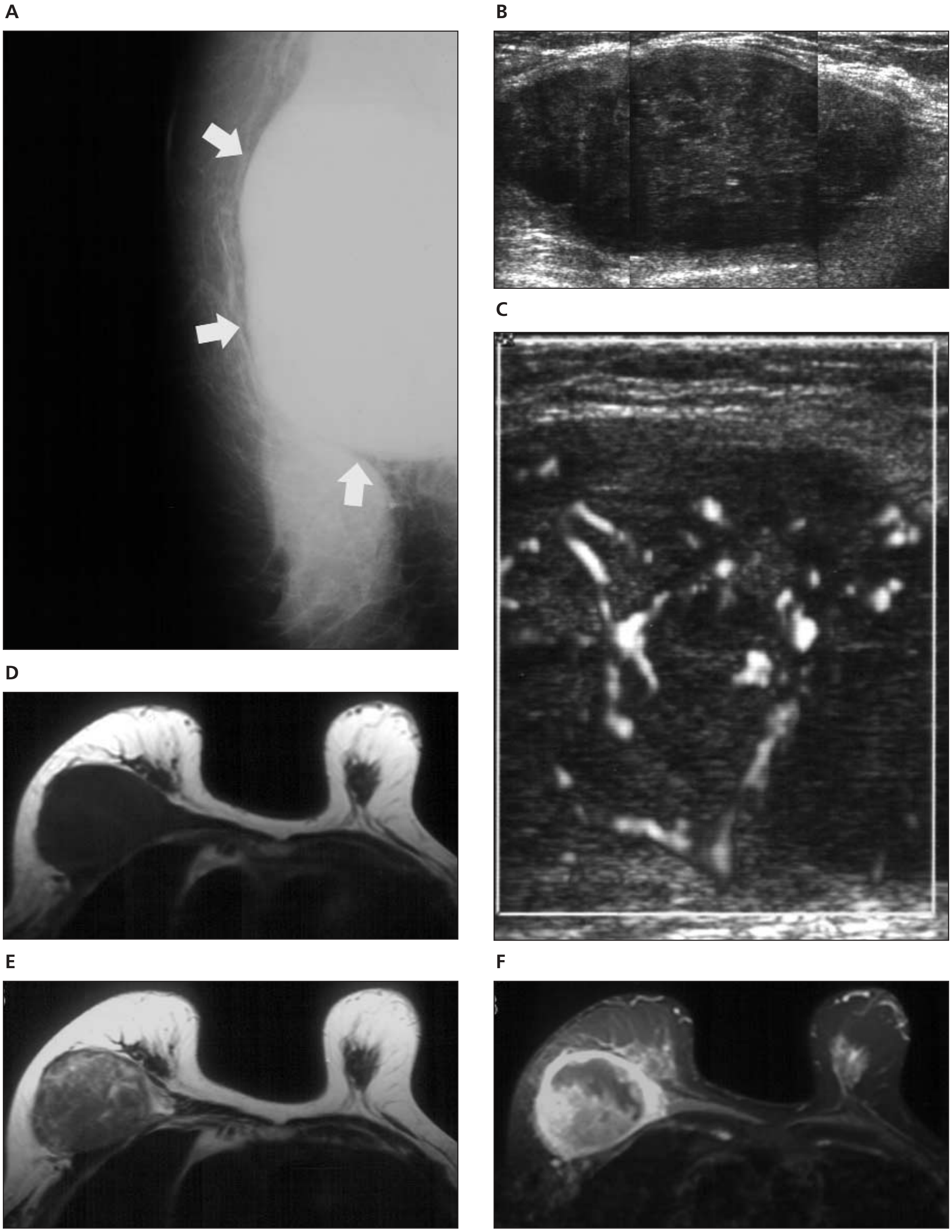


Figure 16. Leiomyosarcoma in a 66-year-old woman with a palpable mass in the right breast. **A**, Mammography shows a circumscribed hyperdense mass posterior to the retromammary fat (arrows). **B**, Sonography shows a circumscribed heterogeneous hypoechoic mass posterior to the retromammary fat. **C**, Corresponding power Doppler imaging shows increased vascularity within the mass. **D–F**, Magnetic resonance imaging shows a well-defined heterogeneous mass within the pectoral muscle posterior to the breast. The mass is hypointense on T1-weighted imaging (**D**), hyperintense on T2-weighted imaging (**E**), and heterogeneously enhanced with strong rim enhancement on contrast-enhanced T1-weighted imaging (**F**).



intercostal nerves and spinal nerve roots or in the brachial plexus. In approximately 50% of patients, an association of these tumors with type 1 neurofibromatosis is found.[26,32] Pain is more common in patients with type 1 neurofibromatosis, and development of pain in a neurofibroma portends malignant transformation.[26] Most tumors are homogeneous and hypoechoic, with posterior acoustic enhancement and peripheral nerve contiguity on sonography. However, sonography cannot distinguish among schwannomas, neurofibromas, and malignant peripheral nerve sheath tumors.[33] The only findings that might make the examiner suspect that the lesion is malignant are a sudden increase in the size of a previously stable mass, the presence of indistinct tumor margins, and adhesions between the mass and surrounding tissues (Figure 17, A and B).[11] Computed tomographic scans usually show a large heterogeneous mass, occasionally accompanied by bone destruction (Figure 17C). Magnetic resonance images show a large invasive mass located along the course of a peripheral nerve. The internal architecture of the tumor may be heterogeneous and irregular in accordance with the extent of necrosis, hemorrhage, and cellularity. On T2-weighted images, the signal intensity is markedly increased. Heterogeneous enhancement is observed after intravenous administration of contrast material. The findings of tumor invasion in the surrounding fatty tissue or other neighboring structures and bone or perilesional edema can help in the diagnosis.[26]

A

B

C

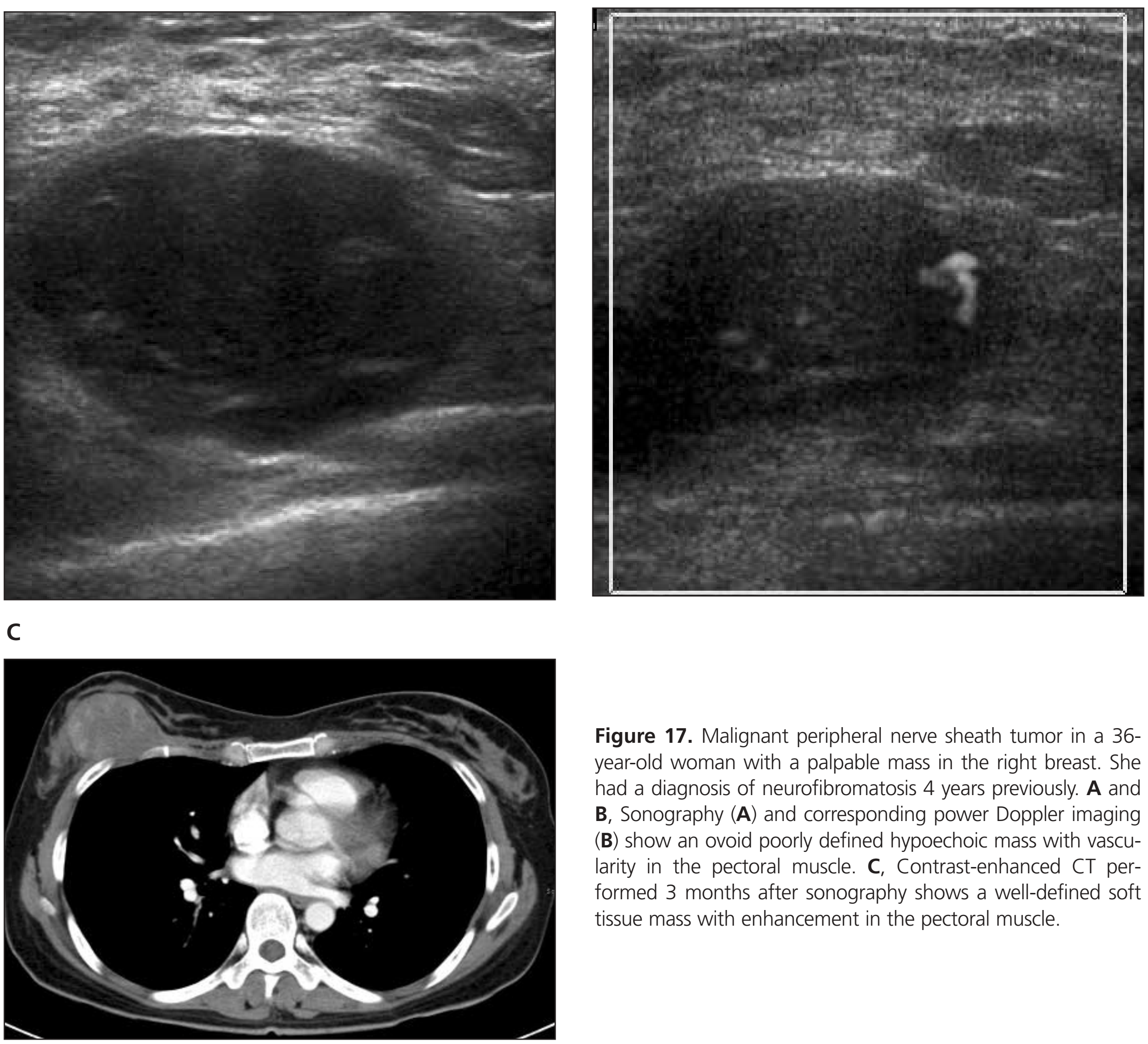


Figure 17. Malignant peripheral nerve sheath tumor in a 36-year-old woman with a palpable mass in the right breast. She had a diagnosis of neurofibromatosis 4 years previously. **A** and **B**, Sonography (**A**) and corresponding power Doppler imaging (**B**) show an ovoid poorly defined hypoechoic mass with vascularity in the pectoral muscle. **C**, Contrast-enhanced CT performed 3 months after sonography shows a well-defined soft tissue mass with enhancement in the pectoral muscle.

Discussion

A chest wall lesion may have clinical features that can cause it to be confused with a breast lesion. Breast sonography can be performed initially for evaluation of a chest wall lesion presenting as a breast lump. It is important to remember that not all breast masses arise from the breast itself.[1,34,35]

Sonography is used with increasing frequency in evaluation of palpable superficial chest wall abnormalities. The relatively risk-free noninvasive nature and fast examination time of this imaging modality make it a useful screening tool. With a high-frequency linear transducer, sonography can aid in determining whether a lesion is present, where it is located, and whether a palpable lesion is cystic or solid. Additionally, color Doppler sonography and spectral tracings can provide important information regarding vascular flow, particularly in evaluation of vascular masses such as malformations and hemangiomas. The inability to see deeper structures and to penetrate bone limits the usefulness in sufficiently assessing lesions that do not originate superficially or within soft tissue.[36] Unfortunately, sonography of chest wall masses is frequently nonspecific, showing a mass of variable echogenicity.[21] In many instances, CT and MRI are complementary studies that provide useful information about the nature and extent of chest wall diseases.[37] When the lesions are suspected to arise from the chest wall beneath the breast according to breast sonography, knowing the exact site of origin may be useful for studying them more accurately.

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