Chest wall – a structure underestimated in ultrasonography. Part III: Neoplastic lesions

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Abstract

Chest wall neoplasms mainly include malignancies, metastatic in particular. Differential diagnosis should include clinical data; tumor location, extent, delineation; the degree of homogeneity; the presence of calcifications; the nature of bone destruction and the degree of vascularization. The aim of the paper is to present both the benefits and limitations of ultrasound for the diagnosis of chest wall neoplasms. The neoplastic process may be limited to the chest wall; it may spread from the chest wall into the intrathoracic structures or spread from the inside of the chest towards the chest wall. Benign tumors basically originate from vessels, nerves, bones, cartilage and soft tissues. In this paper, we briefly discuss malformations of blood and lymphatic vessels, glomus tumor as well as neurogenic tumors originating in the thoracic branches of the spinal nerves and the autonomic visceral system. Metastases, particularly lung, breast, kidney cancer, melanoma and prostate cancer, are predominant tumors of the osteocartilaginous structures of the chest wall. Plasma cell myeloma is also relatively common. The vast majority of these lesions are osteolytic, which is reflected in ultrasound as irregular cortical defects. Osteoblastic foci result only in irregular outline of the bone surface. Lipomas are the most common neoplasms of the chest wall soft tissue. Elastofibroma is another tumor with characteristic echostructure. Desmoid fibromatosis, which is considered to be a benign lesion with local aggressivity and recurrences after surgical resection, represents an interesting tumor form the clinical point of view. Ultrasonography represents an optimal tool for the monitoring of different biopsies of pathological lesions located in the chest wall. Based on our experiences and literature data, this method should be considered as a preliminary diagnosis of patients with chest wall tumors.

Chest wall neoplasms mainly include malignancies, metastatic in particular. Clinical differences between these neoplasms usually involve asymptomatic benign tumors and painful malignancies. There are no pathognomonic features that would allow for reliable discrimination based on diagnostic imaging. However, an assessment of clinical data; tumor location, extent, delineation; the degree of homogeneity; the presence of calcifications; the nature of bone destruction and the degree of vascular-ization may increase diagnostic accuracy[1–14]. The neoplastic process may be limited to the chest wall, spread from the chest wall into the intrathoracic structures or spread from the inside of the chest towards the chest wall. Benign tumors basically originate from vessels, nerves, bones, cartilage and soft tissues. Metastases of lung, breast, kidney, and prostate cancer as well as melanoma are predominant tumors found in the chest wall[1,2,4–14].
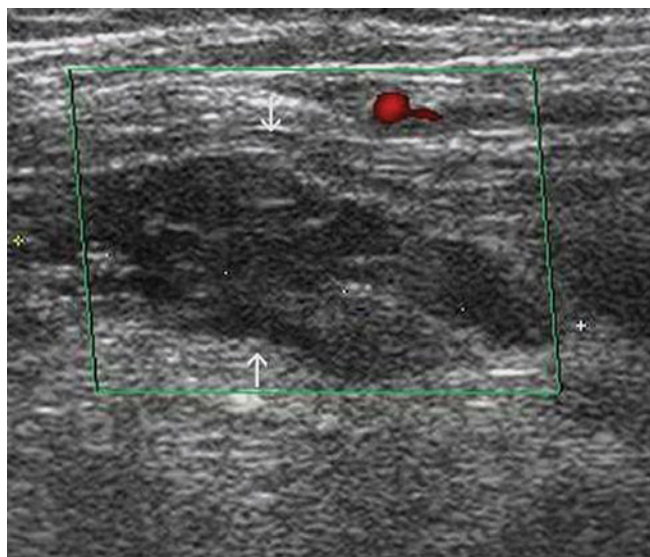
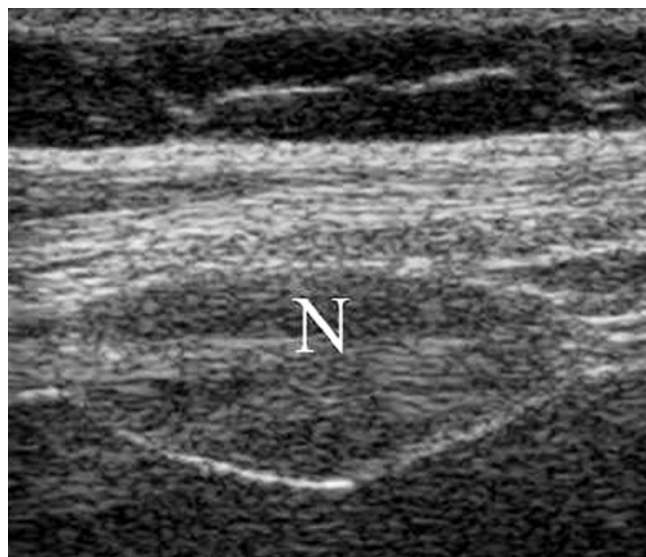**Fig. 1.** *Cavernous angioma (arrows) in the dorsal chest*

Fig. 2. *Neurofibroma (N) in the 10th intercostal space*

Vascular neoplasms

Hemangioma is a typical example of vascular neoplasms (Fig. 1). It is usually found in the skin or the subcutaneous tissue of the head and the neck, where it generally reaches a large size and is poorly delineated from healthy tissues. Large lesions, especially those with arteriovenous fistulas, may cause smooth osseous defects. The presence of phleboliths within the tumor, which is estimated at 30%, is an important feature[3]. In ultrasound, it presents as an area of multiple hypo- and anechoic, small (several millimeters) cyst-like lesions with a varying degree of vascularization. Compared to hemangiomas, lymphangiomas usually present as large clusters of non-vascularized anechoic lesions[5]. Hemangioma is rarely located in osseous structures of the chest other than the thoracic spine. For example, it is found in the sternum only in 1% of cases[2]. Hemangiosarcoma is one of the least common tumors found in the chest. Idiopathic osteolysis, also known as Gorham's disease, rep-

resents an interesting and rare pathology, which mainly affects the bones of the shoulder girdle. For unknown reasons, the growing lymphatic or blood endothelium in the bone causes non-reactive bone atrophy, which may also involve the soft tissue[15]. Glomus tumor, which is comprised of modified smooth muscle cells and arteriovenous anastomoses, is a benign tumor usually situated underneath the finger nail. A single lesion manifested by nagging pain usually shows abundant vasculature in Doppler imaging. Larger, intramuscularly located tumors may cause bone erosion[3,16].
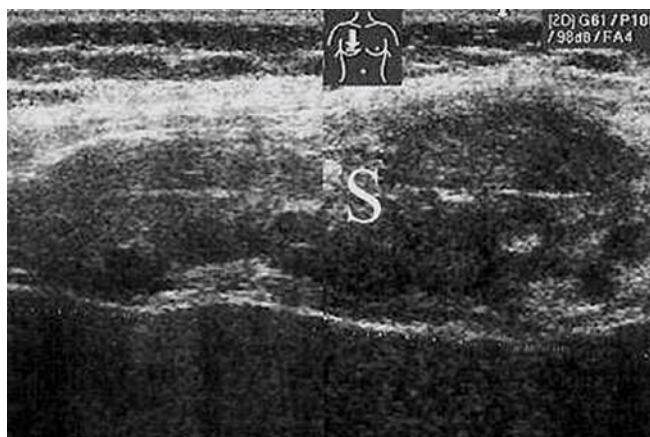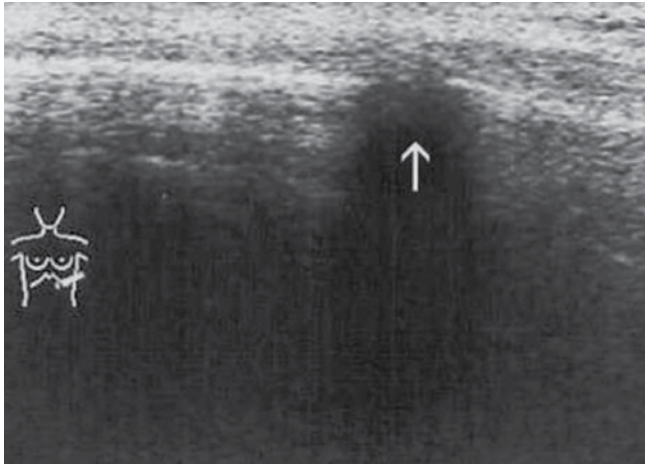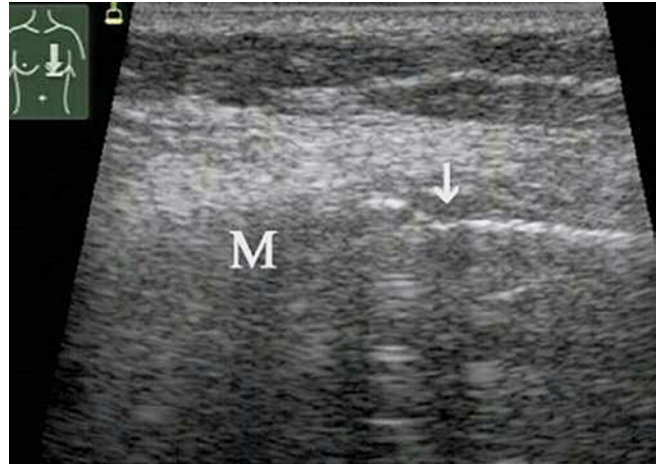

Fig. 4. *A giant neuroma in the posterior right mediastinum (T)*

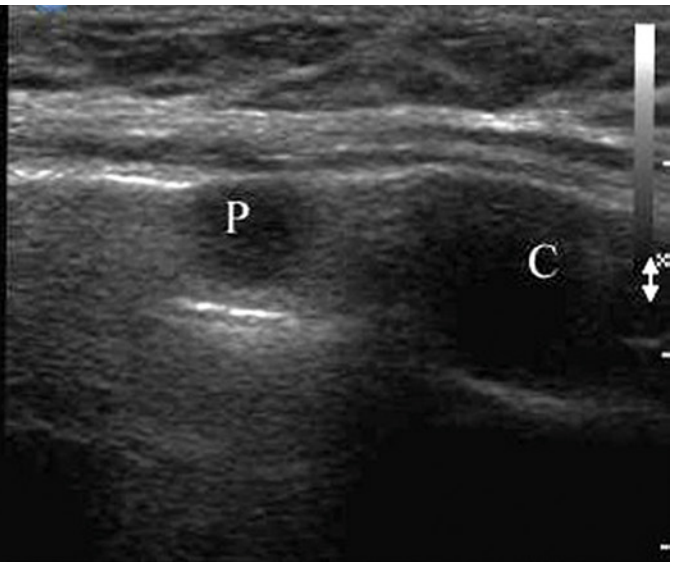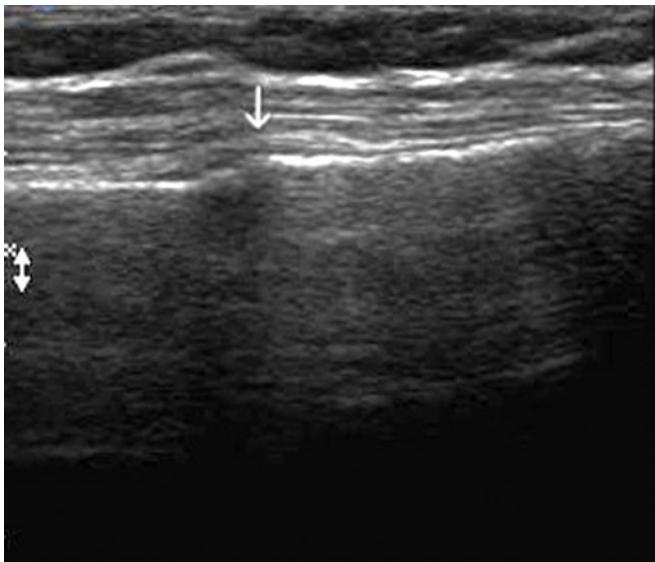**Fig. 3.** *A large schwannoma (S) causing dilation of the 5th intercostal space*

Fig. 5. *Breast cancer metastasis to the rib (arrow) causes focal bone destruction*


Fig. 6. *Colon cancer metastasis to the rib (M) with pathological fracture (arrow)*

Fig. 7. *Multiple myeloma. Divided image: only disrupted cortical matter (arrow) may be seen on the left side; again on the right – the same image from the edge of the upper rib shows focal bone destruction (P). C – costal cartilage*
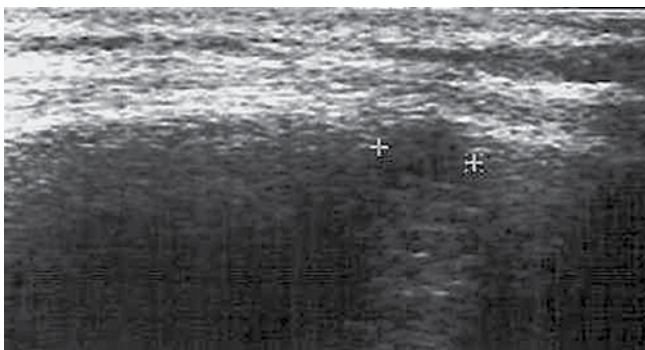
Fig. 8. *Multiple myeloma. A distinct osteolytic focus involving the whole bone thickness (distance indicators)*
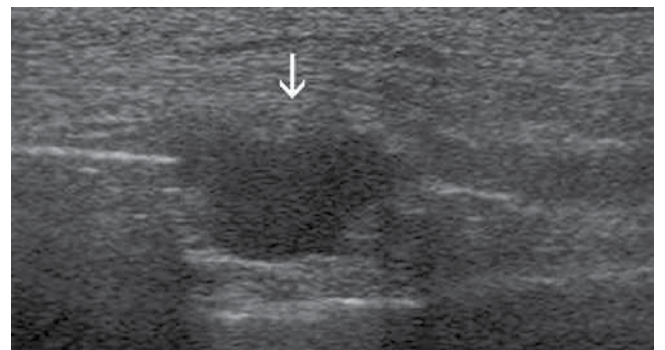
Fig. 9. *Multiple myeloma. Infiltration of the ribs and surrounding soft tissue (arrow)*
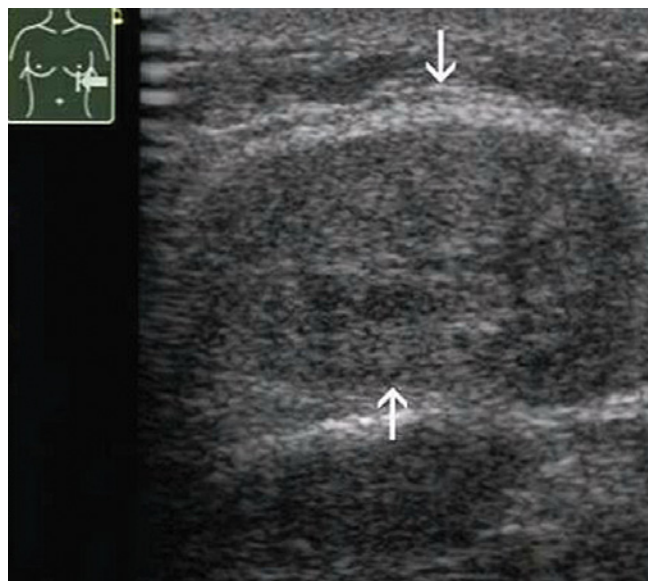
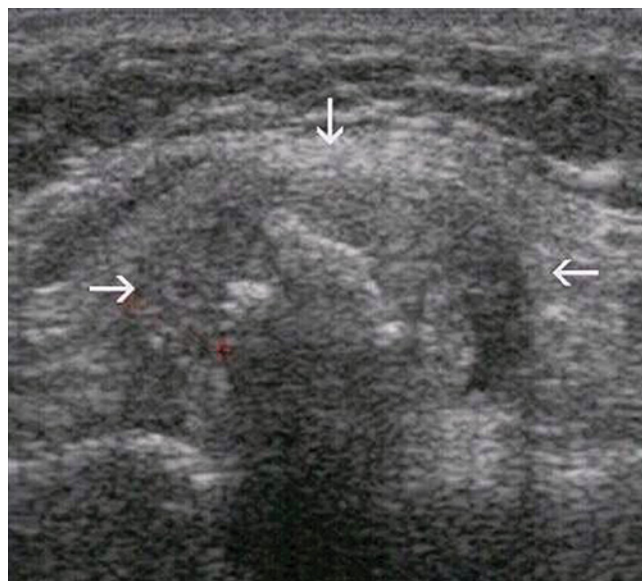Fig. 10. *Chondrosarcoma of the cartilage in the left 7th rib*

Fig. 11. *Chondroma of the sternal clavicle (arrows)*

Neurogenic tumors

Neurogenic tumors of the chest wall may be either benign or malignant. Neurofibroma (Fig. 2) and schwannoma (Fig. 3) are typically located in the intercostal space. The macroscopic difference between these tumors is that the first tumor grows in the nerve axis, whereas the latter one shows an eccentric growth pattern and is encapsulated. The vast majority of lesions present as single nodules, while multiple neuromas, which may occur in plexiform, are observed in neurofibromatosis type I (NF1), also known as von Recklinghausen's disease. Both these types of neurogenic tumors are mostly hypoechoic. Small tumors are homogeneous, whereas larger lesions may contain anechoic foci, which indicate degeneration and bleeding, and may cause rib erosion,

particularly in schwannomas. Hyperechoic foci, which correspond to collagen deposits, may be found in both types of neuromas. Furthermore, a small posterior enhancement is often observed behind these lesions. This corresponds to avascular or poorly vascularized tumors in color Doppler imaging. A 2% risk of malignant transformation into malignant tumors of the peripheral nerve sheath is particularly seen in patients with neurofibromatosis type I. These tumors are distinguished by a larger size, heterogeneous structure and irregular outlines. Computed tomography and, in particular, magnetic resonance, allow for a more detailed determination of the nature of the tumor compared to ultrasound. However, aspiration biopsy is used for this purpose in some cases[3,4,17–19]. Neurogenic tumors, such as ganglionic neuroma, neuroblastoma, ganglioneuroblastoma
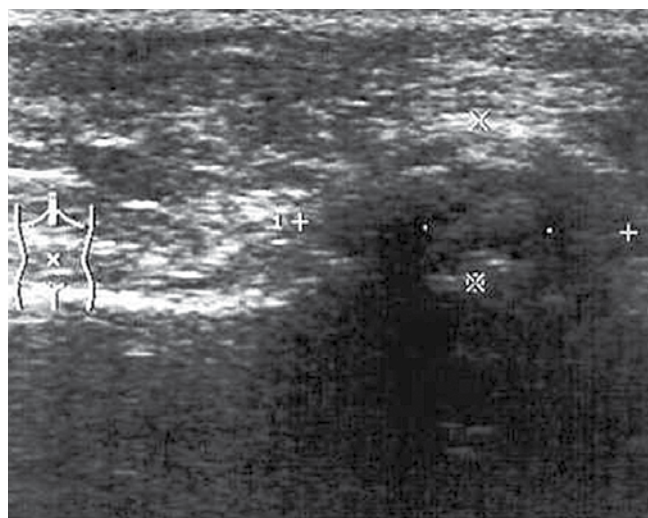

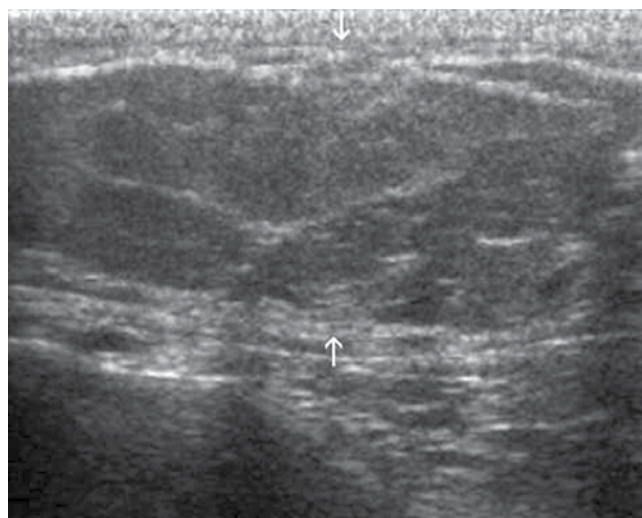Fig. 12. *Chondroma of the xiphoid process (distance indicators)*

Fig. 13. *A typical image of lipoma in the subcutaneous tissue of the chest (arrows)*
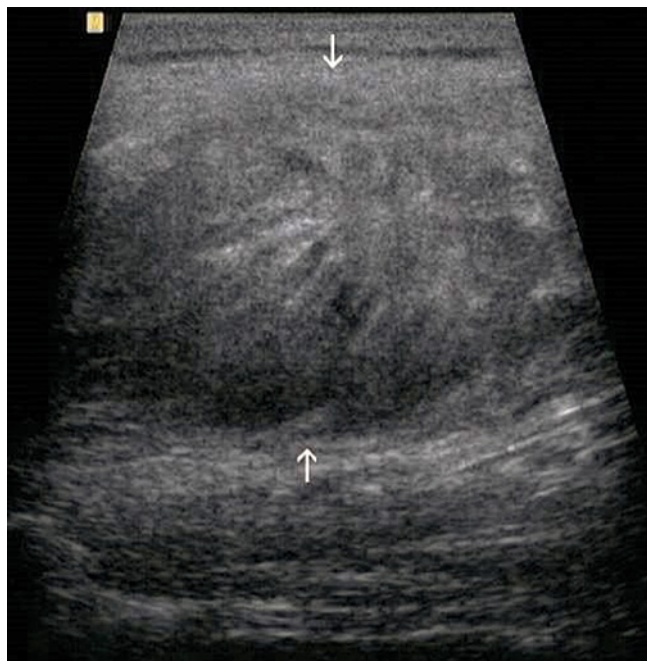
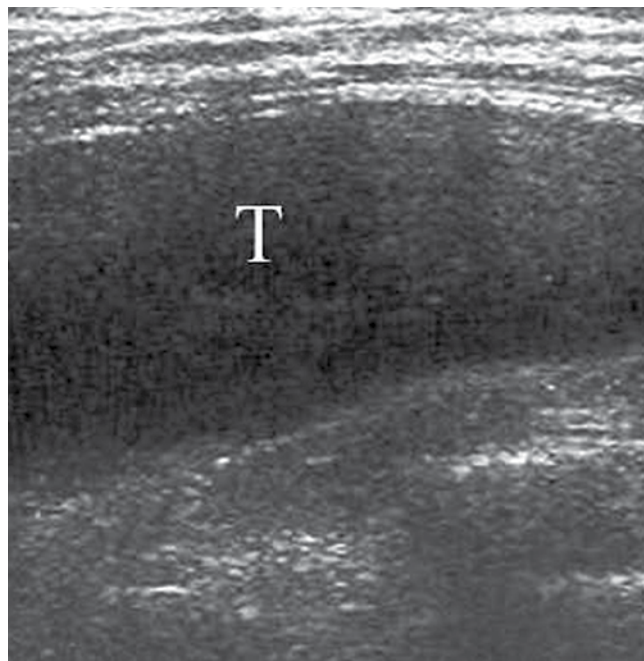**Fig. 14.** *Desmoid fibroma infiltrating chest integuments (arrows)*

Fig. 15. *Chondrosarcoma (T) located in the dorsal chest*

and paraganglioma originate in the autonomous system, therefore they are usually situated in the posterior mediastinum, at the spine. The first three tumors are usually found in small children. Neuroblastoma is particularly malignant, however, the prognosis improves if the tumor is located in the chest as opposed to the adrenal gland. It often contains calcifications and rapidly metastases to lymph nodes and bone marrow. Paraganglioma affects mainly middle-aged adults and is benign in most cases. Abundant vasculature is a distinctive feature of this tumor. Tumors originating in the autonomous system are characterized by their long axis almost parallel to the spine (Fig. 4)[3,4,16,19].

Tumors located in the osteocartilaginous structures of the chest wall

Metastases, mainly from lung, breast, kidney and prostate cancer, are predominant is this region (Figs. 5, 6). Plasma cell myeloma is also relatively common in this area (Fig. 7, 8, 9)[1–12]. The vast majority of such tumors are osteolytic. Ultrasound detection of osseous defects is possible only after the damage of the anterior compact substance. Larger tumors may cause local fractures or invade the neighboring soft tissue. In this situation the patient usually experiences local pain, which facilitates the identification of an ongoing process based on an ul-
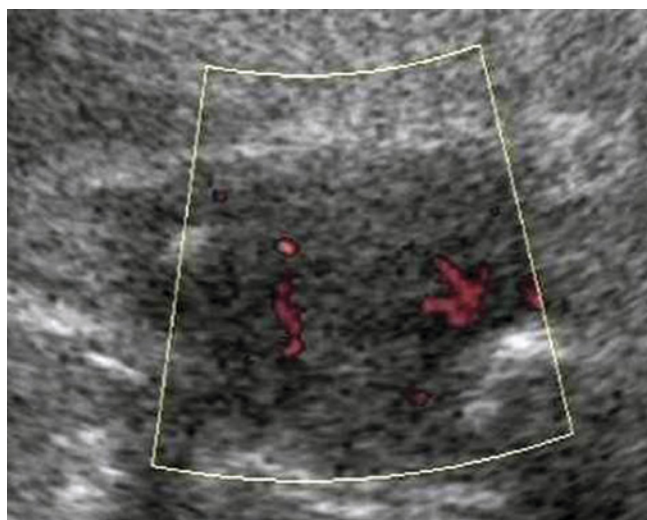

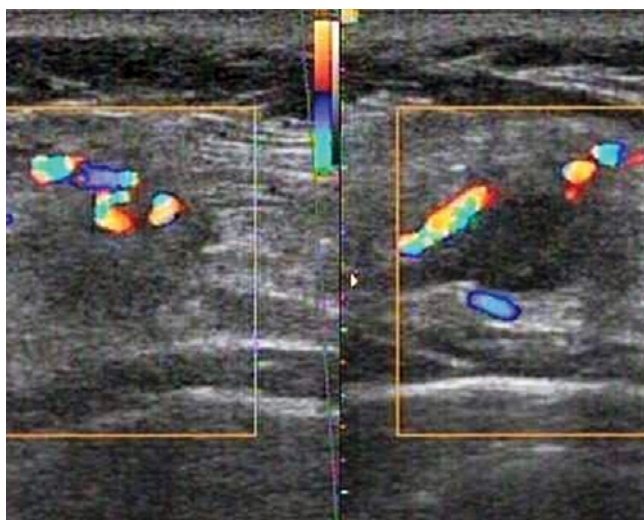**Fig. 16.** *Vascularized metastasis of lung cancer into chest integuments*

Fig. 17. *Two cross-sectional views of vascularized metastasis of breast cancer into chest integuments*

trasound image. Paik et al.[20] demonstrated high usefulness of ultrasonography (94%) and poor utility of conventional radiography (39%) for the diagnosis of such tumors. Metastatic foci were characterized by cortical defects or an irregular cortical edge and/or a mass invading local soft tissues, including pleura in some cases. Lee et al.[21] compared a group of patients with rib metastases from renal cancer with a group of patients with prostate cancer metastases in their prospective study. A locally irregular surface of the costal cortex in the absence of fracture or the presence of masses within the soft tissue represented the only sonographic feature of prostate cancer osteoblastic foci. This type of image may also indicate previous rib fracture, which should be included in the differential diagnosis. CT, MRI or PET/CT is necessary in cases of suspected cancer spread within the chest[8–12]. Primary malignant tumors of the osteocartilaginous scaffold of the chest wall are exceptional. Chondrosarcoma is typically located in the osteocartilaginous portion of the ribs or in the sternum (Fig. 10). Amorphous calcifications are often observed in the chondral mass[4,12]. Liu et al.[22] described the usefulness of contrast-enhanced ultrasonography in chest chondrosarcoma. Osteosarcoma is even less common, however, it is similarly located, i.e. in the anterior chest wall. This type of tumor may manifest as a lesion with the predominance of calcifications mainly located centrally or in the form of an almost entirely osteolytic mass[4,12]. Other rare osteocartilaginous chest tumors that should be considered during differential diagnosis include chondroma, aneurysmal bone cyst, giant cell tumor, chondromyxofibroma, other rare sarcomas and fibrous dysplasia (Figs. 11 and 12)[2,3,4,8,12].

Soft tissue tumors

These tumors, when located in the chest wall, are most frequently represented by lipomas, often in a multiple form. The appearance of the tumor is typical: non-vascularized, lobular mass, slightly echogenic compared to subcutaneous adipose tissue, encapsulated (Fig. 13). Elastofibroma is another tumor found in the chest. Its typical location near the inferior angle of the shoulder blade, echostructure in the form of hypoechoic bands against echogenic background and avascularity facilitate diagnosis. Rhabdomyoma, which differs from the muscle only by its nodular form, is another tumor that may be found in the chest wall. Desmoid fibromatosis, which is considered to be a benign lesion with local aggressivity and recurrences after surgical resection, represents an interesting lesion form the clinical point of view (Fig. 14). Wang et al.[23] analyzed ultrasound findings of 44 patients affected by this pathology – all tumors were hypoechoic and usually well-delineated. Color Doppler imaging revealed no blood flow in 66%, moderate vascularization in 23% and abundant vascularization in 11% of cases. Differential diagnosis should primarily include histiocytic fibroma and liposarcoma. Other malignancies, such as rhabdomyoma or leiomyosarcoma, lymphoma and metastases of various cancers may be also found in the soft tissues of the chest wall (Figs. 15, 16, 17). It is also important to remember about breast cancer recurrences following modified mastectomy (Fig. 18). Such tumors invade the chest wall most often in the form of hypoechoic tumors, but they may also present as hyperechoic[7]. Ultrasonography has become an important tool for the assessment of chest wall invasion by intrathoracic tumors, such as lung cancer or mesothelioma of the pleura (Figs. 19, 20). A number of studies have demonstrated its higher accuracy compared to computed tomography[24–31].

## Ultrasound-guided biopsy of tumors located in the chest wall

As with all superficial structures, ultrasonography is an optimal method for the monitoring of different types of biopsy of pathological lesions found in the chest.
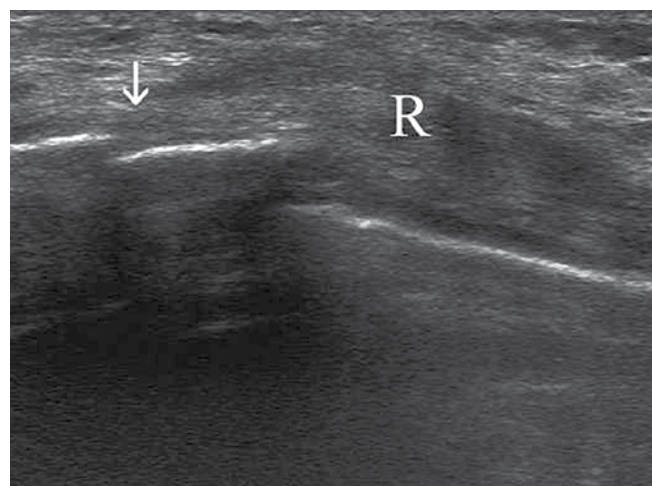
Fig. 18. *Breast cancer recurrence (R) with pathological rib fracture (arrow)*
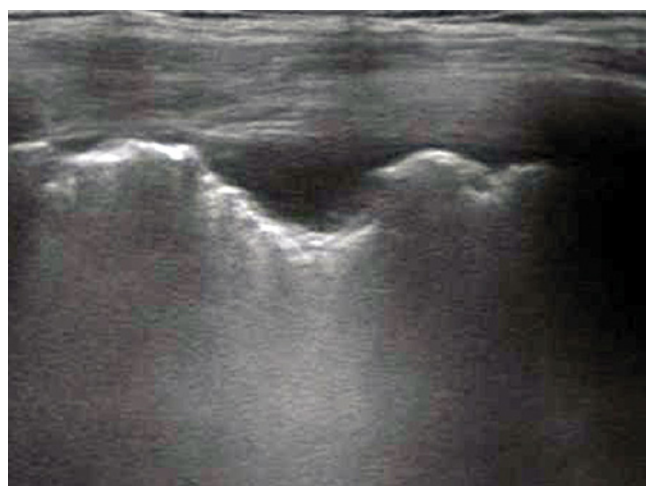
Fig. 19. *Subpleural metastasis of lung cancer with pleural infiltration*
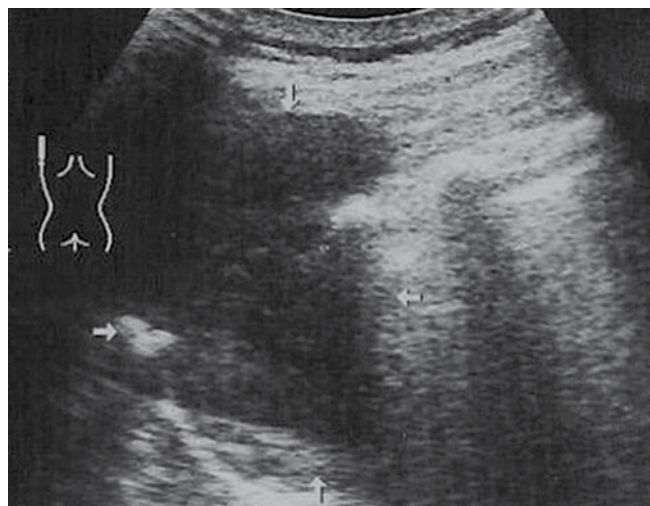
Fig. 20. *Lung cancer infiltrating almost the entire chest wall and the ribs (arrows)*

A simultaneous use of color Doppler imaging allows to avoid damage to larger vessels[3–7,9–11,31,32]. Furthermore, compared to CT-guided procedures, this method is more effective in obtaining diagnostic material for assessment and does not involve patient exposure to the negative effects of ionizing radiation[32].

Conclusions

Based on our experiences and literature data, ultrasonography should be considered as a preliminary diagnosis of patients with chest wall tumors. High efficacy in obtaining cytological/tissue material during ultrasound-guided procedures is another advantage of the discussed technique. However, local and general progression of cancer requires the use of CT, MRI or PT/CT.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations, which might negatively affect the content of this publication and/or claim authorship rights to this publication.

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