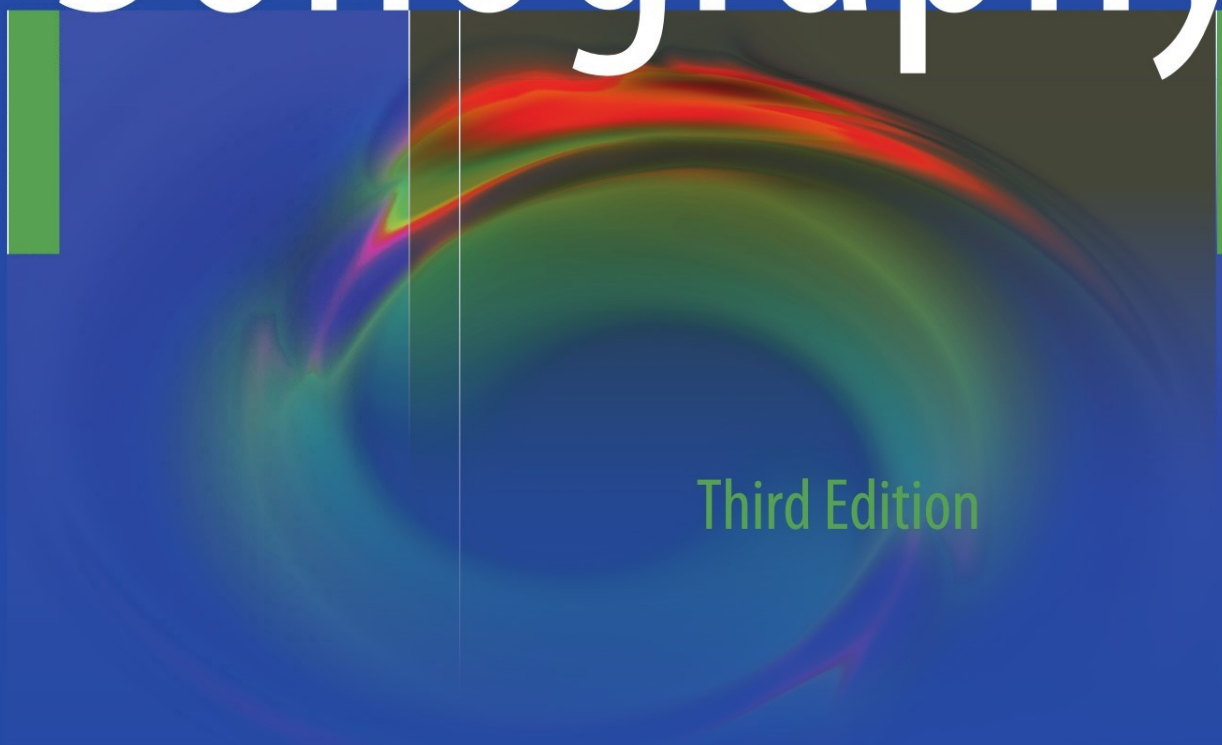
Chest Sonography

Gebhard Mathis *Editor*



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Editor
Prof. Dr. Gebhard Mathis
Internistische Praxis
Bahnhofstrasse 16/2
6830 Rankweil
Austria
gebhard.mathis@cable.vol.at

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Preface

The scope of application of chest sonography has been significantly widened in the last few years. Portable ultrasound systems are being used to an increasing extent in preclinical sonography, at the site of trauma, in the ambulance of the emergency physician or in ambulance helicopters. In the emergency room, at the intensive care unit and in clinical routine, chest sonography has proved its worth as a strategic instrument to be used directly after the clinical investigation. It helps the investigator to decide – very rapidly – whether a traumatized patient is suffering such severe internal hemorrhage that he or she needs to be transported to the operating room immediately or whether there still is time for further investigations like CT. Several diagnoses such as pneumothorax, pneumonia or pulmonary embolism can be established immediately.

The present new issue has been extended to include two subjects. Emergency sonography in the chest is getting more important every year. The evidence of interstitial syndrome has shown a significant correlation with extravascular lung water in cases of pulmonary edema and noncardiogenic pulmonary edema. An international consensus conference last year worked out the value of lung ultrasound in several conditions, e.g., pneumothorax, interstitial syndrome and lung consolidation.

Newborns, infants and children do not show a different picture than adults at lung ultrasound examination. Also the pathological changes described in adults' diseases are similar. The use of ultrasound in respiratory diseases of the newborn and the child needs to be encouraged not simply as a valid diagnostic alternative but as a necessary ethical choice. Ultrasound avoids the use of ionising radiation. Therefore sonography reduces the risk of developing malignancies later in life.

I am most deeply indebted to the team of authors for their creative cooperation and timely submissions. I also thank Springer-Verlag for their close collaboration and careful production of the book.

The purpose of this pictorial atlas is to help colleagues serve their patients better. It will hopefully enable clinicians to establish diagnoses rapidly at the patient's bedside with greater accuracy and efficiency, and to initiate appropriate therapeutic measures on time.

Rankweil, Austria — Gebhard Mathis

Contents

Indications, Technical Prerequisites and Investigation Procedure

1

Sonja Beckh

1.1 Indications

Sonography is a long-established supplementary imaging procedure in the diagnosis of pleural effusions. Technical advancement and ongoing scientific evidence have caused the spectrum of application for sonography in diseases of the chest to be steadily extended over the last few years (Broaddus and Light 1994; Müller 1997; Kinasewitz 1998; Beckh et al. 2002; Fig. 1.1). In clinical routine the ultrasound investigation is a rapid orientation guide for differential diagnosis of dyspnea and pain in the chest (Beaulieu and Marik 2005; Diacon et al. 2005; Soldati et al. 2006; Arbelot et al. 2008; Copetti and Cattarossi 2008; Noble et al. 2009).

The sonographic image does not provide a complete overview of the chest; however, it does image a certain section of it, which, given a specific problem under investigation, provides valuable additional information to substantiate overview radiographs. Occasionally sonography is the only noninvasive diagnostic procedure that throws significant light on pathological findings (Walz and Muhr 1990; Fraser et al. 1999).

Up to 99% of the ultrasound wave is reflected in the healthy lung. Intrapulmonary processes can be detected by sonography only when they extend up to the visceral pleura or can be imaged through a sound-conducting medium such as fluid or consolidated lung tissue (Fig. 1.2).

S. Beckh
Klinikum Nord, Medizinische Klinik 3, Pneumologie,
Prof. Ernst-Nathan-Straße 1, 90419 Nürnberg, Germany
e-mail: beckh@klinikum-nuernberg.de

Sonic shadow zones are caused by nearly complete absorption of the ultrasound wave in bone, especially behind the sternum, scapula and vertebral column. Limitations caused by rib shadows can at least partially be balanced by respiratory mechanics.

From a percutaneous route the immediate retrosternal and posterior portions of the mediastinum cannot be viewed. A complementary method for this location is transesophageal and transbronchial sonography, which, however, are invasive investigation procedures in terms of effort and handling. (Lam and Becker 1996; Arita et al. 1996; Silvestri et al. 1996; Becker et al. 1997; Broderick et al. 1997; Serna et al. 1998; Aabakken et al. 1999; Herth et al. 2004; Fig. 1.3).

Sonography provides diagnostic information when individual structures of the thorax are investigated:

1. Thorax wall
   (a) Benign lesions
      - Benign neoplasms (e.g., lipoma)
      - Hematoma
      - Abscess
      - Reactivated lymph nodes
      - Perichondritis, Tietze's syndrome
      - Rib fracture
   (b) Malignant lesions
      - Lymph node metastases (initial diagnosis and course of disease during treatment)
      - Invasive, growing carcinomas
      - Osteolysis
2. Pleura
   (a) Solid structures: thickening of the pleura, callus, calcification, asbestosis plaques
   (b) Space-occupying mass

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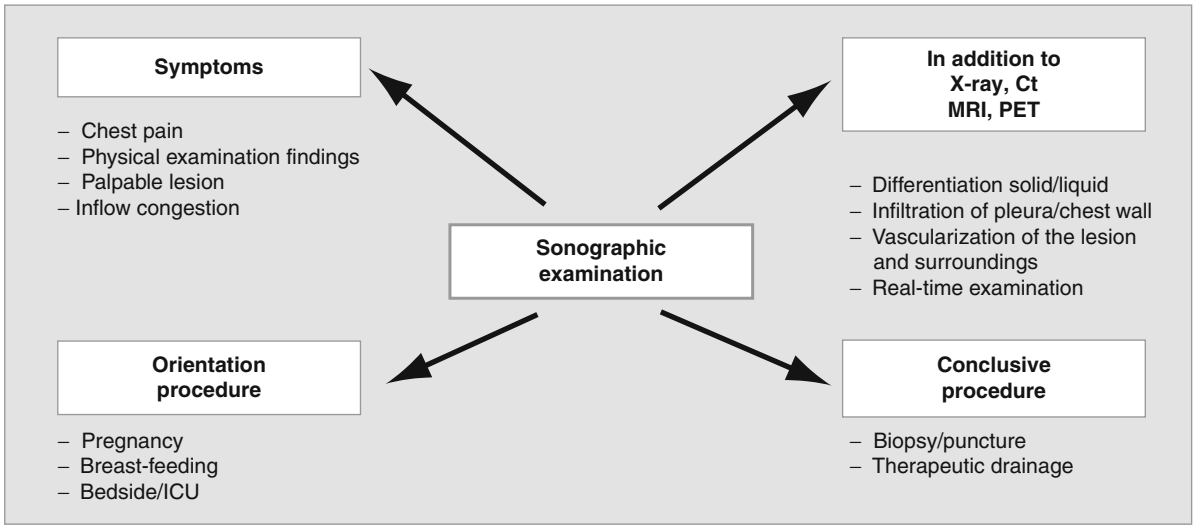

Fig. 1.1 Spectrum of application of sonography for pleural and pulmonary disease

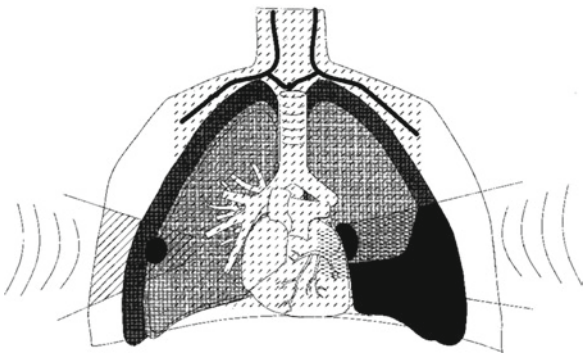

Fig. 1.2 Structures and pathological changes accessible to sonography

- Benign: fibrous tumor, lipoma
- Malignant: circumscribed metastases, diffuse carcinosis, malignant pleural mesothelioma

(c) Fluid: effusion, hematothorax, pyothorax, chylothorax

(d) Dynamic investigation
- Pneumothorax
- Distinguishing between effusion and callus formation
- Adherence of a space-occupying mass
- Invasion by a space-occupying mass
- Mobility of the diaphragm

3. Formation of peripheral foci in the lung
   (a) Benign: inflammation, abscess, embolism, atelectasis
   (b) Malignant: peripheral metastasis, peripheral carcinoma, tumor/atelectasis
4. Mediastinum, percutaneous
   (a) Space-occupying masses in the upper anterior mediastinum
   (b) Lymph nodes in the aorticopulmonary window
   (c) Thrombosis of the vena cava and its supplying branches
   (d) Imaging collateral circulation
   (e) Pericardial effusion

Further pathological alterations in the heart visualized by sonography will not be described in this book. For this subject the reader is referred to pertinent textbooks on echocardiography.

1.2 Technical Requirements in Terms of Equipment

All the apparatuses used for sonographic investigation of the abdomen and thyroid may also be used to examine the thorax. A high-resolution linear transducer of

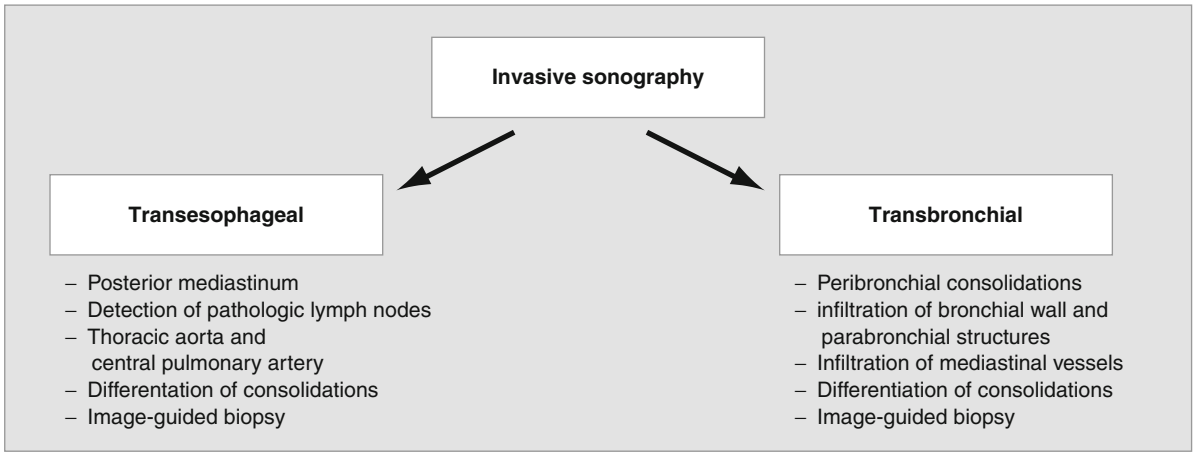

Fig. 1.3 Indications for invasive sonography

5–10 MHz is suitable for imaging the *thorax wall* and the *parietal pleura* (Mathis 2004). More recently introduced probes of 10–13 MHz are excellent for evaluating *lymph nodes* (Gritzmann 2005), pleura and the surface of the lung.

For investigation of the *lung* a convex or sector probe of 3–5 MHz provides adequate depth of penetration.

Vector, sector or narrow convex probes are recommended for the *mediastinum*. The smaller the connecting surface, the better the transducer can be placed in the jugulum or the supraclavicular fossa. The range of frequency should be 3.5–5 MHz. It should be noted that device settings commonly used for examining the heart are not suitable for the rest of the mediastinum. Contrast, image rate and gray-scale depth balance must be adjusted to image structures of the mediastinum.

Transesophageal sonography requires a special probe with a suitable connecting tube to the sonography device. Endobronchial sonography is performed with special, thin high-frequency probes (12–20 MHz) that are introduced via the working tube of the flexible bronchoscope. Currently very few manufacturers offer suitable probes along with a sonography unit.

1.3 Investigation Procedure

1.3.1 Thorax Wall, Pleura, Diaphragm, Lung

The investigation is performed as far as possible with the patient seated, during inspiration and expiration, if necessary in combination with respiratory maneuvers such as coughing or "sniffing." Raising the arms and crossing them behind the head causes intercostal spaces to be extended and facilitates access. The transducer is moved from ventral to dorsal along the longitudinal lines in the thorax (Fig. 1.4):

- Parasternal line
- Middle and lateral clavicular line
- Anterior, middle and posterior axillary line
- Lateral and medial scapular line
- Paravertebral line

Every finding should be allocated to its respective anatomic location and the latter should be specifically mentioned.

Subsequent transverse transducer movement parallel to the ribs in the intercostal space (Fig. 1.5) provides the additional information required for accurate localization of the respective finding.

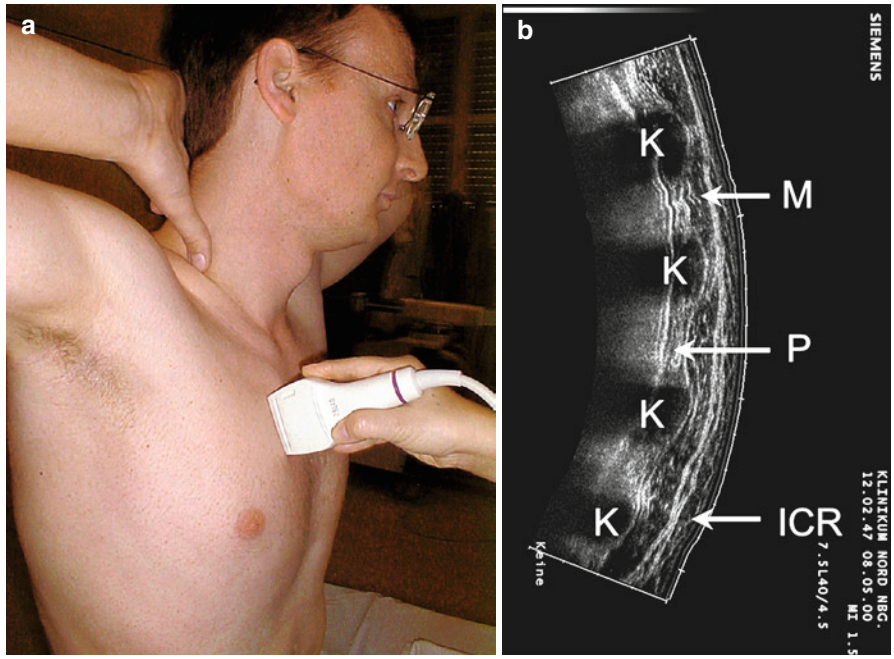

Fig. 1.4 Examination of the seated patient. (**a**) Linear probe placed longitudinally on the right parasternal line. (**b**) Corresponding sonographic longitudinal panoramic image (SieScape). *K* cartilage at the point of insertion of the rib, *ICR* intercostal space, *M* muscle, *P* line of the pleura

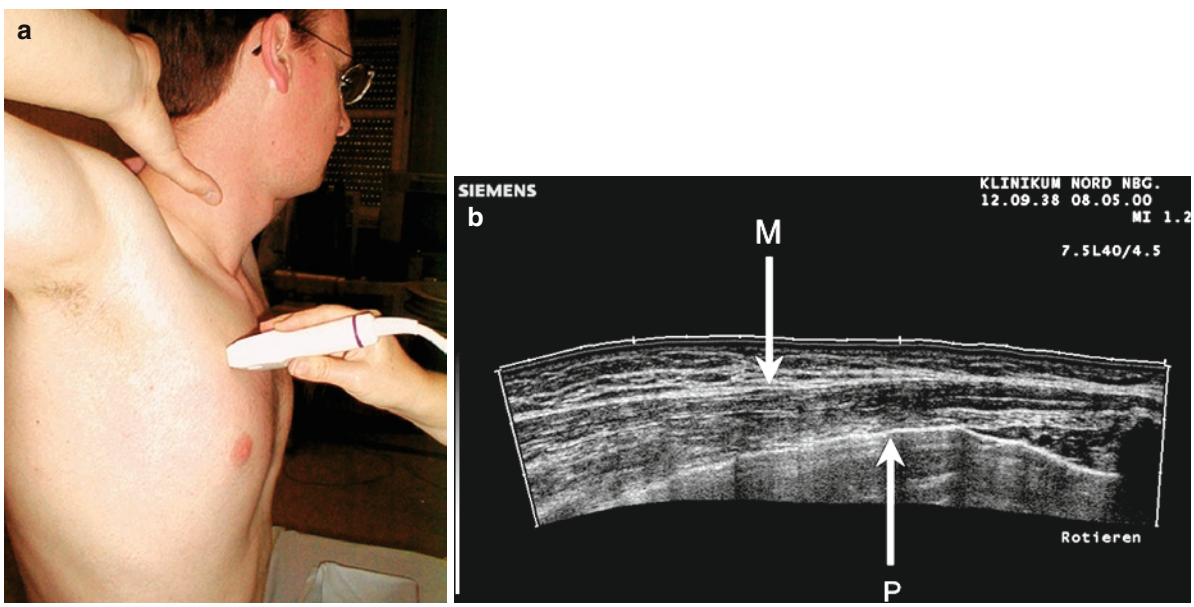

Fig. 1.5 Examination of the seated patient. (**a**) Linear probe placed parallel to the ribs in the third intercostal space. (**b**) Corresponding sonographic transverse panoramic image (SieScape). *M* muscle, *P* line of the pleura

Fig. 1.6 Position of the patient when structures behind the scapula are examined

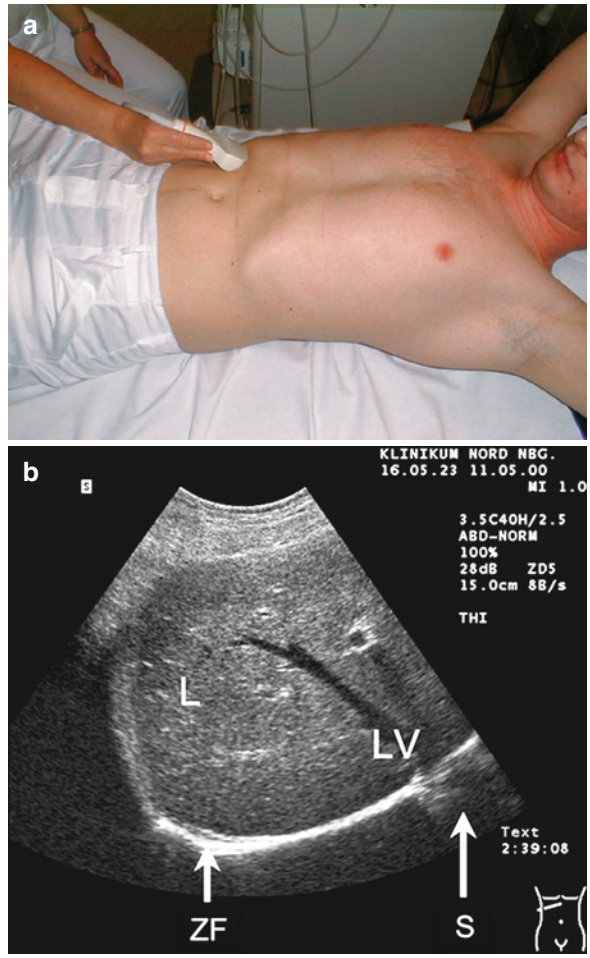

Fig. 1.7 Transhepatic examination. (**a**) Convex probe placed subcostally from the right. Slight tilting in cranial direction. (**b**) Corresponding sonographic image. *L* liver, *LV* liver vein, *ZF* diaphragm, *S* reflection of the liver above the diaphragm

The investigation of foci behind the scapula needs maximum adduction of the arms until the contralateral shoulder is encircled (Fig. 1.6). The supraclavicular access allows the investigator to view the tip of the lung and the region of the brachial plexus (Sect. 1.3.2).

From suprasternal, the anterior upper mediastinum can be viewed. From the abdomen, in subcostal section by the transhepatic route on the right side (Fig. 1.7) and to a lesser extent through the spleen on the left side, the diaphragm is examined. Additionally, the longitudinal resonance plane from the flank images both phrenicocostal recesses (Fig. 1.8).

The supine patient is examined in the same manner. The abdominal access is better for this purpose. However, viewing intercostal spaces might be more difficult, as the mobility of the shoulder girdle is usually somewhat restricted.

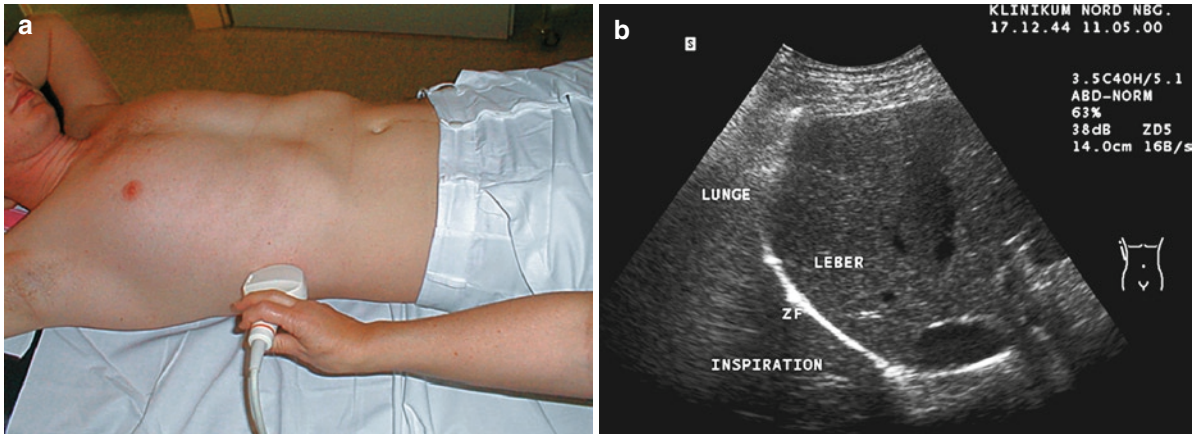

Fig. 1.8 Examination from the lateral aspect. (**a**) Convex probe placed longitudinally in the mid portion of the right axillary line. (**b**) Corresponding sonographic image. *D* diaphragm. The normal mobile lung is shifted during inspiration into the phrenicocostal recess and covers the upper margin of the liver

1.3.2 Investigation of the Supraclavicular Region

The investigation of the supraclavicular region requires special transducer movements. High-resolution probes allow the imaging of nerves. The viewing of the branches of the brachial plexus means a diagnostic enrichment in sonography of diseases of the chest. The plexus and its branches should be examined in the following cases:

- Infiltration of Pancoast's tumor
- Trauma (birth, accident)
- Punctures of the supraclavicular region
- Anesthesia of the brachial plexus

The examination starts on the lateral base of the neck (Fig. 1.9). The branches of the brachial plexus lead lateral and downward between the gap of M. scalenus anterior and medius. They reach the axilla between the first rib and the clavicula. Infraclavicular placement of the probe shows the course of the nerve along the axillary artery (Fig. 1.10).

The investigation procedure terminates with the probe placed in the axilla (Fig. 1.11).

The procedure for transesophageal and transbronchial sonography is described in the respective chapters.

1.4 Summary

The high resolution of the sonographic image and the real-time examination make a major contribution to the diagnosis of diseases of the chest. Structures of the chest wall and pleural lesions are visualized by ultrasound. Pulmonary consolidations are detected if they reach the visceral pleura, or if they are situated behind an acoustic window. The anterior and superior mediastinum is accessible percutaneously with certain positions of the probe. For thoracic sonography a linear probe (5–10 MHz) for close resolution and a convex or sector transducer (3.5–5 MHz) for access to deeper areas is recommended. The investigation of the supraclavicular region requires high-resolution transducers (5–13 MHz) for making visible the nerves of the brachial plexus.

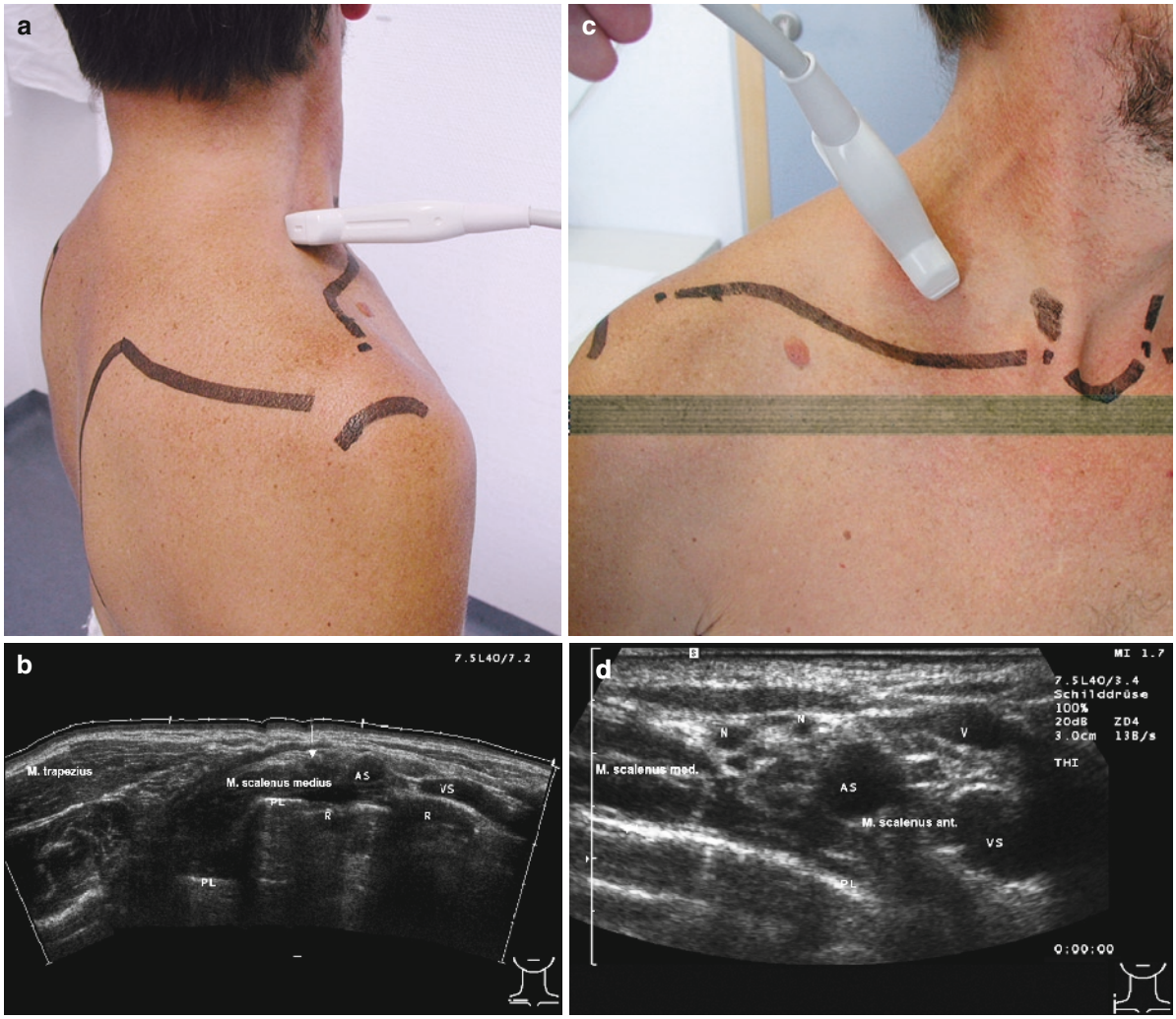

Fig. 1.9 Examination of the supraclavicular region. (**a**) Linear probe placed longitudinally on the lateral base of the neck (**b**) Corresponding sonographic panoramic image. *AS* a. subclavia, *VS* v. subclavia, *R* rib, *PL* pleura, *arrow* branch of brachial plexus. (**c**) Linear probe placed medium sagittal on the lateral base of the neck. (**d**) Corresponding sonographic image. *N* Branches of brachial plexus, *V* v. anonyma

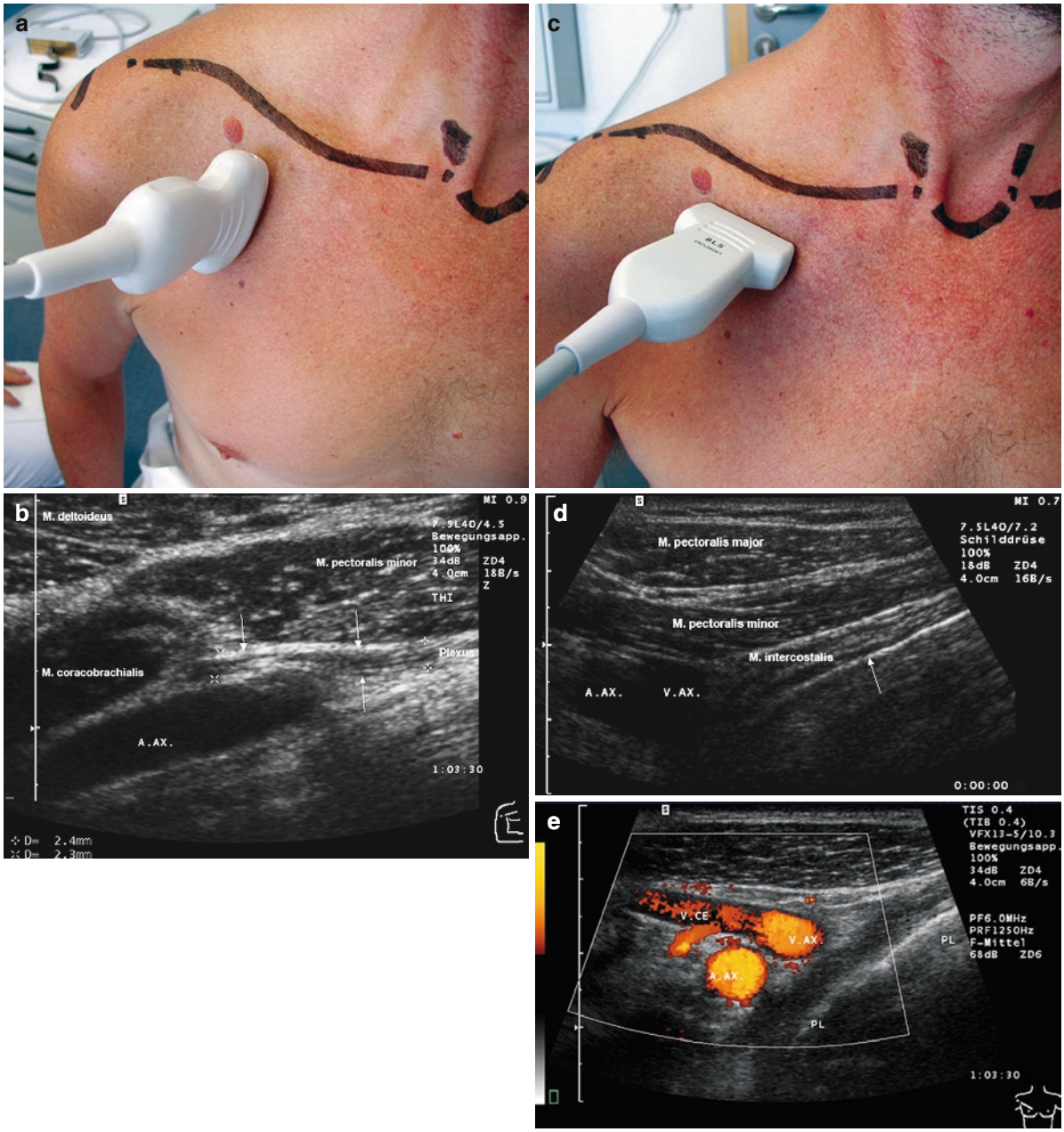

Fig. 1.10 (**a**) Linear probe placed oblique longitudinally in the middle clavicular line. (**b**) Corresponding sonographic image. *A.AX.* a. axillaris. The *arrows* and *crosses* mark the course of the plexus nerve. (**c**) Linear probe placed infraclavicular transverse in the *middle* clavicular line parallel to clavicula. (**d**) Corresponding sonographic image. The *arrow* points to pleural line. (**e**) Corresponding color image. *V.CE.* v. cephalica

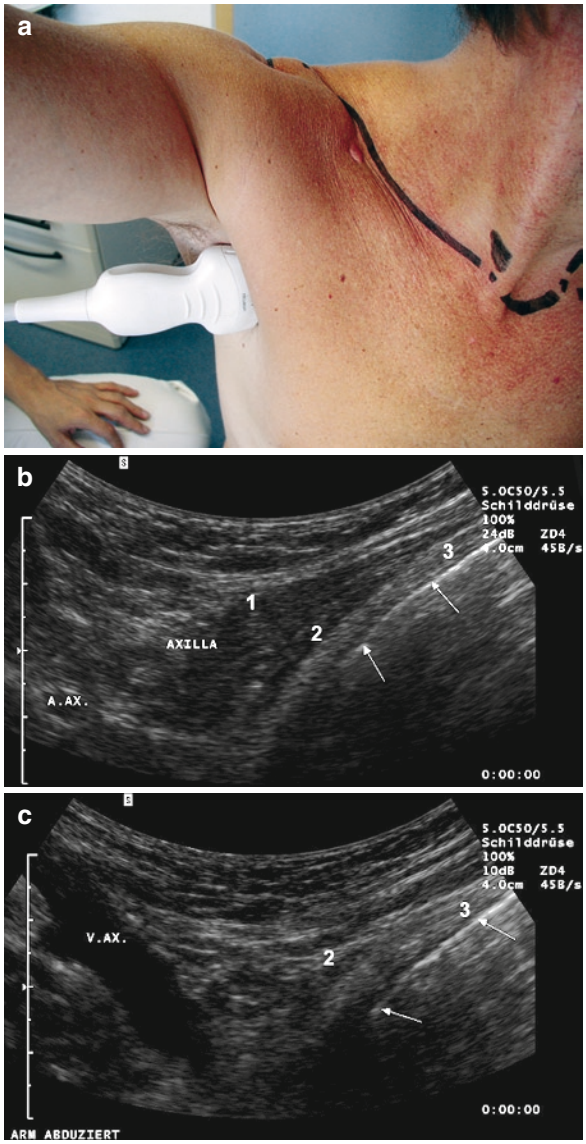

Fig. 1.11 (**a**) Linear probe placed longitudinally in the mid axilla. (**b**) Corresponding sonographic imaging, probe inclined dorsad. *1* m. serratus anterior, *2* m. intercostalis, *3* pleural line (*arrows*). (**c**) Corresponding sonographic image, probe inclined ventrad

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The Chest Wall

2

Gebhard Mathis and Wolfgang Blank

The chest wall—with the exception of the parietal pleura behind the ribs—is well accessed by sonography because of its position immediately next to the ultrasound transducer (Sakai et al. 1990). Any suspicious findings on palpation of the chest (whether inflammatory or neoplastic) may be an indication for chest sonography. Quite often the subsequent procedure consists of sonographic control investigations and sonography-guided aspiration. Chest trauma is an excellent indication for sonography of the chest wall. Fractures of the rib and the sternum can be diagnosed with great accuracy. Concomitant conditions such as local hematoma, pleural effusion or pneumothorax can also be identified by sonography (Mathis 1997).

Indications for sonography of the chest wall:

- Pain
- Ambiguous findings on palpation
- Ambiguous X-ray findings
- Chest trauma
- Tumor staging
- Intervention
- Follow-up

G. Mathis (✉)
Internistische Praxis, Bahnhofstrasse 16/2, 6830 Rankweil, Austria
e-mail: gebhard.mathis@cable.vol.at

W. Blank
Klinikum am Steinenberg, Medizinische Klinik
Akademisches Lehrkrankenhaus der Universität Tübingen,
Steinenbergstraße 31, 72764 Reutlingen, Germany
e-mail: blank_w@kreiskliniken-reutlingen.de

Pathological sonography findings in the chest wall:

1. Soft tissue
   (a) Accumulation of fluid
      - Hematoma
      - Seroma
      - Lymphatic cyst
      - Abscess
   (b) Tumors
      - Lipoma
      - Fibroma
      - Sarcoma
      - Metastases
      - Invasion by carcinoma
   (c) Lymph nodes
      - Inflammatory lymph nodes
      - Malignant lymphoma
      - Lymph node metastases
2. Bone
   (a) Fractures
      - Ribs
      - Sternum
      - Clavicle
      - Scapula
   (b) Osteolysis—metastases
      - Bronchial carcinoma
      - Breast carcinoma
      - Prostate carcinoma
      - Multiple myeloma
      - Others

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2.1 Soft Tissue

2.1.1 Accumulation of Fluid

2.1.1.1 Hematoma

Depending on the erythrocyte content and the degree of organization—hence also depending on the age of the lesion—hematomas may be accompanied by various echo patterns. They are usually anechoic or hypoechoic (Fig. 2.1). Occasionally one finds fine, hazy central echoes. In rare cases there may be intermediate forms or denser echoes in the central region. Organized hematomas may have very inhomogeneous echoes.

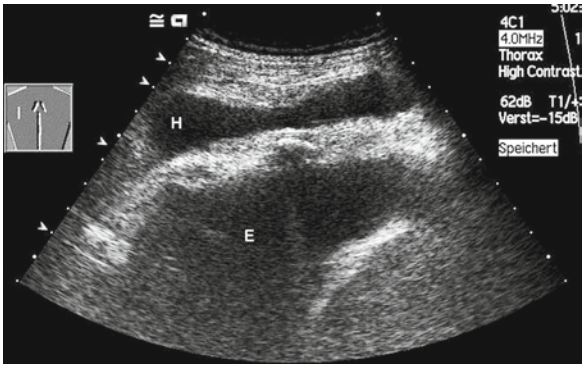

Fig. 2.1 A subcutaneous hematoma after blunt trauma (*H*). At this site the hematoma is largely anechoic. A large quantity of fluid in the pleural cavity (*E*) turns out to be a hemothorax on puncture

2.1.1.2 Seroma, Lymphatic Cyst

Postoperative seromas are largely anechoic, round or bizarre in shape and have no capsule. Lymphatic cysts are similar in terms of structure, usually round or oval. The occluded lymphatic vessel can be visualized (Fig. 2.2).

2.1.1.3 Abscess

The cellular and protein content of the cavity of an abscess may result in different central structures. The content of abscesses may be similar to that of hematomas. Differentiation may be difficult because intermediate stages such as infected hematomas may be present. Capsular formations of different degrees are an important distinction criterion for abscesses. Floating internal structures may be present (Fig. 2.3).

2.1.2 Tumors

2.1.2.1 Lipoma, Fibroma

The echogenicity of lipomas and fibromas depends on their cellular fat content, their connective tissue content, and impedance differences in interstitial tissue. The sonographic texture may vary from hypoechoic to relatively echodense forms and the lesions may be poorly demarcated from the surrounding tissue. A capsule may be present (Fig. 2.4).

2.1.2.2 Sarcomas, Soft-Tissue Metastases

Invasive growth is one of the main criteria of a malignant space-occupying lesion. The texture is usually hypoechoic and may be combined with inhomogeneous hyperechoic portions. Color-Doppler sonography may be useful for the assessment of hypoechoic structures suspected of malignancy. The type of vascularization and the course of the vessels may help to confirm a suspected malignant lesion (Figs. 2.5–2.8).

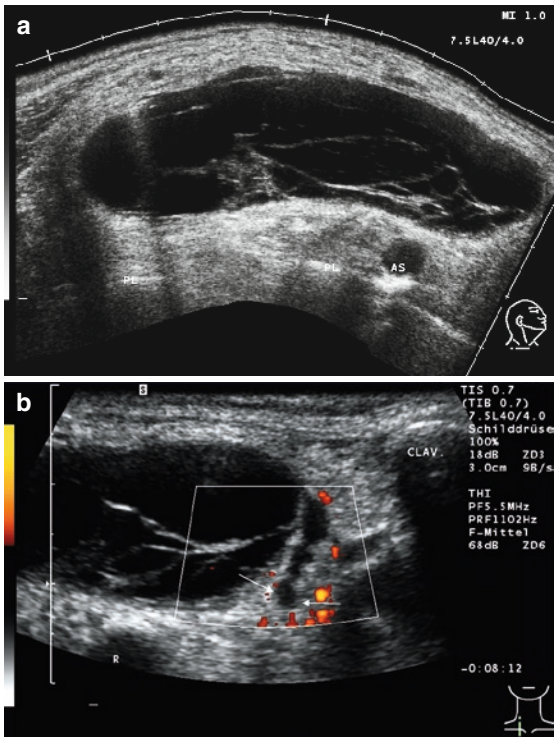

Fig. 2.2 Painful postoperative swelling in the lateral region of the neck on the left side. (**a**) Sonography reveals an echo-free, chambered space-occupying lesion measuring 10 cm × 4 3 cm in size. (**b**) An occluded lymph tract (*arrows*)

Knowledge of the vascularization pattern is also very useful when performing sonography-guided aspiration. At

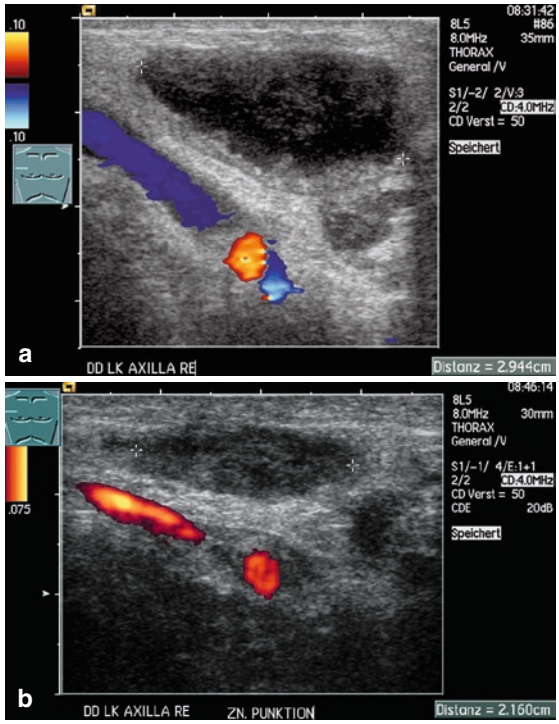

Fig. 2.3 A painful swelling in the region of the right axilla is indicative of a sweat gland abscess. (**a**) Sonography reveals a largely anechoic space-occupying lesion measuring 3 cm × 1.5 cm in size. The moderately echogenic margin is indicative of a starting capsular formation. (**b**) Sonography-guided aspiration yields pus. The residual fluid is absorbed

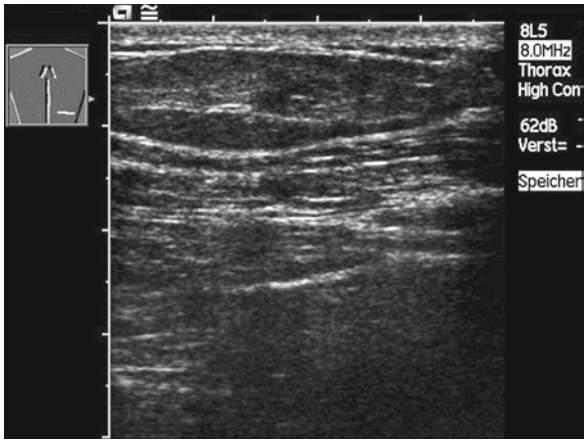

Fig. 2.4 Moderately echogenic lipoma in infrascapular location, with slightly blurred margins

this favorable location close to the transducer, sonography-guided aspiration is a most useful method to obtain histological material and finally to confirm the diagnosis.

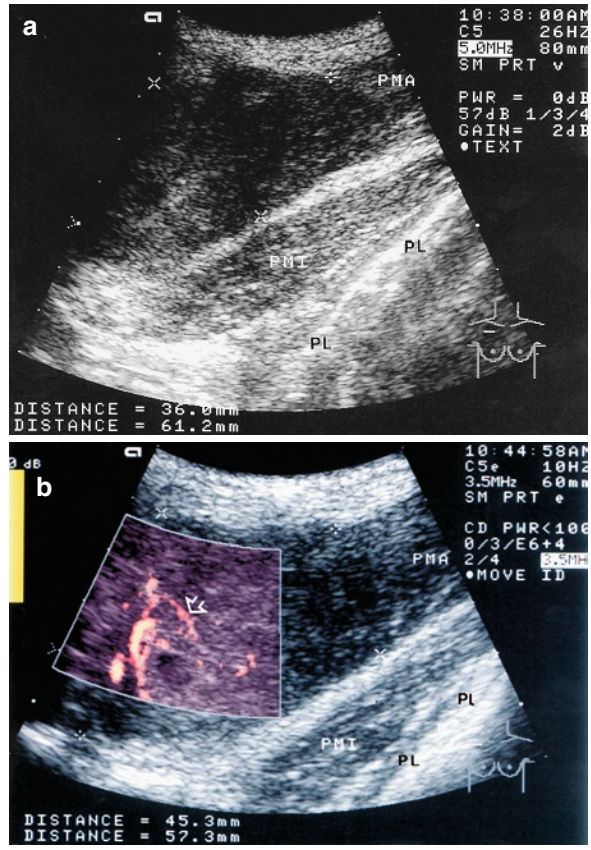

Fig. 2.5 (**a**) Muscle lymphoma. A 20-year-old man who experienced pain in the chest wall when exercising (bodybuilding). Clinical investigation showed hardening and swelling in the pectoral muscles on the right side. On sonography there was a hypoechoic transformation in the lateral portions of the pectoralis major muscle, which was interpreted as hemorrhage on B-mode sonography. (**b**) Evidence of a markedly vascularized lesion on color-Doppler sonography; atypical vessels (corkscrew, fluctuations in diameter, "high-velocity" signals). The surgical biopsy revealed a non-Hodgkin's lymphoma in the pectoral muscle

2.1.3 Lymph Nodes

Subcutaneous palpable swellings are usually caused by lymph nodes. The sonomorphology of lymph nodes is indicative of their origin and allows cautious assessment of the benign or malignant nature of the lesion when viewed in conjunction with the clinical condition. High-frequency probes yield a differentiated B-mode image. The vascularization pattern on color-Doppler sonography images provides further information about the type of lymph node (Bruneton et al. 1986; Hergan et al. 1994). The possibilities of assessing the benign or

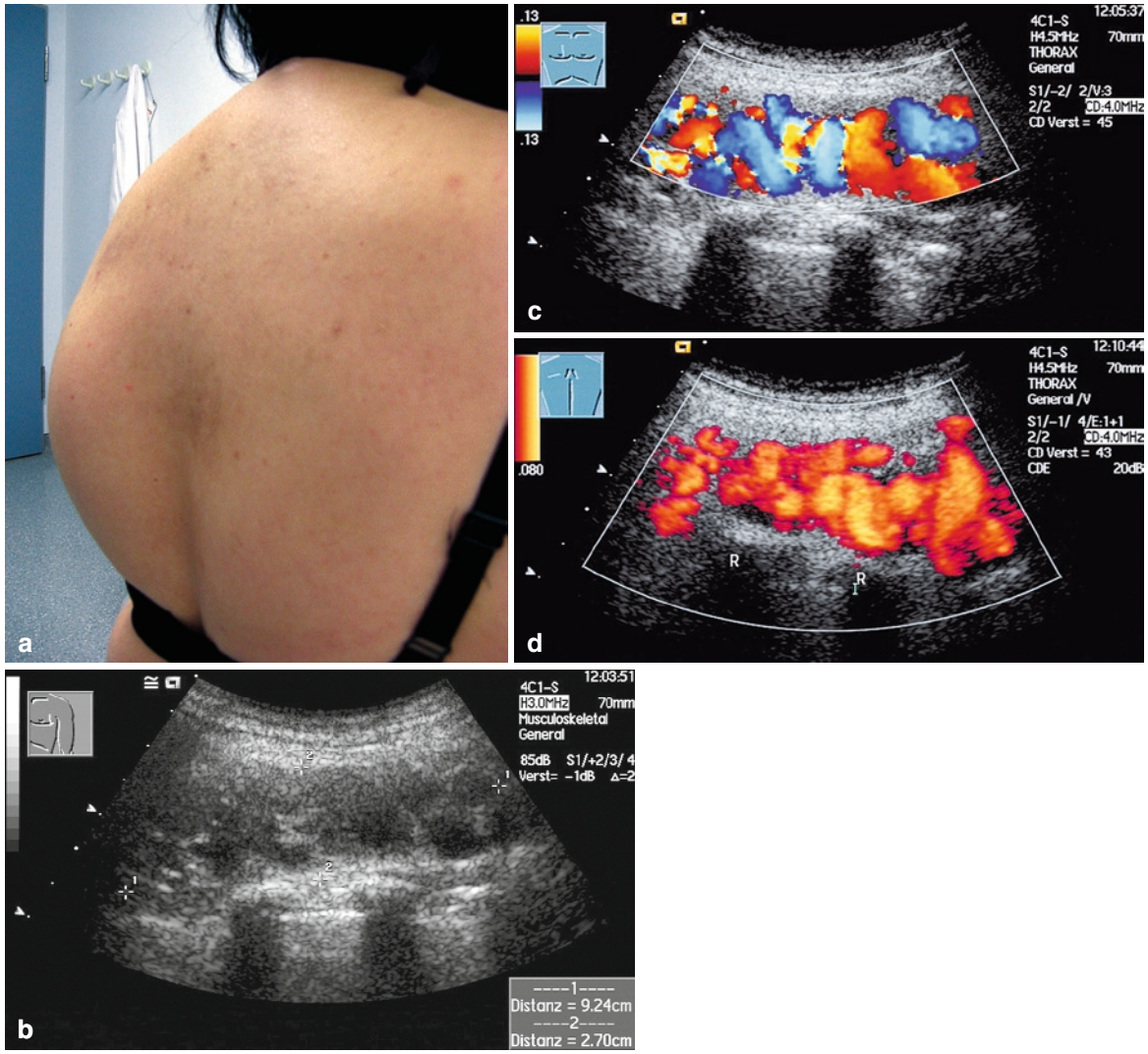

Fig. 2.6 (**a**) Hemangioma in the dorsal chest wall. Soft swelling on the left aspect of the spine; the swelling has been growing in the last few years. (**b**) Space-occupying lesion at the level of the scapula with no invasion of the surrounding structures. (**c**, **d**) The space-occupying lesion is of the vascular type; it is supplied and drained by paravertebral vessels

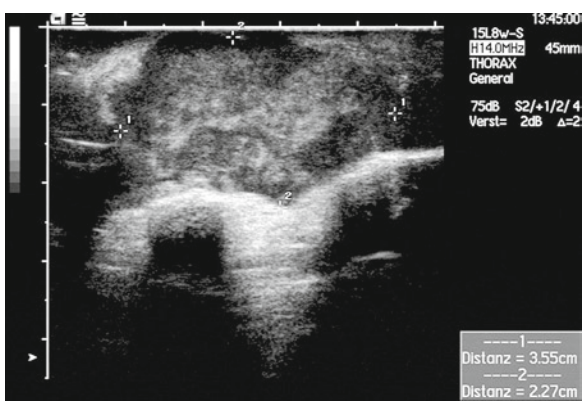

Fig. 2.7 Soft-tissue metastasis of a sarcoma

malignant nature of a lesion have been definitely improved by better resolution of the B-mode image as well as the use of various Doppler procedures to assess the pattern of vascularization (Chang et al. 1994; Tschammler et al. 1998; Table 2.1).

However, the benign or malignant nature of a lesion should be established with caution on the basis of sonomorphological criteria alone; the final assessment can only be made by histological confirmation of the diagnosis after aspiration or on the basis of disease progression. Changes in size and sonomorphology are of great significance in clinical practice. Thus, sonography controls may be used to confirm the diagnosis in

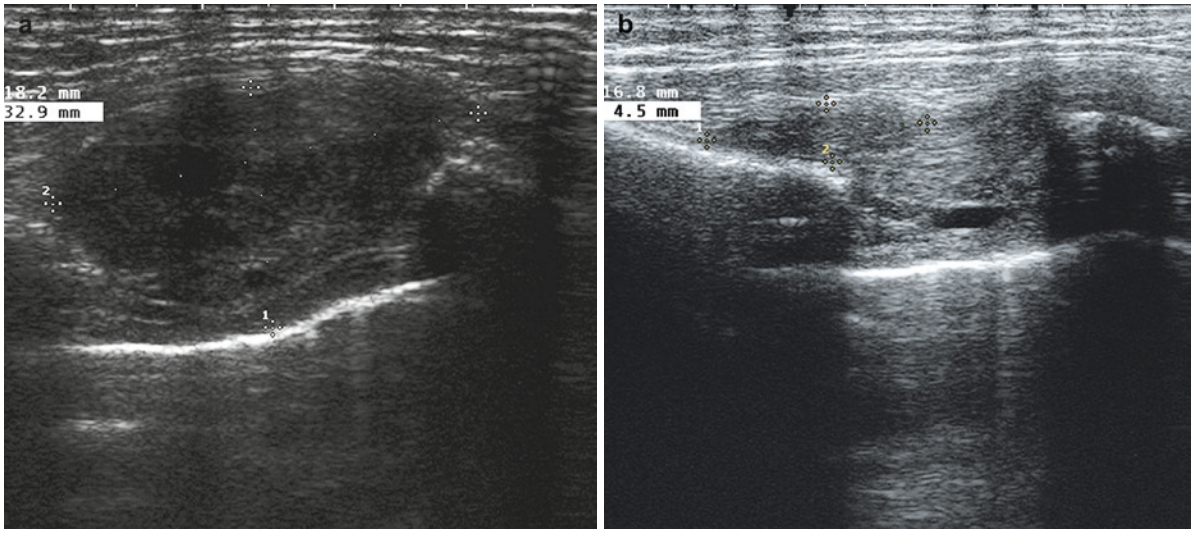

Fig. 2.8 (**a**) Solitary soft-tissue metastasis in parasternal location 15 years after breast carcinoma, confirmed by US-guided biopsy. (**b**) Resolution under radiotherapy

Table 2.1 Sonomorphology of lymph nodes

	Inflammatory	Malignant lymphoma	Lymph node metastasis
Morphology	Oval, longitudinal	Round, oval	Round
Margin	Smooth	Smooth	Irregular
Demarcation	Sharp	Sharp	Blurred
Growth	Bead-like	Expansive, displacing	Invasive
Mobility	Good	Good, moderate	Poor
Echogenicity	Hypoechoic margin "signs of hilar fat"	Hypoechoic, cystic	Inhomogeneous echoes
Vascularization	Regular, central	Irregular	Corkscrew-like

cases of inflammatory disease and to document the success of therapy in cases of malignant lymph nodes.

2.1.3.1 Inflammatory Lymph Nodes

Inflammatory lymph nodes seldom exceed 20 mm in size. Usually they have smooth margins, are oval, triangular or longitudinal in shape (Fig. 2.9). In cases of lymphadenitis, lymph nodes are typically arranged in a pearl-like fashion along the lymph node sites. In keeping with the anatomy, one frequently finds a more or less marked echogenic central zone which is termed a hilar fat sign, representing fat and connective tissue in the center of the lymph node. This sign is seen particularly during the healing phase of inflammatory processes (Fig. 2.10). The zone that is sharply demarcated from the surrounding tissue is hypoechoic. In this region one frequently finds vessels running a regular course on Doppler ultrasound images. The hilum of the lymph node with its arteries and veins is also visualized.

2.1.3.2 Malignant Lymphoma

A homogeneous, hypoechoic lesion with sharp margins is characteristic of malignant lymphoma. Centrocytic and Hodgkin's lymphomas are usually nearly anechoic in terms of structure and look like cysts in such cases. Malignant lymphomas may be round, tightly oval, or very rarely triangular in shape (Figs. 2.11 and 2.12). The presence of vessels on both sides (sandwich) is also indicative of a malignant lymphoma. Malignant lymphomas may be strongly vascularized, but the vascularization may be irregular in the margins.

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Acutely inflammatory lymph nodes look very similar to malignant lymphoma

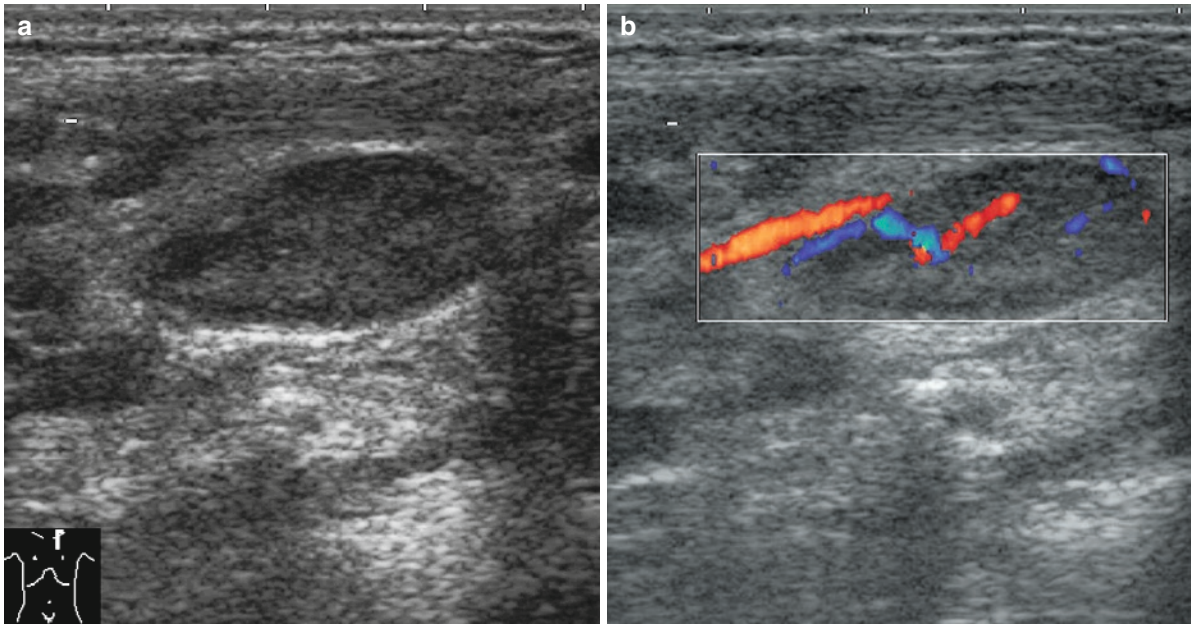

Fig. 2.9 Reactive inflammatory lymph node in the presence of listeriosis. (**a**) Hypoechoic margin, (**b**) regular perfusion

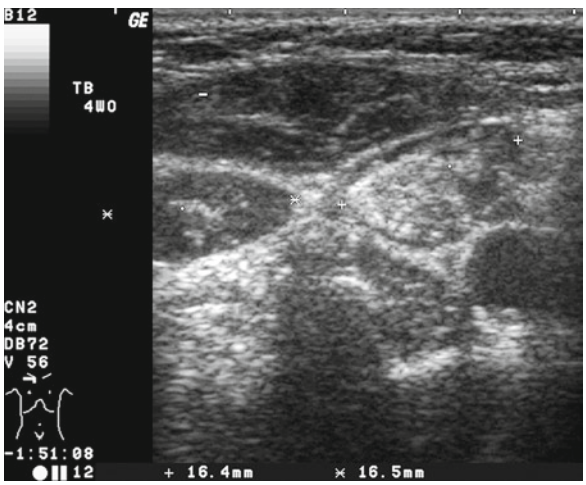

Fig. 2.10 Healing lymph node in the presence of tuberculosis. A narrow hypoechoic margin and a large echogenic center

2.1.3.3 Lymph Node Metastases

Lymph node metastases appear inhomogeneous on the ultrasound image. Moderately hyperechoic portions are often predominant. The demarcation to the surrounding tissue is usually blurred. Aggressive growth may be manifested as invasion of muscles and vessels (Gritzmann et al. 1990; Fig. 2.13). The size of lymph nodes is an unreliable criterion. However, metastases are more often larger than the maximum size of 20 mm achieved by inflammatory lymph nodes. Morphology is an important criterion. Metastatic lymph nodes tend to be round. One occasionally finds reactive lymph nodes in the vicinity of metastatic ones.

The vascularization pattern of lymph node metastases is typical: Vessels are frequently located at the margin, irregularly organized, run a chaotic course, flow in various directions, and tend to change their color (Tschammler et al. 2002).

Nonpalpable lymph nodes can also be visualized; therefore, sonography of the axilla is recommended for preoperative staging and monitoring the progress of breast carcinoma (Bruneton et al. 1984; Hergan et al. 1996; Fig. 2.14). Since recently the "sentinel lymph node" is also identified by sonography.

Currently, sonography is routinely demanded for staging a bronchial carcinoma because it is markedly superior to computed tomography in showing lymph node metastases in the supraclavicular groove (N3) and invasion of the chest wall (Suzuki et al. 1993). Nonpalpable lymph nodes are frequently discovered by this procedure (Fultz et al. 2002; van Overhagen et al. 2004, Prosch et al. 2007). Sonography discloses 17–36% more lymph nodes in this setting; in 3% the staging is upgraded. Further unnecessary investigations are avoided in about 10%. The cervical lymph nodes must be searched for because their presence indicates stage M1 disease.

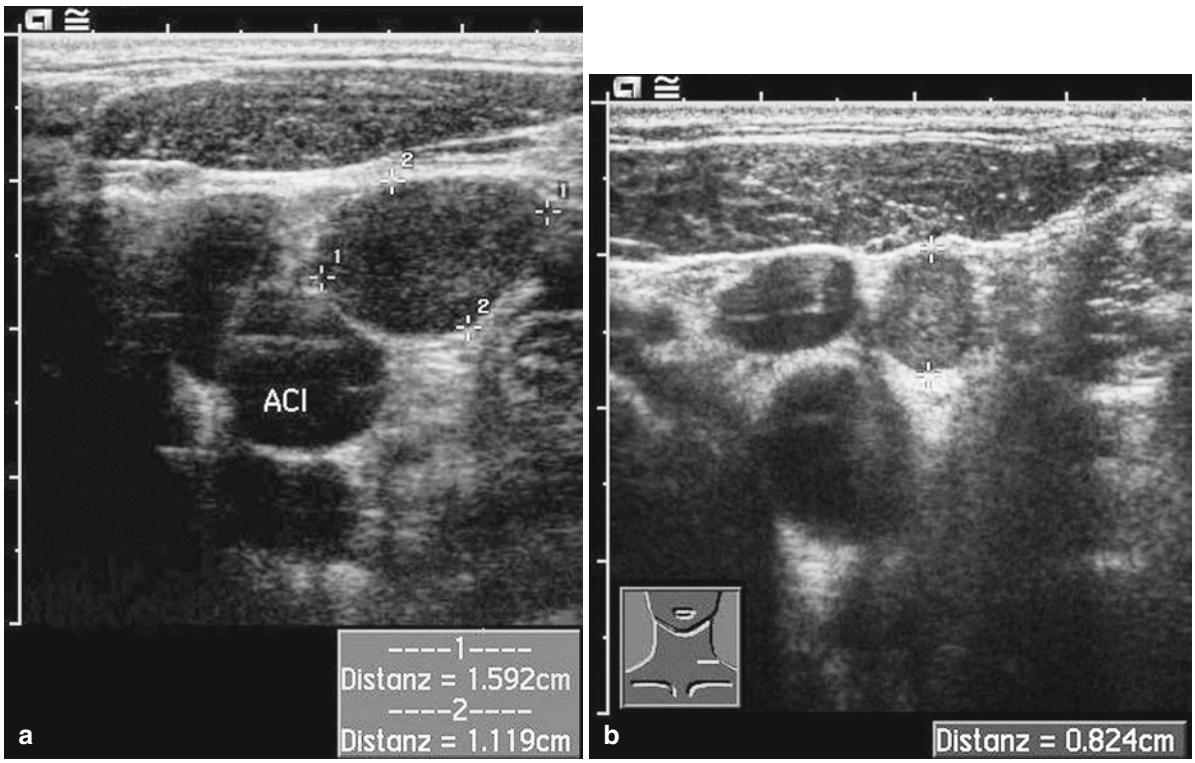

Fig. 2.11 Hodgkin's lymphoma. (**a**) At the time of diagnosis. (**b**) After three chemotherapy cycles. Reduced in size by more than 50%, then complete remission

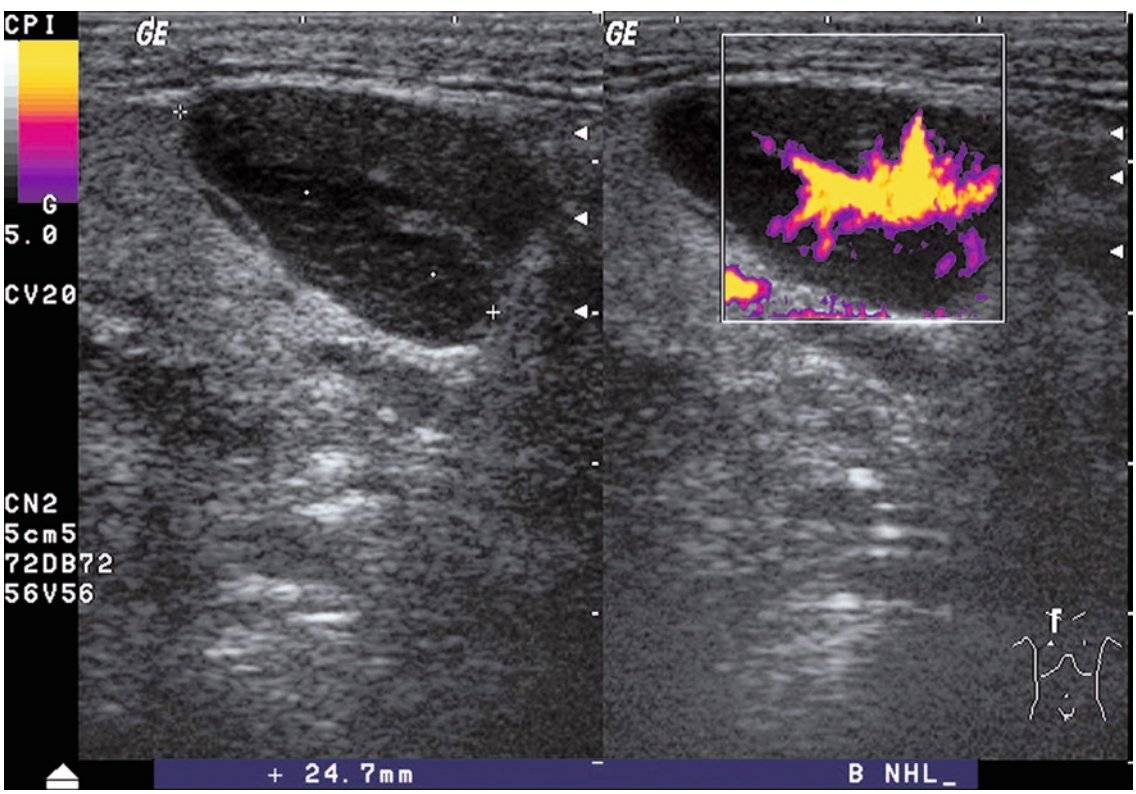

Fig. 2.12 B-cell chronic lymphocytic leukemia: hypoechoic lymph node with minimal hilar signs; strong and somewhat irregular vascularization

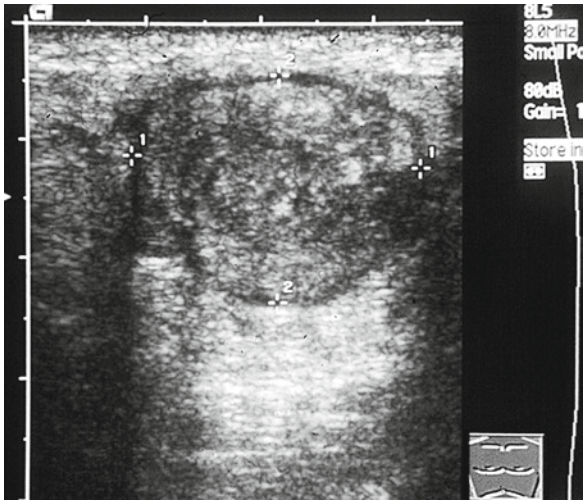

Fig. 2.13 Lymph node metastasis of an epidermoid lung carcinoma. Invasive growth into the vicinity. On palpation the mobility of the lesion was markedly reduced. The affected lymph node itself is characterized by inhomogeneous echoes, is onion-shaped in terms of structure, and invades its surroundings

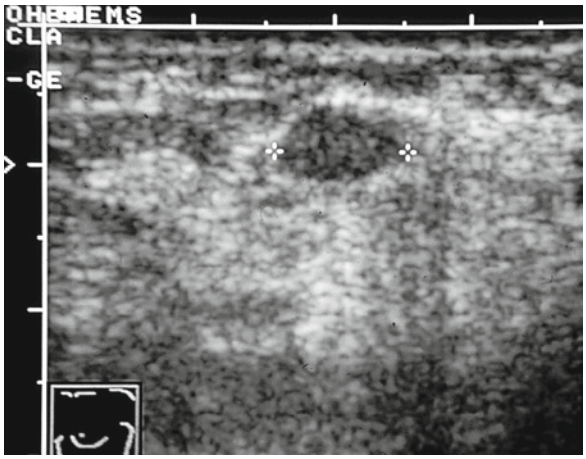

Fig 2.14 Nonpalpable axillary lymph node metastasis measuring 7 mm in size, in the presence of breast carcinoma

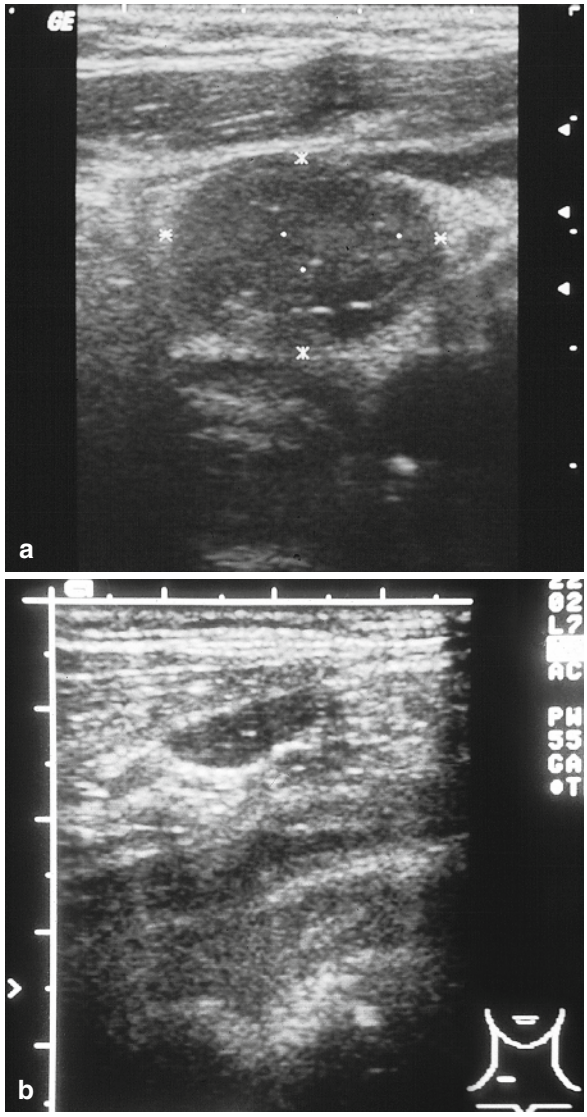

Fig. 2.15 (**a**) Cervical lymph node metastasis of a large-cell carcinoma of the lung. (**b**) After two cycles of chemotherapy this lymph node metastasis had resolved and now looks like a reactive lymph node

Ultrasound is also the most sensitive imaging procedure when the investigator is confronted with the question as to whether a tumor is invading the chest wall. For one thing, the resolution in the area of the soft tissues—using correspondingly high frequencies—is unexcelled to date. Furthermore, the dynamic investigation is able to show whether the tumor is breath dependent in terms of motion. Therefore, the current S-3 guidelines demand a sonography for staging in lung cancer (Goeckenjan et al. 2011).

Lymph node metastases are good parameters to monitor therapy. If the patient responds to chemotherapy or radiotherapy, reactive lymph nodes may persist (Fig. 2.15).

2.2 The Bony Chest

2.2.1 Fractures of the Ribs and the Sternum

Radiological diagnosis of the chest may prove difficult; nondislocated fractures are frequently not