High-resolution Ultrasonography in Superficial Soft Tissue Tumors

Hong-Jen Chiou*, Yi-Hong Chou, See-Ying Chiou, Hsin-Kai Wang

Surgical removal and clinical follow-up of soft tissue masses are easily managed in clinical practice but are dependent on the experience of the clinician. Occasionally, however, a patient is referred from a local clinician to our clinic with an inoperable mass following a surgical procedure. We consider it important to fully understand the nature of the mass prior to surgery, thus avoiding unnecessary surgery in some cases. High-resolution ultrasonography has been widely applied in the musculoskeletal system over the past two decades and is very useful in evaluating the nature of superficial soft tissue masses. It enables the differentiation of benign and malignant masses and the detection of many different types of histology in superficial soft tissue masses. The purpose of this review is to demonstrate the characteristic findings of high-resolution ultrasonography and color Doppler ultrasonography in superficial soft tissue tumors.

KEY WORDS — color Doppler ultrasonography, soft tissue sarcoma, soft tissue tumor, ultrasonography

Introduction

Soft tissue tumors are not uncommon, with most being benign. In Taiwan, the incidence of malignant soft tissue tumor is approximately 0.64%, which is the 21st most common occurrence rate for whole tumors [1]. In soft tissue sarcoma, the prognosis is better for low-grade than high-grade tumor, and small size has a better prognosis than large size [2,3]. Therefore, the prognosis for soft tissue malignancy depends on factors such as the grade, location, and size of the tumor.

Several imaging modalities have been used to assess soft tissue tumors following physical examination, including plain film, nuclear medicine, high-resolution ultrasound (HRUS), computed tomography, magnetic resonance imaging, angiography, and positron emission tomography. Although many reports state that HRUS cannot differentiate benign from malignant tumors, HRUS does have a high sensitivity in detecting tumors [4–10]. Recent advances in ultrasound technology have enabled the echotexture of soft tissue tumors to be presented in greater detail. In this review, we summarize the typical presentation of soft tissue tumors using state-of-the-art techniques.

Ultrasound Technique

Grayscale and color Doppler ultrasonography (CDUS) is applied to the lesion in at least two

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perpendicular scanning planes. CDUS is performed at various settings that include decreasing the scale level or pulse repetition frequency, increasing the color gain until color noise appears, and decreasing probe pressure on the lesion to avoid compressing the small vessels and thereby causing the disappearance of low-velocity blood signals [11]. Spectral analysis is also recommended if vessels are detected within the lesion.

The following major parameters should be determined: echogenicity, contour, margin, composition, size, related surrounding tissue in grayscale ultrasonography, the grading of CDUS, and resistive index (RI) in spectral Doppler. Many more specific patterns can be observed, including phleboliths, cellulitis-like changes, to-and-fro flow pattern, hyperechoic fat lobules, parallel echoic lines, C-shaped cysts, pannus, echogenic rim, gas bubbles, tortuous tubular structures, compressibility, and central necrosis. These patterns are not seen in each lesion but are diagnostic when they appear.

Equipment

We suggest the use of a high-frequency probe (>10 MHz) for small superficial lesions and 5–10 MHz for larger lesions. A curved probe (3–5 MHz) should be used for deeply located lesions. Each ultrasound machine should be equipped with a color Doppler function.

Benign Soft Tissue Neoplasms

Ganglion

A ganglion is a cystic mass that is usually attached to tendon sheaths and is occasionally found within tendons, muscle, fat tissue, cartilage, and even bone [12]. It typically has uni- or multilocular cystic spaces with a myxoid matrix and usually presents as being homogeneous in content. In our experience and in previous reports, more than 95% of ganglions present as echo-free and well-defined, with nonvascular supply [13] (Fig. 1). Only in rare cases do they
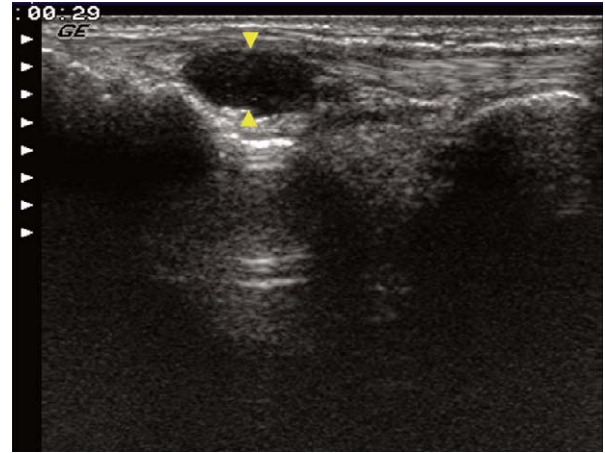
Fig. 1. *Ganglion in a 21-year-old woman. Longitudinal section of the dorsal wrist shows a hypoechoic cystic structure (arrowheads) beneath the extensor tendon.*

present as echogenic and color encoding to mimic a solid soft tissue tumor.

Lipoma

Lipoma is a benign tumor that contains mature fat cells within a thin fibrous capsule; it is usually located subcutaneously, with distribution throughout the whole body. Lipomas are the most common noncancerous soft tissue growth [14]. Most lipomas occur in the superficial soft tissues and are generally slightly hyperechoic relative to the surrounding fat lobule or muscle; however, they sometimes appear isoechoic or hypoechoic [15]. In our experience, most lipomas present specific patterns of "parallel echogenic lines" or focal homogeneous hyperechogenicity (Fig. 2). On CDUS, most lipomas present as avascular; weak vascularity is observed within the tumor in a small number of patients.

Baker cyst

Baker cyst represents fluid distention of the bursa between the gastrocnemius and semimembranosus tendons via a communication with the knee joint [16]. Most Baker cysts display the "C-shaped cyst" pattern in the transverse image (Fig. 3). Baker cyst typically appears as an anechoic mass with posterior enhancement and sharply defined margins, especially in the posterior wall. Complex Baker
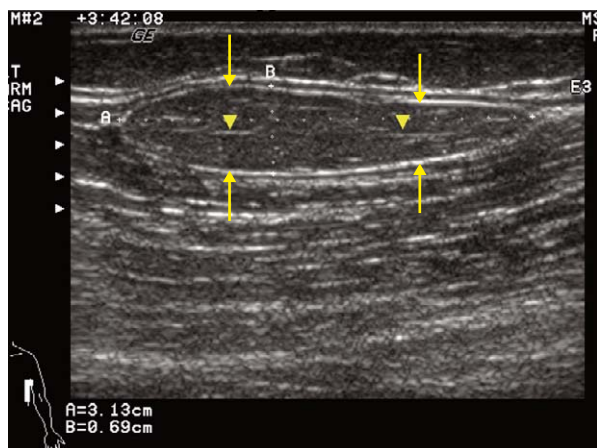
Fig. 2. *Lipoma in a 54-year-old woman who complained of a palpable nodule in her left medial arm for more than 1 year. Longitudinal section ultrasonography shows a heterogeneous echoic nodule with well-defined margins (arrows) in the left medial arm; parallel echogenic lines (arrowheads) were observed within the tumor.*
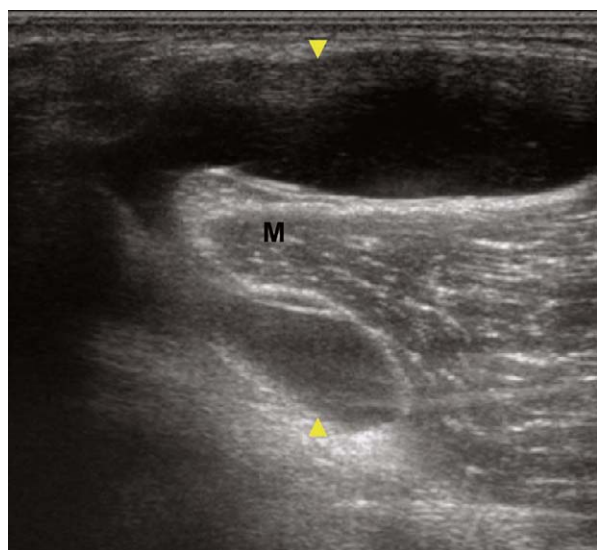
Fig. 3. *Baker cyst in a 49-year-old woman. Transverse section shows a well-defined C-shaped hypoechoic cystic lesion (arrowheads) in the popliteal fossa. M = medial head of gastrocnemius muscle.*

cysts sometimes exhibit cyst heterogeneity due to synovial hyperplasia, hemorrhage or calcified loose bodies within the cyst. In patients with inflammatory disease processes such as rheumatoid arthritis, hyperemic change in the synovial membrane can result in increased color encoding.

Rupture of a Baker cyst commonly results in severe calf pain and swelling that should be differentiated from deep vein thrombosis and calf muscle tear with hematoma.
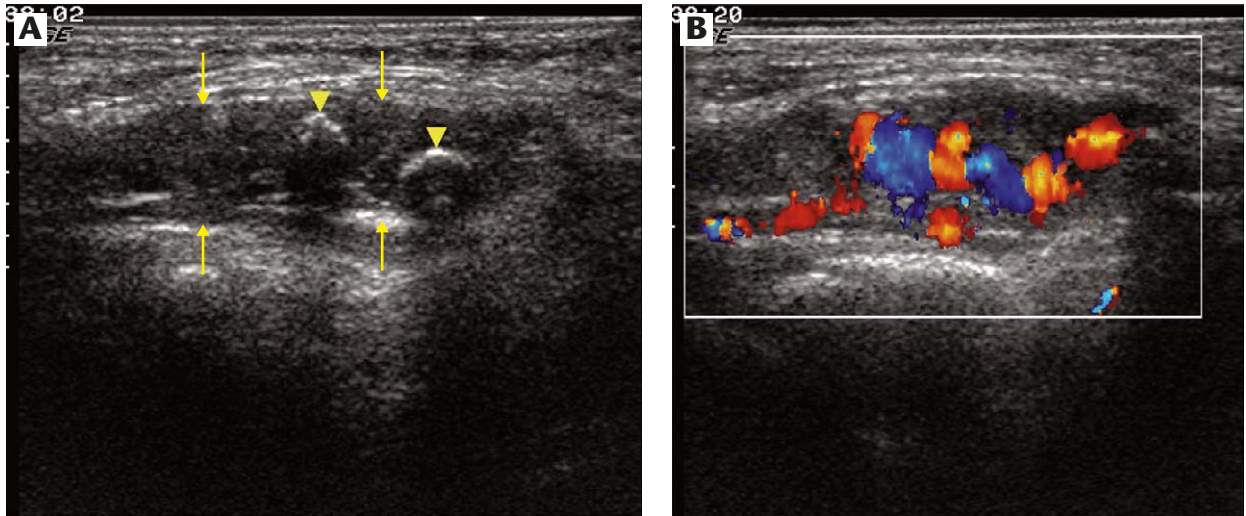
Hemangioma

Hemangioma is the most frequently encountered vascular soft-tissue abnormality, comprising approximately 7% of all benign soft tissue tumors [17]. The most commonly used classification system is based on clinical findings, cellular turnover, and histologic features. Using this system, vascular anomalies are classified into two major groups: hemangiomas and vascular malformations. Infantile hemangiomas tend to be small or absent at birth. Shortly after birth, they enter a proliferative phase with rapid growth that may last several months, followed by a stationary period, and finally, a period of involution. In contrast, vascular malformations are always present at birth and enlarge in proportion to growth [18].

The typical ultrasonographic patterns are heterogeneous echogenicity, ill-defined margins, solid and cystic in composition, and hypervascularity [19]; however, good compressibility, echogenic rim, and the presence of phleboliths have very high positive predictive value for hemangioma (Fig. 4).

Giant cell tumor

There are few reports regarding giant cell tumor of the tendon sheath (GCTTS) and even fewer regarding the US findings of pigmented villonodular synovitis (PVNS) [20]. Jaffe et al defined the synovium of the tendon sheath, bursa, and joint as an anatomic unit; therefore, GCTTS, localized and diffuse PVNS, and extra-articular PVNS belong to the same family of synovial disease. Their report of the US of PVNS included findings of a complex heterogeneous hypoechoic mass and thickened synovium, and localized joint effusion and increased vascularity on CDUS [20,21]. The typical patterns in giant cell tumor are heterogeneous hypoechogenicity, ovoid or lobulated contour, solid composition, moderate size, grade 1 CDUS, and location along the tendon (Fig. 5). Although the US pattern

Fig. 4. *Cavernous hemangioma in a 92-year-old man who complained of local tenderness over the left medial plantar region. (A) Grayscale ultrasonography shows a heterogeneous hypoechoic mass with ill-defined margins (arrows) in the left plantar region of the foot with arc-shaped phleboliths (arrowheads). (B) Color Doppler ultrasonography reveals tortuous tubular color encoding.*
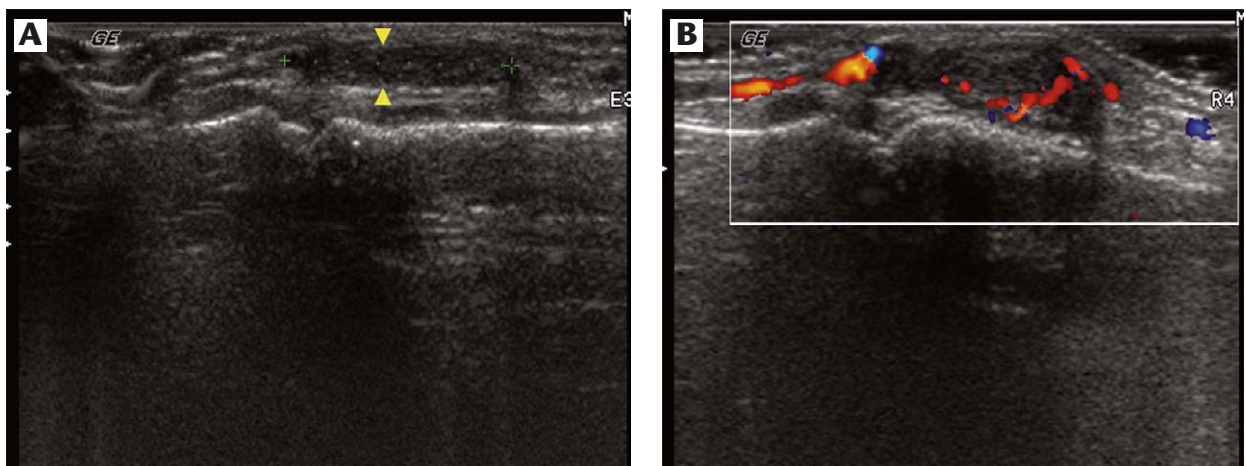
Fig. 5. *Giant cell tumor of the tendon sheath in a 50-year-old woman who complained of a palpable nodule in her right thumb. (A) Grayscale ultrasonography shows an ovoid-shaped hypoechoic nodule (arrowheads) along the extensor tendon. (B) Color Doppler ultrasonography reveals hypervascularity within the tumor.*

of most GCTTSs includes a well-defined margin and moderate RI, this pattern is not statistically significant. The ultrasonographic features are, however, nonspecific and indistinguishable from other types of synovitis.
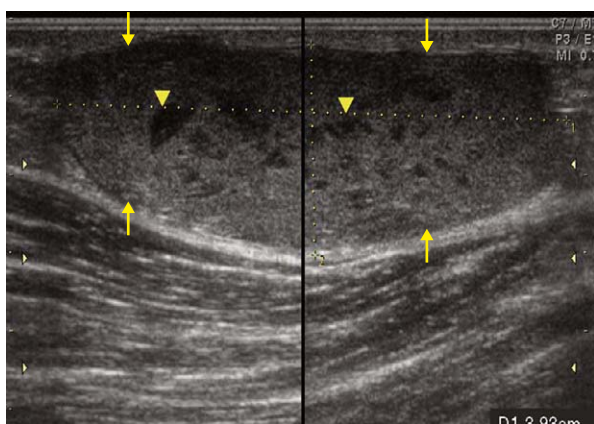
Epidermoid cyst
The ultrasound appearance of epidermoid cyst is of a solid, well-defined, echogenic mass with internal echoes resulting from the presence of debris [22].

The typical findings for epidermoid cyst are well-defined margins, ovoid contour, solid composition, moderate size, and avascularity on CDUS (Fig. 6). The specific sign of a homogeneous hypoechoic segment or plaque-like material disseminated within the lesion is possibly due to clustered cholesterol material or oil-droplets [23]; some intraperitoneal teratomas display this homogeneous hypoechoic pattern due to the presence of oil or cholesterol materials.

Neurogenic tumor

A neurogenic tumor usually presents as a fluid-filled cyst with well-defined margins and is heterogeneously hypoechoic with mass continuity to the nerve bundle, with or without distal sound enhancement [24–26]. In our experience, only 33% of patients have a surrounding prominent nerve bundle and target pattern. Differentiation of schwannoma and solitary neurofibroma is very difficult. From our previous experience, if the nerve bundle surrounds the tumor, the neurofibroma will be in close contact with the peripheral nerve bundle [27] (Fig. 7).

Fig. 6. *Epidermoid cyst in a 17-year-old boy who complained of a palpable mass in his left medial thigh. Grayscale ultrasonography shows a heterogeneous echoic nodule (arrows) with some echogenic structure (arrowheads) in the subcutaneous layer of the left upper thigh.*

Glomus tumor

Glomus tumors are benign neoplasms derived from the neuromyoarterial glomus bodies [28]. They are located in the subungual region, digits, and palms, and cause joint tenderness and pain. Most glomus tumors occur in the nail-base of the hand and appear as homogeneous hypoechoic lesions with well-defined margins, ovoid shape, solid composition, small size, and marked hypervascularity on CDUS (Fig. 8).

Exostosis

The features of exostosis in most patients are heterogeneous hyperechogenicity with well-defined margins, lobulated contour, solid content, with calcification, hypoechoic cartilage cap [29], moderate size, and relative hypovascularity or mild vascularity on CDUS. Some patients present with a bony protrusion from the cortex and away from the joint, with a thin hypoechoic cap covering the protruding bone. The hypoechoic cartilage cap in exostosis is commonly less than 2 cm in diameter [29] (Fig. 9).

Lymphangioma

The characteristic finding of lymphangioma is multiloculated cystic with septation. In most patients, the features are heterogeneous hypoechogenicity with ill-defined margins, lobulated contour, solid and cystic inner contents, large size, and avascularity
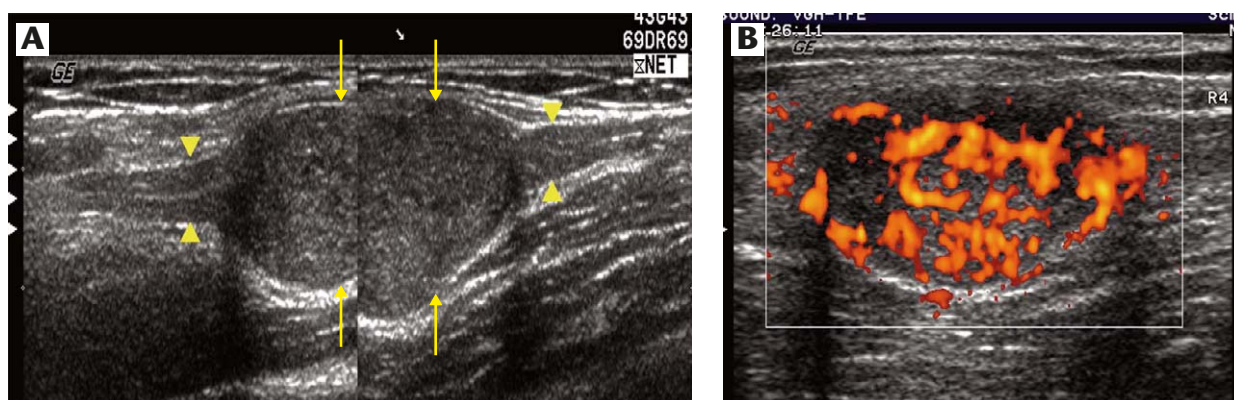
Fig. 7. *Neurofibroma in a 58-year-old man who complained of a palpable mass in his left medial arm. (A) Grayscale ultrasonography shows an ovoid-shaped hypoechoic nodule (arrows) over the left arm in close contact with the ulnar nerve (arrowheads). (B) CDUS reveals marked hypervascularity.*

or mild vascularity on CDUS. In some patients, a tortuous tubular structure is apparent within the lesion, and some have bleeding within the cystic component. The echogenic component possibly correlates to the cluster of abnormal lymphatic channels that are too small to reflect the sound beam. Large lesions have ill-defined boundaries with cystic components that dissect normal tissue planes [30] (Fig. 10).

Traumatic neuroma

The formation of traumatic neuroma results from the non-neoplastic proliferation of the proximal end of an injured nerve (completely or partially transected), hypertrophy of fibroblasts and scar tissue that encase

the nerve, or direct dissection of the nerve following trauma or surgery to a nerve [31,32]. The typical ultrasonography findings are heterogeneous hypo-echogenicity, ill-defined margins, ovoid contour, and solid inner content, small or moderate size, and avas-cular or hypovascular on CDUS [32].

Fibromatosis

Fibromatosis is a benign fibroblastic proliferation. Although fibromatosis is histologically benign, its relationship to adjacent tissue is marked by inter-digitating and infiltrative growth. Griffith et al report that most palmar fibromatosis presents as hypoechoic and is well-defined, with posterior enhancement and hypervascularity [33]. In our
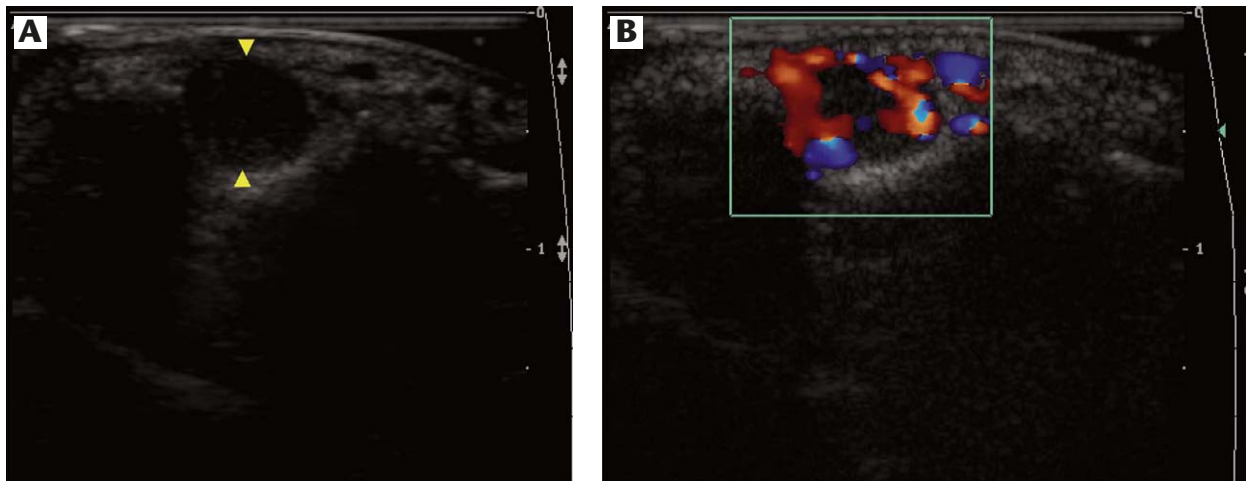

Fig. 8. *Glomus tumor in a 76-year-old man who complained of a painful nodule in his right index finger. (A) Grayscale ultrasonography shows a homogeneous hypoechoic nodule (arrowheads) in the ulnar aspect of the distal interphalangeal joint of the right index finger. (B) Color Doppler ultrasonography reveals marked hypervascularity within the lesion.*
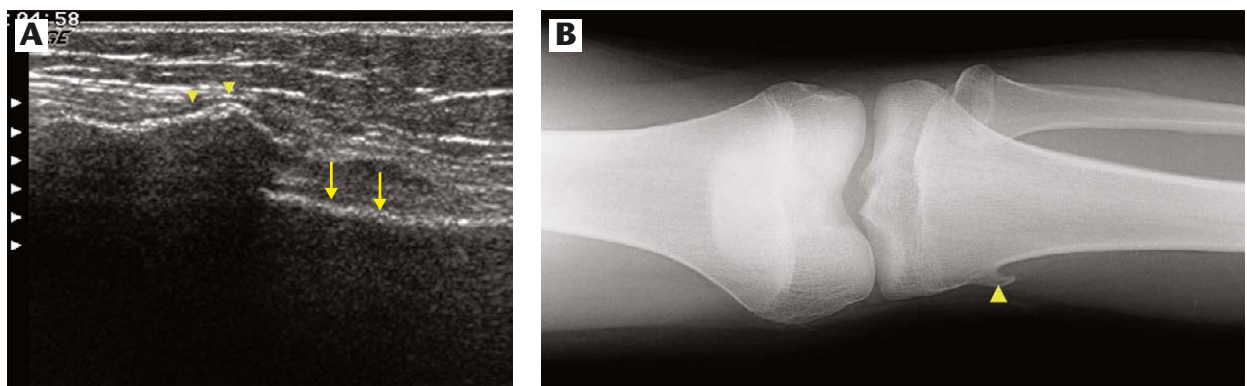
Fig. 9. *Exostosis in a 13-year-old boy. (A) Longitudinal section shows an exostosis with a thin cartilage cap (arrowheads). Arrows point to normal tibial cortex. (B) Plain film of the left knee demonstrates exostosis (arrowheads) of the medial tibia.*
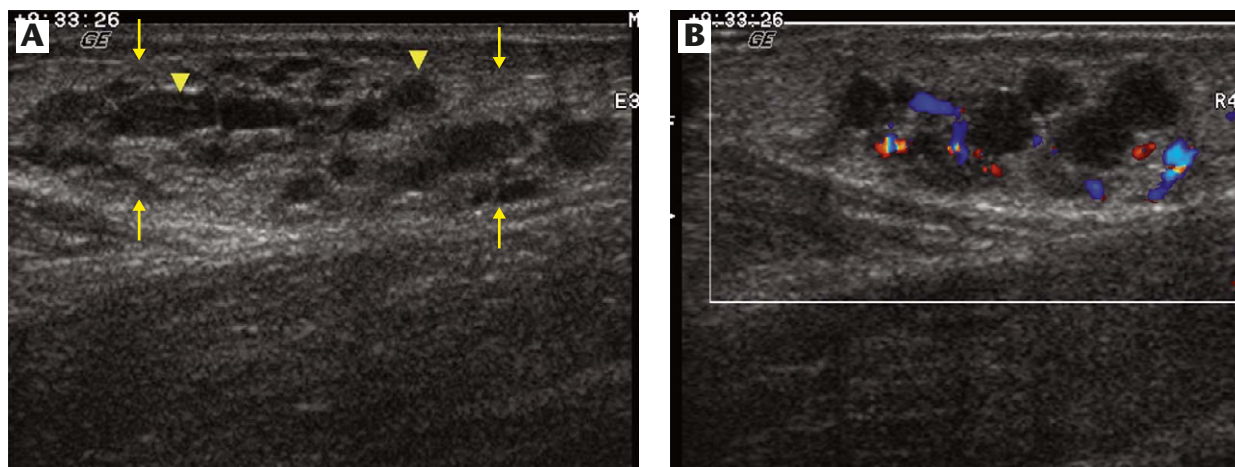
Fig. 10. *Cystic lymphangioma in an 8-year-old boy. (A) Grayscale ultrasonography shows an ill-defined heterogeneous echoic mass (arrows) with a cystic component (arrowheads). (B) Color Doppler ultrasonography reveals vascularity within the lesion but not in the cystic part.*
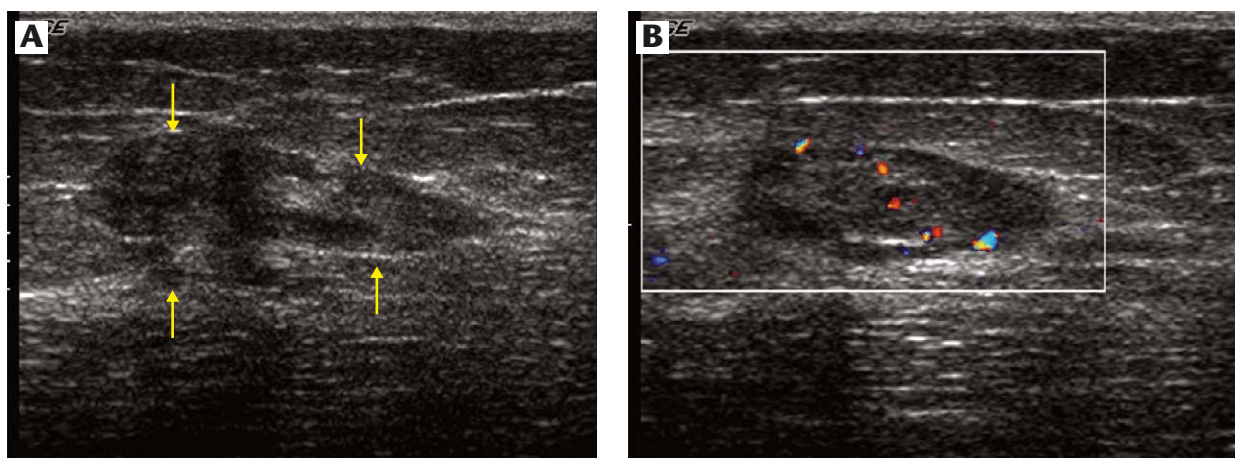
Fig. 11. *Fibromatosis in a 28-year-old woman who complained of tenderness over her right thigh. (A) Grayscale ultrasonography shows an irregular hypoechoic area (arrows) over the subcutaneous layer of the right thigh, with invasion to the muscle layer. (B) Color Doppler ultrasonography reveals mild increased vascularity within the lesion.*

experience, it also presents as heterogeneous hypo-echogenicity with infiltrated margins, lobulated contour if well-defined in margin, solid content, moderate to large size, and mild to moderate vascularity with moderate RI on CDUS. If the tumor is close to the bone, irregularity may occur over the bony cortex (Fig. 11).

PVNS

PVNS is a rare monoarticular arthropathy that is most common between 20 and 50 years of age. It usually involves the knee or hip and less frequently the ankle, elbow, and shoulder [34]. It typically

appears on ultrasonography with heterogeneous hypoechogenicity, ill-defined margins, lobulated contour, solid content, moderate to large size, and mild to moderate vascularity, with moderate RI on CDUS. Joint effusion is apparent in some patients (Fig. 12).

Fibroma

Fibroma of the tendon sheath is a benign, slow-growing, dense, fibrous nodule attached to the tendon sheath and is more common on the hands and feet [35]. In our experience, the typical pattern is heterogeneous hypoechogenicity, well-defined margins, ovoid or lobulated contour, solid content,
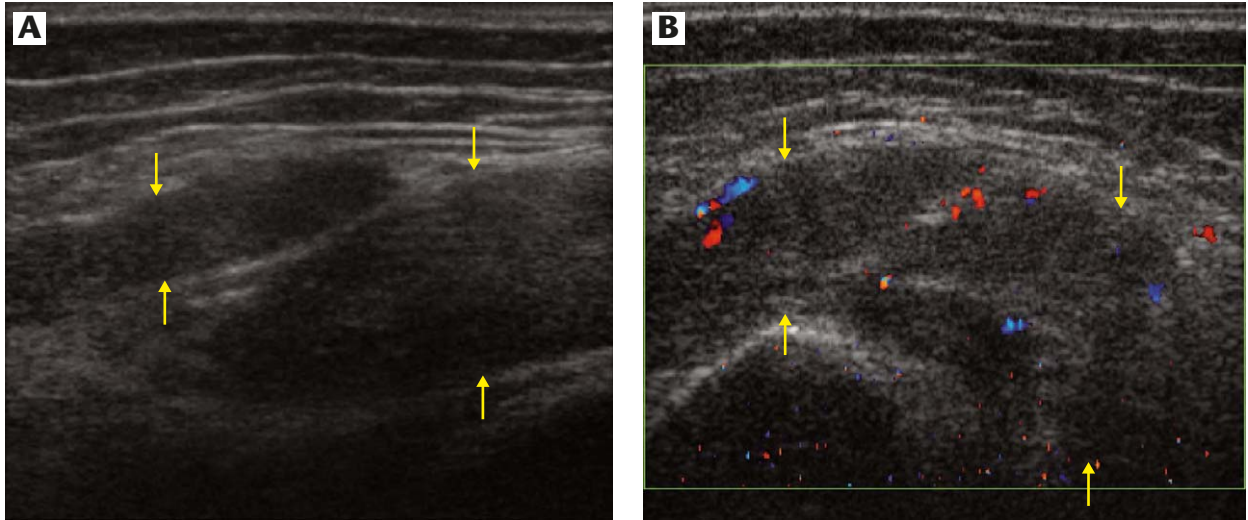
Fig. 12. *Pigmented villonodular synovitis in a 27-year-old woman who complained of a palpable mass over her right lower leg near the knee joint. (A) Grayscale ultrasonography longitudinal section demonstrates a lobulated hypoechoic nodule (arrows) in the medial aspect of the right knee near the pes anserinus bursa. (B) Color Doppler ultrasonography transverse section shows mild increased vascularity.*
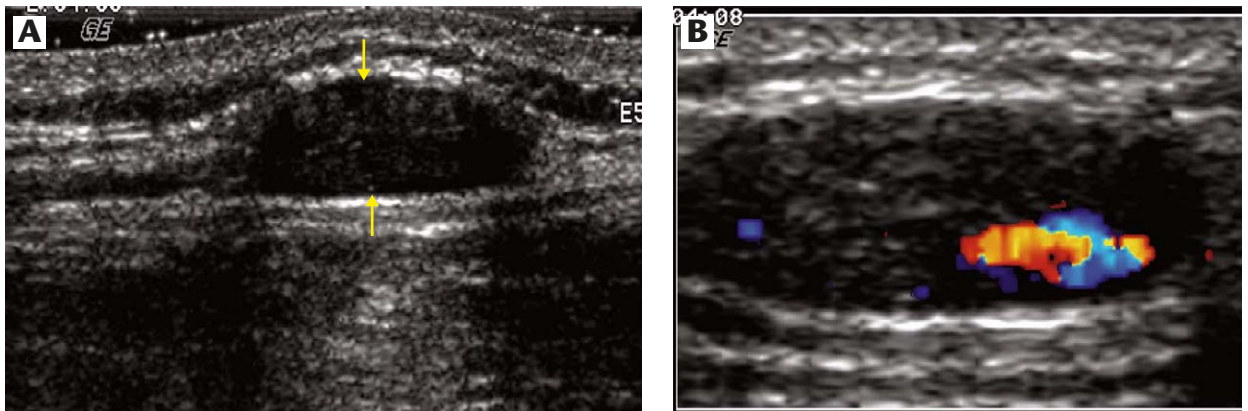
Fig. 13. *Fibroma in an 11-year-old boy who complained of a palpable nodule on his back. (A) Grayscale ultrasonography shows a hypoechoic nodule (arrows) with well-defined margins in the subcutaneous layer. (B) Color Doppler ultrasonography shows relatively increased vascularity within the tumor.*

moderate size, moderate vascularity on CDUS, moderate RI, and with a lesion observed along the tendon (Fig. 13).
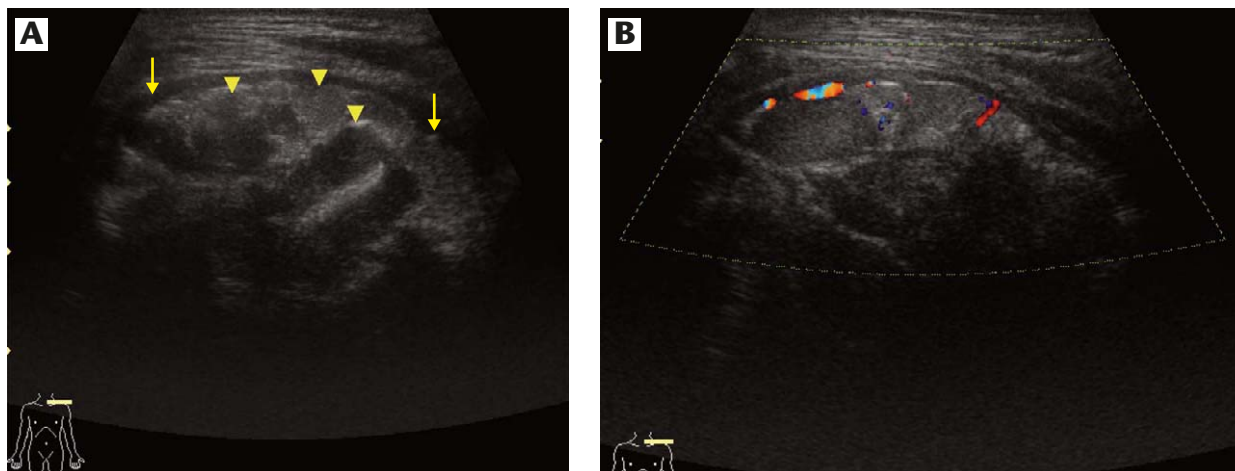
Tumoral calcinosis

Tumoral calcinosis is a rare disease of unknown origin. The characteristic findings are multiple calcified masses resembling neoplasms that are located in the soft tissue near large joints. These masses are thought to originate from bursal calcifications that extend with growth to adjacent tissues, but rarely causing erosion of bone [36,37].

Common ultrasound findings are heterogeneous hyperechogenicity, well-defined margins, lobulated contour, solid and cystic components, echogenic calcification, moderate to large size, and mild to moderate vascularity on CDUS. The mass usually presents with an echogenic rim (Fig. 14).

Enchondroma

Ultrasound detects enchondroma only when there is extreme cortical thinning or breakthrough status, in which case it appears with heterogeneous hypoechogenicity, ill-defined margins, ovoid contour,

Fig. 14. *Tumoral calcinosis in a 76-year-old male uremia patient who complained of a painful mass on his left shoulder. (A) Grayscale ultrasonography shows a heterogeneous echoic mass (arrows) with a lobulated cystic lesion (arrowheads) in the left supraclavicular region. (B) Color Doppler ultrasonography reveals relatively increased vascularity in the margin of the lesion.*

solid content, with bony fragments, small size, and mild vascularity on CDUS.

Leiomyoma

The typical ultrasonography findings of leiomyoma are heterogeneous hypoechogenicity, well-defined margins, solid content, small to moderate size, and mild vascularity on CDUS. Angioleiomyoma usually presents with well-defined margins, ovoid shape, some intratumoral calcification, hypervascularity, and low RI [38].

Corn

Ultrasound application to corns is rarely reported. In our experience, corns commonly appear as heterogeneous hypoechogenicity, infiltrated margins, ovoid contour, solid content, small size, and marked hypervascularity on CDUS.

Myositis ossificans

Myositis ossificans is generally a solitary and benign self-limiting ossifying process that occurs in the musculature of the extremities in young men, and is related to trauma in approximately half of the cases. It commonly involves the limbs, with lamellar bone forms at the periphery of the lesion that proceed toward its center [39,40]. The centrifugal pattern of calcification and ossification presents as a "zoning"
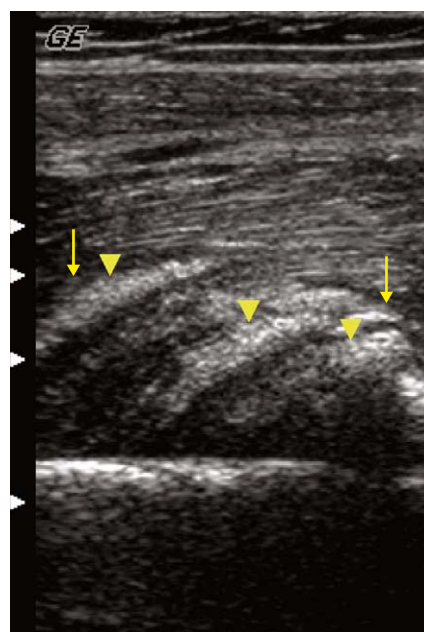
Fig. 15. *Myositis ossificans in a 21-year-old woman who complained of a painful swelling in her left anterior thigh. Grayscale ultrasonography shows heterogeneous hypoechogenicity, ill-defined margin mass (arrows), and segmental calcification (arrowheads).*

phenomenon on computed tomography [41]. The ultrasound findings of myositis ossificans are heterogeneous hyperechogenicity, ill-defined margins, lobulated shape, solid content, large size, and grade 2 on CDUS, with moderate RI and prominent segmental calcification (Fig. 15).
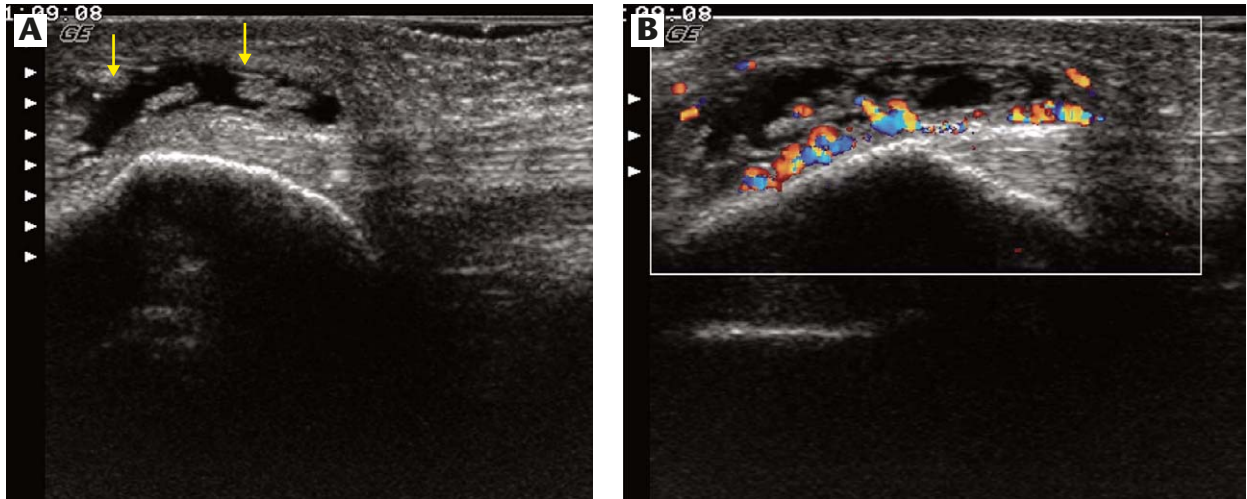
Fig. 16. *A 48-year-old man complained of a painful nodule in the olecranon region. (A) Grayscale ultrasonography shows a heterogeneous hypoechoic area (arrows) in the olecranon bursa. (B) Color Doppler ultrasound reveals hypervascularity within the margin of the olecranon bursitis.*

Other Tumor-like Soft Tissue Masses

Bursitis

Synovial bursae are distributed throughout nearly the whole body. Bursitis can be caused by post-traumatic or systemic inflammatory processes such as rheumatoid arthritis. The typical patterns in bursitis are reported to be hypoechoic or anechoic fluid accumulation with or without septum formation [42]. Typical findings include ill-defined margins, septated cystic composition, and grade 2 vascularization on CDUS (Fig. 16). Bursitis is commonly associated with an inflammatory process surrounding the subcutaneous layer in clinical presentation. Bursitis is differentiated from ganglion by its hypervascularity and ill-defined margins.

Abscess

Soft tissue abscesses have variable sonographic appearances; however, they are typically anechoic or hypoechoic, well-defined, with posterior acoustic enhancement and possible anechoic fluid motion during transducer compression [43], and hypervascularity [44]. In our experience, abscesses present with heterogeneous hypoechogenicity, ill-defined margins, lobulated contour, solid and cystic composition, moderate size, moderate RI, with hyperechogenicity

in the subcutaneous layer, and hypervascularity, especially on the margin of the lesion (Fig. 17). In addition to US findings, clinical symptoms such as infectious signs are also important.

Hematoma

Typical patterns of hematoma are heterogeneous hypoechogenicity, well- or ill-defined margins, and avascularity on CDUS.
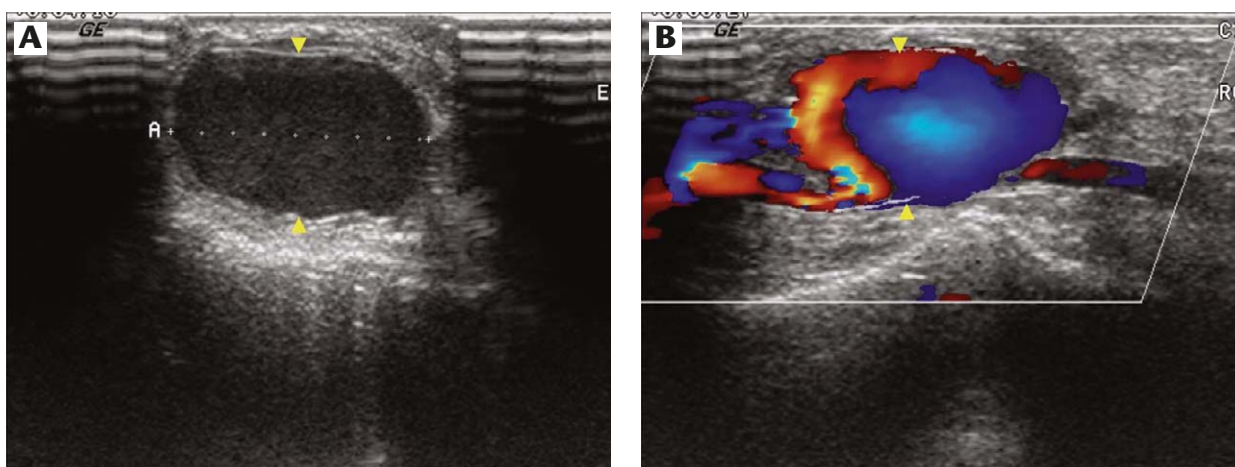
Pseudoaneurysm

The characteristic appearance of pseudoaneurysm is the extraluminal pattern of blood flow, which shows variable echogenicity, interval complexity, and to-and-fro flow pattern on CDUS [45] (Fig. 18).

Idiopathic myositis

The US findings in myositis are increased muscle diameter and the appearance of a reverse image of normal muscle, i.e. the attacked muscle fibers (endomysium) become hyperechoic and the fibroadipose septa (perimysium) that are filled with inflammatory exudate become hypoechoic [46]. The typical patterns in idiopathic myositis are heterogeneous hyperechogenicity, ill-defined margins, ovoid contour, solid composition, moderate size, and moderate hypervascularity on CDUS. In our
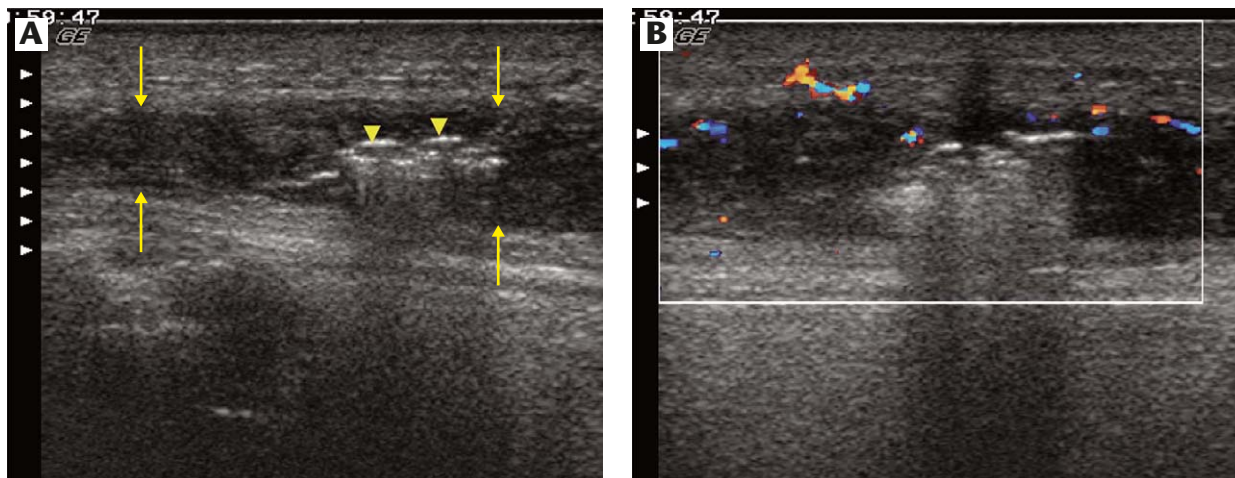
Fig. 17. *Abscess in a 70-year-old man who complained of a painful swelling in his lower back. (A) Sagittal section of the buttock reveals a heterogeneous hypoechoic area (arrows) with echogenic gas accumulation (arrowheads) in the buttock. (B) Color Doppler ultrasonography shows hypervascularity over the margin of the abscess.*

Fig. 18. *Pseudoaneurysm in an 83-year-old man who complained of a palpable mass in his right wrist. (A) Grayscale ultrasonography reveals a homogeneous hypoechoic nodule (arrowheads). (B) Color Doppler ultrasonography shows the "yin-yang" sign (arrowheads) of turbulent flow.*

experience, most patients display the specific pattern of clustered echoic endomysium and hypoechoic perimysium; this may be caused by edema in the endomysium and perimysium, and results in an increase in the size of the endomysium by the reflected sound beam, while fluid accumulation in the perimysium results in a decrease in the reflected interface (Fig. 19). This pattern can be observed in some infiltrative lesions such as myositis-type lymphoma [11]. These findings are not specific and must be correlated with the symptoms and the clinical picture.

Chronic inflammation or granulomatous lesions

The typical patterns in chronic inflammation or granulomatous lesions are heterogeneous hypoechogenicity, ill-defined margins, lobulated morphology, solid composition, moderate size, and moderate RI.

Tenosynovitis

The characteristic US findings of tenosynovitis are anechoic or hypoechoic peritendinous fluid with synovial thickening and increased vascularity [47].
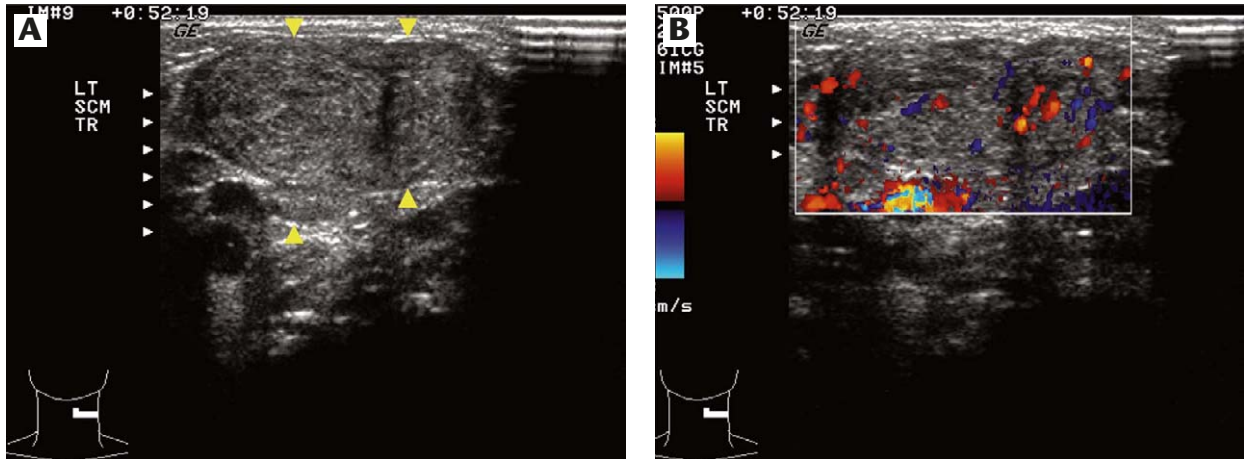
Fig. 19. *Idiopathic myositis in a 1-month-old boy with left torticollis with palpable mass. (A) Grayscale ultrasonography reveals heterogeneous hyperechogenicity in the left sternocleidomastoid muscle (arrowheads). (B) Color Doppler ultrasonography shows increased vascularity within the lesion.*
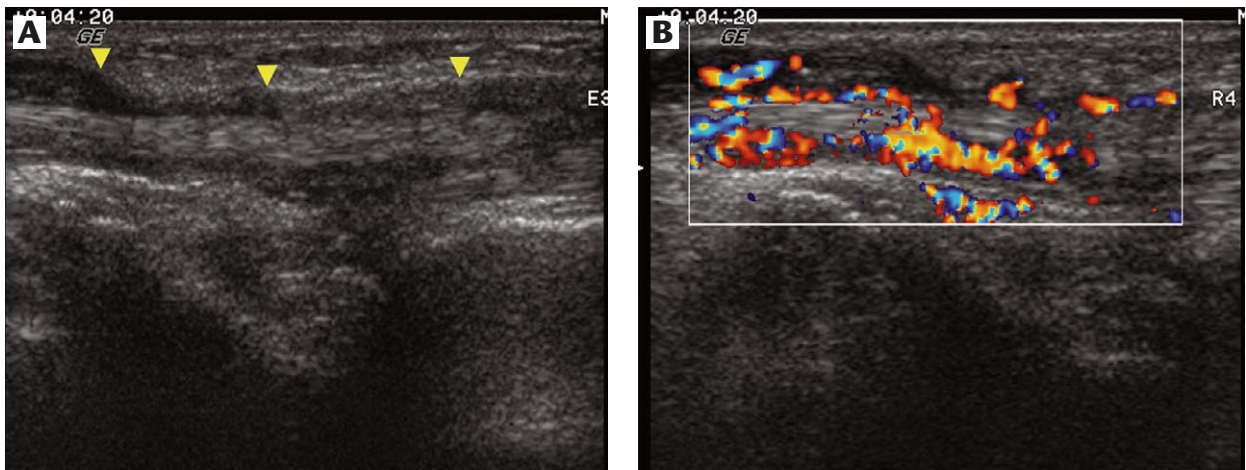
Fig. 20. *Tenosynovitis in a 51-year-old woman who complained of painful swelling in her left wrist. (A) Grayscale ultrasonography reveals a hypoechoic structure (arrowheads) surrounding the tendon. (B) Color Doppler ultrasonography shows hypervascularity within the lesion.*

The typical patterns in tenosynovitis are heterogeneous hypoechogenicity, lobulated contour, moderate size, mild to moderate hypervascularity on CDUS, and fluid accumulation along the tendon (Fig. 20).

Foreign body retention
Foreign body retention usually appears as heterogeneous echogenicity, with well- or ill-defined margins, ovoid contour, solid content, small size, and mild to moderate hypervascularity on CDUS, with echogenic foreign bodies present within the lesion (Fig. 21).
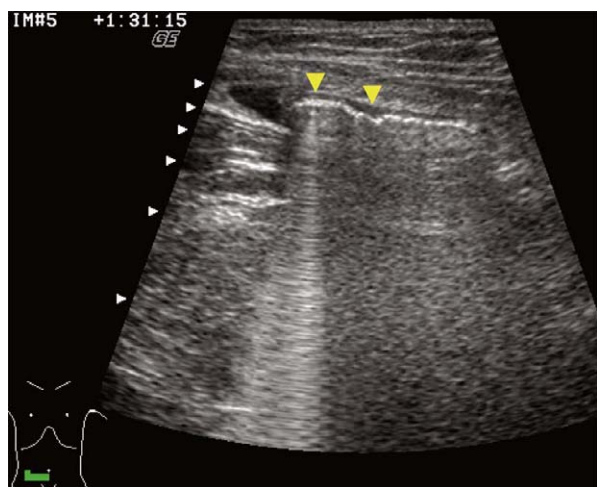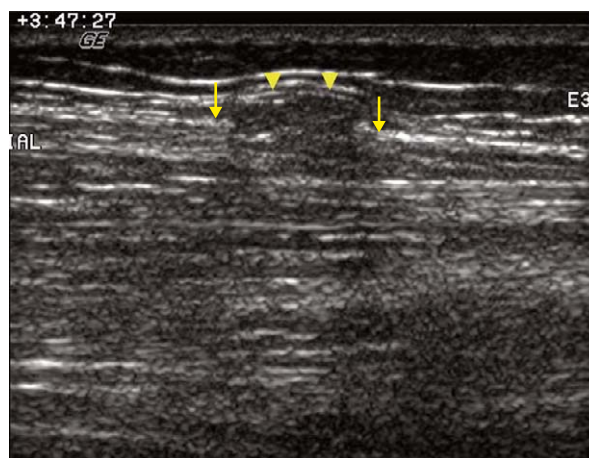
Hernia
The US appearance of hernia depends on the contents of the hernia sac and the presence of a bowel loop; real-time ultrasonography readily demonstrates peristalsis or dilatation of the bowel loop (Fig. 22). If there is fat content, the US pattern is of sliding mesentery fat during the Valsalva maneuver. If muscle has herniated, the typical pattern is
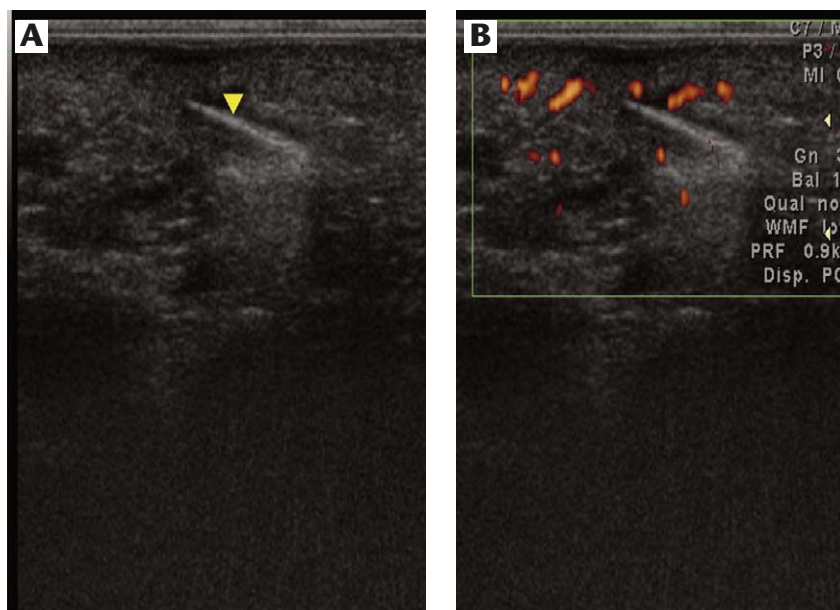
Fig. 21. *Foreign body in a 31-year-old man who complained of a painful nodule in his right palm for 6 months. (A) Grayscale ultrasonography shows increased echogenicity in the subcutaneous layer of the right palm, with echogenic foreign body (arrowhead) retention. (B) Power Doppler ultrasonography shows hypervascularity in the echogenic subcutaneous layer.*

Fig. 22. *Ventral hernia in a 76-year-old man who complained of a bulging mass in the right lower abdominal wall. The transverse ultrasound section shows a bowel loop containing gas (arrowheads) protruding within the abdominal wall muscle.*

Fig. 23. *Muscle hernia in a 23-year-old woman who complained of a palpable nodule in her left lower leg for 1 year. Grayscale ultrasonography shows protruding muscle fiber (arrowheads) and a defect of the epimysium (arrows) in the left anterior tibialis.*

defect in the epimysium with protrusion of muscle perimysium during muscle stress (Fig. 23).

Lymphadenitis
The typical US pattern in lymphadenitis is heterogeneous hypoechogenicity, well-defined margins, ovoid contour, solid content, small to moderate size, moderate to marked hypervascularity of the hilum on CDUS, and moderate RI. Most patients presented with a hilum within the lesion, some with several nodules and increased echogenicity surrounding the fat (Fig. 24).
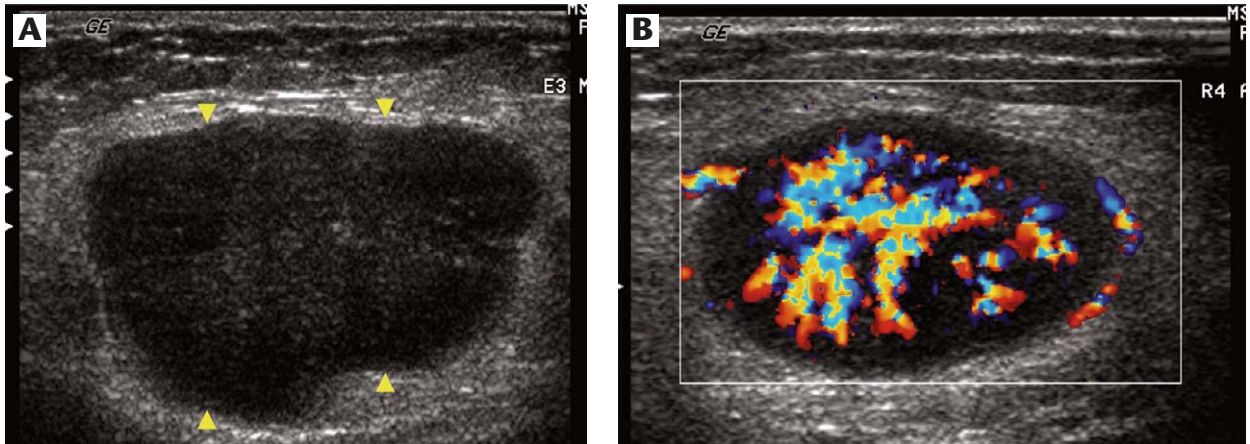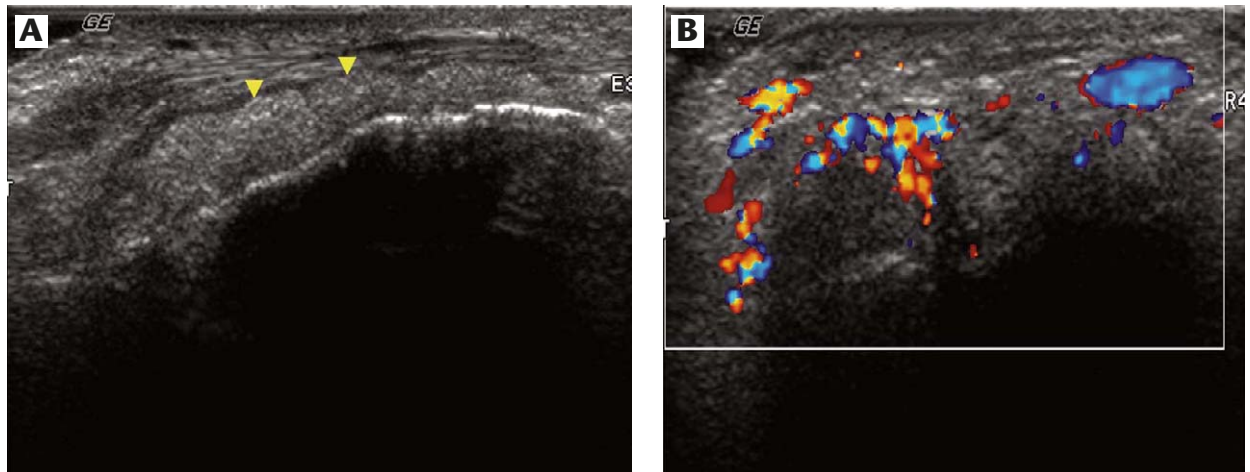
Fig. 24. *Lymphadenitis in a 32-year-old man who complained of a painful mass in his left upper thigh. (A) Grayscale ultrasonography shows a hypoechoic nodule (arrowheads) in the left inguinal region. (B) CDUS shows hypervascularity with a central pattern of vessels.*

Fig. 25. *Gout in a 47-year-old woman who complained of a painful swelling on her right foot. (A) Grayscale ultrasonography reveals a hyperechoic lesion (arrowheads) on the right dorsal foot beneath the tendon. (B) CDUS shows increased vascularity in the crystal margin.*

Gout

Gout is a metabolic disorder characterized by hyperuricemia and deposits of monosodium urate monohydrate crystals in periarticular soft tissues. Gout most commonly affects the first metatarsophalangeal joint, followed by the ankle, knee, wrist, fingers, and elbow. Clinical and radiographic findings are usually diagnostic.

The typical ultrasonographic pattern is of heterogeneous hyperechogenicity, ill-defined margins, lobulated contour, solid content, moderate size, and mild vascularity on CDUS. Most lesions are associated with echogenic spots caused by calcification or urate crystal deposition distributed along the tendon, sometimes with overhanging bony erosion (Fig. 25).

Varix

Varix is a focal dilatation of the venous system that commonly presents as an echo-free or heterogeneous hypoechogenicity, with well-defined margins, ovoid contour, cystic inner content, moderate size, moderate vascularity or thrombus on CDUS, and turbulent flow pattern. The saccular

cystic structure should connect to the vessel during tracing.

Neuritis

Inflammatory change in a neural bundle may be due to bacteria, viral infection or autoimmune change; however, inflammatory or infectious change in perineural soft tissue might result in compression or invasion of the surrounding nerve. The cause of neuritis is usually unknown. HRUS of peripheral nerve neuritis commonly reveals normal morphology or diffuse swelling of the nerve with decreased echogenicity [32]. The ultrasonographic findings are heterogeneous hypoechoic appearance, well-defined margins, ovoid or lobulated contour, solid content, small to moderate size, hypovascularity on CDUS, and swelling of the neural fascicles.
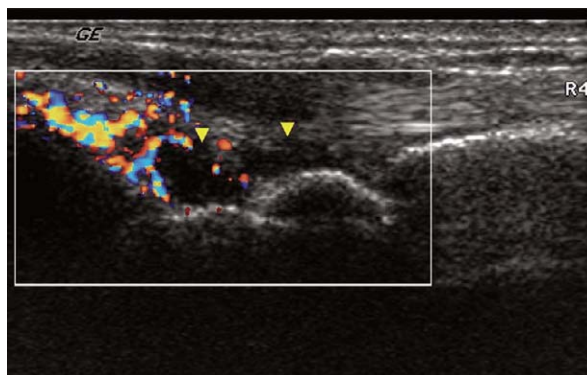
Rheumatoid arthritis with pannus formation

A previous study reports that rheumatoid arthritis usually presents with hypoechoic tendon sheaths, tendon rupture, discrete elongated hypoechoic soft-tissue nodules, and a hypoechoic rim around the tendon [48]. In our experience, the appearances in most patients are heterogeneous hypoechogenicity, well-defined margins, lobulated contour, solid content, moderate size, moderate vascularity on CDUS, and moderate RI. Other features, such as pannus formation and bony erosion, may be found (Fig. 26).

Muscle rupture

Muscle rupture appears mass-like, most commonly occurring in the long head of the biceps tendon. The ultrasonographic appearance in most patients is heterogeneous hyperechoic on the muscle retraction side, ill-defined margins, ovoid contour, solid content, moderate size, and avascular or hypovascular on CDUS. It is sometimes associated with heterogeneous blood clot or echo-free fluid accumulation (Fig. 27).

Perineuritic fibrosis

The ultrasonographic pattern is similar to that in traumatic neuroma, i.e. heterogeneous hypoechogenicity, ill-defined margins, lobulated contour,

Fig. 26. *In a 72-year-old man with rheumatoid arthritis, color Doppler ultrasound of the dorsal wrist shows hypoechoic pannus (arrowheads) formation with hypervascularity.*

solid content, small to moderate size, and hypovascular on CDUS. The lesion usually encases the nerve trunk.

Malignant Soft Tissue Neoplasms

The prevalence of malignant soft tissue tumors is approximately 5.1–15.5% worldwide [49,50], which is similar to our data [51].

Metastasis

The origin of most metastases is from carcinoma, rarely from sarcoma. Most are moderate or large in size, with heterogeneous hypoechogenicity, infiltrated margins, scalloped contour, solid composition, moderate hypervascularity on CDUS, and moderate RI. Tumors located close to the bony cortex commonly result in surrounding bony destruction (Fig. 28).

Osteogenic sarcoma (OGS)

Most OGSs with soft tissue involvement present with heterogeneous hyperechogenicity, infiltrated margins, scalloped contour, solid composition, large size, moderate hypervascularity on CDUS, and moderate RI. Surrounding bony destruction, bony fragments, and sunburst periosteal reaction is observed in most patients. OGS occurs most commonly in the lower limb, especially the knee joint (Fig. 29). Recurrence of OGS may appear as
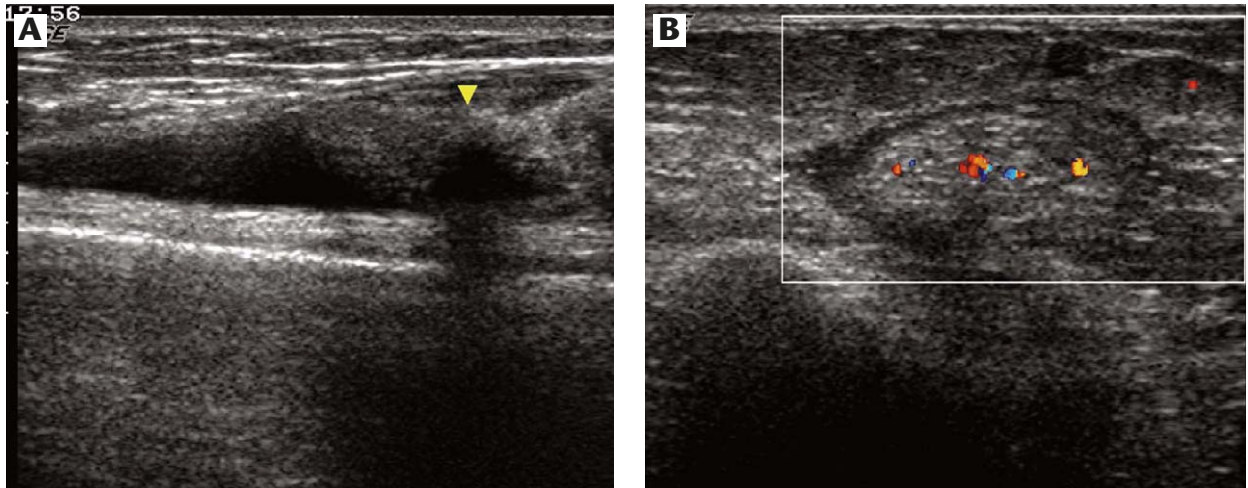
Fig. 27. *Muscle rupture in a 71-year-old patient who complained of painful disability over the right upper arm, with a palpable mass. (A) Longitudinal section ultrasonography of the biceps muscle reveals a heterogeneous echoic structure (arrowhead) with shadowing over the bicep muscle and surrounding echo-free hematoma. (B) CDUS shows increased vascularity in the retracted muscle.*
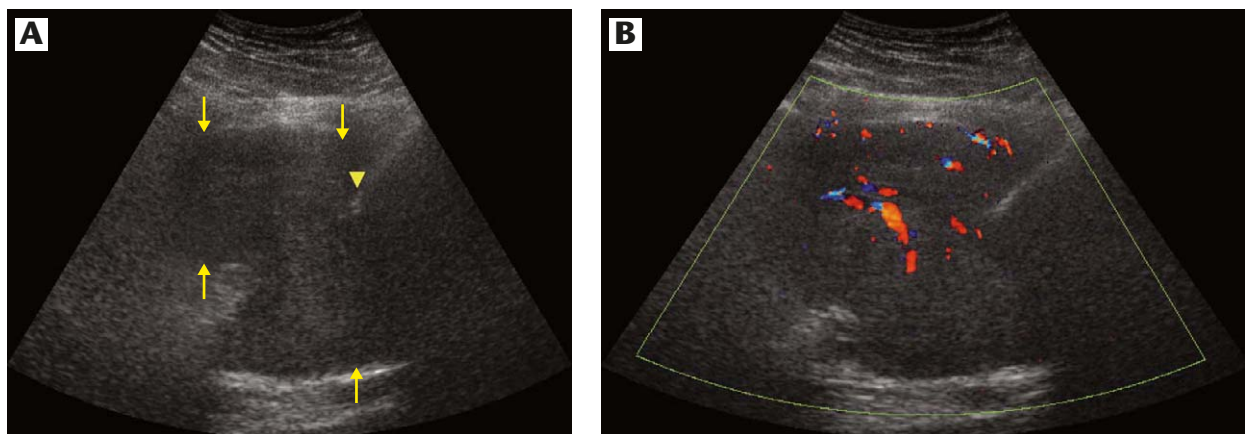
Fig. 28. *A 72-year-old woman who complained of pelvic pain. (A) Grayscale ultrasonography revealed a dumbbell-shaped hypo-echoic mass (arrows) in the left pelvic region with iliac bone destruction (arrowhead). (B) CDUS shows hypervascularity within the tumor. The mass was a metastasis from thyroid carcinoma.*

a well-defined ovoid hypoechoic nodule that differs from the original OGS.

Malignant fibrohistiocytoma (MFH)

MFH is divided histologically into pleomorphic, myxoid, giant cell, inflammatory, and angiomatoid subtypes; the pleomorphic type is the most common. Echo reflection differs depending on the subtype; however, the typical pattern in MFH is heterogeneous hypoechogenicity, infiltrated margin, scalloped contour, solid composition, large size, and moderate hypervascularity on CDUS (Fig. 30).

The ultrasonographic appearance of MFH with bony destruction differs to that of OGS because soft tissue periosteal thickening is present without the sunburst periosteal reaction. Cases with advanced amorphous calcification within the tumor can be differentiated from myositis ossificans, which has relatively linear laminated calcification.

Liposarcoma

The echogenicity of liposarcomas generally differs according to the cell type. In well-differentiated liposarcoma, US usually reveals hyperechogenicity,

while in the myxoid type (the most common liposarcoma), US usually appears heterogeneous and hypoechoic with or without hyperechoic area, which retains lipoblast nets. The typical pattern in liposarcoma is heterogeneous hyperechogenicity, infiltrated margins, scalloped contour, solid composition, large size, moderate hypervascularity on CDUS, with echogenic fat visible within the tumor (Fig. 31). Abnormal fat cell hyperplasia in liposarcoma increases the sono-reflected interface and results in increased echogenicity. Even in myxoid change of liposarcoma, some mature fat cells or lipoblasts could still exist within the tumor, resulting in focal hyperechoic areas.

Lymphoma

Peripheral soft tissue lymphoma can present as mass, nodal, nodular, myositis, and cellulitis types [11]. The ultrasonographic pattern of peripheral soft tissue lymphoma depends on the type. The typical pattern for the mass, nodal, and myositis types of peripheral lymphoma is relatively homogeneous hypoechogenicity, infiltrated margins, scalloped contour, solid composition, large size, and marked
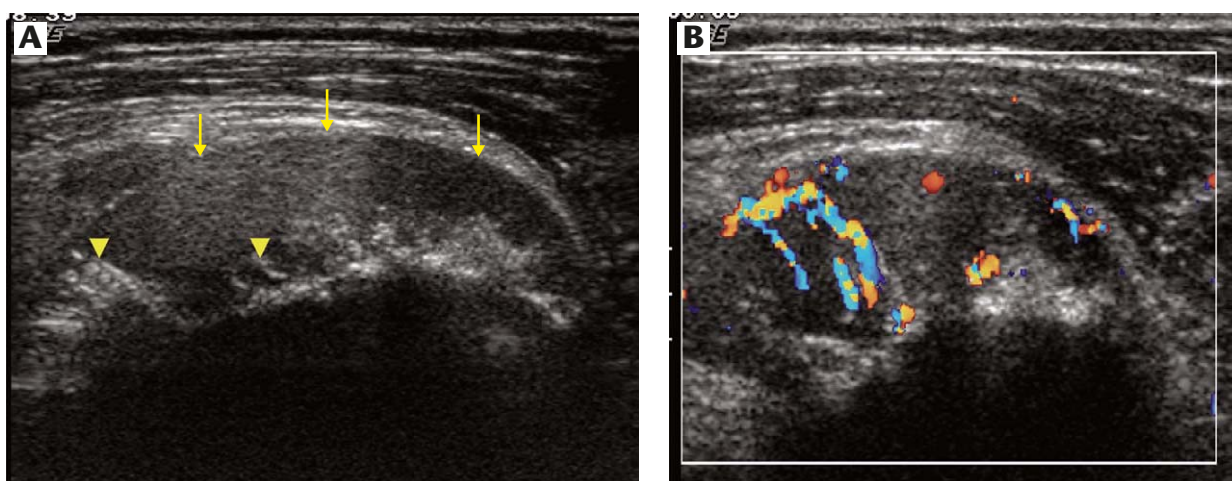
Fig. 29. *Osteosarcoma in a 10-year-old girl who complained of right knee pain. (A) Grayscale ultrasonography shows a heterogeneous hypoechoic mass (arrows) in the right lower femoral bone with sunburst new bone (arrowheads) formation. (B) Color Doppler ultrasonography shows hypervascularity within the tumor.*
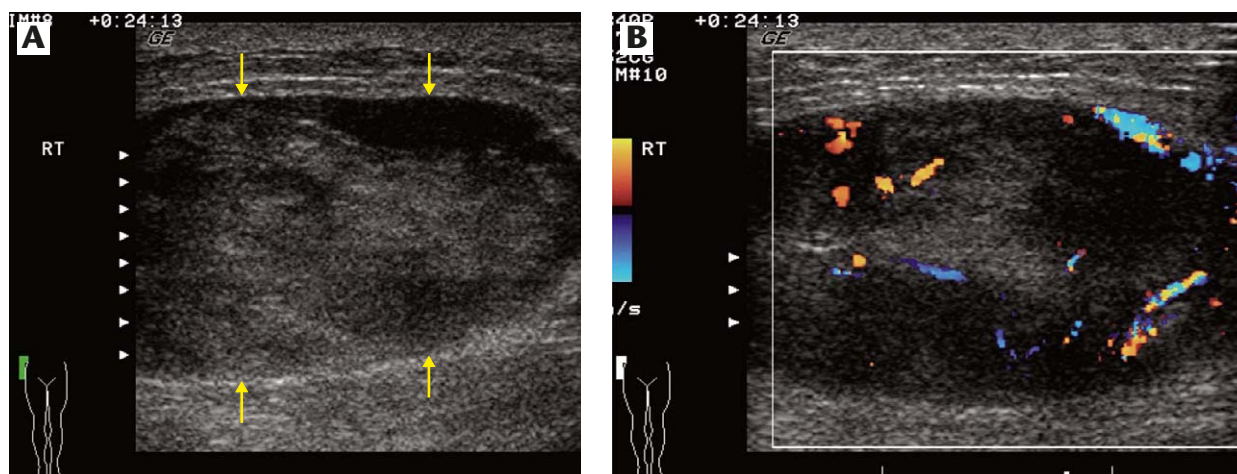
Fig. 30. *Malignant fibrohistiocytoma in a 78-year-old man who complained of a painless mass in his right lateral thigh. (A) Longitudinal ultrasound section reveals a heterogeneous hypoechoic mass (arrows). (B) Color Doppler ultrasonography shows hypervascularity.*

hypervascularity on CDUS. In the nodular type, the typical presentation is multiple small hypoechoic nodules with hypervascularity. In the cellulitis type, the typical presentation is echogenic subcutaneous fat lobules, ill-defined margins, and hypervascularity. Our previous study [11] found that the mass and nodal types are the most common types of peripheral soft tissue lymphoma (Fig. 32).
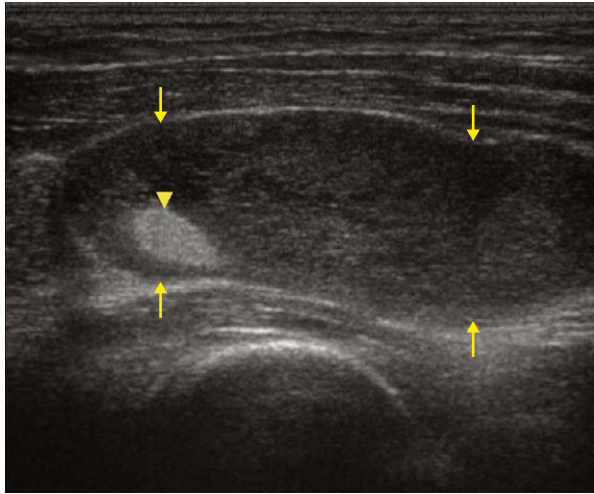
Fig. 31. *Liposarcoma (myxoid type) in a 70-year-old man who complained of a progressively swelling mass on his left elbow. Grayscale ultrasonography reveals a heterogeneous hypoechoic mass (arrows) with a homogeneous hyperechoic area (arrowheads) on the left elbow.*

Leiomyosarcoma

In leiomyosarcoma, the role of ultrasound is to provide information regarding tumor size and internal characteristics, and in guided biopsy. The typical US pattern is heterogeneous hypoechogenicity, infiltrated margins, scalloped contour, solid content, large size, moderate hypervascularity on CDUS, and moderate RI.

Synovial sarcoma

Synovial sarcoma is the fourth most common type of sarcoma following MFH, liposarcoma, and rhabdomyosarcoma [52]. It occurs predominantly in the extremities, especially the knee joint [53]. Previous studies reported that it presents as a well-defined solid mass with prominent vascularity [54,55]. The typical US pattern is heterogeneous hypoechogenicity, well-defined or infiltrated margins, scalloped contour, solid and/or with necrotic content, moderate to large size, moderate hypervascularity on CDUS, and moderate RI (Fig. 33).

Dermatofibrosarcoma

Dermatofibrosarcoma protuberans generally occurs on the trunk and the extremities. The lesion initially has well-defined margins before extending from the dermis to epidermis, subcutaneous fat,
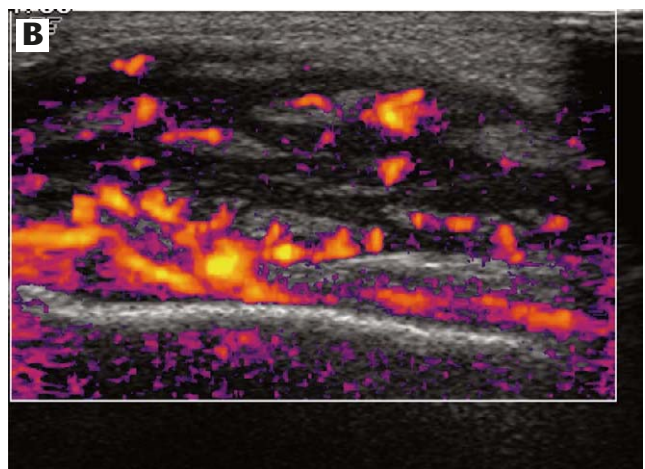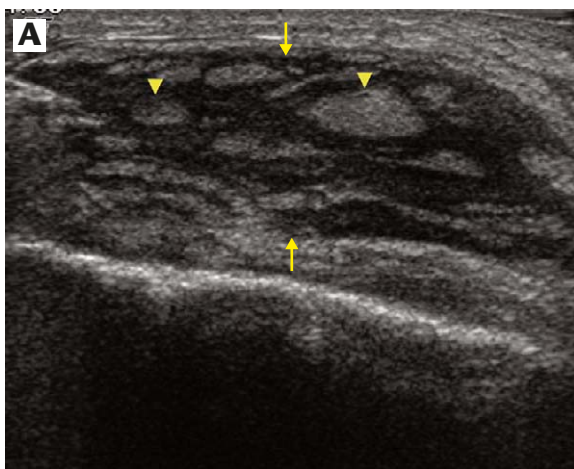
Fig. 32. *A 72-year-old man complained of a painful mass in his right proximal tibial region for 3 months. (A) Grayscale ultrasonography reveals a heterogeneous echoic lesion (arrows) with ill-defined margin in the anterior tibial region. (B) CDUS shows marked hypervascularity within the tumor. The arrowheads indicate lymphoma cell infiltration to the subcutaneous fat lobule. Ultrasonography-guided biopsy revealed a large B-cell lymphoma.*

muscle, fascia, and bone [56,57]. The typical ultra-sonographic pattern of dermatofibrosarcoma is homogeneous hypoechogenicity, infiltrated margins, ovoid contour, solid content, moderate size, marked hypervascularity on CDUS, and moderate RI (Fig. 34).

Small round-cell tumor
Small round-cell tumor contains conventional neuroblastoma, rhabdomyosarcoma, lymphoma, and Ewing sarcoma [58]. Ultrasonography is nonspecific

and may reveal mixed echogenicity with or without cystic components [59]. In our experience, it could appear with heterogeneous hypoechogenicity, infiltrated margins, scalloped contour, solid content, large size, moderate vascularity on CDUS, and low RI.

Hemangiopericytoma
Hemangiopericytoma is an uncommon tumor arising from the cells of Zimmerman that are located around vessels. They are moderately aggressive,
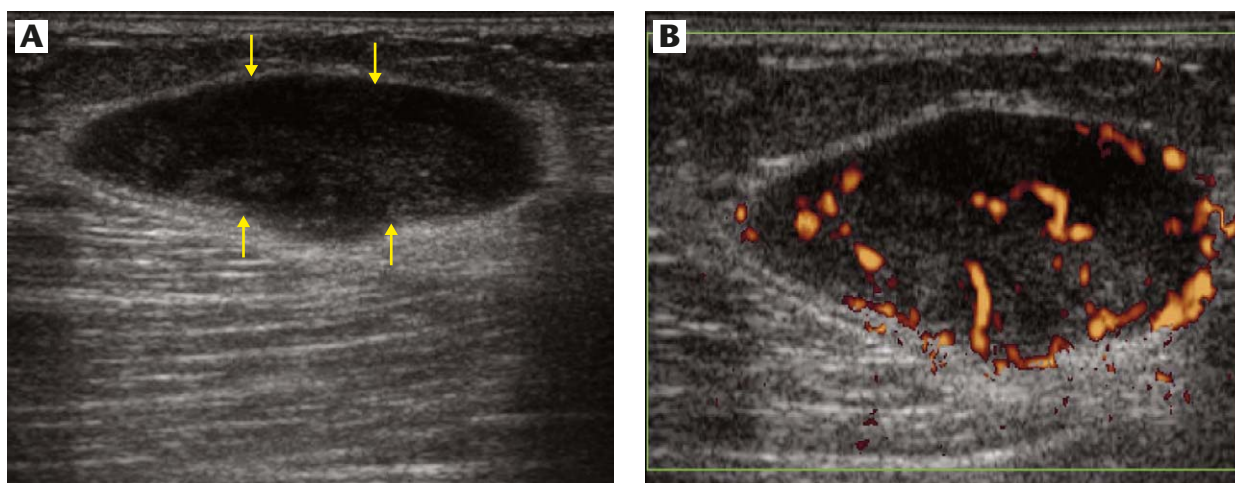
Fig. 33. *A 47-year-old woman complained of a painful right popliteal mass. (A) Grayscale ultrasonography shows a heterogeneous hypoechoic mass (arrows) over the right posterior thigh, with subcutaneous layer invasion to the muscle fascia. (B) Color Doppler ultrasonography shows prominent hypervascularity within the tumor. The mass was found to be synovial sarcoma, monophasic type.*
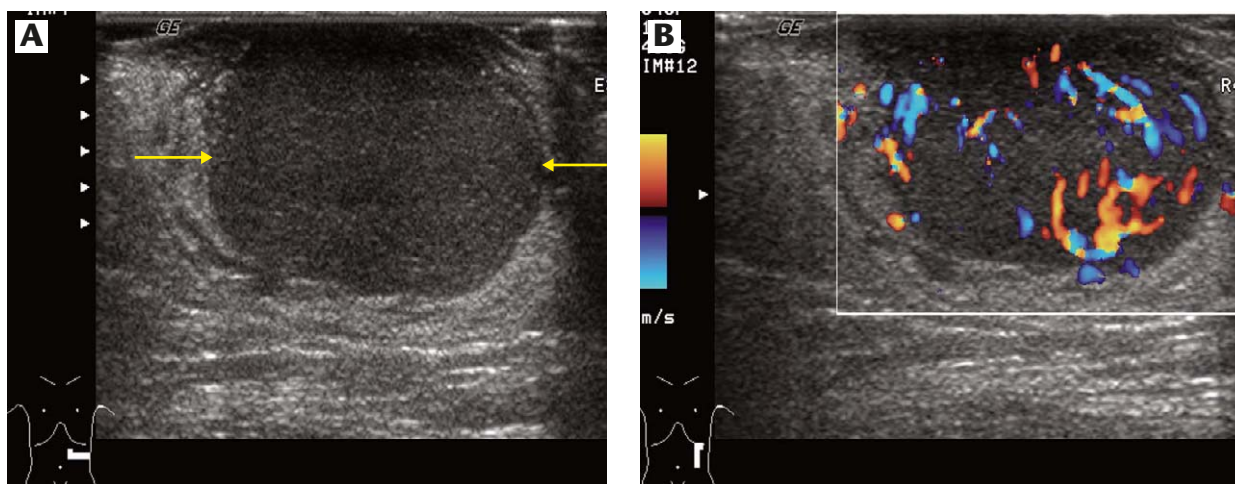
Fig. 34. *Dermatofibrosarcoma in a 64-year-old woman who complained of a slow-growing mass over the left abdominal wall for 2 years. (A) Grayscale ultrasonography shows a homogeneous hypoechoic nodule (arrows) in the left upper abdominal wall, located mainly in the subcutaneous layer. (B) CDUS reveals marked hypervascularity within the tumor.*

having both benign and malignant forms. Hemangiopericytoma commonly involves the lower extremities, pelvis, and retroperitoneum [60]. Some hemangiopericytomas may exhibit prominent serpentine vessels—a finding that reflects rich tumor vascularization. The presence of intratumoral necrosis indicates malignancy [61]. The typical presentation on ultrasonography is heterogeneous hypoechogenicity, well-defined or infiltrated margins, scalloped contour, solid and/or necrotic content, moderate to large size, marked hypervascularity on CDUS, low to moderate RI, and surrounding bony destruction if the tumor involves the bone.

Rhabdomyosarcoma

Rhabdomyosarcoma is the most common soft tissue malignancy in children, but is rare in the extremities [62]. The role of ultrasound is to provide information regarding tumor size and internal characteristics, and in guided biopsy. CDUS can determine vascularity but does not aid in differential diagnosis [63,64]. The ultrasonographic pattern is heterogeneous hypoechogenicity, infiltrated margins, lobulated contour, solid content, moderate size, moderate vascularity on CDUS, and moderate RI.

Fibromyxoid sarcoma

Fibromyxoid sarcoma is classified as a fibromyoblastic soft tissue tumor. Its incidence is very rare. The ultrasonographic pattern is heterogeneous hypoechogenicity, well-defined margins, ovoid contour, solid content, moderate size, moderate vascularity on CDUS, and low RI.

Alveolar soft part sarcoma

Alveolar soft part sarcoma presents with a pseudoalveolar pattern formed by aggregates of large granular cells surrounded by vascular channels that mimic the alveolar pattern of respiratory alveoli. The tumor is very hypervascular and is commonly surrounded by tortuous vessels [65]. It occurs predominantly between the ages of 10–35 years. Ultrasound reveals a variable echo pattern, while CDUS shows prominent vascularity within the tumor [66]. The ultrasonographic pattern is heterogeneous hypoechogenicity, infiltrated margins, ovoid contour, solid content, moderate size, marked hypervascularity on CDUS, and low RI (Fig. 35).

Malignant peripheral nerve sheath tumor (MPNST)

MPNST has previously been referred to as malignant schwannoma, neurogenic sarcoma, and neurofibrosarcoma; the current term is MPNST. The typical clinical presentation is of a large mass with an irregular border and rapid growth. MPNST and neurofibroma are usually indistinguishable on
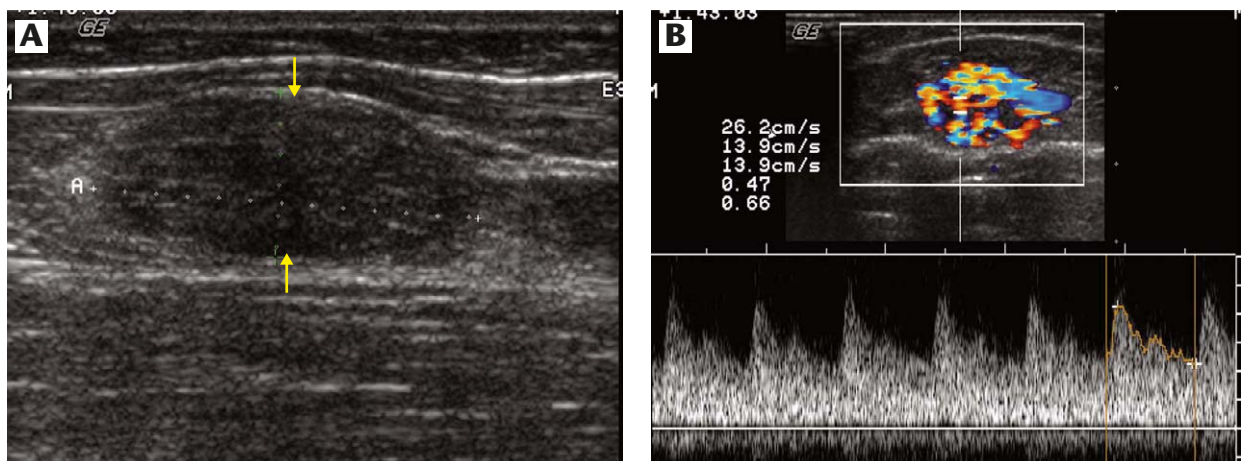
Fig. 35. *A 20-year-old woman complained of a palpable mass over her left forearm. (A) Grayscale ultrasonography reveals a heterogeneous hypoechoic nodule (arrows) in the left forearm, with marginal infiltration. (B) Color Doppler ultrasonography shows marked hypervascularity.*

imaging studies [67]. In our experience, it usually presents with heterogeneous hypoechogenicity, infiltrated margins, scalloped or ovoid contour, solid content, large size, and mild to moderate vascularity on CDUS.

Fibrosarcoma

Ultrasonography of fibrosarcoma typically reveals heterogeneous hypoechogenicity, ill-defined margins, ovoid contour, solid content, large size, mild vascularity on CDUS, and moderate RI.

Unclassified sarcoma

In unclassified sarcoma, the ultrasonography can reveal heterogeneous hypoechogenicity or heterogeneous hyperechogenicity, ill-defined or infiltrated margins, scalloped contour, solid and/or necrotic content, moderate to large size, mild to moderate vascularity on CDUS, moderate RI, and bony destruction and fragments when located close to the bone.

Conclusion

Superficial lesions are sometimes very small and located on the dermis or in the subcutaneous layer. We would like to emphasize the importance of gentle scan technique, such as using extra jelly on the skin and holding the probe with only slight skin contact to avoid compressing the lesion. It is not necessary to apply any pressure on the skin or lesion to detect small vessels and low-velocity signals with CDUS and spectral analysis.

Several ultrasonographic parameters are used to evaluate peripheral soft tissue masses, such as echogenicity, margins, morphology, composition, size, vascularity, and other specific patterns. High-resolution ultrasonography enables differential diagnosis among ganglion, hemangioma, lipoma, Baker cyst, glomus tumor, epidermoid cyst, tenosynovitis, bursitis, hematoma, abscess, and pseudoaneurysm. HRUS is also a useful modality in detecting soft tissue tumors and in differentiating benign from malignant.

References

1. Bureau of Health Promotion, Department of Health, Executive Yuan. Soft tissue malignancy. Cancer Registry Annual Report, 2002, Republic of China, 2005:74.
2. American Joint Committee on Cancer. Soft tissues. In: Fleming ID, Cooper JS, Henson DE, et al (eds). *AJCC Cancer Staging Manual*, 5th edition. Philadelphia: Lippincott-Raven, 1997:149–56.
3. Sarcoma Meta-analysis Collaboration. Adjuvant chemotherapy for localised resectable soft-tissue sarcoma of adults: meta-analysis of individual data. *Lancet* 1997;350:1647–54.
4. Alexander AA, Nazarian LN, Feld RI. Superficial soft-tissue masses suggestive of recurrent malignancy: sonographic localization and biopsy. *AJR Am J Roentgenol* 1997;169:1449–51.
5. Yao L, Nelson SD, Seeger LL, et al. Primary musculoskeletal neoplasms: effectiveness of core-needle biopsy. *Radiology* 1999;212:682–6.
6. Lagalla R, Iovane A, Caruso G, et al. Color Doppler ultrasonography of soft-tissue masses. *Acta Radiol* 1998;39:421–6.
7. Bodner G, Schocke MF, Rachbauer F, et al. Differentiation of malignant and benign musculoskeletal tumors: combined color and power Doppler US and spectral wave analysis. *Radiology* 2002;223:410–6.
8. Latifi HR, Siegel MJ. Color Doppler flow imaging of pediatric soft tissue masses. *J Ultrasound Med* 1994; 13:165–9.
9. Ozbek SS, Arkun R, Killi R, et al. Image-directed color Doppler ultrasonography in the evaluation of superficial solid tumors. *J Clin Ultrasound* 1995;23: 233–8.
10. Van der Woude HJ, Vanderschueren G. Ultrasound in musculoskeletal tumors with emphasis on its role in tumor follow-up. *Radiol Clin North Am* 1999;37:753–66.
11. Chiou HJ, Chou YH, Chiou SY, et al. High-resolution ultrasonography of primary peripheral soft tissue lymphoma. *J Ultrasound Med* 2005;24:77–86.
12. McEvedy BV. Simple ganglia. *Br J Surg* 1962;218: 585–94.
13. Cardinal E, Buckwalter KA, Braunstein EM, et al. Occult dorsal carpal ganglion: comparison of US and MR imaging. *Radiology* 1994;193:259–62.
14. Weiss SW. Lipomatous tumors. In: Weiss SW, Brooks JSJ, eds. *Soft Tissue Tumors*. Baltimore: Williams & Wilkins, 1996:207–51.
15. Fornage BD, Tassin GB. Sonographic appearances of superficial soft tissue lipomas. *J Clin Ultrasound* 1991; 19:215–20.

16. Jovanovic RJ, Skakic V, Markovic Z, et al. The frequency of Baker cyst in rheumatoid arthritis. *Acta Fac Med Naiss* 2004;21:231–6.

17. Allen PW, Enzinger FM. Hemangioma of skeletal muscle: an analysis of 89 cases. *Cancer* 1972;29:8–22.

18. Mulliken JB, Glowacki J. Hemangiomas and vascular malformations in infants and children: a classification based on endothelial characteristics. *Plast Reconstr Surg* 1982;69:412–22.

19. Paltiel HL, Burrows PE, Mulliken JB. Color Doppler ultrasound of soft tissue vascular anomalies. *Radiology* 1994;193:292–5.

20. Jaffe HL, Lichtenstein L, Sutro CJ. Pigmented villonodular synovitis, bursitis, and tenosynovitis: a discussion of the synovial and bursal equivalents of the tenosynovial lesions commonly denoted as xanthoma, xanthogranuloma, giant cell tumor or myeloplaxoma of the tendon sheath, with some consideration of the tendon sheath lesion itself. *Arch Pathol* 1941;31:731–65.

21. Lin J, Jacobson JA, Jamadar DA, et al. Pigmented villonodular synovitis and related lesions: the spectrum of imaging findings. *AJR Am J Roentgenol* 1999;172: 191–7.

22. Yasumoto M, Shibuya H, Gomi N, et al. Ultrasonographic appearance of dermoid and epidermoid cysts in the head and neck. *J Clin Ultrasound* 1991;19:455–61.

23. Reynolds JH, Wolinski AP. Sonographic appearance of branchial cysts. *Clin Radiol* 1993;48:109–10.

24. Simonovsky V. Peripheral nerve schwannoma preoperatively diagnosed by sonography: report of three cases and discussion. *Eur J Radiol* 1997;25:47–51.

25. Obayashi T, Itoh K, Nakano A. Ultrasonic diagnosis of schwannoma. *Neurology* 1987;37:1817.

26. Kececi Y, Gurler T, Gundogan H, et al. Benign giant schwannoma located in the upper arm. *Ann Plast Surg* 1997;39:100–2.

27. Tsai WC, Chiou HJ, Chou YH, et al. Differentiation between schwannoma and neurofibroma in extremities and superficial body: the role of high resolution ultrasonography [abstract]. 92nd Scientific Assembly and Annual Meeting of the Radiological Society of North America, Chicago, 2006:P834.

28. Weiss SW, Goldblum JR. Benign tumors and tumor-like lesions of blood vessels. In: Weiss SW, Goldblum JR, eds. *Enzinger and Weiss's Soft Tissue Tumors*, 4th edition. St Louis: Mosby, 2001:837–90.

29. Malghem J, Vande Berg B, Noel H, et al. Benign osteochondromas and exostotic chondrosarcomas: evaluation of cartilage cap thickness by ultrasound. *Skeletal Radiol* 1992;21:33–7.

30. Sheth S, Nussbaum AR, Hutchins GM, et al. Cystic hygromas in children: sonographic-pathologic correlation. *Radiology* 1987;162:821–4.

31. Spencer PS. The traumatic neuroma and proximal stump. *Bull Hosp Joint Dis* 1974;35:85–102.

32. Chiou HJ, Chou YH, Chiou SY, et al. Peripheral nerve lesions: role of high-resolution US. *Radiographics* 2003; 23:e15.

33. Griffith JF, Wong TY, Wong SM, et al. Sonography of plantar fibromatosis. *AJR Am J Roentgenol* 2002;179: 1167–72.

34. De Schepper AMA, Ramon F, eds. *Medical Imaging of Soft Tissue Tumors*. Berlin: Schering AG, 1993.

35. De Schepper AMA, Vandevenne JE. Tumors of fibrous tissue. In: DeSchepper AM, ed. *Imaging of Soft Tissue Tumors*. Berlin: Springer-Verlag, 1997:150.

36. Martinez S, Vogler JB 3rd, Harrelson JM, et al. Imaging of tumoral calcinosis: new observations. *Radiology* 1990;174:215–22.

37. Seeger LL, Butler DL, Eckardt JJ, et al. Tumoral calcinosis-like lesion of the proximal linea aspera. *Skeletal Radiol* 1990;19:579–83.

38. Gomez-Dermit V, Gallardo E, Landeras R, et al. Subcutaneous angioleiomyomas: gray-scale and color Doppler sonographic appearances. *J Clin Ultrasound* 2006;34:50–4.

39. Enzinger FM, Weiss SW. Osseous soft tissue tumors. In: Enzinger FM, Wess SW, eds. *Soft Tissue Tumors*, 3rd edition. St Louis: Mosby, 1995: 1013–38.

40. Meis-Kindblom JM, Enzinger FM. Extraskeletal osseous and cartilaginous tumors. In: Meis-Kindblom JM, Enzinger FM, eds. *Color Atlas of Soft Tissue Tumors*. St Louis: Mosby-Wolfe, 1996:259–72.

41. Amendola MA, Glazer GM, Agha FP, et al. Myositis ossificans circumscripta: computed tomographic diagnosis. *Radiology* 1983;149:775–9.

42. Kim SM, Shin MJ, Kim KS, et al. Imaging features of ischial bursitis with an emphasis on ultrasonography. *Skeletal Radiol* 2002;31:631–6.

43. Loyer EM, DuBrow RA, David CL, et al. Imaging of superficial soft-tissue infections: sonographic findings in cases of cellulitis and abscess. *AJR Am J Roentgenol* 1996;166:149–52.

44. Arslan H, Sakarya ME, Bozkurt M, et al. The role of power Doppler sonography in the evaluation of superficial soft tissue abscesses. *Eur J Ultrasound* 1998;8: 101–6.

45. Eisenberg L, Paulson EK, Kliewer MA, et al. Sonographically guided compression repair of

pseudoaneurysms: further experience from a single institution. *AJR Am J Roentgenol* 1999;173:1567–73.

46. Peetrons P. Ultrasound of muscles. *Eur Radiol* 2002; 12:35–43.

47. Fessell DP, Jamadar DA, Jacobson JA, et al. Sonography of dorsal ankle and foot abnormalities. *AJR Am J Roentgenol* 2003;181:1573–81.

48. Fornage BD. Soft-tissue changes in the hand in rheumatoid arthritis: evaluation with US. *Radiology* 1989;173:735–7.

49. Kreicbergs A, Tribukait B, Willems J, et al. DNA flow analysis of soft tissue tumors. *Cancer* 1987;59:128–33.

50. Myhre-Jensen O. A consecutive 7-year series of 1331 benign soft tissue tumours: clinicopathologic data. Comparison with sarcomas. *Acta Orthop Scand* 1981; 52:287–93.

51. Chiou HJ, Chou YH, Chiou SY, et al. Diagnosis of soft tissue masses: the role of high-resolution ultrasonography [abstract]. 90th Scientific Assembly and Annual Meeting of the Radiological Society of North America, Chicago, 2004:738.

52. Cadman NL, Soule EH, Kelly PJ. Synovial sarcoma: an analysis of 134 tumors. *Cancer* 1965;18:613–27.

53. Enzinger FM, Weiss SW. Synovial sarcoma. In: Enzinger FM, Weiss SW, eds. *Soft Tissue Tumors*, 3rd edition. St Louis: Mosby, 1995:735–86.

54. Acton CM, Morrison WA, Slavin JL. Synovial sarcoma: an unexpected ultrasound finding in a post-partum patient. *Australas Radiol* 1996;40:452–3.

55. Marzano L, Failoni S, Gallazzi M, et al. The role of diagnostic imaging in synovial sarcoma. Our experience. *Radiol Med (Torino)* 2004;107:533–40.

56. Daly BD, Currie AR, Choi PCL. Case report: computed tomographic and scintigraphic appearances of dermatofibrosarcoma protuberans. *Clin Radiol* 1993;48:63–5.

57. Fukushima H, Suda K, Matsuda M, et al. A case of dermatofibrosarcoma protuberans in the skin over the breast of a young woman. *Breast Cancer* 1998;5: 407–9.

58. Triche TJ, Askin FB. Neuroblastoma and the differential diagnosis of small-, round-, blue-cell tumors. *Hum Pathol* 1983;14:569–96.

59. Saifuddin A, Robertson RJH, Smith SEW. The radiology of Askin tumours. *Clin Radiol* 1991;43:19–23.

60. Kransdorf MJ, Murphey MD. Radiologic evaluation of soft-tissue masses: a current perspective. *AJR Am J Roentgenol* 2000;175:575–87.

61. De Schepper A, Ramon F, Degryse H. Statistical analysis of MRI parameters predicting malignancy in 141 soft tissue masses. *Rofo* 1992;156:587–91.

62. Stout AP, Lattes R. Tumors of the soft tissues. In: *Atlas of Tumor Pathology*. Washington DC: American Forces Institute of Pathology, 2001.

63. Christensen RA, Van Sonnenberg E, Casola G, et al. Interventional ultrasound in the musculoskeletal system. *Radiol Clin North Am* 1988;26:145–56.

64. Vincent LM. Ultrasound of soft tissue abnormalities of the extremities. *Radiol Clin North Am* 1988;26: 131–44.

65. Asvall J, Hoeg K, Kleppe K, et al. Alveolar soft part sarcoma. *Clin Radiol* 1969;20:426–32.

66. Daly BD, Cheung H, Gaines PA, et al. Imaging of alveolar soft part sarcoma. *Clin Radiol* 1992;46: 253–6.

67. Hrehorovich PA, Franke HR, Maximin S, et al. Malignant peripheral nerve sheath tumor. *Radiographics* 2003;23:790–94.