Sonography of Fat Necrosis Involving the Extremity and Torso With Magnetic Resonance Imaging and Histologic Correlation

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Objective. The purpose of this study was to describe the sonographic appearance of pathologically proven isolated fat necrosis involving the extremities or torso with magnetic resonance imaging (MRI) correlation. ***Methods.*** A query of the Department of Pathology database at our institution for the diagnosis of fat necrosis resulted in 1539 cases. Review of the cases and medical records excluded cases without sonographic imaging, those involving the breast, and those within or adjacent to a primary process, including masses or prior surgery, which resulted in a total of 5 cases of primary fat necrosis, 2 of which were evaluated with MRI. Sonograms were reviewed by 2 musculoskeletal radiologists and characterized with regard to location, echogenicity, shadowing, posterior through-transmission, a hypoechoic rim or halo, definition of borders, homogeneity, a mass effect, and vascularity. The patient medical records, histologic results, and MRI findings were also reviewed. ***Results.*** Of the 5 cases of isolated fat necrosis, 2 involved the torso and 3 the lower extremities. On sonography, all were located in the subcutaneous fat; 2 were isoechoic; 3 were hyperechoic; 2 had a hypoechoic halo; none showed shadowing or posterior through-transmission; 2 were well defined; 3 were masslike; 4 were heterogeneous; and 2 showed increased flow on color or power Doppler imaging. Magnetic resonance imaging showed an intermediate signal and either diffuse or ring enhancement. ***Conclusions.*** Isolated fat necrosis of the extremities and torso had 2 sonographic appearances, which included a well-defined isoechoic mass with a hypoechoic halo and a poorly defined hyperechoic region in the subcutaneous fat. ***Key words:*** fat; fat necrosis; soft tissues; sonography; subcutaneous.

Abbreviations
MRI, magnetic resonance imaging; TE, echo time; TR, repetition time

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Fat necrosis is a benign entity frequently presenting as a palpable mass within the subcutaneous tissues or the breast. Numerous etiologies have been ascribed to fat necrosis, with a variable history of trauma because the patient often does not recall a specific traumatic event.[1,2] Patients with fat necrosis may undergo imaging of a palpable soft tissue mass.

The sonographic findings of fat necrosis of the breast have been well described in the literature, ranging from cystic to solid masses of variable echogenicity.[3,4]

However, the sonographic appearance of isolated fat necrosis of the trunk or extremities has not been well characterized in the literature, with most describing a hypoechoic appearance. In addition, many reports describing the sonographic characteristics of fat necrosis do not have histologic proof or do not exclusively evaluate isolated fat necrosis but rather include cases arising in lipomatous lesions or other mass lesions.[1,5,6]

In our clinical practice, we have noted a variable sonographic appearance of fat necrosis and in many cases a hyperechoic appearance. In addition, we have noted a hypoechoic halo, which to the best of our knowledge has not been previously described in the literature. Therefore, the purpose of this study was to retrospectively characterize the sonographic appearance of primary fat necrosis with magnetic resonance imaging (MRI) and histologic correlation.

Materials and Methods

Institutional Review Board approval was obtained, with informed consent waived. The Department of Pathology database at our institution was queried for "fat necrosis" from January 1, 1998, through July 12, 2007, resulting in 1539 cases. Medical records, including imaging and pathology reports, were then reviewed by one of the authors. Patients were excluded if the fat necrosis originated in a lipoma, if the fat necrosis was associated with another mass or foreign body, and if sonographic imaging was not performed or available for review. After the exclusion criteria were applied, a total of 5 cases of pathologically proven isolated fat necrosis involving the torso or extremities were identified.

Sonograms were acquired as part of clinical patient care with 5- to 15-MHz transducers (LOGIQ 9, GE Healthcare, Milwaukee, WI; HDI 5000 and iU22, Philips Medical Systems, Bothell, WA) by 1 of 5 radiologists. The sonograms, both static images and cine loops (when completed), were retrospectively reviewed on a departmental picture archiving and communications workstation by 2 musculoskeletal radiologists (each with 10 years of musculoskeletal ultrasound experience). Data were recorded with regard to location, echogenicity (anechoic, hypoechoic, isoechoic, or hyperechoic relative to adjacent subcutaneous fat), shadowing, increased posterior through-transmission, a hypoechoic rim or halo (partial or complete regardless of thickness), definition of borders (poorly defined or well defined), homogeneity, a mass effect, and vascularity (presence or absence on color or power Doppler imaging). Correlation was made with MRI (1.5-T magnet; Signa, GE Healthcare) if available, and imaging findings were recorded, such as signal intensity, enhancement, and the presence of a mass effect (deformation or displacement of adjacent structures). Patient records and other imaging tests, such as computed tomography and positron emission tomography were reviewed where available.

The diagnosis of fat necrosis at pathologic examination was based on the microscopic findings (hematoxylin-eosin stain) of necrotic adipocytes devoid of nuclear material. The presence of a fibrous capsule was also noted.

Results

The study group included 4 female patients and 1 male patient ranging in age from 13 to 49 years (mean, 36 years). All of the patients had a palpable subcutaneous mass but could not recall a history of antecedent trauma. Two of the patients reported the nodule to be tender, whereas the other 3 did not report a history of tenderness. One patient had a history of malignancy for which the mass was biopsied to evaluate for potential metastatic disease. Three of the cases involved the lower extremities; 1 was within the anterior abdominal wall; and 1 was within the gluteal subcutaneous tissue. Two of the cases had image-guided core biopsy, and 3 had open biopsy.

In each of the 5 cases, the focus of the fat necrosis was within the subcutaneous fat. Echogenicity was isoechoic in 40% (2 of 5), hyperechoic in 60% (3 of 5), heterogeneous in 80% (4 of 5), and homogeneous in 20% (1 of 5). A completely surrounding hypoechoic halo was seen in 40% (2 of 5). The area of fat necrosis was poorly defined in 60% (3 of 5) and well defined in 40% (2 of 5), showing a mass effect in 60% (3 of 5). In no cases was there increased posterior through-transmission or shadowing. Internal vascularity was noted in 40% (2 of 5).

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In 2 of our patients, we found a well-defined heterogeneous subcutaneous masslike process, which was isoechoic to fat and showed a completely surrounding hypoechoic halo (Figures 1 and 2). One measured 6 mm and the other 18 mm in the largest dimension. No posterior acoustic shadowing or through-transmission was appreciated. One of these cases did show internal vascularity. In 1 case (Figure 2), the masslike area was freely mobile with transducer pressure, as shown by cine images. Histologic confirmation was obtained by open biopsy in both of these cases, which showed a well-demarcated lobule of fat necrosis surrounded by a fibrous capsule. One case showed internal complex septations and cystic areas, whereas the other showed minimal septations.

Three patients had a poorly defined heterogeneous or homogeneous region of subcutaneous fat that was hyperechoic to the fat without a completely surrounding hypoechoic halo or increased posterior through-transmission (Figures 3 and 4). Internal vascularity was seen in 1 of the 3 cases. Histologic correlation was obtained by sonographically guided biopsy in 2 cases and open biopsy in 1, which showed necrotic adipose tissue and additional granulation tissue consisting of neovascularization and lymphocytic inflammation (Figure 3) or extensive lymphocytic inflammation and vasculitis (Figure 4). In 1 case (Figure 3), MRI showed a focal intermediate signal on T1- and intermediate-weighted sequences and enhancement within the subcutaneous fat. In another case (Figure 4), MRI showed a more heterogeneous intermediate signal on T1- and intermediate-weighted sequences within the subcutaneous fat and ring enhancement after intravenous gadolinium administration. In the third case, computed tomography showed focal soft tissue attenuation, which also showed mild uptake on fluorodeoxyglucose positron emission tomography.

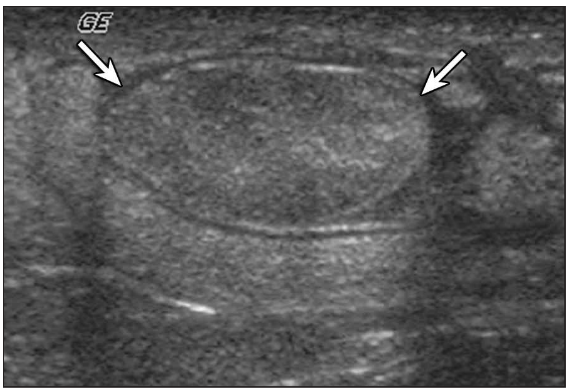
Discussion

The sonographic appearance of isolated fat necrosis of the torso or extremities has been reported as variable in the literature, often described as predominantly hypoechoic. In this research, we identified 2 appearances of fat necrosis, either appearing as a well-defined isoechoic mass with a hypoechoic halo or a poorly defined hyperechoic region, both located in the subcutaneous fat.

Subcutaneous fat necrosis is a benign entity that can often present with a palpable subcutaneous nodule of the torso or extremities. Numerous etiologies have been ascribed to fat necrosis, including trauma, cold exposure, iatrogenic injections, autoimmune disorders such as systemic lupus erythematosous or scleroderma, sickle cell disease, obstetric trauma, and vasculitis.[7] The end result has been described as vascular impairment or saponification of fat by lipase originating from blood.[5,6] The presence of antecedent trauma is variable because it may be

Figure 1. Fat necrosis of the abdominal wall proven at open biopsy in a 38-year-old woman. **A**, Sonogram showing isoechoic fat necrosis (arrows) with a surrounding hypoechoic rim. **B**, Hematoxylin-eosin stain (original magnification ×40) showing a well-demarcated lobule of fat necrosis (arrows) surrounded by a fibrous capsule (arrowhead) with complex septations and cystic areas.

A



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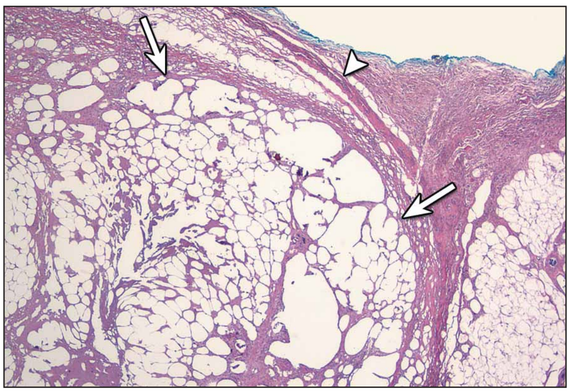


quite remote from the presentation, and patients often may not recall the inciting event, especially if it followed a minor traumatic event. In our series, none of the patients had a known history of local trauma in which fat necrosis was diagnosed. Three of our 5 cases involved the extremity, similar to what is reported in the literature, as a possible predisposing factor for local trauma.[8] Fat necrosis has been reported as more common in women, similar to 4 of our 5 patients with fat necrosis.[8]

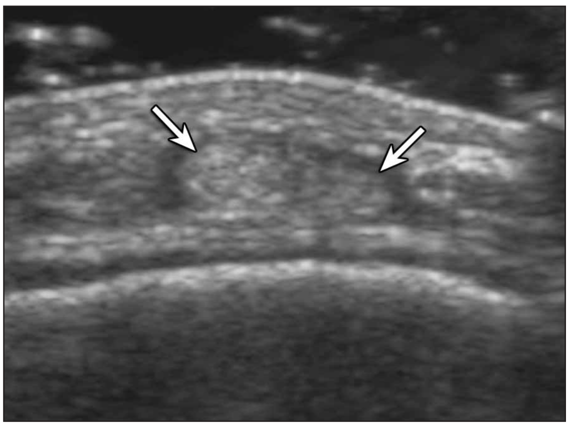
Unlike fat necrosis of the torso or extremities, fat necrosis involving the breast has been extensively reported in the literature, described sonographically as a complex irregular heterogeneous masslike process. Other descriptions include increased echogenicity within the subcutaneous tissues with variable posterior acoustic shadowing or increased through-transmission, a surrounding halo, or distortion of the surrounding parenchymal architecture.[3,4] Fat necrosis of the breast is sonographically variable, also appearing as a cystic area or solid mass.[5]

Less has been reported on the sonographic appearance of fat necrosis outside the breast. Fernando et al[5] described a case of posttraumatic fat necrosis sonographically appearing as multiple well-circumscribed hypoechoic areas encapsulated by a hyperechoic border with increased posterior through-transmission. Robinson et al[6] described the sonographic appearance of 3 subgroups of fat necrosis: those with an inflammatory infiltrate, those within a lipomatous mass, and those associated with Morel-Lavallée lesions. They described both hyperechoic and hypoechoic appearances, although 2 of their subgroups were associated with other conditions, and it was unclear how many cases represented isolated fat necrosis without confounding variables such as radiation treatment. In contrast to these prior reports, we have noted appearances of isolated fat necrosis that were isoechoic and hyperechoic to the surrounding soft tissues, often with a hypoechoic halo.

We appreciated 2 different sonographic appearances of isolated extremity and torso fat necrosis in our study. The first manifested as a well-defined isoechoic mass with a surrounding hypoechoic halo. At histologic examination, this represented focal fat necrosis surrounded by a fibrous capsule. The other manifestation was that of a poorly defined hyperechoic region in the subcutaneous fat. Histologic examination in these cases revealed inflammation in addition to necrotic adipose tissue. This hyperechoic appearance has also been described with subcutaneous inflammation from early cellulitis.[9] It is unclear why the fat necrosis had 2 distinct sonographic appearances. Possible explanations include the duration of the fat necrosis (acute versus chronic) and the extent (a solitary fat lobule versus diffuse adipose necrosis). Because of

Figure 2. Fat necrosis of the knee proven at open biopsy in a 13-year-old boy. **A**, Sonogram showing isoechoic fat necrosis (arrows) with a surrounding hypoechoic rim, which was mobile under transducer pressure. **B**, Hematoxylin-eosin stain (original magnification ×20) showing a well-demarcated lobule of fat necrosis (arrows) surrounded by a distinct fibrous capsule (arrowhead) and minimal intralesional fibrous septations.

A



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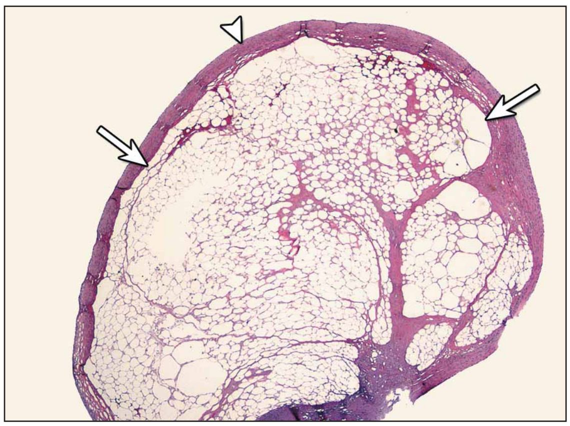


the retrospective nature of this study and small sample size, we were unable to confidently correlate these variables with the sonographic appearance to help explain the differences between the 2 sonographic appearances. Of interest, the enhancement pattern after intravenous gadolinium administration on MRI appeared as both diffuse enhancement and focal

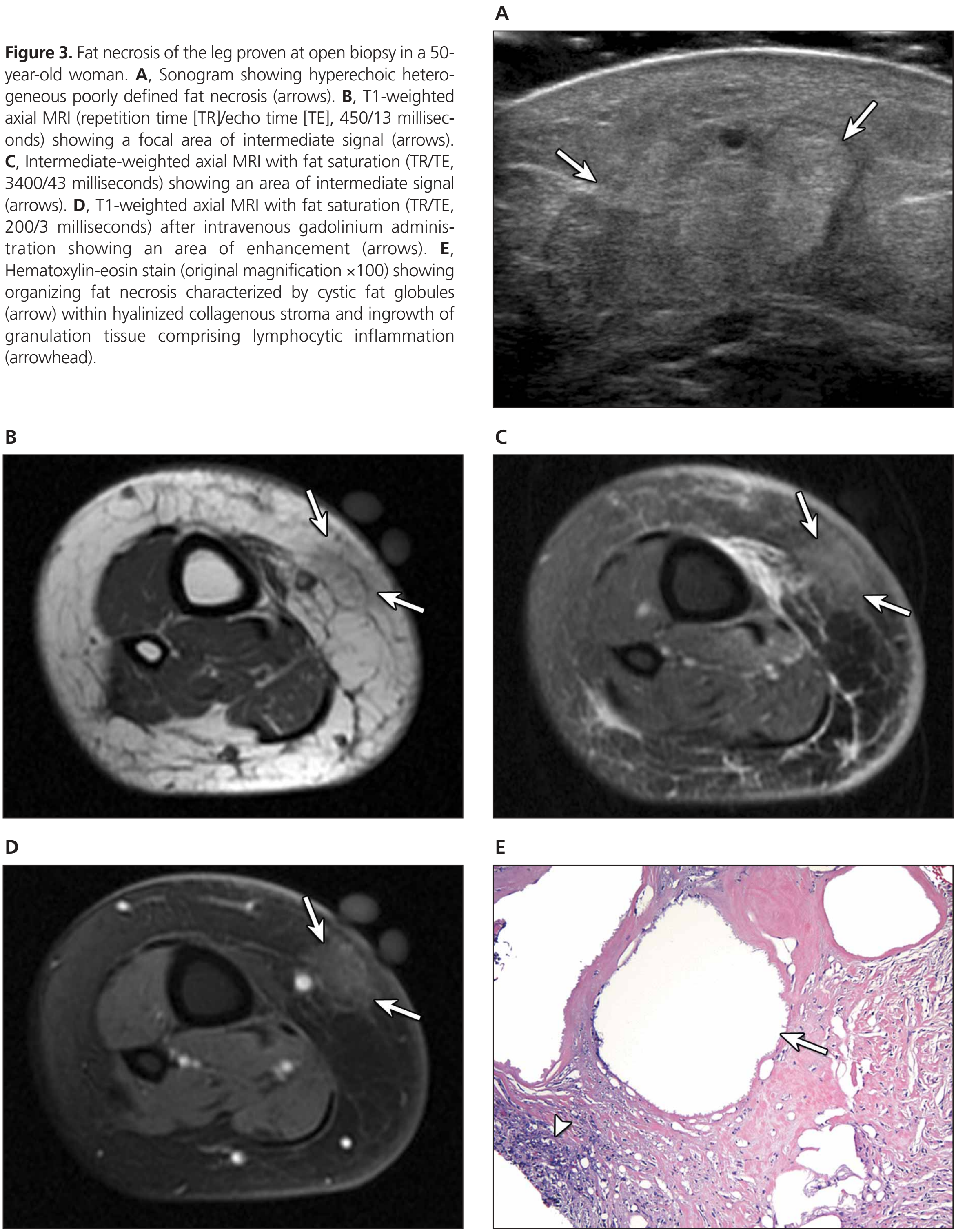


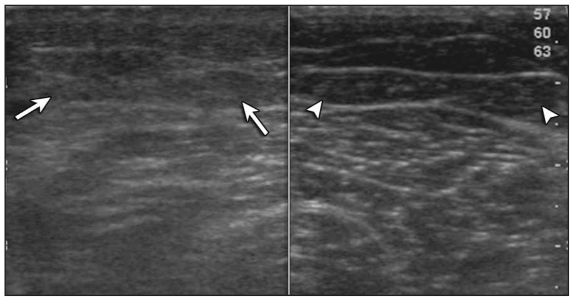
Figure 3. Fat necrosis of the leg proven at open biopsy in a 50-year-old woman. **A**, Sonogram showing hyperechoic heterogeneous poorly defined fat necrosis (arrows). **B**, T1-weighted axial MRI (repetition time [TR]/echo time [TE], 450/13 milliseconds) showing a focal area of intermediate signal (arrows). **C**, Intermediate-weighted axial MRI with fat saturation (TR/TE, 3400/43 milliseconds) showing an area of intermediate signal (arrows). **D**, T1-weighted axial MRI with fat saturation (TR/TE, 200/3 milliseconds) after intravenous gadolinium administration showing an area of enhancement (arrows). **E**, Hematoxylin-eosin stain (original magnification ×100) showing organizing fat necrosis characterized by cystic fat globules (arrow) within hyalinized collagenous stroma and ingrowth of granulation tissue comprising lymphocytic inflammation (arrowhead).

ring enhancement in the cases of poorly defined hyperechoic regions on sonography.

A differential diagnosis exists for the 2 appearances of fat necrosis seen in our patients. One cause of a hyperechoic masslike area in the subcutaneous fat is a lipoma.[10] Lipomas are variable in echogenicity because pure fat is hypoechoic, whereas the presence of interspersed fibrous tissue within a lipoma creates a hyperechoic appearance.[11] Lipomas may be well defined as seen in fat necrosis; however, lipomas are often oblong and if palpable are often soft, somewhat mobile, and nontender. Another cause of a focal hyperechoic abnormality in the subcutaneous tissues is an

Figure 4. Fat necrosis of the thigh proven at core biopsy in a 40-year-old woman. **A**, Left, Sonogram showing hyperechoic homogeneous poorly defined fat necrosis (arrows). Right, Normal subcutaneous fat (arrowheads) of the contralateral thigh. **B**, T1-weighted axial MRI (TR/TE, 716/9 milliseconds) showing a poorly defined area of intermediate signal (arrows). **C**, Intermediate-weighted axial MRI with fat saturation (TR/TE, 3316/41 milliseconds) showing a poorly defined area of intermediate signal (arrows). **D**, T1-weighted axial MRI with fat saturation (TR/TE, 160/1.5 milliseconds) after intravenous gadolinium administration showing an area of ring enhancement (arrowheads). **E**, Hematoxylin-eosin stain (original magnification ×100) showing organizing fat necrosis with necrotic adipose tissue (arrows) and granulation tissue comprising lymphocytic inflammation (arrowheads).

A



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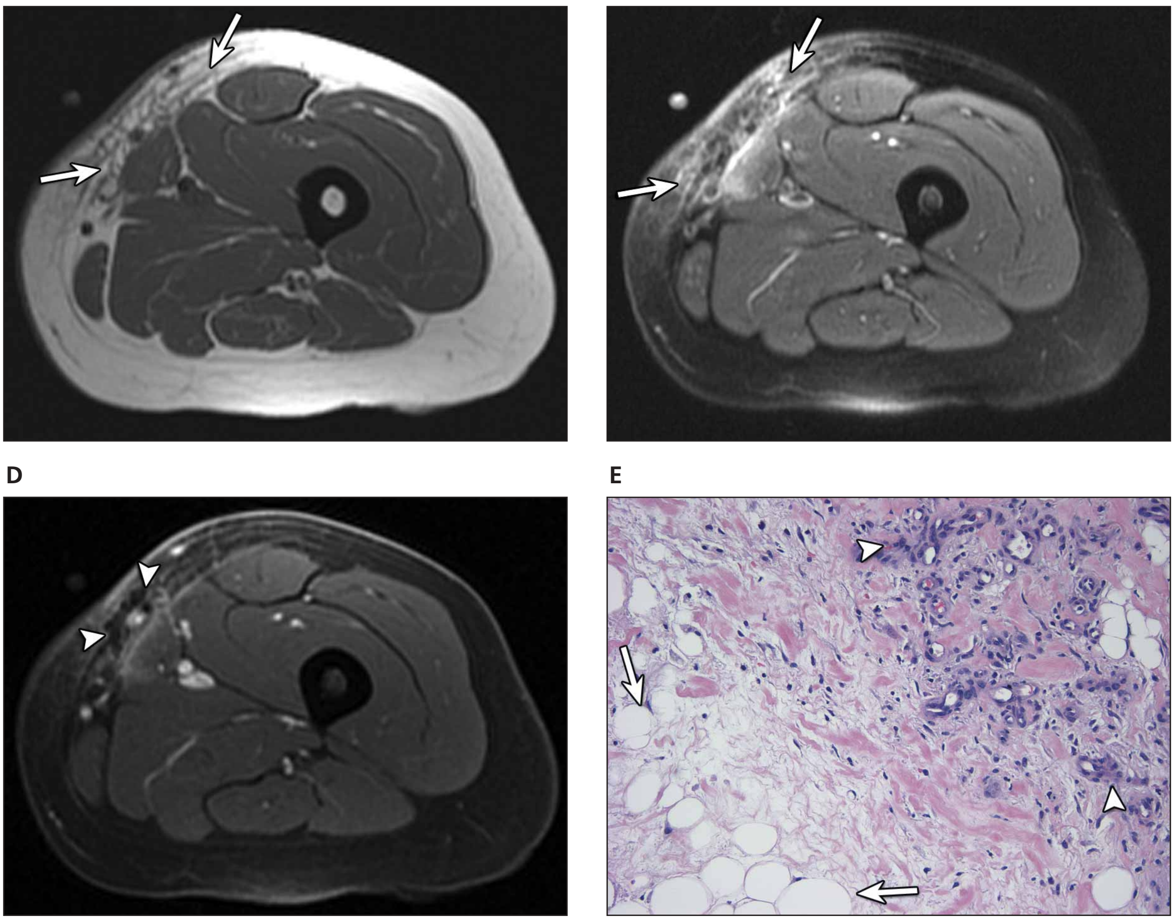

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angiomyolipoma, which is considered a vascular variant of a lipoma.[12] Angiomyolipomas account for up to 17% of lipomas. Although tender to palpation in 50%, similar to our patients with fat necrosis, angiomyolipomas are more common in men.[12] Another diagnostic consideration is an epidermal inclusion cyst; however, the presence of increased posterior through-transmission suggests an epidermal inclusion cyst instead of fat necrosis.[13] It is important to also consider a dermatofibrosarcoma protuberans in the differential diagnosis with fat necrosis because this malignant tumor can also appear as a heterogeneous echogenic mass and may potentially simulate fat necrosis.[14] With regard to the other appearance of fat necrosis in our patients, a poorly defined hyperechoic area, one must consider cellulitis.[9] Although more chronic cellulitis may appear as branching hypoechoic channels, acute cellulitis may appear as poorly defined increased echogenicity with attenuation of the ultrasound beam.

The limitations of this study included a potential selection bias because we only included cases that had biopsy; however, this was needed to provide histologic proof of our cases. Another limitation was the retrospective review of the sonograms, which introduced variability because this relies on real-time imaging and documentation of the abnormality by the individual performing the sonographic examination. Last, the low number of cases was a limitation because they may not have encompassed the entire spectrum of fat necrosis on sonography; however, our initial patient number was 1539 before applying exclusion criteria. Such criteria were needed to isolate and identify only those cases with primary fat necrosis because fat necrosis may be an incidental finding when adjacent disease areas are sampled.

In conclusion, the sonographic appearance of extremity or torso fat necrosis includes a well-defined isoechoic mass with hypoechoic halo and a poorly defined hyperechoic abnormality within the subcutaneous fat. Knowledge of these appearances will assist in the differential diagnosis of a palpable subcutaneous abnormality seen on sonography.

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