Skeletal Radiol (1992) 21:11–18

Skeletal Radiology

Imaging strategies in the evaluation of soft-tissue hemangiomas of the extremities: correlation of the findings of plain radiography, angiography, CT, MRI, and ultrasonography in 12 histologically proven cases

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Abstract. Twelve patients with the histologic diagnosis of soft-tissue hemangioma of the extremities (nine intramuscular, two subcutaneous, and one synovial) were evaluated in a retrospective study using plain film radiography ($n=12$), angiography ($n=8$), computed tomography (CT; $n=4$), magnetic resonance imaging (MRI; $n=3$), and ultrasonography (US; $n=2$). In eight of nine intramuscular lesions, the plain film demonstration of phleboliths suggested the diagnosis, while the plain radiographs were normal in three. Angiograms showed the pathognomonic features of soft-tissue hemangioma in six patients. MRI was characteristic in all three patients: The lesion demonstrated intermediate signal intensity on T1-weighted spin echo images and extremely bright signal on T2-weighting. US showed a hypoechoic soft-tissue mass in one case and a mixed echo pattern in the other. In one case, a central echogenic focus with acoustic shadowing consistent with a calcified phlebolith was identified, and one lesion exhibited increased color flow and low resistance arterial Doppler signal. CT showed a nonspecific mass in one of four cases and a mass with phleboliths in three. If a deep hemangioma is suspected, we recommend initial imaging with plain radiography followed by MRI. US may be useful in confirming the presence of a mass in doubtful cases or if MRI is unavailable. CT offers no distinct advantage over the combined use of plain radiography and MRI. Although angiography demonstrated the pathognomonic features in all six deeply situated lesions, because of its invasiveness it should be reserved chiefly for those patients undergoing surgical resection.

Key words: Hemangioma, soft-tissue – Angioma, muscular – Extremities, magnetic resonance studies

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Hemangiomas of bone are rare benign lesions, constituting 1% of all primary bone tumors [8]; extraskeletal (soft-tissue) hemangiomas are even less common [11]. Soft-tissue hemangiomas may be cutaneous, subcutaneous, intramuscular, or synovial depending on their site of origin. Cutaneous and superficial subcutaneous lesions usually do not present significant diagnostic problems to the referring physician. The bluish skin discoloration and palpable mass serve as helpful diagnostic clues. On the other hand, deeply situated hemangiomas that arise in the deep subcutaneous soft tissues, in muscle, or in synovium invariably pose diagnostic difficulties. This report seeks to provide imaging strategies for the evaluation of supsected soft-tissue hemangiomas by correlating the findings from a variety of imaging techniques in 12 patients with soft-tissue hemangiomas seen from 1987 to 1990.

Patients and methods

Twelve patients were the subjects of this investigation, seven women and five men, aged 7–45 years. Each had a histologic diagnosis of soft-tissue hemangioma; nine lesions were intramuscular, two were subcutaneous, and one was synovial. The patients were studied using plain film radiography ($n=12$), angiography ($n=8$), computed tomography (CT; $n=4$), ultrasonography (US; $n=2$), and magnetic resonance imaging (MRI; $n=3$).

US images were obtained using a computed sonographic system employing a 5 MHz linear array transducer (Acuson, Sunnyvale, CA). Evaluation included real-time imaging with color flow and pulsed Doppler performed over the soft-tissue mass. MRI was performed on a 1.5T Signa unit (GE Medical Systems, Milwaukee, WI) to obtain proton density, T1-, and T2-weighted spin echo images as well as multiplanar gradient recalled (MPGR) images in coronal, sagittal, and axial planes. Due to time constraints and the limits of patient tolerance, not all of the above pulse sequences were used in every patient; however, at least two orthogonal planes and two sequences of echo were available for review in each patient. Slice thickness and interslice gap were varied to cover the entire lesion. CT was performed with Toshiba 600S and Toshiba 900S scanners with 1-cm contiguous slices obtained with and without contrast. Protocol for contrast injection consisted of a total of

Table 1. Imaging features of 12 histologically proven soft-tissue hemangiomas

Patient no.	Sex	Age (years)	Histologic diagnosis	Imaging modalities				
				Plain films	Ultrasound	CT	MRI	Angiography
1.	♂	20	Intramuscular hemangioma (cavernous type) with features of AV malformation	Soft-tissue mass at the base of the 3rd and 4th metacarpal and phlebolith	Not done	Not done	Not done	Abnormal accumulation of contrast in dilated vascular structures
2. (Fig. 1)	♂	28	Intramuscular hemangioma with features of AV malformation in soleus muscle	Soft-tissue mass and several phleboliths	Not done	Not done	Not done	Abnormal accumulation of contrast in dilated vascular structures and AV shunting
3. (Fig. 2)	♀	34	Intramuscular hemangioma with features of AV malformation eroding the base of 5th metacarpal	Soft-tissue mass and phleboliths, associated with bony erosion and pathologic fracture	Hypoechoic mass with bony erosion and associated color flow	Soft-tissue mass eroding bone of 5th metacarpal and hamate bone; phlebolith. Contrast injection slightly enhanced mass	Mass at the base of 5th metacarpal. T1-intermediate signal intensity, T2-high signal intensity	Not done
4. (Fig. 3)	♀	34	Intramuscular hemangioma (mixed type) in pronator quadratus	Soft-tissue mass associated with phlebolith; bony erosion with periosteal reaction	Hypoechoic mass with phlebolith Lack of significant blood flow	Soft-tissue mass situated in interosseous membrane and pronator quadratus; central phlebolith; benign type of periosteal reaction. Contrast injection enhanced mass	Mass situated in the interosseous membrane. T1-intermediate signal intensity, T2-high signal intensity, T2* MPGR – high signal intensity	Not done
5.	♀	26	Intramuscular hemangioma (cavernous type) in peroneus brevis	Phleboliths	Not done	Not done	Mass lateral aspect of leg, located in peroneus brevis. T1-intermediate signal intensity, T2-high signal intensity	Not done
6.	♀	29	Intramuscular hemangioma (cavernous type) in the palmaris longus	Soft-tissue mass with multiple phleboliths	Not done	Not done	Not done	Abnormal accumulation of contrast in dilated vascular structures
7	♂	41	Intramuscular hemangioma (mixed type) in subscapularis muscle	Multiple phleboliths	Not done	Soft-tissue mass situated in subscapularis muscle with phleboliths; contrast injection slightly enhanced mass	Not done	Abnormal accumulation of contrast in dilated vascular structures
8.	♀	33	Intramuscular hemangioma (cavernous type) in lateral head of gastrocnemius	Normal	Not done	Soft tissue mass; contrast study not done	Not done	Abnormal accumulation of contrast in dilated vascular structures
9.	♀	40	Intramuscular hemangioma (mixed type) in rectus femoris	Soft-tissue mass with phleboliths	Not done	Not done	Not done	Abnormal accumulation of contrast in dilated vascular structures
10.	♀	34	Subcutaneous hemangioma (capillary type) palmar aspect of hand	Normal	Not done	Not done	Not done	Normal
11.	♂	20	Subcutaneous hemangioma (mixed type)	Normal	Not done	Not done	Not done	Normal
12.	♂	7	Synovial hemangioma in the knee joint	Joint effusion. Arthrography – lobulated filling defect in the knee joint capsule	Not done	Not done	Not done	Not done

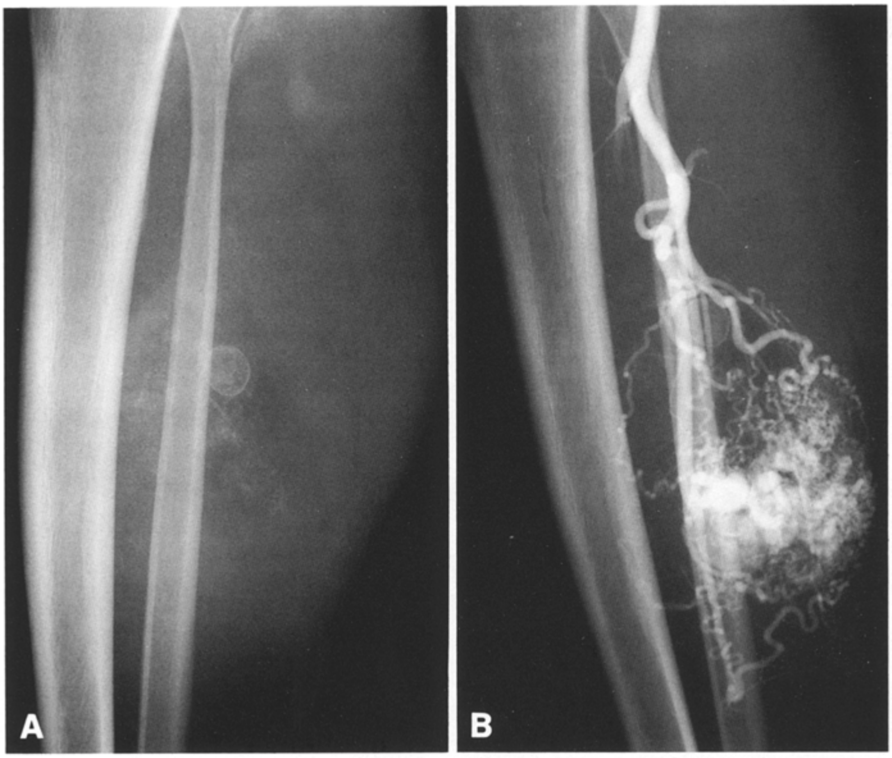

Fig. 1 A, B. A 28-year-old man with an intramuscular hemangioma in lateral head of soleus (arteriovenous type) by angiographic demonstration. **A** Plain radiograph of right leg shows large soft-tissue mass and several phleboliths, varying in size. **B** Arteriogram shows enlarged and tortuous anterior and posterior tibial arteries, arteriovenous shunting, as well as pooling of contrast into small lakes

150 cc of Conray 60 (60% meglumine iothalamate, Mallinckrodt, St. Louis, MO), injected at the rate of 2.5 cc/s for 20 s, then 1 cc/s for 100 s with a 50-s delay. Angiography was performed using standard peripheral angiographic techniques. The examinations were evaluated by two of us (A.G. and J.P.M.) with knowledge of the histopathologic findings.

Results

The findings of the various imaging studies in the 12 patients are summarized in Table 1. In eight of nine intramuscular lesions, the plain film demonstration of phleboliths suggested the diagnosis. In six intramuscular lesions, a nonspecific soft-tissue mass was seen, yet plain radiographs were normal in one intramuscular and two subcutaneous hemangiomas. In the one case of a synovial lesion in the knee joint, plain films showed joint effusion (the diagnosis was suggested by arthrography). After plain radiography, the next most commonly performed technique in this group of patients was angiography. Angiograms demonstrated the pathognomonic features of soft-tissue hemangioma – contrast pooling in dilated vascular spaces – in six of the eight patients for whom they were performed (Fig. 1). In the two remaining patients whose lesions were very superficially located subcutaneous hemangiomas, the angiograms were completely normal. CT scans were obtained in four patients. Phleboliths and slight enhancement of the soft-tissue mass after intravenous injection of contrast medium were seen in these studies, and in only one patient, a nonspecific soft-tissue mass was demonstrated (Fig. 2 A–C).

Sonography demonstrated the soft-tissue mass to be hypoechoic in one case and of mixed echo pattern in another. In one case, accompanying bony erosions could also be identified; in addition, the lesion exhibited increased color flow and low resistance arterial Doppler signal (Fig. 2 D–F). The other mass showed an absence of significant blood flow; however, it demonstrated a central echogenic focus with acoustic shadowing, consistent with the presence of a calcified phlebolith (see Fig. 3 B).

All three patients in whom MR scans were obtained had lesions that exhibited an intermediate signal intensity (higher than that of muscle but lower than that of fat) on T1-weighted spin echo imaging and a high signal intensity (brighter than that of fat) on T2-weighted imaging (Figs. 2 G, H and 3 C). In one of the these patients, the mass appeared nonhomogeneous on T1, T2, and T2* (MPGR) sequences, with only the central portion displaying a characteristic brightness in signal intensity with increased weighting (Fig. 3 A–D). The characteristic lacelike and serpentine linear structures displaying low signal intensity were identified in all three lesions.

No characteristic MR features were observed to distinguish the different histologic forms of hemangioma; however, this may be related to the relatively small number of MRI examinations performed.

Discussion

Hemangiomas, whether of bone or soft tissue, are rare, benign neoplasms. The soft-tissue types, which are less

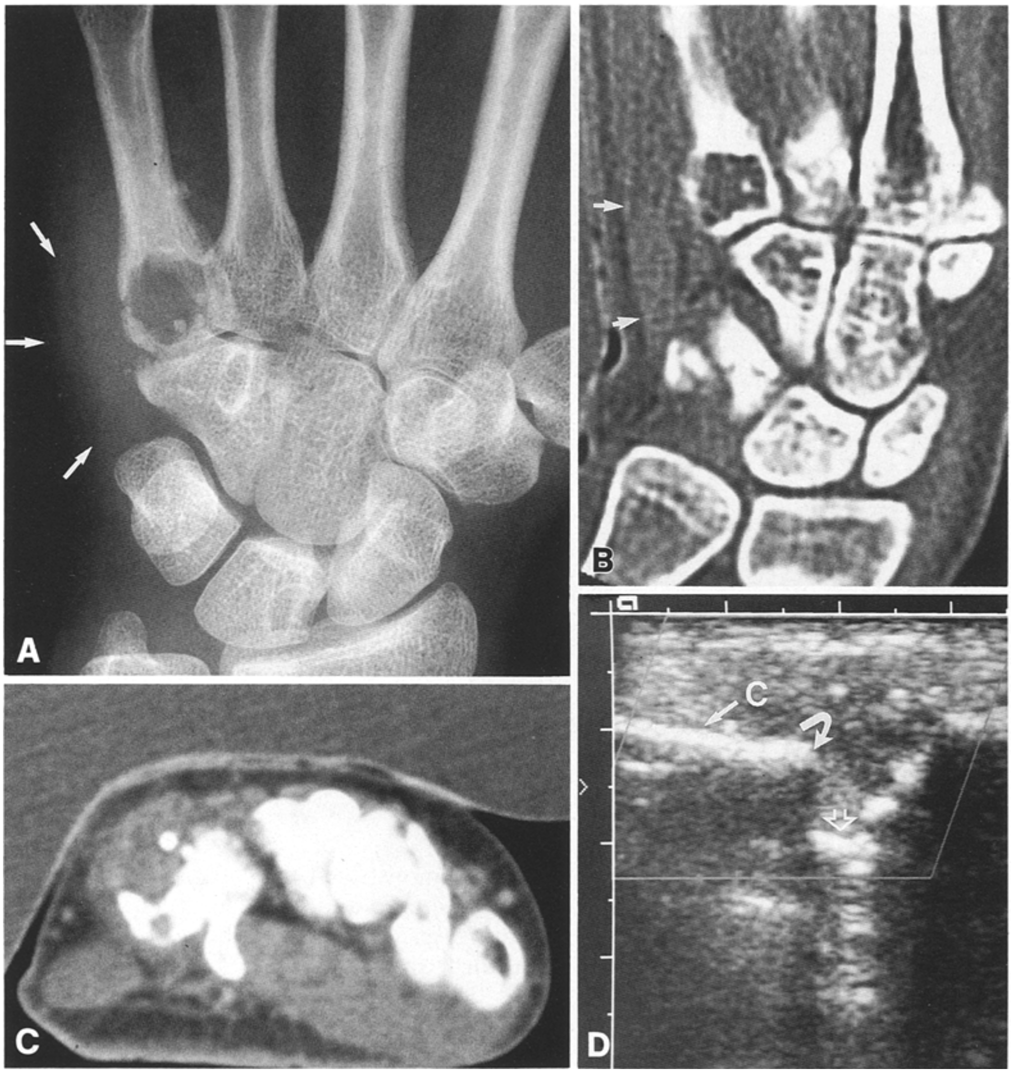

Fig. 2A–H. A 34-year-old woman with intramuscular hemangioma eroding base of fifth metacarpal. (*Figure and caption continued next page*)

common than hemangiomas of bone, most often arise in the skin and subcutaneous tissues; muscle and synovium are less frequent sites of origin. Soft-tissue hemangiomas exhibit a variety of clinical and histologic patterns that permit classification into several types. Five types are identified on the basis of their histologic features: cavernous, venous, arteriovenous, capillary, and mixed [1].

The *cavernous* and *mixed* types of hemangiomas are vascular in their gross appearance, exhibiting a blue-red, hemorrhagic cut surface. Microscopically, a cavernous lesion consists of large, dilated, thin-walled vessels lined by flattened endothelial cells. The mixed type of hemangioma is marked by microscopic features combining those of the cavernous and the capillary types. In its gross appearance, a *capillary* hemangioma usually has a spongy texture, and its vascular nature is not apparent until microscopic sections are reviewed, revealing a disordered proliferation of capillary-sized blood vessels lined by endothelial cells with plump nuclei. Microscopy may show marked mitotic activity in a capillary hemangioma, but this finding does not indicate malignancy [11]. *Venous* hemangiomas are most common in deep locations; in the muscles they present as large conglomerates of gaping venous vessels. Histologically they are distinguished from capillary and cavernous hemangiomas by the fact that their vessels are thick-walled [11]. The *arteriovenous* type may be superficial, occurring as small asymptomatic nodules; it may also be located at a deep site and associated with a variable amount of shunting. Lesions with shunting may show altered flow characteristics. In response to high pressures, vessels may become stenotic due to myointimal proliferation, which leads to decreased flow and thrombosis.

Soft-tissue hemangiomas may recur. The mixed type has the greatest tendency for local recurrence (as many as 28% of cases), followed by the capillary (20%) and the cavernous (9%) types [11]. The reason for the higher rate of recurrence of the mixed type is unknown.

Intramuscular lesions represent the most common type of deep soft-tissue hemangioma, although they are themselves still quite rare [25]. In Watson and McCarthy's study, only 0.8% of hemangiomas were intramuscular [24], a frequency confirmed by Derchi and

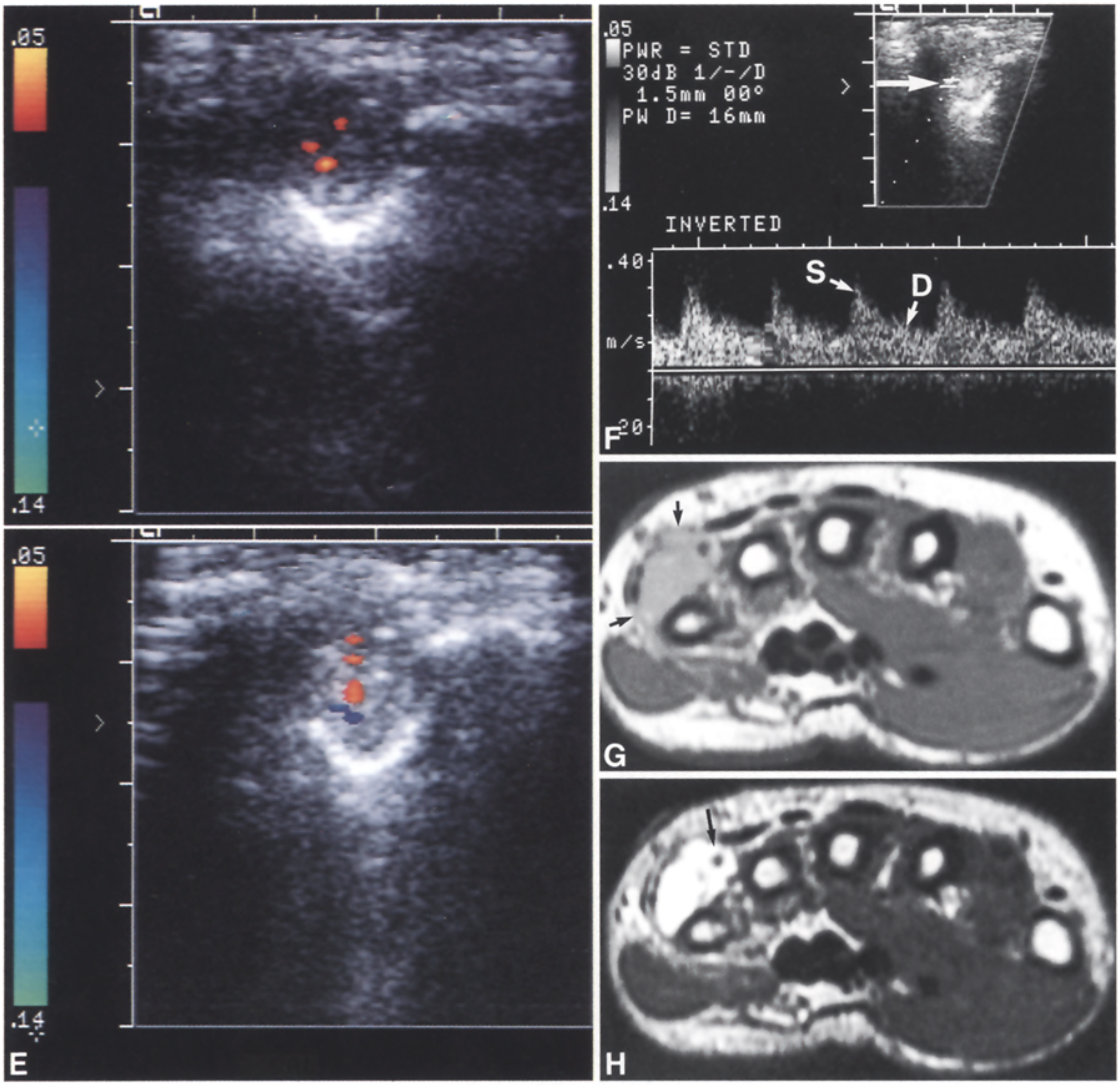

Fig. 2. A Plain radiograph of the left hand shows soft-tissue mass situated medially to the base of fifth metacarpal and extending to the carpus (*arrows*). Within eroded bone, three phleboliths are identified. **B** Coronal CT scan shows soft-tissue mass (*arrows*), bony erosion, and phlebolith. **C** Axial CT scan shows erosion of hamate (not well appreciated on plain films), dorsal extent of soft-tissue mass, and lack of invasion of subcutaneous tissues. Phleboliths are well demonstrated. **D** Parasagittal ultrasound scan demonstrates cortex of fifth metacarpal (*C*), interrupted at its base (*curved arrow*) by mass which extends to volar aspect of patient's hand (*open arrow*). **E** Transverse scan through mass shows colored areas in red and blue corresponding to arterial and venous flow within hemangioma. **F** Color flow image is used to place pulsed Doppler cursor (*arrow*) to arterial branch which has uncharacteristic peripheral arterial velocity, in that there is forward flow not only during systole (*S*), but also diastole (*D*), indicating low resistance arterial pattern. **G** T1-weighted spin echo (TR 600/TE 20) axial MR image shows intermediate (higher than muscle but lower than fat) signal intensity mass, adjacent to fifth metacarpal (*arrows*). **H** T2-weighted spin echo (TR 2000/TE80) axial MR image shows mass to be brighter than fat. *Arrow* points to phlebolith

colleagues in a more recent study [9]. More than 85% of cases occur in the first 3 decades of life [11], most during childhood and adolescence [2, 12]. The diagnosis of intramuscular hemangioma is rarely suspected clinically. The lesions usually do not exhibit any of the vascular signs characteristic of superficial hemangiomas, and there is rarely any overlying skin discoloration or bruit. A smooth, mobile, soft-tissue swelling is the most common presentation; there may or may not be accompanying pain [25], although the mass is usually painful to palpation [9]. The duration of symptoms ranges from 2 months to 18 years [1, 25].

When intramuscular lesions are small, they are extremely difficult to detect, even if they are symptomatic. Because they grow rapidly, skeletal muscle hemangiomas may easily be misinterpreted as malignancies [1, 10–12].

Imaging studies

Plain radiography, xeroradiography, CT, MRI, US, scintigraphy, and angiography may be helpful in the evaluation of soft-tissue hemangiomas.

The findings on plain radiographs are usually helpful

Fig. 3A–D. A 34-year-old woman with intramuscular hemangioma in pronator quadratus (mixed type). **A** PA radiograph of distal forearm shows well organized periosteal reaction at lateral aspect of ulna and medial aspect of radius with overlapping phlebolith (*arrow*). **B** Ultrasound demonstrates a hypoechoic mass with a central echogenic focus (*curved arrow*) and acoustic shadowing (*arrows*), consistent with calcified phlebolith. **C** T2-weighted spin echo (TR 2000/TE 80) axial MR image shows mass to be of higher intensity than fat. Central phlebolith demonstrates low signal intensity. **D** T2* gradient echo (MPGR) coronal MR image of distal forearm demonstrates the mass (*arrows*) to be inhomogeneous in appearance: Central areas of high signal intensity are surrounded by areas of intermediate signal intensity. Pathologic sections revealed mixed type hemangioma, with a central portion representing a largely cavernous component and a capillary component at the periphery

in diagnosing and characterizing soft-tissue hemangiomas, although on occasion the findings are normal. Most often, plain films reveal abnormal soft tissues and/or a mass lesion. Demonstration of phleboliths, as occurred in eight of the nine patients with intramuscular masses, is a more specific finding for soft-tissue hemangiomas. As lesions increase in size, plain films may show associated bone erosion.

Xeroradiography is a less commonly used modality that yields similar findings to those of plain radiography. Although an uncommon finding, dilated vessels may be more readily identified by this technique.

Scintigraphy employing technetium 99m is rarely used in the evaluation of soft-tissue hemangiomas, usually being reserved for cases in which plain films reveal bony destruction. In the rare instances in which technetium has been observed to accumulate in soft-tissue hemangiomas, the finding was not considered pathognomonic of the lesion [18].

Computed tomography may achieve better delineation of a mass seen on plain films given its superior definition of soft tissues and associated bone involvement, as well as its greater sensitivity in detecting associated phleboliths [16]. Moreover, scans obtained after injection of contrast may show some enhancement of the mass. CT may also be useful in excluding some other soft-tissue masses such as lipomas, which are well demarcated and display low density attenuation. Except, however, for the detection of phleboliths or occasional bony erosion, CT demonstrates no other characteristic features of hemangioma.

Angiography may supply more definitive information about the nature of soft-tissue hemangiomas, although small, peripherally located lesions may show no abnormal findings [20]. In a recent case report by Yao and Lee, angiography was effective in confirming the presence of a hypervascular tumor consistent with hemangioma in a patient whose plain films showed a surface hemangioma of the ulna exhibiting prominent bony sclerosis, thus mimicking osteoid osteoma [26]. On the other hand, a report by Yuh et al. suggests that angiography may not always be helpful in studying these lesions [27].

In our experience, except for very superficial lesions, angiography was useful in planning a surgical approach.

Sonography is often used together with plain radiography as the first imaging procedure in patients with suspected soft-tissue masses [12]. It is widely used in the study of disorders of skeletal muscles and tendons because of its capability of imaging these tissues [3, 13, 14]. Derchi et al. reported that sonography was effective in identifying an intramuscular mass in each of the seven patients in their study of the sonographic appearances of skeletal muscle hemangiomas [9]. In the two cases we report, US demonstrated the masses and their extent, as well as accompanying bone involvement in one case and a calcified phlebolith in the other. The report by Derchi et al. seems to imply that the real-time US appearance of soft-tissue hemangiomas is not pathognomonic. Yet sonography did demonstrate a central echogenic focus with acoustic shadowing consistent with a calcified phlebolith centrally within the mass in one of our patients. Sonography may also be useful in guiding biopsy of a nonpalpable soft-tissue mass in selected cases. It is doubtful whether fine needle aspiration biopsy of a soft-tissue hemangioma would be useful in establishing the diagnosis; however, rapid return of blood with biopsy may suggest the diagnosis.

We can find no reports on the use of Doppler sonography or color flow imaging in the evaluation of soft-tissue hemangiomas. We employed both techniques in the two cases in which US was used. In one case, an intramuscular hemangioma with features of an AV malformation at the base of the fifth metacarpal showed increased color flow within the mass and an abnormal low resistance arterial Doppler signal marked by forward flow during both systole and diastole. This is in contrast to the normal pattern in peripheral arteries – forward flow during systole but reversal of flow during diastole – and indicates high vascular resistance. In the other case in which Doppler was used, an intramuscular hemangioma of the mixed type, no Doppler signal was noted. This finding could be expected of such a lesion, because flow within most hemangiomas, except for the arteriovenous type, is so slow that it is below the sensitivity of most Doppler instruments.

Recently, there have been several reports that have suggested a significant role for MRI in the diagnosis of soft-tissue hemangiomas [4–7, 15, 17, 19, 21–23], one study even recommending it as the diagnostic procedure of choice when an intramuscular hemangioma is suspected [27]. The MR findings for these lesions consist of an intermediate signal intensity on T1 weighted spin echo images and a strikingly intense signal on the T2-weighted spin echo images; these are characteristic but not pathognomonic. This appearance is reported by Hawnaur et al. in a study involving 11 patients with intramuscular and deep soft-tissue hemangiomas [15]. They described the signal intensity of these masses as being intermediate between that of fat and muscle on T1-weighted spin echo images, and the borders of the lesion appeared rather indistinct. T2-weighting revealed lesions with well-defined margins, appearing brighter than fat and exhibiting lobulations; heavily T2-weighted images showed the best contrast differentiation between the hemangioma and the surrounding normal tissues. Heterogeneous signal was noted on both T1- and T2-weighted images. These areas of heterogeneous signal correspond to flowing blood in serpentine vessels. This feature is corroborative evidence of soft-tissue hemangiomas.

Nelson et al. [19] described a similarly increased signal intensity with more heavily T_2-weighted images. They conclude that prolonged T2-weighted images (TR 2000 ms, TE 150 ms) together with standard spin echo T1 and T2 pulse sequences are a good substitute for contrast-enhanced CT and arteriography in evaluating these lesions.

This high signal intensity of deep soft-tissue hemangiomas on T2-weighted MR images appears to be related to the prolonged T2 relaxation time of these lesions compared with the relatively short one of normal muscle. The morphology of hemangiomas probably also contributes to their characteristic MR appearance. Although they are vascular tumors, they contain variable amounts of nonvascular tissue such as fat, smooth muscle, fibrous tissue, myxoid stroma, hemosiderin, thrombus, and even bone [1, 15]. Thus, a high signal intensity may reflect pooling of blood within cavernous spaces, slow flow within dilated venous channels, and thrombosis or fatty elements within the lesions. Buetow et al. described a marked hyperintensity of hemangiomas on T2-weighted images that appeared to be related to increased free water within stagnant blood pooled in larger vessels of the lesions [5]. Moreover, they identified low-signal linear structures representing fibrous septa between vessels throughout the lesions. High-intensity, lacelike, and linear patterns within the tumor represented fat between the vascular elements, a feature to be emphasized. Likewise, Yuh et al. [27] stressed that hemangiomas are more likely to exhibit an overall nonhomogeneous pattern with serpentine areas and signs of muscle atrophy.

Conclusions

Cutaneous and subcutaneous hemangiomas usually pose few diagnostic difficulties, and we agree with Palmieri [20] that, when a subcutaneous hemangioma is suspected on clinical examination, it should be excised without resort to expensive invasive diagnostic procedures. Deeply situated and intramuscular soft-tissue hemangiomas, on the other hand, are difficult to detect and are often misdiagnosed. The choice of imaging modality or modalities facing the clinician presented with a deeply sited, focal, soft-tissue swelling is dictated, not only by the clinical appearances, but also by the availability of equipment and expertise, the time and cost of procedures, and restrictions referable to individual patients (e.g., allergy to ionic or nonionic iodinated contrast agents). All these considerations should work to discourage redundant studies. Thus, when a deep hemangioma is suspected, we recommend plain radiography followed, if necessary, by MRI. Plain films have proved to be useful in demonstrating soft-tissue masses, phleboliths, and erosions, but MRI has been shown to provide more specific information, making possible the identification of characteristic (although not pathognomonic) features such as the presence of low-signal linear and serpentine structures throughout the lesion and strikingly intense signal with a heavy T2-weighting. Sonography may also be used to confirm a mass or if MRI is not readily available. Angiography may be called upon to demonstrate further the vascularity of a mass and provide a road map for surgical resection. For example, if physical examination reveals a bruit in a very vascular lesion or US demonstrates a characteristic low-resistance flow pattern, angiography can identify vessels feeding the lesion or an associated AV malformation. Since MRI cannot differentiate feeding arteries from draining veins, angiography is required in those instances in which embolization is contemplated or in cases with potential difficulties for surgical resection. CT scanning should be reserved for further delineation of osseous involvement.

Acknowledgement. We would like to express our thanks to Valerie Anderson for her invaluable secretarial assistance in preparation of this manuscript.

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