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Magnetic Resonance Imaging of Fluid Levels in an Aneurysmal Bone Cyst and in Anticoagulated Human Blood

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Abstract. Magnetic resonance imaging (MRI) demonstrated a fluid level within an aneurysmal bone cyst (ABC). Since the ABC contained gross blood at operation, an anticoagulated human blood sample was studied by MRI also, and a fluid level was again clearly visible. MRI pulse sequences emphasizing T_1 contrast showed the fluid levels most clearly in both the ABC and the blood. Sequences emphasizing T_2 contrast showed homogeneous, bright signals in the ABC and in the blood, with no visible fluid level in the ABC and a nearly invisible one in the blood. In the blood sample, the calculated plasma T_1 value was 1585 ms, and that of the red cells was 794 ms.

Key words: Magnetic resonance imaging – Aneurysmal bone cyst – Neoplasms, musculoskeletal

Fluid levels have been detected by computed tomography (CT) within aneurysmal bone cysts (ABCs) and telangiectatic osteosarcomas; both lesions characteristically contain large spaces filled with blood or bloody fluid [3, 4]. We detected fluid levels by magnetic resonance imaging (MRI), as well as CT, of an aneurysmal bone cyst. We also performed MRI on a sample of human blood, and we wish to discuss the characteristics of the fluid within the ABC and of the human blood, as disclosed by MRI with various pulse sequences.

Materials and Methods

Computed tomography was performed on a Philips Tomoscan 310 unit using intravenous iodinated contrast medium infusion.

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MRI of the patient and the human blood sample were performed using a Technicare Teslacon 0.15 Tesla unit. For the clinical study, a series of two-dimensional images were obtained using spin-echo (SE) techniques at repetition rates (TR) of 500 and 1000 ms, and echo delay times (TE) of 30 and 60 ms. An inversion-recovery (IR) image was obtained with TR = 1,500, TI = 450 ms, and TE = 30 ms. For the experimental study, a unit of expired human blood contained in a plastic bag was obtained from the blood bank and allowed to stand upright overnight to permit most of the red blood cells to settle. The bag was then placed upright in the MRI machine and a series of two-dimensional images was obtained. Intensity measurements obtained using a moveable region-of-interest cursor were plotted against time (in ms) for four separate SE sequences at TE = 30 ms, and TR = 250, 500, 1,000, and 1,250 ms. Then, T_1 relaxation values of the supernatant plasma and the dependent red cells were calculated using a four-point nonlinear least squares program. SE images also were obtained with TR = 1,000 ms and TE = 60 and 120 ms. An IR image was obtained using TR = 1,500 ms, TI = 450 ms, and TE = 30 ms.

Case Report

A 16-year-old boy complained of pain and swelling in the distal right fibula for two months. A plain radiograph revealed a lytic, expansible lesion of the distal fibular metaphysis (Fig. 1 A). CT disclosed an expansile lesion containing a distinct fluid level (Fig. 1 B). MRI also disclosed a distinct fluid level on the SE images with TE = 30 ms. The upper area produced a medium intensity signal while the dependent area produced a much brighter signal (Fig. 1 C). When the TE was increased to 60 ms, the signal became homogenously bright throughout the entire lesion and no fluid level was visible (Fig. 1 D). The IR image disclosed two fluid levels with upper areas of very low signal intensity and dependent areas of moderate signal intensity (Fig. 1 E). The lesion was curetted and bone grafted after incisional biopsy yielded a diagnosis of aneurysmal bone cyst. Gross fluid resembling normal blood was found in the cyst.

Blood Sample

The MRI of the human blood sample disclosed a very sharp fluid level on the SE images with TE = 30 and 60 ms. The supernatant plasma produced a moderately intense signal while the dependent red blood cell portion produced a much brighter signal (Fig. 2 A and B). When the TE was increased to 120 ms, the SE image showed a nearly homogeneous, moderately bright signal throughout the bag of blood, with no or only a barely

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visible fluid level (Fig. 2C). The IR image also showed the fluid level, with a very low signal from the plasma (Fig. 2D). The calculated T_1 of the superantant plasma was 1,585 ms and the calculated T_1 of the dependent red blood cell portion was 794 ms.

Discussion

Aneurysmal bone cysts (ABCs) are lytic, expansile lesions that most often occur in the distal parts of long bones or within the posterior spinal elements of patients less than 20 years old. Pathologically, they contain fibrous and vascular tissue that forms thin membranes or even large solid areas. They also contain spaces that vary from tiny cysts to large cavities occupying most of the lesion, and the spaces are filled with blood, clear fluid, or blood-tinged fluid [5].

Computed tomography can demonstrate fluid levels within ABCs [3, 4]. Demonstration of fluid levels depends upon the lesion remaining motionless for a period of time sufficient to allow the fluid components to layer out, and upon viewing and photographing the images at a sufficiently narrow window width [4]. However, detection of fluid levels does not correlate with the type of fluid found within the ABC at operation [4].

Early experience suggests that MRI, like CT, can help characterize and define the extent of bone and soft tissue tumors [1, 2, 6]. One of the lesions reported was a fluid-filled sacral cyst which exhibited a low intensity signal (dark appearance) on a SE image [6].

The only bone lesions in which fluid levels have been imaged by CT are ABCs and telangiectatic osteosarcomas [3, 4], although in the future fluid levels may be found in other lesions, especially ABCs arising secondarily within other primary bone lesions. In the case we report, the demonstration of fluid levels within the lesion, in combination with the patient's age and the location and plain radiographic appearance of the lesion, strongly suggested the correct diagnosis of ABC. The detection of fluid levels by MRI is not surprising, but it is difficult to be certain of the exact correlation between the types of fluid found within the lesion and the MRI appearance. We used human blood as a model for the fluid contained within the ABC since fluid resembling blood was found in this lesion at surgery, but this fluid was not available for study. Not all ABCs contain blood; some contain a serous fluid and some contain little free fluid at all. Nonetheless, anticoagulated human blood seemed a reasonable model to use for MRI study to compare with the clinical MRI images.

The calculated T_1 of the supernatant plasma of the blood sample was nearly twice the calculated T_1 value of the dependent red blood cell portion. The IR image showed a very sharp, distinct fluid level with a moderately bright signal from the dependent red blood cells, and a much weaker signal from the supernatant plasma. This is consistent with the calculated T_1 values, since IR images are heavily T_1 dependent, shorter T_1 values yielding brighter signals. SE images are influenced by T_1 and T_2 values, as well as proton density. As TE is increased, SE images reflect more T_2 contrast. The SE images of the blood sample with relatively short TE values of 30 and 60 ms showed fluid levels, but when the TE was increased to 120 ms, the fluid level was nearly invisible. Since the IR image, depending heavily on T_1, also showed the fluid level clearly, we conclude that the signal intensity difference between plasma and red blood cells that created the visible fluid level was due chiefly to the difference in T_1 values. When the images were more T_2 dependent, the fluid level was invisible or only barely perceptible; therefore the T_2 values of plasma and red cells must have been similar.

The clinical MRI images of the aneurysmal bone cyst reflected the same characteristics. The SE with TE = 30 ms showed a distinct fluid level, with a very bright signal from the dependent part of the lesion and a lower signal from the upper part of the cyst. When the TE was increased to 60 ms, there was no visible fluid level. Instead, there was a homogeneous, very bright signal from the entire ABC. The IR image of the ABC showed two distinct fluid levels with very dark areas of low signal intensity superiorly, and moderately bright areas of high signal intensity in the dependent areas. Thus, the clinical MRI images suggested a fluid within the ABC similar to uncoagulated blood, with a considerably higher T_1 value for the supernatant plasma compared to the dependent red blood cell portion, and probably very similar T_2 values of the two components. Although the SE 1000/60 image did *not* show a fluid level within the ABC, it *did* show a fluid level in the blood sample. Only the SE 1000/120 image of blood failed to show clearly a fluid level. This difference between the ABC and the blood sample may indicate that the fluid within the cyst, while similar, was not identical to blood.

MRI demonstration of fluid levels within a bone lesion strongly suggests the diagnosis of aneurysmal bone cyst. Telangiectatic osteosarcoma should also be considered, and in the future other lesions may be found to contain fluid levels as well. In the case we report, the MRI characteristics

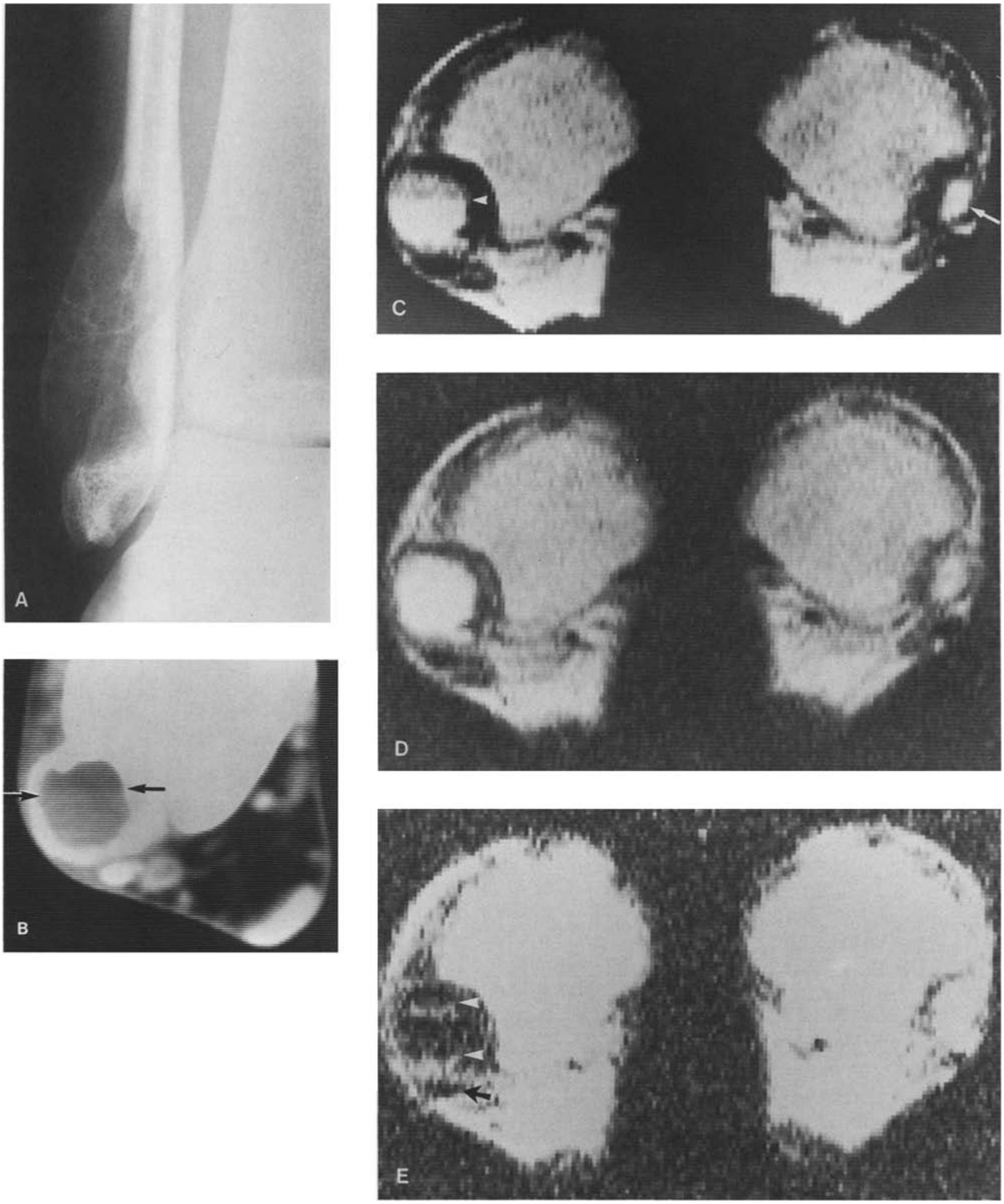

Fig. 1A–E. Aneurysmal bone cyst. **A** Typical ABC: an eccentric, lytic, expansile lesion of the distal fibular metaphysis. **B** CT shows fluid level (*arrows*) within expansile lesion. **C** SE 1,000/30 image shows fluid level (arrowhead). High intensity (bright) signal from dependent red-cell component; medium intensity signal from supernatant plasma. Uniform, bright signal from fatty marrow of normal left fibula (*arrow*). **D** SE 1,000/60 image shows, uniform, high intensity (*bright*) signal from the ABC. **E** IR 1,500/450/30 image shows two fluid levels (*arrowheads*). Medium intensity signal from dependent red cells; very low intensity (*dark*) signal from plasma. *Dark area* posterior to fibula (*arrow*) represents tendons (similar *dark area* on SE images also)

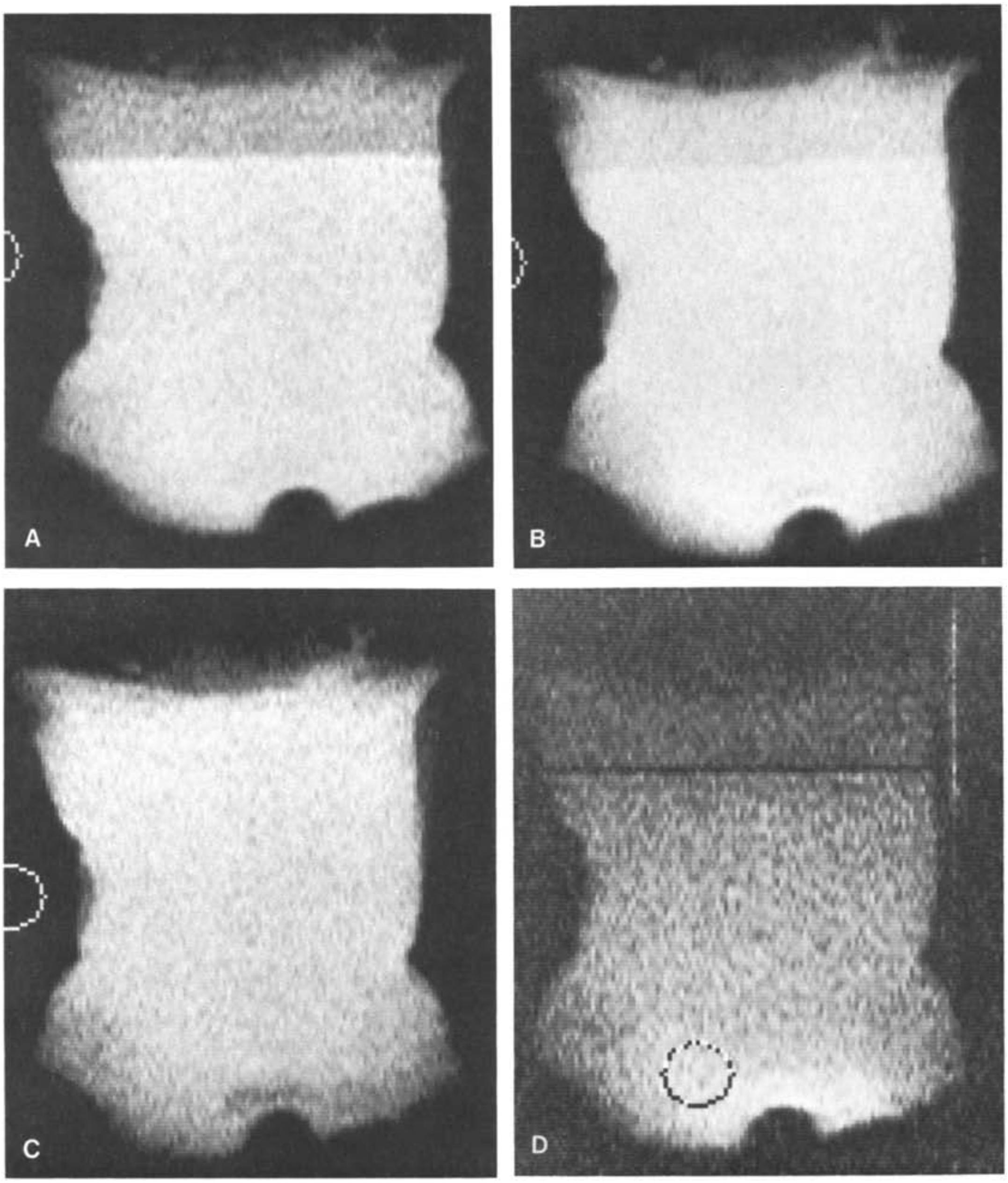

Fig. 2A–D. Anticoagulated human blood. **A** SE 1,000/30 image shows fluid level, bright signal from red cells, and lower intensity signal from plasma. **B** SE 1,000/60 image still shows fluid level, but there is less difference between the upper and lower signal intensities. **C** SE 1,000/120 image shows uniformly bright signal with nearly invisible fluid level. **D** IR 1,500/450/30 image shows fluid level. Signal intensities are less than SE images; very low signal from plasma

strongly suggested the presence of uncoagulated blood within the ABC. Further experience may demonstrate the ability of MRI to characterize other fluids contained within bone cysts.

References

1. Brady TJ, Gebhardt MC, Pykett IL (1982) NMR imaging of forearms in healthy volunteers and patients with giant-cell tumors of bone. Radiology 144:542
2. Brady TJ, Rosen BR, Pykett IL, McGuire MH, Mankin HJ, Rosenthal DI (1983) NMR imaging of leg tumors. Radiology 149:181
3. Hertzanu Y, Mendelsohn DB, Gootschalk F (1984) Aneurysmal bone cyst of the calcaneus. Radiology 151:51
4. Hudson TM (1984) Fluid levels in aneurysmal bone cysts: A CT feature. AJR 141:1001
5. Jaffe HL (1950) Aneurysmal bone cyst. Bull Hosp Joint Dis 11:3
6. Moon KL Jr, Genant HK, Helms CA, Chafetz NI, Crooks LE, Kaufman L (1983) Musculoskeletal applications of nuclear magnetic resonance. Radiology 147:161