Imaging Features and Review Literature of Aneurysmal Bone Cyst

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Aneurysmal bone cyst (ABC) accounts for 1.4% of all bone tumors and 15% of all primary spinal tumors. Radiography shows an eccentric ballooned or aneurysmal, expanded radiolucency, mostly in the metaphysis of long bone. The margin of ABC is usually well circumscribed with or without a sclerotic rim. Trabeculation is sometimes seen in the lesion but without significant mineralization or calcification. In spine, it demonstrates a purely lytic lesion in the posterior elements and body. Six patients in our hospital with primary ABC with histopathologic confirmation were studied with conventional radiographs, contrast-enhanced computed tomography study, contrast-enhanced MRI study and nuclear medicine bone scintigraphy separately. All cases showed expansile radiolucent lesions with soup bubble appearance and one case with pathologic fracture. Relevant literature was also reviewed. We discuss and emphasize characteristic imaging features and clinical course of ABC.

Key words: Bone, neoplasm; Computed tomography (CT); Magnetic Resonance Imaging

Aneurysmal bone cysts (ABCs) was first introduced by Jaffe and Lichtenstein in 1942 and in more detailed description in 1950. Thereafter, several new series of studies were reported, even though some of them consisting of part of previously described cases [1, 2, 3, 4].

Jaffe reserved the adjective “aneurysmal” for vascular, cystic lesions characterized by an eccentric distension of bone, a feature best seen on radiography. ABCs are “benign” solitary bone tumors characterized by unique “blown out or soap bubble” radiolucency [1, 2, 3, 4].

The purpose of this paper is to describe the clinical course, radiographic features of ABCs characterized by computed tomography (CT), magnetic resonance imaging (MRI) and nuclear medicine (NM) as well as imaging follow-up after treatment of ABCs.

MATERIALS AND METHOD

From March 1993 to March 2005, six patients with primary aneurysmal bone cysts of the bone were studied. The ages of these patients ranged from 8 to 47 years (mean, 22.5 years). Four patients were male and two were female. All patients had conventional radiographs (Anteroposterior view). Three patients also underwent computed tomography (Siemens Somatom plus 4A or Siemens Somatom sensation 16) with intravenous contrast media injection (Iopamiro 370; Bracco s.p.a. Italia; 1-1.5ml per kilogram of body weight). Transverse CT images were obtained with 3-8mm section thickness, with bone and/or soft-tissue windows available for review. Two patients underwent magnetic resonance imaging (Siemens Magnetom Symphony, 1.5T) with intravenous injection of gadopentetate dimeglumine (Magnevist; Schering, Berlin, Germany; 0.1mmol per kilogram of body weight). MR images available for review included T1-weighted spin-echo (520-700/12-20 [repetition time msec/echo time msec]), T2-weighted spin-echo (2900-
3200/96-108), and contrast-enhanced T1-weighted spin-echo images. Four patients underwent nuclear medicine bone scintigraphy (G-E Helix) ([512 x 512], Te99m, energy window: 10%, speed: 30cm/min).

Images were reviewed in consensus by experienced musculoskeletal radiologist with complete knowledge of the pathologic findings. Images were obtained with radiography (n = 6), bone scintigraphy (n = 4), CT (n = 3), and MR imaging (n = 2). Evaluation of the anatomic site included the specific bone affected (proximal or distal for long bone lesions) and side involved. Tumor size and character appearance were determined. Pathologic material was reviewed in an attempt to correlate with the imaging findings in all the patients.

RESULTS

Six cases of primary aneurysmal bone cysts occurred in the following sites. One each was located in the right proximal radius, left proximal femur, medial condyle of left distal humerus (Fig. 1), right patella, right proximal tibia and T10 vertebra.

The clinical symptoms of these patients included joint pain, limited range of motion, soft tissue mass. Severe back pain was found in one case.

Radiographic features revealed “soap bubble” or blow out” radiolucent lesions. One case was associated with pathologic fracture. Obliteration of spine pedicle was noted on the conventional radiography (Fig. 3a).

CT scan demonstrated the intraosseous and extraosseous extents of the lesion. Cortical thinning and multiple septal-like structures were noted within the tumor. Fluid-fluid levels may be seen in the cysts when the scans are obtained in the plane perpendicular to that of the fluid levels.

T1-weighted images showed predominantly low-to-intermediate signal intensity with or without fluid levels. T2-weighted images showed areas of low-to-intermediate signal intensity or some areas of heterogeneous high signal intensity. A rim of low signal intensity with internal septa generated a multicystic appearance.

All the bone scan showed increased radioactivity (Fig. 3d).

All tumors were proven to be aneurysmal bone cysts by histopathologic study from surgical specimens of biopsy or curettage.

The clinical symptoms, tumor location and radiographic features of the 12 aneurysmal bone cyst were shown in the Table 1.

DISCUSSION

Aneurysmal bone cysts (ABCs) of the bone comprise 1.4% of all bone tumors. They often involve the metaphysis of the long bones (51%) and have a predilection in the distal femur [2, 3, 4]. The spine is another common site (15%), where the posterior element is usually involved [1, 5, 6, 7]. In addition, ABC in calcaneus, occipital bone, the pubic ramus, the

![Figure 1. Aneurysmal bone cyst in the medial condyle of distal humerus of a 18 years old man. Anteroposterior (Fig. 1a) and lateral (Fig. 1b) radiographs showing a soap bubble radiolucent lesion with perioisteal reaction (long arrows).](image-url)
metacarpals, the metatarsals, the scapula, the clavicle and the phalanx have been reported. There is slightly female predominance and at the age between 10 and 20 years. The mean age at diagnosis varied from 14 to 16 years in several large studies [1, 2, 3, 4, 5].

There are many etiologic theories and concepts regarding ABCs. Two major theories are better recognized. The first is that the cyst is a secondary manifestation developing in a pre-existing lesion altered by the cystic change, hemorrhage or some superimposed pathologic process. The second is more widely accepted; namely, the lesion is caused by vascular supply anomalies or hemodynamic change in the area [1, 2, 3, 4].

The duration of symptoms prior to diagnosis is usually 4 to 8 months. Local pain is the most common feature of this disease, and is often worse at night and with recumbency. This can be associated with swelling or a palpable tender mass [2, 3]. Restriction of range of motion in adjacent joint or pathologic fracture (10%) may occur. The main symptoms in ABCs of the spine are: pain, presence of a mass that is often with tenderness, and symptoms secondary to spinal cord compression [1, 5, 6, 7]. Radiographically, ABCs often have a characteristic roentgenographic appearance. Typically the lesion consists of eccentric ballooned or aneurysmal, expanded radiolucency originating in the metaphysis, the margin is usually well circumscribed with or without a sclerotic rim (Fig. 1). The cyst often shows apparent trabeculation but without significant mineralization or calcification, soft tissue extension, and usually a marginal periosteal reaction of the lesion (Fig. 1). A pathologic fracture may present with eccentric radiolucent lesion (Fig. 2).

The spinal ABCs characteristically show a purely lytic lesion of the vertebral body and posterior element or less commonly only limited to the posterior element of vertebra. It rarely involves the vertebral body alone. CT findings of ABCs reveals the integrity of cortex and the extent of any soft tissue component and intraosseous involvement. CT scan provides the most complete and accurate anatomic evaluation including the anatomical relationship with major vessels and nerves as well as that the density within the cyst. Rosenthal found that ABCs show “mixed intermediate densities in the soft tissue range on CT [8]. Fluid levels had been demonstrated in ABCs using CT. (Fig.3b). These fluid levels are thought to represent sedimentation of red blood cells and serum within the cystic cavities [8].

MRI is an effective imaging modality in evaluating bone tumors because of its multiplanar capability and excellent soft tissue contrast (Fig. 3c). MRI is also useful in determining the extent of tumor invasion in marrow, cortical bone thinning or destruction, joint involvement and soft tissue extension.

MRI is the best modality in demonstrating multiple internal septations (Fig. 3c), cyst with fluid-fluid levels of varying intensity and an intact hypo intense signal rim [9, 10] of surrounding the lesion.

CT has demonstrated fluid levels in ABCs and telangiectatic osteosarcoma. MR imaging is even more specific the CT. The constellation of findings include

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Sex</th>
<th>Symptoms</th>
<th>Tumor location</th>
<th>Radiographic appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18</td>
<td>F</td>
<td>Elbow pain</td>
<td>Distal humerus</td>
<td>A soup buble radiolucent lesion</td>
</tr>
<tr>
<td>2</td>
<td>47</td>
<td>M</td>
<td>Knee pain &amp; soreness</td>
<td>Proximal tibia</td>
<td>Expansile radiolucent lesion</td>
</tr>
<tr>
<td>3</td>
<td>22</td>
<td>F</td>
<td>Hip pain</td>
<td>Femoral neck</td>
<td>Pathologic fracture</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>M</td>
<td>Forearm mass and weakness</td>
<td>Proximal radius</td>
<td>Soft tissue mass with expansile radiolucent lesion</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>M</td>
<td>Knee pain and swelling</td>
<td>Patella</td>
<td>blow out radiolucent lesion</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>M</td>
<td>Back pain</td>
<td>Spine, T10</td>
<td>blow out lesion with thecal sac compression</td>
</tr>
</tbody>
</table>

Figure 2. Aneurysmal bone cyst with pathologic fracture of the trochanter of left femoral in a 22 years old female who had pain in her left hip for 1 month.
fluid levels, well-defined cystic spaces with a wide range of signal intensities from the fluid filled cysts, diverticula-like projections and a dark line of decreased signal intensity surrounding the lesion at both the bone-tumor interface and the soft tissue-tumor interface [9, 10].

Bone scintigraphy was performed in 4 of the 6 cases, which showed hypervascularity and intraosseous uptake of the lesion at delayed imaging (Fig. 3d), although this is not specific for the lesion.

Differential diagnoses with ABCs include unicameral bone cysts, fibrous dysplasia, giant cell tumor, osteoblastoma, telangiectatic sarcomas, giant cell reparative granuloma and hemangioma [3]. Giant cell tumors are aggressive tumors of unknown origin that develop within bone and apparently arise from mes-
enchymal cells in the connective tissue framework. Some giant cell tumors are benign histologically, while behaving aggressively; other appear “aggressive” histologically, but behave in a benign manner [2, 3]. Giant cell tumors are potentially malignant. 60% of lesions recur after curettage and 10% metastasize to the lungs [2, 3]. Eighty-five percent giant cell tumors occur in patients over 20 years of age; whereas, ninety percent of patients with ABCs under than 20 years of age [2, 3].

Unicameral bone cyst are seen as a well-defined oval metaphyseal lesion without aggressive characteristics and occasionally presenting with a “fallen fragment sign” when the cyst wall is disrupted by a pathological fracture on plain radiography [11]. A “ground-glass” radiological appearance favors fibrous dysplasia. Osteogenic sarcomas occasionally appear osteolytic on radiographs and may be associated with soft tissue masses. Osteoblastoma are common in vertebral arches and intertubular bones. Lesions are eccentrically located in the metaphyses or shaft, and the epiphysis is not involved. The characteristic radiographic feature is a well circumscribed, expansile lesion which may be surrounded by a fine calcified margin.

Giant cell reparative granuloma is an uncommon lesion that is not a true neoplasm, but rather a reactive process. Jaffe originally coined the term giant cell reparative granuloma to describe lesions he believed represented a response to intraosseous hemorrhage from jaw trauma. Other researchers prefer the term giant cell granuloma to describe this lesion, noting the inconsistent history of trauma and lack of significant elements of reparative tissue. GCRG usually involves the mandible, but it more recently has been recognized to occur in the metacarpals, metatarsals, and phalanges. The radiologic manifestations of GCRG are nonspecific. Gnathic lesions demonstrate expansile remodeling of bone and a multilocular appearance. The cortex, although thin, is usually intact. Lysis with expansile remodeling is the most common radiographic appearance of GCRG affecting the hands and feet. These lesions most commonly involve the metaphysis with or without extension into the diaphysis. Extension into the epiphysis is unusual, and, to our knowledge, extension across an unfused physis has not been described. The lesions are typically 2-2.5 cm in diameter with internal trabeculation on radiographs [1, 2, 3].

Treatments of ABC include curettage with or without bone grafting, complete excision, embolization, radiation therapy. The optimal treatment of ABCs of spine, however remains a subject of controversy in the literature [1, 2, 3, 4]. All our cases were treated with curettage and bone allografts with occasional use of cement fixation.

Pathological characteristics on gross inspection, aneurysmal bone cysts have a multilocular, sponge-like appearance consisting of blood-filled cavities separated by thin, fibrous septa. They are expansile lesions that erode and destroy the surrounding bone, leaving an eggshell-thin rim of subperiosteal new bone that is continuous with the adjacent cortex. The core of the tumor consists of soft, fleshy, vascular tissue, in addition to a cystic trabeculation of the interior of the mass containing unclotted blood. The mass may invade adjacent soft tissue or surround the thecal sac. Bleeding appears to come from the soft tissue lining the cysts and may be profuse and difficult to control until all the lining has been removed [1].

On histological examination, ABCs show the fibrous septa made of fibroblasts, myofibroblasts, multinucleated osteoclast-like giant cells, hemosiderin deposits, blood vessels, and fields of osteoid and woven bone. The cavernous, blood-filled cysts are not true vascular channels because they lack an endothelial lining and the elastic tissue or smooth muscle that is found in the walls of normal blood vessels. Mitosis may be observed, which indicates proliferation activity. Aneurysmal bone cysts may expand by enlargement of the cavities or by proliferation of the basic tissue. The tumor has a well-differentiated, benign histological feature, but can behave aggres-
sively by invading adjacent vertebrae and surrounding soft tissues, causing neurological compromise [1].

In conclusion, the correlations of radiographic, clinical and pathologic findings facilitated accurate diagnosis of ABC. The combination of the imaging modalities is helpful in preoperative assessment and postoperative follow up.

REFERENCES

動脈瘤樣骨囊腫之影像表現及文獻回顧

陳良光1,2,3 陳旭漪1,2 彭惠玲1 吳金珠1 蔡裕豐1 蘇誠道1,2 羅偉業1 張家千1
新光吳火獅紀念醫院 影像醫學部 放射診斷科1
天主教輔仁大學 醫學院 醫學系2
元培科學技術學院 放射技術系3

動脈瘤樣骨囊腫佔1.4%之所有原發性骨骼腫瘤和15%於所有脊椎原發性骨骼腫瘤，其發生是良性，並且經過刮除術後極少有復發之機率。
其發生年齡由10至20歲，平均年齡為14至16歲，女性多於男性，於臨床上其會產生局部痛覺，尤其於晚上，腫脹或腫塊和病理性骨折（10%），另外如果發於脊椎會造成脊髓受到壓迫。
其最常侵犯部位為長骨骨幹骺端部（51%）特別於股骨末端，另外脊椎（15%）的後背成份，並有少許侵犯跟骨、頭骨、顱骨、等，於常規放射線攝影所顯示為擴張離心的放射透射或肥皂泡沫性病灶和會侵入鄰近的軟組織，另外，會有病理性骨折和少有骨膜反應，但無鈣化。
新光吳火獅紀念醫院內1993年3月至2005年3月共收集了6例疑似動脈瘤樣骨囊腫年齡由8歲至47歲，平均年齡為22.5歲；男性4位，女性2位。這些病患都接受常規放射線攝影，其中2例接受電腦斷層攝影，2例接受磁共振造影，4例則接受核子醫學骨骼掃描，並且經過開刀和病理組織診斷為動脈瘤樣骨囊腫。因此我們將其影像特徵和回顧文獻報告，提供給大家參考指教。

關鍵詞：電腦斷層攝影；骨、腫瘤；磁共振造影；核子醫學骨骼掃描