COMPUTED TOMOGRAPHY IN THE ANALYSIS OF CALCIFICATION PATTERNS IN PEDIATRIC BONE TUMORS OF THE HIP: A NEW APPROACH*

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Abstract **OBJECTIVE: In the pediatric group, the radiological diagnosis of bone tumors of the hip is difficult and presents some peculiarities, but reviewed literature does not approach this specific problem. The objective of the present study was to investigate the existence of reliable radiological patterns for the differential diagnosis of these tumors. MATERIALS AND METHODS: Radiological findings of bone tumors of the hip in ten patients in the age range between 8 and 19 years have been reviewed. RESULTS: Bone reaction (sclerosis or lysis), periosteal reaction (lamellar with single or multiple layers, or radial), tumor extent in the bone and level of soft tissues invasion have presented low specificity. Soft tissue calcifications, when considered as a whole, were non-specific. However, when those calcifications with varied shapes and sizes, nearby the affected bone (pattern I) were separated from those, thin and amorphous, away from the bone (pattern II), we have observed that the pattern I was totally non-specific, and the pattern II was found in the three cases of osteosarcoma (100%) and in only one case of Ewing's sarcoma (16.6%). CONCLUSION: In the present study, pattern II calcifications have shown a 100% sensitivity and 90% specificity for osteosarcoma. However, their importance may be not limited to the radiological diagnosis. Pattern II calcifications indicate probably ideal sites for biopsy.**

Keywords: Bone tumors; Ilium; Hip; Pelvis; Pediatrics; Computed tomography.

Resumo *Tomografia computadorizada na análise dos padrões de calcificações nos tumores ósseos da bacia em pediatria: nova aboardagem.*

OBJETIVO: No grupo pediátrico, o diagnóstico radiológico dos tumores dos ossos ilíacos, ísquios e púbis apresenta dificuldades e peculiaridades próprias, mas a literatura revisada não trata especificamente desse tema. Este trabalho pretende investigar a existência de padrões radiológicos confiáveis para o diagnóstico diferencial desses tumores. MATERIAIS E MÉTODOS: Foram revistos os achados radiológicos de tumores dos ossos do quadril em dez pacientes com idades entre 8 e 19 anos. RESULTADOS: Reação óssea (esclerose ou lise), reação periosteal (lamelar em camada única, múltiplas camadas ou radial), extensão do tumor no osso e grau de invasão das partes moles revelaram baixa especificidade. As calcificações nas partes moles, consideradas em conjunto, foram inespecíficas. Contudo, separando as próximas do osso comprometido, que apresentam formas e tamanhos variados — padrão I —, daquelas afastadas do osso, finas e amorfas — padrão II —, observamos que o padrão I foi totalmente inespecífico e o padrão II foi identificado nos três casos de osteossarcoma (100%) e em apenas um dos casos de Ewing (16,6%). CONCLUSÃO: Neste material, as calcificações padrão II revelaram sensibilidade de 100% e especificidade de 90% para osteossarcoma. Contudo, sua importância pode não se limitar ao diagnóstico radiológico. As calcificações padrão II indicam, provavelmente, os sítios ideais para biópsia.

Unitermos: Tumores ósseos; Ilíaco; Quadril; Pediatria; Tomografia computadorizada.

INTRODUCTION

In long bones, orthogonal plain films are very useful in the formulation of diagnostic hypotheses. Different lesions tend towards presenting higher incidence in epiphyses, metaphyses or diaphyses[(1)]. Osteosarcomas, for example, use to be metaphyseal; the Ewing's sarcoma, diaphyseal or metadiaphyseal. In the hip bones (ilium, ischium and pubis), on the contrary, orthogonal incidences are not feasible and the lesions can not be classified according to their longitudinal disposition. Additionally, the overlapping of pelvic viscus and its contents images complicate the analysis of plain films, so computed tomography (CT) becomes essential for the diagnosis. The hematopoiesis maintenance is another feature of the hip bones — in long bones, the red bone marrow is replaced by yellow marrow. As a result of these particularities, iliac tumors present some distinct radiological aspects.

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In the reviewed pediatrics literature, we have not found any specific study on the radiological semiology of bone tumors of the hip.

MATERIALS AND METHODS

We have retrospectively analyzed the dossiers of ten patients with histologically confirmed bone tumors of the hip documented by means of plain films and CT. The CT studies have been analyzed in the non-contrast phase to avoid the confusion between tumor vessels and calcifications. Magnetic resonance imaging (MRI) is poorly appropriate for diagnosis, and has not been presented in this study, despite its fundamental role in the staging of this kind of lesions. Post-chemo-radiotherapy images have not been utilized, as well as post-contrast images. In the first case, because of a significant calcification increase in the soft parts of the tumor, probably resulting from tissular necrosis. In the second case, because the tissular, neovascular enhancement could be confused with tumor calcifications.

The sacrum and coccyx, although included in the bone structure of the hip, have been excluded from this study for presenting peculiar characteristics, besides other in common with vertebrae.

The casuistic has been limited to the first decades of life because of the several diseases affecting these bones in the other age ranges. Six cases had histological diagnosis for Ewing's sarcoma, three for osteosarcoma, and one for chondrosarcoma. Ages ranged between 8 and 19 years. Six patients were male and four, female.

Other criteria employed in the analysis are shown in Table 1.

Table 1 Criteria employed in tumors evaluation.

Clinical presentation	
Affected bones	Ilium; isquium; pubis
Bone lesion size*	< 25%; 25–50%; > 50%
Predominant osseous reaction	Lytic; sclerotic; mixed (balanced lytic + sclerotic)
Cortical involvement	Absent; present
Type of periosteal reaction	Sunburst; single lamellar; multiple lamellar
Extra-osseous tumor mass†	Absent; present
Pattern I calcifications‡	Absent; present
Pattern II calcifications§	Absent; present
Pattern III calcifications¶	Absent; present
Contiguity invasion**	Absent; present
Metastases at diagnosis	Absent; present

* Considered in relation to the percentage of bone affected. If more than one bone (ilium, ischium or pubis) is involved, the size of the lesion in the largest bone will be considered.

† Considered in relation to the highest thickness of the affected bone.

‡ With different sizes and shapes, localized at a distance equal or lower than the measure of the highest thickness of the contralateral, normal bone in the same cut plane (Case 3, Figure C).

§ When thin and amorphous, localized at a distance higher than the highest thickness of the contralateral normal bone, in the same cut plane.

¶ When rounded, defined, usually found in calcified chondroid matrices.

** In the absence of a cartilage separating the ilium, ischium and pubis, the involvement of more than one of these bones will not be considered as a contiguity invasion.

RESULTS

All of the patients presented with pain as their initial symptom, reported as restricted to the hip in seven patients; in the hip irradiating to the coxa in one; and in the coxa and/or knee in two. All of them presented with a palpable mass at diagnosis.

The lesion involved less than 25% of the bone in two cases of Ewing's sarcoma, and in one case of chondrosarcoma. Between 25% and 50% in one case of Ewing's sarcoma, and in one of osteosarcoma, and more than 50% in three cases of Ewing's sarcoma, and in two of osteosarcomas.

All of the three cases of osteosarcomas had predominantly sclerotic bone lesions (cases 7, 8 and 9). In the cases of Ewing's sarcoma, there was a predominance of sclerotic lesions in three (cases 1, 4 and 6), lytic in two (cases 2 and 5) and a balance between sclerosis and lysis in one (case 3). In the chondrosarcoma, there was a lytic lesion (case 10). Lesions presented with a permeative pattern in all of the cases, with ill-defined limits between the normal and affected areas.

Cortical involvement had occurred in all of the cases.

Periosteal reaction occurred in the three osteosarcomas, in one of them associated with single lamellar reaction (case 9). In the Ewing's sarcomas, two have not presented any periosteal reaction, two presented with single lamellar reaction (cases 1 and 2), and two, mixed reaction (cases 3 and 6). In the

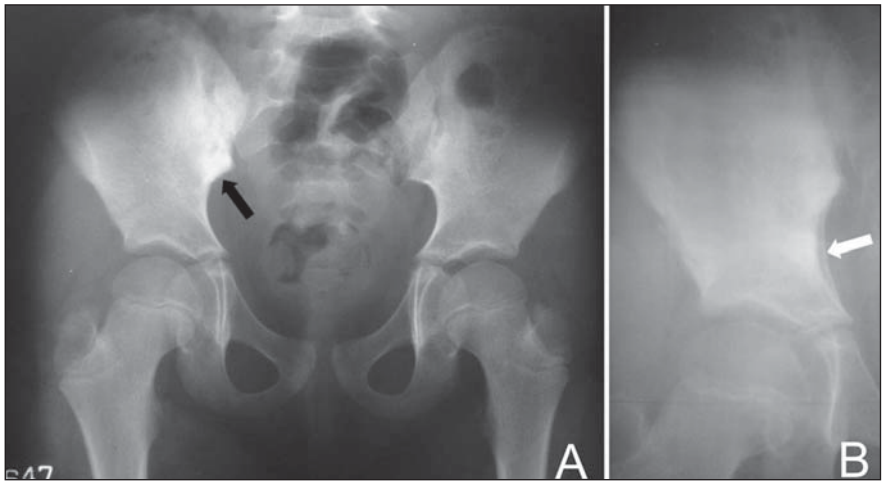


Figure 1. *Case 1*. Ewing's sarcoma. Eight-year-old girl. **A:** Small sclerotic area in the ilium, proximal to the distal third of the sacroiliac joint (arrow). **B:** After four months, the bone lesion increased in size and a single layer periosteal reaction appeared (arrow); on this occasion, there was a palpable mass.

chondrosarcoma, the reaction was of lamellar nature.

An extra-osseous mass was demonstrated in eight cases whose CT and/or MRI were available, always occurring from both faces and exceeding the major transverse axis of the bone.

Calcifications in soft parts were evaluated every time CT was available for analysis; pattern I calcifications were found in all of the cases (Ewing's sarcoma, osteosarcoma, chondrosarcoma); pattern II, in osteosarcomas and in one Ewing's sarcoma (case 6). The majority of calcifications near the bone were pattern I; and the distant ones were pattern II. Pattern III calcifications have not been found.

Contiguity invasion into the sacrum has occurred in only one case of primary iliac osteosarcoma (case 8).

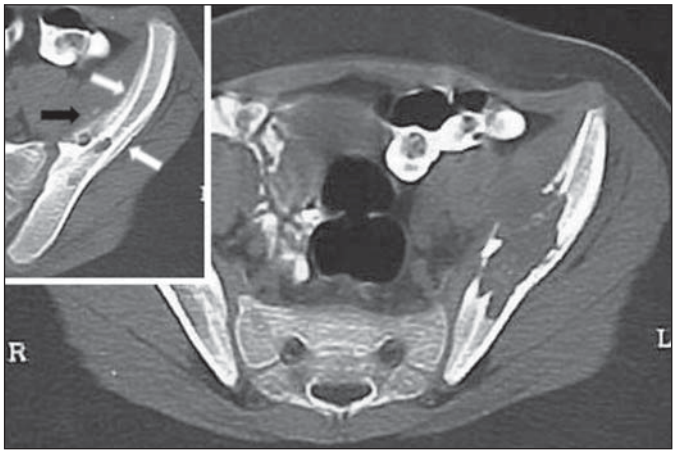


Figure 2. *Case 2*. Ewing's sarcoma. Ten-year old boy. Predominantly lytic, left-sided iliac lesion. On the detail periosteal, single lamellar reaction (white arrows) and gross calcifications proximal to the bone (black arrow), are observed.

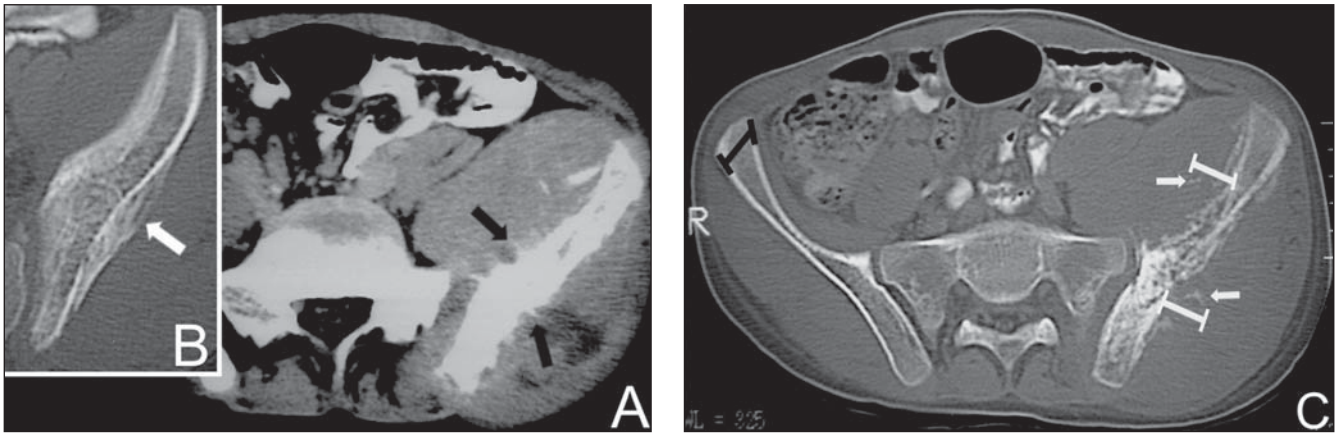


Figure 3. *Case 3*. Ewing's sarcoma. Thirteen-year-old boy. **A:** Left-sided iliac permeative, mixed pattern (sclerosis and lysis) lesion presenting sunburst periosteal reaction (arrows); some gross calcifications maybe representing osseous fragments. **B:** Periosteal, lamellar reaction (multiple layers)(arrow)**C:** Another CT slice showing calcifications in soft parts at a distance lower than the greatest diameter of the contralateral bone taken as a reference.

Figure 4. *Case 4*. Ewing's sarcoma. Fourteen-year-old girl. Left-sided iliac predominantly sclerotic lesion; on the detail cortical rupture is observed.

Figure 5. *Case 5*. Ewing's sarcoma. Male, 16-year-old patient. Right-sided pubic, predominantly lytic lesion.

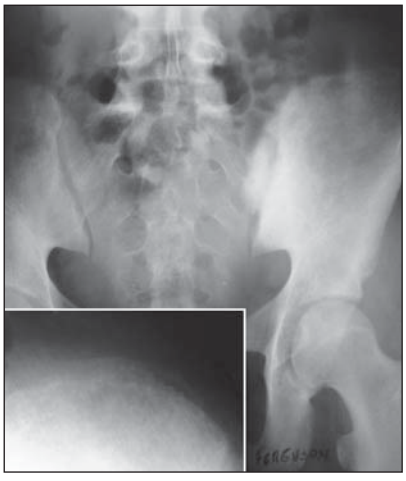
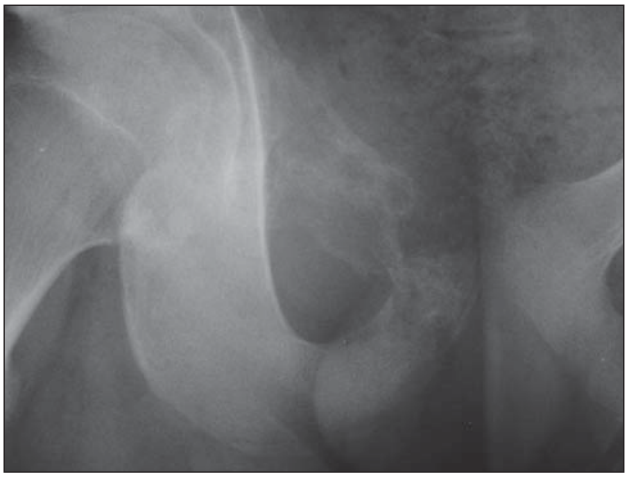


Figure 4



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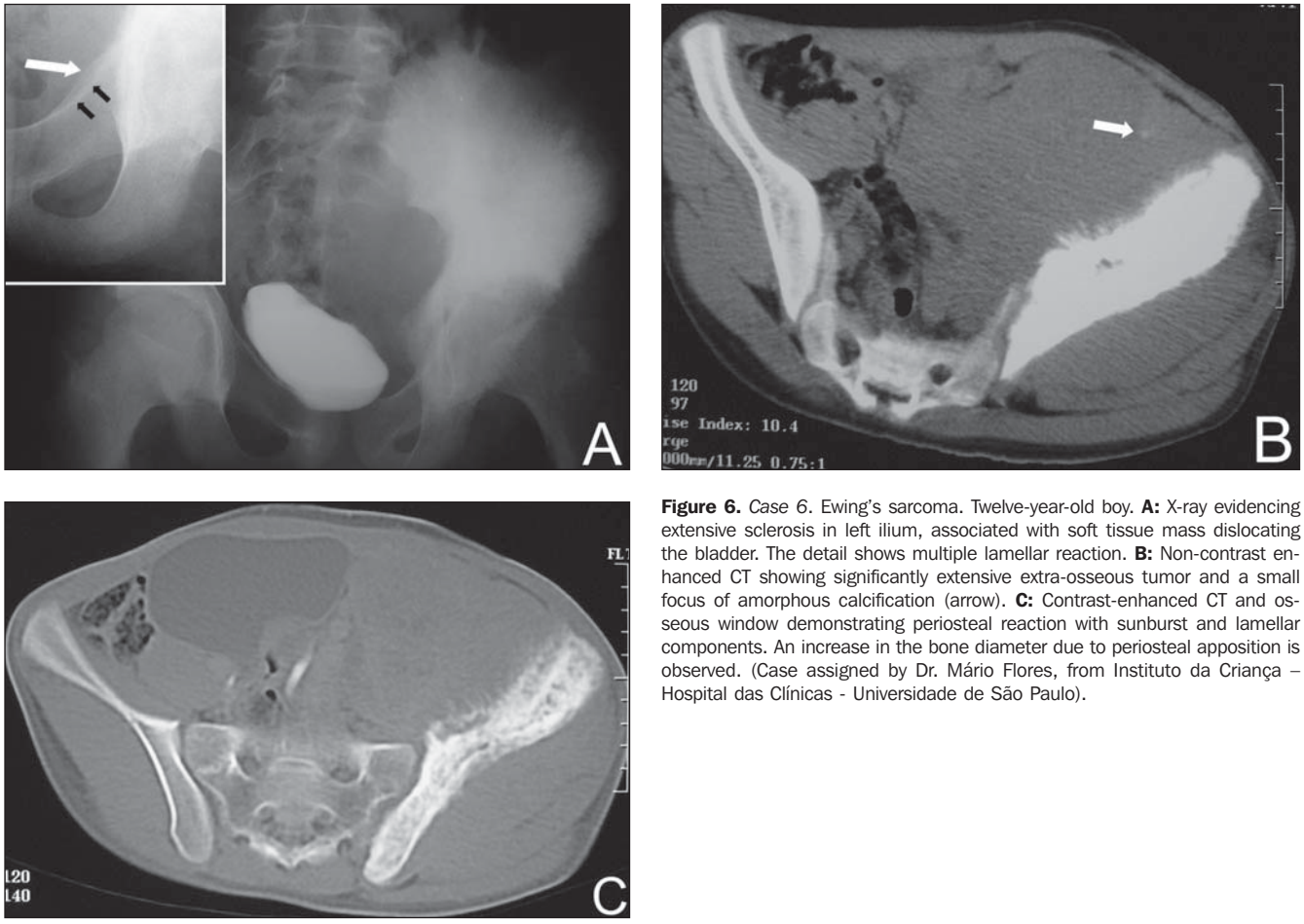

Figure 6. *Case 6*. Ewing's sarcoma. Twelve-year-old boy. **A:** X-ray evidencing extensive sclerosis in left ilium, associated with soft tissue mass dislocating the bladder. The detail shows multiple lamellar reaction. **B:** Non-contrast enhanced CT showing significantly extensive extra-osseous tumor and a small focus of amorphous calcification (arrow). **C:** Contrast-enhanced CT and osseous window demonstrating periosteal reaction with sunburst and lamellar components. An increase in the bone diameter due to periosteal apposition is observed. (Case assigned by Dr. Mário Flores, from Instituto da Criança – Hospital das Clínicas - Universidade de São Paulo).

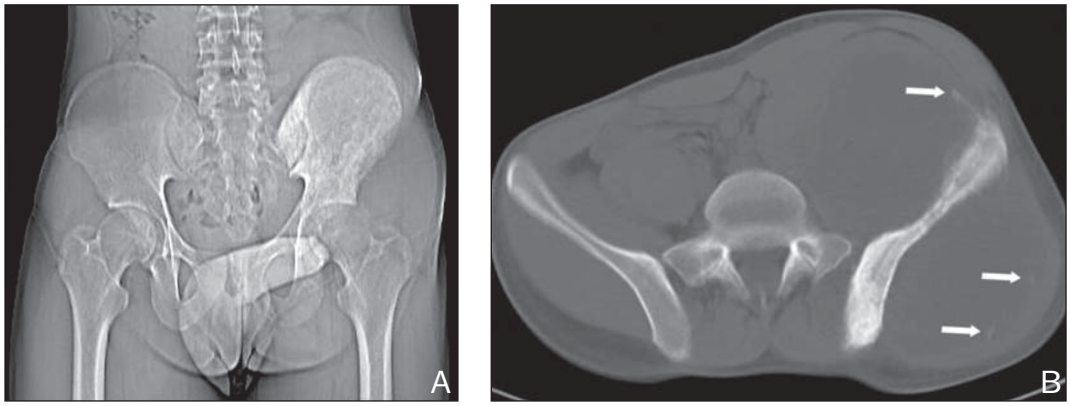

Figure 7. *Case 7*. Osteosarcoma. Male, 18-year-old patient. **A:** Topogram showing sclerosis affecting the whole left ilium. **B:** CT demonstrating, besides sclerotic bone lesion, mild, amorphous calcifications distant from the ilium (arrows). (Case assigned by Dr. Reinaldo B. Salgado, from Hospital São Lucas, Vitória, ES).

Metastasis have been found at diagnosis in only one case of Ewing's sarcoma (case 6, pulmonary metastasis).

DISCUSSION

Iliac involvement occurs in 18% of Ewing's sarcoma, and in 12% of osteosarcomas. Chondrosarcomas, most frequently, affect this bone (60%), but they are rare in the childhood and adolescence[2]. Therefore, the casuistic presented in this study may be considered as representative.

Seven patients presented with a severe bone involvement by the tumor, most probably related to delay in diagnosis. Small alterations on the first x-ray of the hip had been neglected in case 1. In case 6, the patient reported pain in the knee, so the initial imaging investigation — including a MRI — was restricted to this site. Although it is a well known fact, it will never be enough to remind that pain in the coxa and/or knee may be related to a hip bone lesion. Therefore, in cases where knee or coxa x-ray images are normal, the necessity of extending the radiological investigation to the hip must be considered.

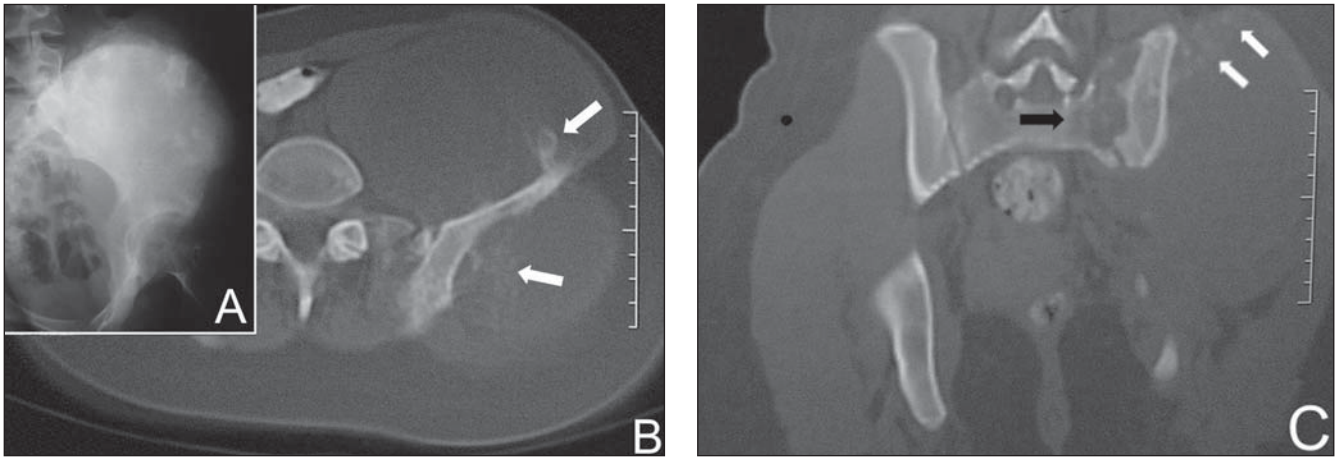

Figure 8. *Case 8*. Osteosarcoma. Female, 19-year-old patient. **A:** X-ray demonstrating sclerosis in the whole left ilium and mild soft tissue calcifications, adjacent to the iliac crest. **B,C:** CT showing mild, amorphous calcifications, some of them distant from the bone (white arrows), and lytic lesion on the left wing of the sacrum, characterizing invasion (black arrow).

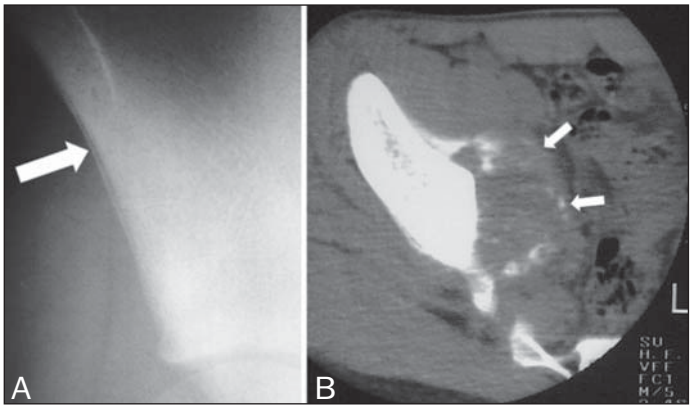

Figure 9. *Case 9*. Osteosarcoma. Fourteen-year-old boy. **A:** X-ray demonstrating sclerosis and periosteal, single lamellar reaction on right ilium (arrow). **B:** CT showing amorphous, cloudlike calcifications, some of them very distant from the bone (arrows).

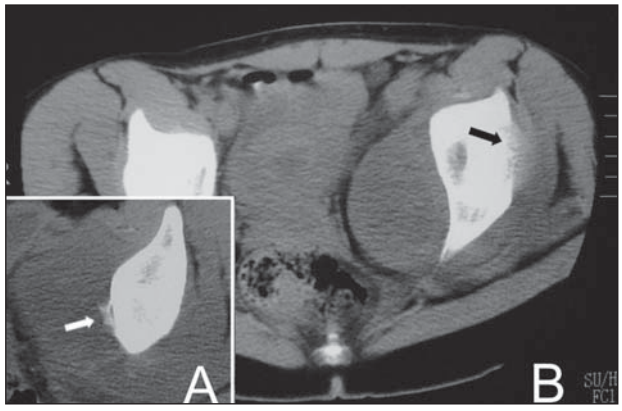

Figure 10. *Case 10*. Chondrosarcoma. Thirteen-year-old girl. **A:** Periosteal, single lamellar reaction (arrow). **B:** Cortical rupture (arrow) and extra-osseous extension.

Other factors may be taken into consideration for the existence of so extensive lesions. Differently from the long bones, in the ilium, ischium and pubis, the barriers constituted by conjugation cartilages and yellow bone marrow — hypovascularized — fat are absent. This absence makes the tumor cells dissemination easier.

Sunburst or lamellated periosteal reactions occurred in all the types of tumors, although the first one has predominated in osteosarcomas. Cortical involvement and extra-osseous tumor mass have been present in all of the cases.

Tumor cells have the capacity to stimulate osteoblasts to produce sclerosis, and osteoclasts, lysis. Mixed lesions occur when these two functions coexist. In osteogenic sarcomas, additionally to this stimulus, tumor cells also produce osteoid matrix (an intercellular substance produced by normal or tumor osteoblasts). Only mineralized matrices can be detected in images[1]. Also it is important to note that the amount of osteoid produced by osteosarcomas depends on the predominant differentiation of tumor cells: osteoblastic, chondroblastic and fibroblastic. However, it is impossible to differentiate the reactional sclerosis from that resulting from the production of osteoid matrix by the tumor osteoblasts.

Predominance of sclerosis has occurred in all of the cases of osteosarcoma, but also in half of cases of Ewing´s sarcoma. Predominance of osteolysis has only occurred in Ewing's sarcomas, but it may also occur in osteosarcomas, mainly the telangiectatic ones, and in osteomyelitis.

With regard to calcification in soft parts, they may occur in areas of tissular necrosis, tumor-induced bone metaplasia, osseous fragments dislocated by the tumor, periosteal reaction, or resulting from calcium deposition on the tumor matrix (osteoid or chondroid). These calcifications present different patterns according Table 1. Pattern I calcifications were totally nonspecific, probably because of the impossibility of distinguishing calcifications resulting from the osteoid matrix (in osteosarcomas) from those resulting from periosteal reaction and dislocated osseous fragments. Pattern II calcifications have been evidenced in all the osteogenic sarcomas

and in one of the Ewing's sarcomas (case 6). In osteosarcomas, presumably, they have resulted from the tumor osteoid matrix calcification (ossification). Since Ewing's sarcomas do not produce osteoid matrix, when present, these calcifications could result from necrosis, or, eventually, from tumor-induced bone metaplasia[3]. Resnick says that 9% of Ewing's sarcomas calcify, but he neither specify which bones are affected nor the types of calcifications. The same author reports two cases of Ewing's sarcoma of the ilium with calcifications in soft parts. In this situation, a mistaken radiological diagnosis of osteosarcoma may be induced[4].

Despite the recent developments of histopathology, immunohistochemistry, cytogenetics and electronic microscopy, the diagnosis of Ewing's sarcoma remains as a challenge, and it is difficult to differentiate them from other tumors, especially small cell osteosarcomas[1,3,5–15], neuroectodermal tumors, mainly the primitive ones, and lymphomas[1,4]. It is known that bone tumors may present different histological aspects, depending on the biopsy area. On CT, areas with pattern II calcifications suggest the presence of osteoid matrix. In a tumor, provided the likelihood of an induced bone metaplasia is remote, the presence of osteoid matrix is usually considered as an indication of osteosarcoma. However, the likelihood of such calcifications being a result of tissular necrosis should not be disregarded.

Therefore, in the hypothesis of the biopsy does not reach areas with pattern II calcifications, there is a possibility of the osteoid tissue - existing only in these areas - not being included in the biopsy slide. The result would be a diagnostic mistake. CT-guided biopsy aimed at areas with pattern II calcifications could avoid this mistake.

In summary, in iliac bone tumors, soft parts calcifications seem to be of significance for the presumed radiological diagnosis, and even more for biopsy guidance. A specific protocol adopting this approach could be employed in prospective studies, especially the multicentric ones.

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