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Research article

Imaging and differential diagnosis of pediatric spinal tuberculosis

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Abstract

Objective: This paper aimed to summarize imaging features of pediatric spinal tuberculosis.
Methods: The spinal X-ray, CT and MR presentations of 21 patients under 18 years old who were confirmed with tuberculosis by biopsy or pathological surgery were retrospectively analyzed.
Results: Among the 21 cases, 14 cases (66.7%) had consecutive multi-vertebral lesions; 2 cases (9.5%) had nonconsecutive multi-vertebral lesions; and 5 cases (23.8%) had single vertebral lesion. Besides, 18 (85.7%) cases presented with typical imaging findings: well-defined bone destruction, intervertebral space stenosis and existence of marginal sclerosis, sequestrum and paravertebral soft tissue. The remaining 3 (14.3%) cases presented with atypical imaging findings, with two cases of single vertebral lesion misdiagnosed as Langerhans cell histiocytosis and one case of nonconsecutive multiple vertebral lesions and ill-defined bone destruction diagnosed as malignant neoplasm.
Conclusion: Pediatric spinal tuberculosis often occurs in the cervical and thoracic vertebrae with typical imaging findings. The cases with atypical manifestations should be differentiated from other diseases such as Langerhans cell histiocytosis and metastatic neoplasm.

Keywords: Pediatric; Spinal tuberculosis; X-ray; CT; MRI

Tuberculosis, as an infectious disease raging around the world, poses potential threats. Of all the victims, children amount to about 10–33% [1–4]. The most vulnerable infection site for pediatric tuberculosis is the respiratory system, which accounts for about 47%. Spinal tuberculosis is relatively rare, making up only 5% [5]. However, since the children are still growing and developing, their spinal anatomical and physiological characteristics are different from those of the adults. Moreover, early diagnosis and timely treatment can effectively reduce the incidence of disabling complications. Therefore, this article undertook to summarize the imaging features of pediatric spinal tuberculosis so as to improve the diagnosis and differentiation of the disease.

1. Materials and methods

1.1. Clinical data (Table 1)

21 patients under 18 years old who were diagnosed with spinal tuberculosis by biopsy or pathological surgery and treated in Peking University Third Hospital from 2000–2014 were enrolled as subjects. There were 14 male cases and 7 female cases, aged from 5 to 18 years old upon diagnosis with a median age of 14 years old. The main clinical manifestations were neck pain in 9 cases, chest and back pain in 8 cases and lower back pain in 4 cases. Besides, one patient with neck pain is found having concurrent myasthenia in right upper limb, and one case with neck pain having concurrent movement disorder.

1.2. Imaging methods

Of the 21 patients, 8 cases received preoperative anteroposterior and lateral X-ray imaging; 15 cases had CT scan of

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Table 1
Clinical data of 21 patients with spinal tuberculosis.

N	Sex	Age	Site	Presentation	Extra spinal TB	X-ray	CT	MR
1	M	5	C5-T4	Neck pain with weight loss	UNK	+		
2	F	5	C2	Neck pain	UNK		+	
3	F	7	T1-3	Back pain	+ pulmonary	+		
4	M	9	C2	Neck pain	+ pulmonary		+	
5	F	10	T2	Back pain with low-grade fever	UNK		+	
6	M	12	T5-12	Back pain	UNK	+	+	+
7	M	13	L3-4	Low back pain	UNK		+	
8	M	14	L3-4	Low back pain	+ pulmonary		+	+
9	M	14	T9-T12	Chest and back pain	UNK		+	
10	M	14	T9-11	Chest and back pain	+ pulmonary		+	
11	F	15	T6-9	Chest and back pain	+ pulmonary	+		
12	M	16	C6	Neck pain with limb numbness	UNK	+	+	+
13	M	16	C, T, L	Neck pain with activity obstacle	+ pulmonary	+	+	+
14	M	17	T12	Back pain	+ pulmonary		+	
15	M	17	C4-6	Neck pain	UNK			+
16	M	17	C1-2	Neck pain	UNK	+		+
17	F	17	T1-4	Chest and back pain	UNK	+		
18	F	18	C5-T1	Chest and back pain	+ pulmonary		+	
19	M	16	L2-3	Low back pain	UNK		+	
20	F	18	L5-S1	Low back pain	UNK		+	+
21	M	16	C, T, L	Neck pain	+ pulmonary		+	

N indicates patient number; UNK-unknown.

the corresponding parts (scan parameters: slice thickness, reconstruction interval and reconstruction slice thickness was 3 mm), with coronal and sagittal reconstruction at GE-ADW 4.3 workstation and 4 cases had enhanced CT; 7 cases underwent MR examination (T1-weighted imaging, T2-weighted imaging, and short T1 inversion recovery/STIR) and enhanced MRI.

1.3. Image analysis

The images were reviewed by two radiologists. Image analysis aimed to ascertain:① change of physiological curvature of spine; ② number of lesions (single or multiple); ③ vertebral collapse; ④ intervertebral space change (narrowed or not); ⑤ type of bone destruction boundary (well-defined or ill-defined); ⑥ sclerotic margin; ⑦ sequestrum; ⑧ endplate sclerosis; ⑨ paravertebral soft tissue; ⑩ enhancement pattern.

2. Results

2.1. Segment distribution

Among the 21 cases, 16 cases (76.2%) manifested multi-vertebral lesions, with 14 cases (66.7%) of consecutive vertebral lesions and 2 cases (9.5%) of nonconsecutive multi-vertebral lesions; and 5 cases (23.8%) showed single lesions. see Table 1 for detailed sites of vertebral lesions. Besides, only one case was found in the posterior area and the rest were inside the vertebrae.

2.2. Imaging findings (Table 2)

2.2.1.

There were 8 patients underwent X-ray examination and 15 patients underwent CT examination, 4 cases enhanced CT scan

Table 2
Imaging data from 21 patients with spinal tuberculosis.

N	Number of lesions	Vertebral collapse	Intervertebral space change	Type of boundary of bone destruction	Sclerotic margin	Sequestrum	Endplate sclerosis	Paravertebral soft tissue
1	Consecutive multiple	Y	Y	Well	Y	Y	N	Y
2	Single	N	N	Well	Y	Y	N	N
3	Consecutive multiple	Y	Y	Well	Y	N	N	Y
4	Single	N	N	Well	Y	N	N	Y
5	Single	Y	N	Well	Y	N	N	N
6	Consecutive multiple	Y	Y	Well	Y	Y	Y	Y
7	Consecutive multiple	N	Y	Well	Y	N	N	Y
8	Consecutive multiple	Y	Y	Well	Y	N	Y	Y
9	Consecutive multiple	Y	Y	Well	Y	N	Y	Y
10	Consecutive multiple	Y	Y	Well	Y	N	N	Y
11	Consecutive multiple	Y	Y	Well	Y	Y	N	Y
12	Singal	Y	N	Well	Y	N	N	N
13	Nonconsecutive multiple	N	N	Ill	N	N	N	Y
14	Singal	N	N	Well	Y	N	N	Y
15	Consecutive multiple	N	N	Well	Y	Y	N	Y
16	Consecutive multiple	N	Y	Well	Y	Y	N	Y
17	Consecutive multiple	Y	Y	Well	Y	Y	N	Y
18	Consecutive multiple	Y	Y	Well	Y	N	N	Y
19	Consecutive multiple	N	N	Well	Y	Y	N	Y
20	Consecutive multiple	N	Y	Well	Y	Y	Y	N
21	Nonconsecutive multiple	N	N	Well	Y	Y	N	Y

Y indicates Yes; N indicates No.

Fig. 1. Sagittal CT of a 12-year-old female patient with kyphosis demonstrated multiple well-defined osteolytic bone destruction, as indicated by the white arrow.

and 7 patients MR examination. The findings demonstrated that 18 patients (18/21, 85.7%) showed typical imaging signs conducive to diagnosis of tuberculosis. Besides, 15 cases out of the 18 patients were found with involvement of two or more centrums and 3 cases with involvement of single centrum. The 6 cases with implications of the thoracic centrums were found with kyphosis (Fig. 1). Meanwhile, 18 cases (18/18, 100%) exhibited well-defined bone destruction and sclerotic margins (Fig. 2). 10 cases (10/18, 55.6%) presented with sequestrums and 12 cases (12/18, 66.7%) with narrowed or absent intervertebral space (Fig. 3). 16 cases (16/18, 88.9%) showed paravertebral soft tissue swelling or abscess. Punctate calcification was detected in the left psoas abscess with obvious peripheral enhancement shown on the enhanced scan. Additionally, there were 3 cases (3/21, 14.3%) indicating atypical imaging signs. 2 out of the 3 cases had single vertebral lesion, respectively at C6 and T2, which demonstrated obvious vertebral compression, no sequestrum, visible sclerotic margins, narrowed intervertebral space and no significant soft tissue swelling or abscess (Fig. 4). The lesions were considered as Langerhans cell histiocytosis (eosinophilic granuloma) before paracentesis. Another case displayed nonconsecutive lesions at the cervical, thoracic and lumbar vertebrae, which were viewed with ill-defined bone desctruction, without significant sclerotic margin, with sequestrum and intervertebral space stenosis as well as paravertebral soft tissue swelling. Meanwhile, peripheral enhancement could be seen on enhanced scan (Fig. 5a).

2.2.2. 7 patients underwent MR examination

The bone destruction of 6 cases presented with low signals on T1WI and high signals on T2WI and T2 fat suppression sequences. Inflammatory edema also showed low signals on T1WI and high signals on T2WI. The implicated intervertebral disk demonstrated low signals on T1WI and high signals on T2WI. Peripheral abscess presented with intermediate-low signals on T1WI and high signals on T2WI, which indicated peripheral enhancement (Fig. 5b and c). Another one case with significant endplate sclerosis in bone destruction areas showed low signals on T1WI and low signals on T2WI. Compression of nerve roots and spinal cord were displayed in 3 cases.

Fig. 2. Coronal CT of a 14-year-old male patient showed L3-4 intervertebral space stenosis (white arrow) and endplate edge sclerosis (red arrow).

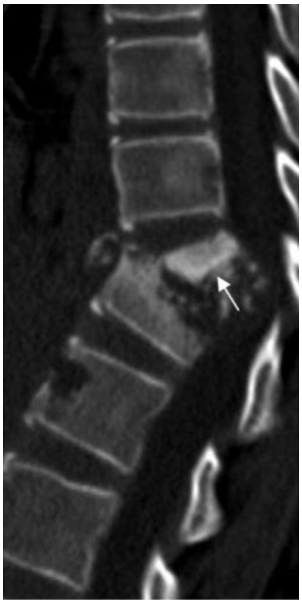

Fig. 3. Imaging of the 13-year-old male patient visualized T10 and T11 with compression change, multiple bone destruction and sequestrum (white arrow).

Fig. 4. Imaging of the 16-year-old male patient indicated the C6 with compression change and bone destruction of marginal sclerosis.

3. Discussions and conclusions

3.1. The clinical and pathological characteristics

Pediatric spinal tuberculosis usually presents with an insidious onset, slow course and mild initial symptoms in clinics. Patients often come to a doctor with localized back pain, loss of appetite, weakness of both lower limbs and inability to walk, which are not typical. Since children have relatively high content of red bone marrow in spine and richer peripheral blood supply than adults, the hematogenous spreading of *Mycobacteria tuberculosis* is fast and easy in different stages, thus frequently implicating multiple vertebrae. Spinal tuberculosis may progress rapidly and lead to nerve compression, spinal deformities and other complications without timely diagnosis and treatment [6]. The most serious case in this study involved invasion of eight centrums and four cases are found with thoracic kyphosis. As for the site of the lesion, spinal tuberculosis of adults mainly involves lower thoracic vertebrae [7] in adults, but commonly implicated the cervicothoracic segement in pediatric patients of this study.

Since mycobacterium tuberculosis could deal severe bone loss and affect body growth, its sequelae are often serious. Moreover, Ashe vertebral bodies of children are cartilaginous and the cartilaginous volume of each vertebral body is negatively correlated with age, tubercular infection in children could result in rapid and consecutive cartilage loss and therefore induce severe deformities within a short span of time in comparison with adults [8].

3.2. Imaging findings and differential diagnosis

The diversity of pathological morphology of spinal tuberculosis leads to different imaging findings. 85.7% patients in this study demonstrated typical imaging findings: involvement of multiple centrums, well-defined bone destruction, sclerotic margin; sequestrums as observed in some lesions, formation of paraspinal abscess, and obvious peripheral enhancement on enhanced scan. Typical cases should be distinguished from spinal pyogenic osteomyelitis. The latter is more prone to invade the lumbar spine and is characterized by spinal endplate edge sclerosis and worm-eaten bone destruction. Besides, the bone destruction incurred by the latter measures smaller in diameter than that from tuberculosis and spinal deformity is less common [9].

Lesions involving single vertebra that were typical of significant compression, no sequestrum and paraspinal abscess

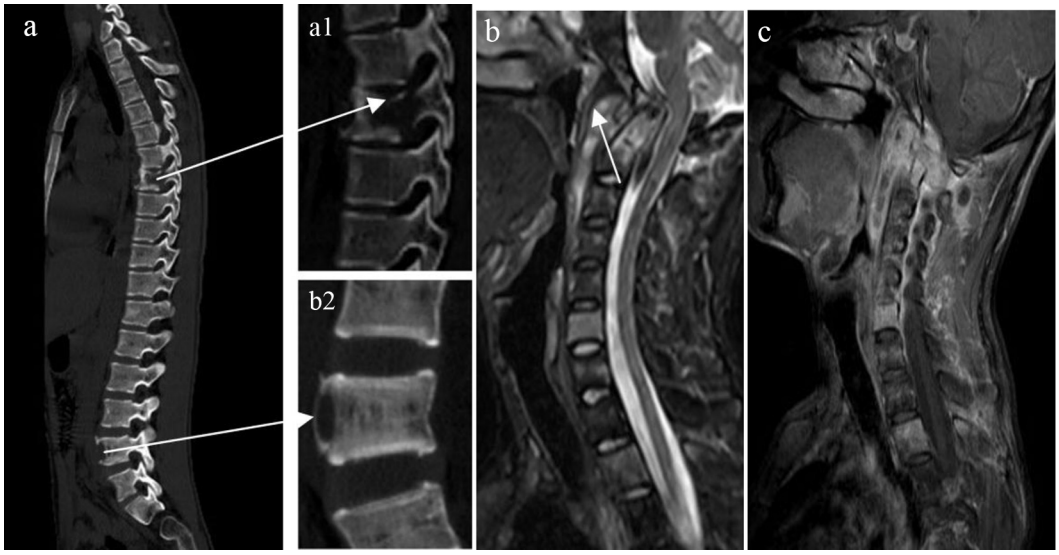

Fig. 5. Imaging of the 16-year-old male patient revealed T7 and L4 with multiple bone destruction (Fig. 5a, Fig. 5a1 and a2 were enlarged views of lesions). (b) Sagittal T2WI MRI showed paravertebral soft tissue (white arrow). (c) Sagittal enhanced T1WI signified obvious enhancement.

should be distinguished from spinal Langerhans cells histiocytosis (LCH). Spinal LCH mainly occurs in children aged 5−10 years old, frequently at cervical vertebrae [10]. It predominantly causes worm-eaten or lobiform osteolytic bone destruction. Besides, 61.76% lesions have different degrees of expansion changes, with partly ambitus hardening [11]. Nevertheless, bone destruction of spinal tuberculosis is often well-circumscribed with sclerotic margin but free of no expansion changes in damage zone.

One case of spinal tuberculosis involved multiple inconsecutive vertebrae and incurred bone destruction of less clear boundary. Generally, spinal tuberculosis could implicate two or more contiguous vertebrae due to hematogenous spread through one vertebral artery feeding two adjacent vertebrae [12] and noncontiguous and remote involvement is rarely reported [13−15]. Therefore, this case was relatively specific and should be differentiated from spinal malignant tumors. Spinal multiple metastases and myelomas are often prevalent in people above 60 years old [16], which rarely involve intervertebral disc or form abscess along the anterior longitudinal ligament. Spinal lymphoma frequently induces worm-eaten bone destruction and masses at paraspinal soft tissue which presents with homogeneous density or signals and equal or slightly higher signals on T2WI [17].

Pediatric spinal tuberculosis is usually accompanied with dormant clinical symptoms and often occurs in cervicothoracic spine, which manifests typical imaging manifestations. Its diagnosis should be concluded based on overall consideration of imaging presentations such as existence of marginal sclerosis, paravertebral soft tissue and sequestrum. As for patients with a single lesion, Langerhans cell histiocytosis should be excluded.

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