Osteomyelitis of the ribs in children: a rare and potentially challenging diagnosis

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ABSTRACT

BACKGROUND

Rib osteomyelitis is rare in children and can mimic other pathologies. Imaging has a major role in the diagnosing rib osteomyelitis.

OBJECTIVE

To evaluate clinical presentation and imaging findings in children with rib osteomyelitis.

MATERIALS AND METHODS

We performed a retrospective (2009–2018) study on children with rib osteomyelitis verified by either positive culture or pathology. We excluded children with multifocal osteomyelitis or empyema necessitans. We reviewed medical charts for clinical, laboratory and pathology data, and treatment. All imaging modalities for rib abnormalities were evaluated for presence and location of osteomyelitis and abscess. We calculated descriptive statistics to compare patient demographics, clinical presentation and imaging findings.

RESULTS

The study group included 10 children (6 boys, 4 girls), with an average age of 7.3 years (range, 3 months to 15.9 years). The most common clinical presentations were fever (n=8) and pain (n=5). Eight children had elevated inflammatory indices (leukocytosis, erythrocyte sedimentation rate [ESR], C-reactive protein [CRP]). Localized chest wall swelling was found initially in six children and later in two more children. Rib osteomyelitis was suspected on presentation in only two children. All children had chest radiographs. Rib lytic changes were found on only one chest radiograph, in two of the four ultrasound studies, and in four of eight CTs. Bone marrow signal abnormalities were seen in all eight MRIs. In nine children the osteomyelitis involved the costochondral junction. Six children had an associated abscess. Staphylococcus aureus was cultured in eight children. Osteomyelitis was diagnosed based on pathology in one child with negative cultures.

CONCLUSION

While rib osteomyelitis is rare, imaging findings of lytic changes at the costochondral junction combined with a history of fever, elevated inflammatory markers or localized soft-tissue swelling in the chest should raise suspicion for this disease.

INTRODUCTION

In the pediatric population, the prevalence of osteomyelitis is 8 in 100,000 in developed nations, and higher elsewhere [1]. It most commonly affects the metaphysis of long bones such as the femur and tibia [2]. Osteomyelitis of the rib is extremely rare, making up only 1% of pediatric cases of osteomyelitis [1]. The classic presentation of rib osteomyelitis includes fever, chest or back pain, and an abscess or draining sinus that fails to heal [3]. However, these features are not always present, and the disease can present in a more indolent fashion [4]. Because of the rarity of this condition in children and the often nonspecific clinical presentation, osteomyelitis of the rib can represent a challenge in differentiating from other pathologies such as Ewing sarcoma family tumors and Langerhans cell histiocytosis [5,6,7]. This can lead to delays in diagnosis and treatment initiation.

Along with a detailed history, physical exam and laboratory results, imaging plays an important role in the diagnosis of rib osteomyelitis. However, imaging findings in these children can be nonspecific and often mimic other pathologies, especially early in the course of infection [8, 9].

Relatively few cases of osteomyelitis of the rib have been reported in children, with even fewer reports focusing on the imaging criteria and modalities that should be used to detect this condition. Much of the literature that discusses imaging specifically is more than 30 years old, before CT and MRI were in widespread use [8, 10]. The purpose of this case series is to explore the clinical presentation and imaging findings of children with rib osteomyelitis, with the goal of improved diagnosis of this rare condition.

MATERIALS AND METHODS

This retrospective study was approved by our institutional review board and complied with the Health Insurance Portability and Accountability Act. From the radiology archive at our tertiary-care children's hospital, we retrospectively identified all pediatric patients from 2009 to 2018 in whom the terms "rib" and "osteomyelitis" were mentioned in the imaging report, with the diagnosis verified by either positive culture or pathology. We excluded

patients with multifocal osteomyelitis or empyema necessitans (extension of empyema to the chest wall).

We reviewed the electronic medical record to obtain patient demographic data, clinical presentation, laboratory values, pathology reports and treatment. The features of clinical presentation evaluated included fever, chest pain, chest wall swelling/palpable mass, chest wall erythema, white blood cell count, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP). Radiologic findings were evaluated on chest radiography, cross-sectional imaging and functional imaging modalities, if performed. For each modality, a pediatric radiologist (B.K.) with 21 years of experience retrospectively reviewed the images and evaluated for presence of pathology at the rib, as well as the presence and location of commonly associated features, including pleural effusion, lung opacity and abscess. We used documentation in the medical record and radiology reports to determine the primary and differential diagnoses at the time of presentation, as well as throughout the course of illness.

We calculated descriptive statistics to evaluate and compare patient demographics, clinical presentation and imaging findings.

RESULTS

PATIENTS

Fourteen children were diagnosed with rib osteomyelitis; we excluded four, who had multifocal osteomyelitis (*n*=3) and blastomycosis empyema necessitans (*n*=1). The final study group included 10 children (6 boys, 4 girls), ages 3 months to 15.9 years (average 7.3 years) at presentation.

The most common presentations were fever (*n*=8) and pain (*n*=5). The location of pain was the upper abdomen in three children and the chest in two. Localized chest wall swelling was found on physical examination in six children at presentation, and in two others later in the course of hospitalization. In one child there was also a draining sinus. Most children (*n*=8) had laboratory findings suggesting an infectious process with either elevated ESR or CRP (*n*=8) and/or leukocytosis (*n*=7). The most common diagnostic considerations at presentation were tumor (*n*=3) and primary chest wall abscess (*n*=2).

Rib osteomyelitis was suspected in only two children at presentation, and the clinical diagnosis of rib osteomyelitis was made an average of 6 days after admission (range, 1–16 days).

IMAGING STUDIES

The imaging findings are summarized in Table 1. All children underwent chest radiography. Five children had chest radiographs demonstrating adjacent lung opacity either at presentation or follow-up (*n*=3) and pleural effusion (*n*=2) (Figs. 1, 2 and 3). Only one initial chest radiograph was positive on retrospective review (Fig. 3), demonstrating a lytic rib lesion. In five children the chest radiographs were normal (Fig. 4).

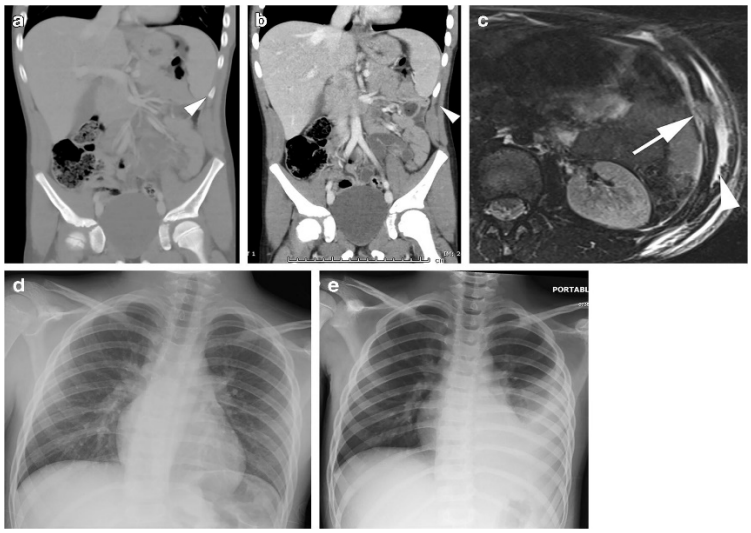
				Chest radiograph	Computed tomography				Magnetic resonance imaging					Ultrasound		
Patient	**Age (years)**	**Gender**	**Rib**	**Rib LC**	**Type of CT**	**Rib LC**	**Pleural effusion**	**Soft tissue**	**Rib BM**	**Rib LC**	**Rib fracture**	**Pleural effusion**	**Soft tissue**	**Rib LC**	**Soft tissue**	**Culture**
1	0.5	Male	Left 7 CC	Yes	Chest	Yes	Yes	No								Negative[a]
2	0.7	Female	Left 2 CC	No	Chest	No	No	Abscess	Yes	No	No	No	Abscess	No	Abscess	*S. aureus*
3	0.3	Male	Right 3 CC	No	Chest	Yes	No	Abscess	Yes	Yes	No	No	Abscess	Yes	Swelling	*S. aureus*
4	13.8	Male	Right 8 CC	No					Yes	No	Yes	No	Abscess	Yes	Abscess	*S. aureus*
5	8.9	Male	Left 9 CC	No	Abdomen	No	No	Swelling	Yes	No	No	Yes	No			*S. aureus*
6	15.9	Male	Right 5 CC	No					Yes	No	Yes	No	Abscess			*S. aureus*
7	12.4	Male	Right 8 CC	No	Abdomen	No	No	Swelling	Yes	Yes	Yes	Yes	Abscess	Yes	Abscess	*S. aureus*

				Chest radiograph	Computed tomography				Magnetic resonance imaging					Ultrasound		
Patient	**Age (years)**	**Gender**	**Rib**	**Rib LC**	**Type of CT**	**Rib LC**	**Pleural effusion**	**Soft tissue**	**Rib BM**	**Rib LC**	**Rib fracture**	**Pleural effusion**	**Soft tissue**	**Rib LC**	**Soft tissue**	**Culture**
8	3.1	Female	Left 6 CC	No	Abdomen	Yes	No	Abscess	Yes	No	No	Yes	Abscess			*S. aureus*
9	14.7	Female	Right 7 An	No	Chest	No	No	Abscess	Yes	No	No	No	Swelling			*S. aureus*
10	2.6	Female	Left 6 CC	No	Abdomen	Yes	No	Swelling								*S. aureus*

An anterior, *CC* costochondral, *Rib BM* bone marrow edema, *Rib LC* lytic, permeative or destructive rib lesion, *S. aureus Staphylococcus aureus*

[a]This child had positive culture for *Staphylococcus aureus* aspiration of a buttock abscess 3 weeks earlier and a positive rib biopsy for osteomyelitis

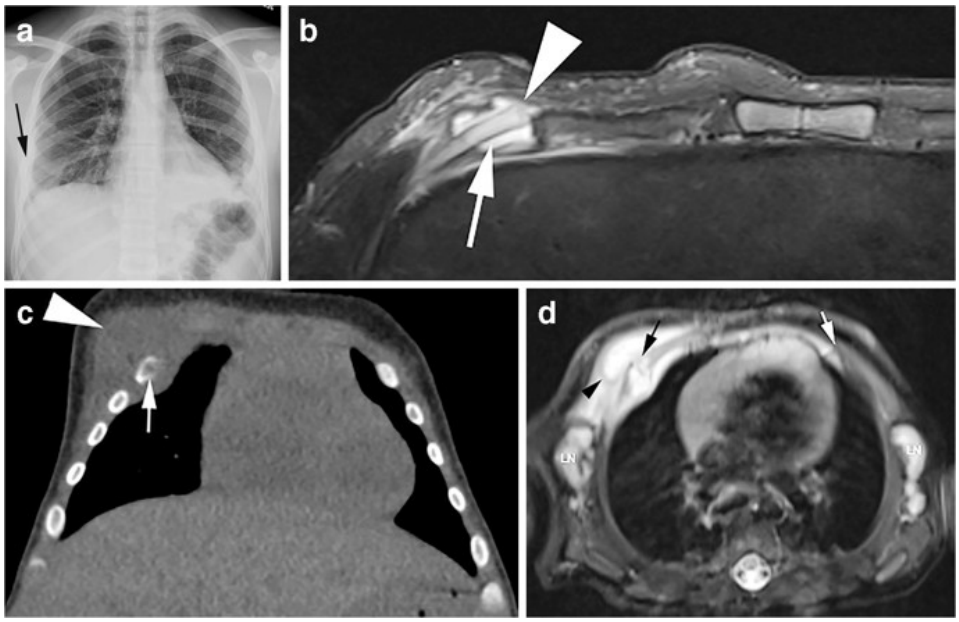
Fig 1.



Ninth rib osteomyelitis in a 9-year-old boy who presented with 2 days of fever, left-side abdominal pain, leukocytosis (15,900 cell/mL) and elevated C-reactive protein

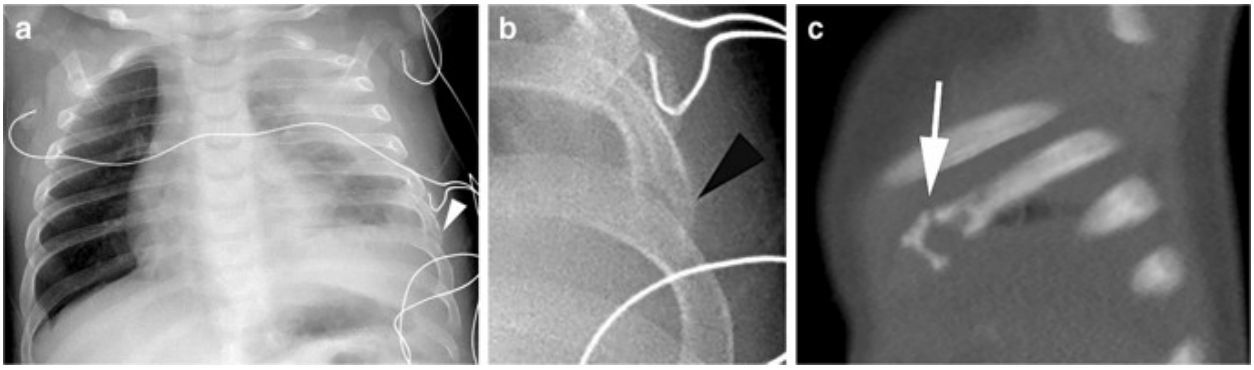
(5.1 mg/mL; normal <1 mg/mL). **a, b** CT of the abdomen was read as normal but on retrospect minimal fluid collection is seen at the chest wall. Coronal CT image with soft-tissue window (**a**) shows a small fluid collection on the left chest wall (*arrowhead*). Coronal CT with a bone window (**b**) shows normal left 9th rib at the costochondral junction (*arrow*). **c** Axial T2-W fat-suppressed MRI shows bone marrow edema of the left 9th rib at the costochondral junction (*arrow*) and the fluid collection (*arrowhead*). **d, e** Anteroposterior (AP) chest radiograph at diagnosis was normal (**d**), but a follow-up AP chest radiograph after 9 days (**e**) demonstrates reactive left pleural effusion and left lower lobe consolidation

Fig 2.



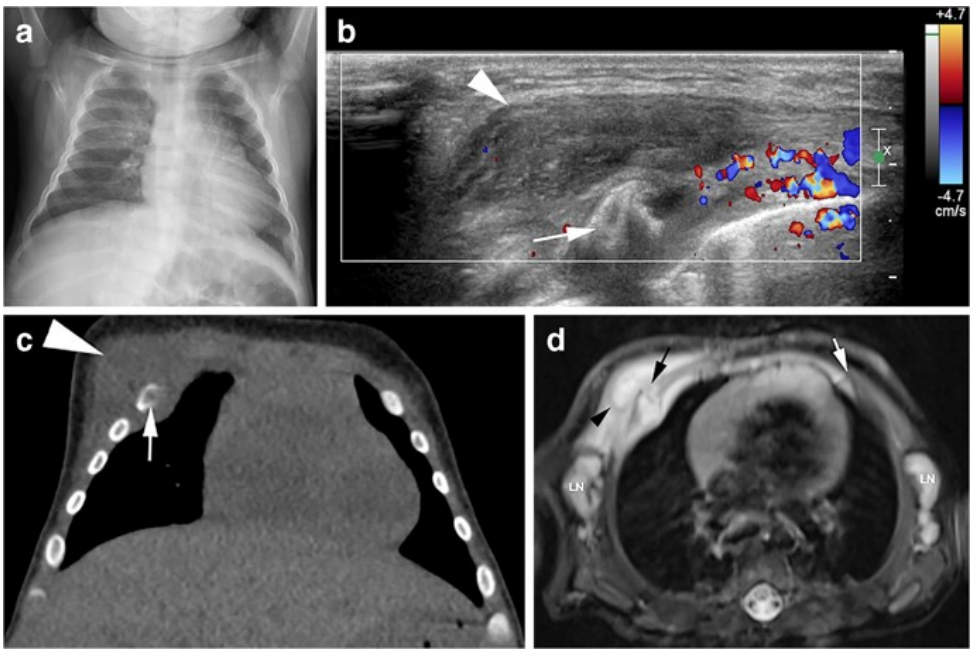
A 16-year-old boy presented with fever and right chest pain and was diagnosed initially with pneumonia based on chest radiography. **a** Posteroanterior chest radiograph demonstrates right small pleural effusion (*arrow*) and bilateral lower lobe consolidations that might be secondary to atelectasis secondary to restriction of full inspiration due to pain. **b** Axial T2-W fat-suppressed MRI demonstrates bone marrow edema of the right 5th rib at the costochondral junction with an abscess (*arrow*). There is a mildly displaced fracture at the costochondral junction (*arrowhead*)

Fig 3.



A 6-month-old boy with left 7th rib osteomyelitis. **a** Anteroposterior chest radiograph demonstrates left lung opacities with a small left pleural effusion. A lytic lesion at the costochondral junction of the 7th rib is seen only retrospectively (*arrowhead*). **b** This is better seen in a magnified image (*arrowhead*). **c** Sagittal CT shows the lytic changes at the costochondral junction (*arrow*)

Fig 4.



A 3-month-old boy with right 3rd rib osteomyelitis presented with right chest wall swelling, fever, leukocytosis (17,600 cell/mL) and elevated C-reactive protein (4.2 mg/mL; normal <3 mg/mL). The primary clinical and imaging diagnosis was a bone tumor. The diagnosis

of osteomyelitis was established by bone biopsy and positive culture for *Staphylococcus aureus*. **a** Anteroposterior chest radiograph at presentation is normal. **b** Transverse color Doppler image on admission demonstrates soft-tissue swelling (*arrowhead*). The destruction of the rib at the costochondral junction was missed (*arrow*). **c** Coronal CT on admission demonstrates destruction of the right 3rd rib (*arrow*) with adjacent soft-tissue swelling (*arrowhead*). **d** Axial MRI the following day again demonstrates rib destruction (*black arrow*) and adjacent soft-tissue swelling (*arrowhead*). The normal contralateral costochondral junction (*white arrow*) and bilateral axillary lymph nodes (*LN*) are also shown

All children had either CT or MRI evaluation. CT was performed in eight children; five received intravenous (IV) contrast agent. Four children had chest CT and four others had abdominal CT because their pain was in the upper abdomen (Fig. 1). CT demonstrated a chest wall abscess (*n*=4) or soft-tissue swelling (*n*=4) (Figs. 1 and 4). Lytic or permeative rib changes were found in four children (Figs. 3 and 4). In three of the eight CT scans, the radiologist report suggested the diagnosis of osteomyelitis. Ewing sarcoma was suggested in one child. In four children the rib pathology was missed; in one of them only the subcutaneous abscess was identified.

Pre- and post-IV contrast-enhanced MRI was performed in eight children; all showed rib abnormality. Abscess was seen in six children (Figs. 1 and 2). In one child the diagnosis was Ewing sarcoma. Osteomyelitis was suggested as a possible diagnosis in seven of the eight children. In one of these seven children the primary diagnostic consideration was Ewing sarcoma and in one other child rib fracture with hematoma was in the differential diagnosis.

Ultrasound (US) was performed in four children. Abscess was seen in three of the US studies, irregularities at the costochondral junction in two (Fig. 4), and soft-tissue swelling in one child. In two of the four US studies, the radiologist report suggested the diagnostic possibility of osteomyelitis. In one child the radiologist diagnosed an abscess without considering the possibility of an underlying osteomyelitis. In one other study that did not have an abscess, the radiologist reported nonspecific heterogeneous tissue.

In nine children the location of osteomyelitis was at the costochondral junction, and in one child it was in the anterior rib. In five children a right rib (ribs 3, 5, 7, 8, 8) was involved and in the others a left rib (ribs 6, 6, 7, 9, 12) was involved. Pathological fracture at the costochondral junction was demonstrated by MRI in three children (Fig. 2).

DIAGNOSIS AND TREATMENT

Osteomyelitis was diagnosed by pathology from biopsy of the rib in one child. Cultures were negative at the time of diagnosis. This child had a positive culture for *Staphylococcus aureus* from an aspiration of a buttock abscess 3 weeks prior to the presentation of the rib osteomyelitis. A pathogen was cultured in nine other children from one or more sources: blood cultures (*n*=5), abscess aspiration (*n*=4) and fine-needle aspiration (*n*=2). All cultures were positive for *Staphylococcus aureus*; only one of them was methicillin-resistant *Staphylococcus aureus*.

All children were treated with antibiotics. Abscess was drained in seven children and thoracentesis was performed in one child with pleural effusion.

DISCUSSION

Rib osteomyelitis is uncommon in children and has been described in only case reports and small case series [3, 4, 8, 10,11,12,13,14]. Because its presentation can often be indolent and nonspecific, the diagnosis of this condition is often delayed and misdiagnosed as other pathology, such as a Ewing sarcoma family tumor and Langerhans cell histiocytosis [4,5,6,7]. Rib osteomyelitis usually presents with fever and is characterized by chest pain and a localized chest wall swelling [3]. In our series, fever was present in most children (8/10, 80%). It is of interest that while localized pain was common at presentation (5/10, 50%), the majority of these exhibited upper abdominal pain (3/5, 60%). The likely reason is referred pain to the abdomen in cases of lower rib osteomyelitis. In our series, six children had osteomyelitis involving the 7th to 12th ribs. Chest wall swelling was present at presentation in six children and developed later in two additional children. One child also had a draining sinus. Almost all children had laboratory findings suggestive of an infectious process (8/10, 80%). However, at the time of presentation, osteomyelitis of the rib specifically was in the differential diagnosis in only

two children (2/10, 20%). The most common diagnosis at presentation was a chest tumor (3/10, 30%). This illustrates the challenge that this diagnosis might present to the clinician.

Imaging demonstrated that osteomyelitis involved the costochondral junction in almost all children (9/10, 90%). This is the equivalent to the metaphyseal area of the long bones, where hematogenous spread usually seeds the long bones because of sluggish blood flow of the capillary loops and venous sinusoids [15]. Osteomyelitis at the costochondral junction was previously described in only a few case reports that used cross-sectional imaging [11, 16]. Rib osteomyelitis was complicated in three of our patients with a pathological fracture at the costochondral junction. This was described previously in a case report [13]. In 7/10 children, rib osteomyelitis was associated with an adjacent abscess.

Chest radiography demonstrated rib lytic changes in only one child. In 5 children, the chest radiographs at presentation or follow-up demonstrated adjacent lung consolidation, 2 of the 5 (40%) with pleural effusion, which can mimic pneumonia.

There are very few prior case reports when either CT or MRI was used for the diagnosis of rib osteomyelitis [3, 11, 16]. In our series, all children had either CT or MRI studies. MRI was found to be more sensitive for the diagnosis of rib osteomyelitis as compared with CT. MRI demonstrated rib abnormality in 8/8 studies, while rib abnormality was demonstrated by CT in only 4/8 studies. The radiologist report only raised the possibility of osteomyelitis in three of the CT interpretations; in one child the diagnosis was bone tumor. The radiologist report included diagnosis of osteomyelitis in seven of the eight MRI studies and bone tumor was a diagnostic consideration in one of them. One child was diagnosed with bone tumor. (Fig. 2).

Staphylococcus aureus was cultured in 90% (9 of 10) of the cases. In one other child with negative culture, *Staphylococcus aureus* was cultured from a buttock aspiration from presentation 3 weeks earlier. *Staphylococcus aureus* is by far the most commonly reported pathogen [1] in hematogenous osteomyelitis and was the most common pathogen in prior case reports [3, 4, 8, 10, 13, 14, 16]. Tuberculosis should be considered in children who live or immigrated from places were tuberculosis is endemic [17]. Actinomycosis is a rare cause of rib osteomyelitis and should be considered when

accompanied with chronic lung consolidation and presented in children with poor oral hygiene [18].

The main limitations of our study are its retrospective nature and small number of patients. However, to our knowledge this is the largest case series reported using cross-sectional imaging modalities for evaluation of rib osteomyelitis.

CONCLUSION

Osteomyelitis of the ribs is a challenging diagnosis and is rarely the primary consideration in the initial diagnostic workup. Fever, abnormal inflammatory markers, and localized soft-tissue swelling in the chest were found in most of our patients. MRI was the most sensitive modality and costochondral junction was the most common location of osteomyelitis.

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