

# Sternal Fracture in Children: Diagnosis by Ultrasonography

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## Abstract

Because of its subcutaneous location, the sternum can be examined sonographically using a linear scanner. We report about two children who experienced blunt chest trauma. Anterior–posterior chest X-rays were normal. Ultrasonic imaging confirmed a fracture of the sternum with dorsal displacement of the distal fragment (by 0.97 cm) in the first child and a transverse fracture of the body of the sternum without displacement in the second child. In both children, pericardial effusion was excluded by sonography. The displaced fracture of the sternum was confirmed by magnetic resonance imaging (MRI), which ruled out concomitant injuries of the soft tissues adjacent to the sternum. Both sternum fractures were managed nonoperatively. These cases serve to emphasize the importance of sonography that represents an ionizing radiation free, noninvasive, efficient, and safe imaging modality to diagnose fractures of the sternum in children while also enabling the assessment of the pericardium.

## Keywords

- ▶ ultrasonography
- ▶ children
- ▶ sternum fracture
- ▶ ultrasound

## New Insights and the Importance for the Pediatric Surgeon

It is important to point out the importance of the use of ultrasound in the diagnosis of fractures in childhood.

## Introduction

Fractures of the sternum are rare, especially in children, with incidences ranging from 0.5 to 3%.<sup>1,2</sup> These injuries occur predominantly due to strong deceleration forces and/or blunt trauma to the chest in motor vehicle incidents. Forced flexion of the sternum across the shoulder harness of the seatbelt can cause sternal fractures in children, while fractures of the sternum without direct trauma are extremely rare.<sup>3,4</sup> Fractures of the sternum usually run transversely and are commonly located in the middle part of the body or manubrium.<sup>5</sup>

To detect bone injury and pneumothorax, plain X-ray images of the thorax are frequently obtained in patients

who have experienced blunt chest trauma. Because of its subcutaneous location, the sternum can be visualized easily by sonography. Since only few data on the effectiveness of ultrasonic imaging in detecting sternal fractures in children have been published, we report our experience with two patients to emphasize the usefulness of sonography in the diagnosis of sternal fractures in children.

## Case Report

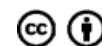
A 13-year-old boy with acute anterior chest pain localized in the region of the sternum was admitted to the emergency room. During a broad jump, he had experienced a cracking

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**Fig. 1** Longitudinal ultrasonic image showing the transverse fracture of the manubrium sterni with dorsal displacement of the distal fragment by 0.97 cm.



**Fig. 3** Lateral chest X-ray without signs of fracture.

noise in the area of his sternum. Physical examination revealed tenderness without swelling above the body of the sternum. Auscultation of the lungs and heart revealed no pathological findings, and the electrocardiogram (ECG) was normal. Anterior–posterior chest X-ray was normal. Ultrasonic imaging revealed a transverse fracture of the manubrium sterni with dorsal displacement of the distal fragment by 0.97 cm (→Fig. 1) in the absence of pericardial effusion. The displaced sternal fracture without combined intrathoracic injuries was confirmed by MRI (→Fig. 2).

The second child, a 6-year-old girl, fell from her bicycle and hit her sternum with the handlebar. She complained about

persisting pain above the sternal body. Cardiopulmonary examination was normal, and anterior–posterior chest X-ray showed no abnormality. In the lateral chest view, no subtle fracture line or displacement was demonstrated (→Fig. 3). Ultrasonic imaging identified a transverse fracture of the middle part of the sternum without displacement or pericardial effusion (→Fig. 4).

Both sternum fractures were managed nonoperatively. Because of persisting chest pain, especially during breathing, the children were admitted to the in-patient ward for observation and pain management. Sport participation was discouraged for 3 months. Sonographic follow-up after 9 months demonstrated consolidation of the fracture and sufficient remodelling of the sternum in both children (→Fig. 5).

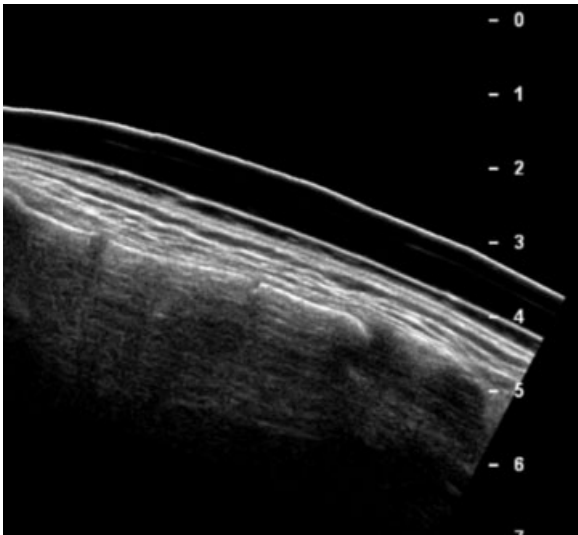
Ultrasonic imaging was performed by pediatric radiologists using a Philips iU22 scanner (Philips AG Healthcare, Zürich, Switzerland) equipped with a 12–5 MHz linear transducer.



**Fig. 2** T2-weighted sagittal MRI showing the fracture (indicated by arrow) of the sternum. MRI, magnetic resonance imaging.



**Fig. 4** Transverse ultrasonic image showing the transverse, nondisplaced fracture of the corpus sterni (indicated by arrow).



**Fig. 5** Longitudinal ultrasonic image obtained 9 months after injury showing consolidation of the fracture and sufficient remodelling of the anterior outline of the sternum.

Transverse and longitudinal planes were described in supine position of the patient. The longitudinal transducer position was found to be the best for visualization of the transverse fractures.

## Discussion

Causes of chest pain after blunt trauma in children may be pulmonary contusion, rib fracture, pneumomediastinum, hemopneumothorax, cardiac, aortic, or diaphragmatic injury, and sternal fracture.<sup>6</sup> Comprehensive medical history and clinical examination help to exclude associated injuries. The presence of multiple rib fractures correlates better with intrathoracic (pulmonary, cardiac, and aortic) or intra-abdominal injuries than severely displaced sternal fractures.<sup>7</sup>

Diagnostic assessment of blunt chest injury usually includes plain chest X-ray and in the case of suspected complex intrathoracic injuries, includes chest computed tomography (CT).<sup>8,9</sup> Ultrasonic imaging in the diagnostic workup of pediatric fractures has not been widely accepted. A retrospective study comprising 2,006 plain X-ray studies demonstrated that fractures were detected in only 17.6% of injuries in children.<sup>10</sup> Moreover, sternal fractures may be missed when displacement is minimal, and only conventional radiography is used.<sup>11,12</sup> In case of tiny sternal fractures, sonography has a higher diagnostic sensitivity and specificity than conventional chest X-ray.<sup>11</sup> In our two cases, lateral chest X-ray missed the sternum fracture in one child.

Despite the well-documented diagnostic value of the CT scan, its use is limited due to the effects of ionizing radiation on the growing tissue in children.<sup>13,14</sup> However, the CT scan remains an essential life-saving tool for diagnosing serious thoracic injuries, as long as it is performed properly (pediatric CT protocol) and justified clinically. In the child with the displaced sternum fracture, we performed magnetic resonance imaging (MRI) of the thorax to rule out concomitant

injuries of the soft tissues surrounding the sternum. The MRI was performed without general anesthesia.

Sternal fractures are usually identified by standard lateral chest X-ray, which, however, may be difficult to obtain in patients with multiple injuries.<sup>2</sup> In contrast, sonography is readily available at the patient's bedside and can easily be performed in the prone position. Sonography is suitable for obtaining dynamic images together with color Doppler studies and allows to examine subcutaneous structures such as the sternum. Furthermore, it can accurately evaluate associated lesions, such as hematomas and pleural or pericardial effusion. However, ultrasonography remains an operator-dependent diagnostic tool and has a smaller scanning area when compared with other imaging modalities, such as MRI, X-ray, or CT.<sup>15</sup>

Sonography has been used to detect stress fractures, to monitor the formation of callus in fractures of long bones and enable early diagnosis of osteomyelitis as well as in the screening for developmental dysplasia of the hip in infants.<sup>16–18</sup> In recent years, evidence has grown that sonography is more sensitive than conventional X-ray in the assessment of sternal fracture, in particular when performed by an expert.<sup>19</sup> However, fissures less than 1 mm wide or nondisplaced epiphyseal fractures (Salter–Harris type 1) are not detected reliably by sonography and therefore still rely on conventional X-ray for diagnosis.<sup>20</sup> Furthermore, ultrasonic visualization of bone areas that reside deeply in soft tissue may be insufficient because of the limited penetration depth.

Normal sternal development should also to be considered when evaluating the sternum by sonography. The sternum, composed of the manubrium, mesosternum (the body, composed of four parts) and xiphoid, develops from two lateral cartilaginous plates and a median rudiment that begin fusing in the midline in cephalocaudal direction during fetal development.<sup>21,22</sup> Each component of the sternum contains several ossification centers. Their pattern of appearance and configuration may vary greatly with the age of the patient.<sup>22,23</sup> Since some ossification centers are discernible until adulthood, they may be misinterpreted as a fracture in childhood. Failure of midline fusion may also be confused with a fracture. To avoid confusion between normal development of the sternum and a pathological finding, sound understanding of sternal development is indispensable, especially in children.

Various congenital anomalies may affect the sternum and also mimic a fracture. These include pectus excavatum (the sternum is displaced posteriorly and the ribs protrude anteriorly) with or without a tilted sternum (the sternum is oriented obliquely in the horizontal axis), pectus carinatum (the sternum is displaced anteriorly), sternal sclerotic band and cleft (vertically oriented midline bands; sternal clefts may occur isolated or in association with an ectopia cordis and pentalogy of Cantrell), sternal foramen, episternal ossicles (retro- or supramanubrial accessory bones), degenerative osteoarthritis with or without osteophytes or cysts, osteomyelitis with lytic osseous lesions, sternal dehiscence after sternotomy, and neoplasms.<sup>24</sup>

Isolated fractures of the sternum are uncommon, and their treatment is generally conservative in the absence of

concomitant injuries, and reduction is rarely required.<sup>15</sup> In our first case, the sternum was probably fractured by forced hyperflexion or repeated trauma. Generally, the surrounding ligaments of the sternum and cartilaginous attachments to the ribs are more elastic in children than in adults, making the sternum of a child less susceptible to fractures.<sup>25</sup> Therefore, a standard protocol for diagnostic workup and treatment does not exist. Given the remodelling capacity of the sternum in children, we decided to treat our patients non-operatively. Formation of callus and complete remodelling of the sternum were monitored sonographically.

In conclusion, sternal fractures and their healing in children can easily be monitored by ultrasonographic imaging using linear probes. Therefore, in case of an isolated fracture of the sternum, we recommend the use of ultrasonic scanning as the first-line diagnostic modality in children. If associated intrathoracic injuries are suspected clinically, complementary diagnostic imaging modalities are indicated.

#### Conflict of Interest

The authors have no conflict of interest to declare.

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