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Pictorial Review

# Imaging and reporting considerations for suspected physical abuse (non-accidental injury) in infants and young children. Part 2: axial skeleton and differential diagnoses

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## ARTICLE INFORMATION

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Recognising the skeletal manifestations of inflicted injury (II) in infants and young children is of crucial importance. There are specific fracture patterns which are highly suspicious of II in addition to common differential diagnoses with which radiologists should be familiar. Our objective is to provide a non-exhaustive review of the important factors relevant to the imaging and reporting of II as a platform for further learning. Part 2 encompasses fracture patterns of the axial skeleton and important differential diagnoses.

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## Introduction

Part 1 discussed important initial considerations of imaging inflicted injury (II) and specific fracture patterns of the appendicular skeleton. Fractures of the axial skeleton can be subtle and have a strong association with II. In this second article of a two-part series, we review the important fracture patterns of the axial skeleton, including rib and skull fractures, in addition to examining the important differential diagnoses of II.

## Specific fracture patterns of the axial skeleton in II

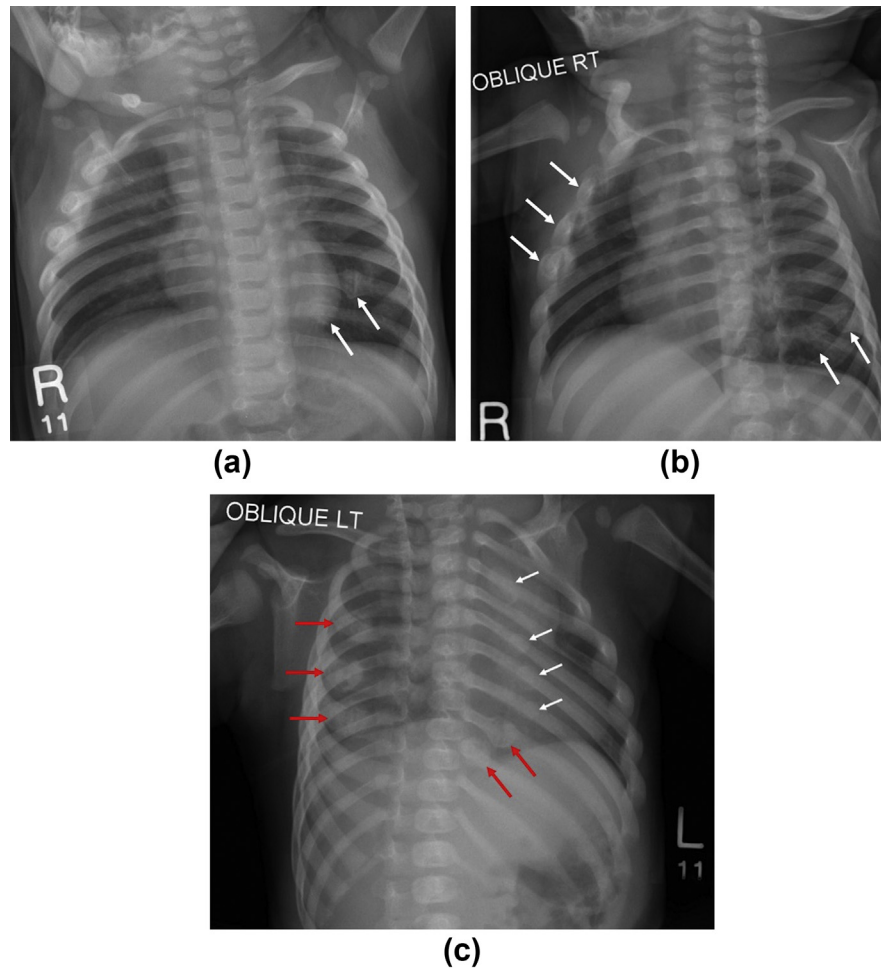
The axial skeleton forms the longitudinal axis of the body and comprises the thoracic cage, the vertebral column, and the skull.<sup>1</sup>

### Rib fractures

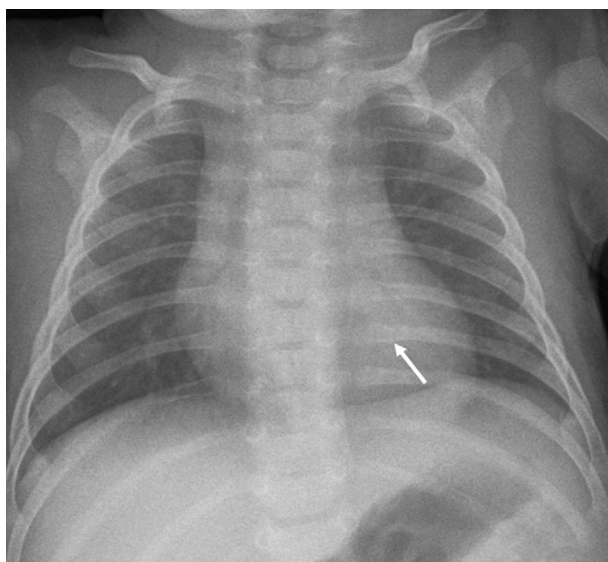
Given the degree of plastic deformity tolerated by the normal paediatric chest wall, rib fractures due to natural events and normal handling are uncommon. Posterior rib fractures are highly specific for abuse and result from substantial squeezing forces generated by adult hands applied to the paediatric chest wall causing "hyperextension of the posterior rib ends over the transverse processes, with

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**Figure 1** Healing rib fractures in a 3-month-old female infant whose twin brother died from inflicted head injury associated with skull and metaphyseal fractures. The co-twin had an acute event, whereas this twin had old rib injuries proving II at different times. (a) AP chest radiograph (arrows), (b) right oblique (arrows) and (c) left oblique (red arrows) show healing fractures of the posterior arcs of the left 8<sup>th</sup> and 9<sup>th</sup> ribs and anterior arcs of the right 2<sup>nd</sup> to 4<sup>th</sup> ribs. Do not mistake the sternal segments (white arrows) seen in (c) for the healing rib fractures (red arrows).



**Figure 2** Acute rib fractures in a 6-week-old with subdural haemorrhage. (a) Acute rib fractures are not always detectable on AP chest radiographs; however, note the left posterior 8<sup>th</sup> acute rib fracture (arrow). This was confirmed by healing callus on radiography 2 weeks later.

fracture of the ventral cortex".<sup>2</sup> Highly suspicious features include: rib fractures in children aged <18 months,<sup>3</sup> and in particular <12 months; fractures of the first rib, which require considerable energy<sup>4,5</sup>; and posteromedial location of the fracture<sup>3,6–8</sup> (Fig 1).

Anterior rib arc and costochondral fractures result from direct blunt forces to the chest wall<sup>6,7,9,10</sup>; the latter may be associated with minimal healing callus. Anterior/costochondral fractures of the lower ribs are associated with major intra-abdominal injury.<sup>10</sup> Those infants and children with abusive rib fractures tend to have more rib fractures and have fewer concurrent intrathoracic injuries than those with confirmed/witnessed accidental injury.<sup>11</sup>

Radiography has a low sensitivity for the detection of acute rib fractures because they are often incomplete and usually minimally displaced<sup>2,10</sup> (Fig 2). In one series concerning sudden unexpected death in infancy (SUDI), nearly 80% of acute rib fractures confirmed on post-mortem were undetectable on chest radiographs, even in retrospect.<sup>12</sup> Computed tomography (CT) has an increasing role in clinical practice as a problem-solver in live children when rib fractures are suspected.<sup>13,14</sup>

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