

# Prevalence and Characteristics of Rib Fractures in Ex-preterm Infants



**WHAT'S KNOWN ON THIS SUBJECT:** Osteopathy of prematurity continues to occur in preterm infants. Osteopathy of prematurity can cause rib fractures in ex-preterm infants.



**WHAT THIS STUDY ADDS:** Rib fractures in ex-preterm infants are often posterior and multiple. Posterior rib fractures may not be diagnostic of nonaccidental injury in ex-preterm infants.

## abstract

**OBJECTIVES:** This study aimed to identify the prevalence and characteristics of rib fractures in ex-preterm infants.

**METHODS:** Infants born at <37 weeks' gestation and admitted before 2011 to 3 regional neonatal units were identified from admission registers. For 2 centers, these data were available from 2000 onward and, for another center, from 2005. Electronic records were searched to identify chest radiographs performed up to age 1 year. Chest radiograph reports were then reviewed for evidence of rib fractures, and the case notes of all affected individuals were scrutinized.

**RESULTS:** Of the 3318 eligible preterm infants, 1446 had a total of 9386 chest radiographs. Of these infants, 26 (1.8%) were identified as having a total of 62 rib fractures. Their median (range) gestation at birth was 26 weeks (23–34). The median chronological age of these infants at the time of the radiograph was 14 weeks (5 weeks to 8 months). The median corrected gestational age at the time of the radiograph was 39 weeks (34 weeks to 4 months). Of the 62 fractures, 27 (36%) were sited posteriorly, and 15 (53%) of the infants with posterior rib fractures were diagnosed with osteopathy of prematurity. Classic risk including conjugated hyperbilirubinemia and diuretics, were present in 23 of 26 (88%) infants. A full skeletal survey was performed in 8 of 26 (31%). Investigations for nonaccidental injury occurred in 4 of 26 (15%) cases.

**CONCLUSIONS:** Evidence of rib fractures is present in ~2% of ex-preterm infants. The evaluation of these fractures in infancy requires a detailed neonatal history irrespective of the site of rib fracture. *Pediatrics* 2012;130:1116–1119

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### KEY WORDS

bone, metabolic disease, nonaccidental injury, osteopathy, prematurity

### ABBREVIATION

NAI—nonaccidental injury

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Overt rib fractures are rare in children of all ages, representing only 1% of fractures in children.<sup>1</sup> They are particularly unusual in infants, and the positive predictive value of nonaccidental injury (NAI) in the absence of trauma or surgery is reported to be ~70%.<sup>2</sup> Posterior rib fractures are considered by some to be more specific for NAI,<sup>3</sup> but, these, as well as fractures at other sites, have been reported in conditions such as osteopathy of prematurity, osteogenesis imperfecta, accidental injury, and birth injury.<sup>4–6</sup>

Approximately 80% of bone mineralization takes place during the third trimester of pregnancy.<sup>7</sup> Consequently, preterm infants are at increased risk of osteopenia, particularly if born at a low birth weight and if their immediate neonatal course is complicated by conditions such as prolonged total parenteral nutrition, conjugated hyperbilirubinemia, hypophosphatemia, and use of furosemide.<sup>8</sup> Indeed, bone mineral content as well as speed of transmission of ultrasound may be markedly reduced when infants are born earlier than 28 weeks' gestation.<sup>9–11</sup> Studies in the past have reported a fracture incidence as high as 33% in infants weighing <1500 g.<sup>12</sup> The incidence of rib fractures, in particular, is not widely reported in the literature. One small study of 25 infants, however, reported an incidence of up to 50%.<sup>13</sup> During the past few decades, there have been several advances in the management of the preterm infant, and a more recent study of 72 infants <33 weeks' gestation reported an incidence of 7%.<sup>3</sup>

The aim of the current study is to extend the limited data that are currently available by describing the prevalence and characteristic features of rib fractures in ex-preterm infants.

## METHODS

Admission details of 2 regional neonatal units were examined from the years

2000–2010 to identify all infants born at <37 weeks' gestation. The admission books from 1 additional neonatal unit were also scrutinized from the years 2005–2010. To ensure that as many children with rib fractures were identified as possible, all skeletal surveys performed between the years of 2000 and 2010 were also reviewed for any evidence of rib fractures in ex-preterm infants. All skeletal surveys were only performed in one of the centers. Electronic hospital records were then linked to these infants to identify any chest radiographs that were performed up to the age of 1 year and reported a rib fracture. Three different forms of diagnostic imaging databases were used to ensure that no radiographs were missed. The case notes of each child with a rib fracture were studied to identify the characteristics of the rib fractures and the affected infant. Any patient with a rib fracture attributed to thoracotomy surgery was excluded.

All data are described as median and ranges. The frequency of potential risk factors and their respective confidence intervals were calculated and a Pearson  $\chi^2$  test was performed for each of the neonatal centers by using Minitab v 16 (Minitab Inc).

The study was considered a health service evaluation and did not require ethics approval or informed consent.

## RESULTS

Of the 3318 infants who were born at <37 weeks' gestation in the 3 centers, 1446 had a total of 9386 chest radiographs. All radiographs were anteroposterior. The median (range) of radiographs performed in any child was 2 (1–128). A total of 62 rib fractures were identified in 26 of these 1446 infants (1.8%) (18 male, 8 female). The median gestational age of the affected infants was 26 weeks (23–34), and the median chronological age at the time of the radiograph that detected

a fracture was 14 weeks (5 weeks to 8 months). The median corrected gestational age at the time of radiograph was 39 weeks (34 weeks to 4.6 months). The respective prevalence in each center was 23 of 768 (2.9%), 1 of 214 (0.5%), and 2 of 464 (0.4%). There was a significant difference in prevalence in each center ( $\chi^2 = 13.3$ ,  $P < .001$ ).

The chest radiographs were undertaken to investigate respiratory tract symptoms ( $n = 10$ , 38%); to be part of an investigation of sepsis ( $n = 7$ , 27%); to confirm the position of an endotracheal tube, nasogastric tube, or central line ( $n = 6$ , 23%); and to investigate abdominal symptoms ( $n = 3$ , 12%).

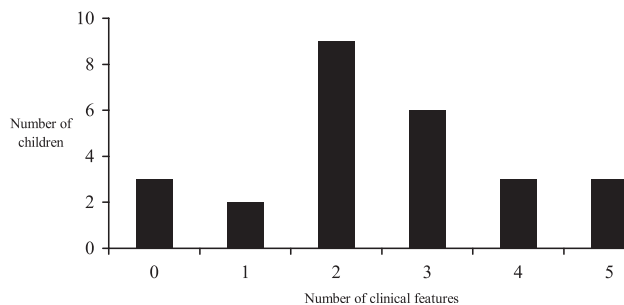
Anatomically, the highest rib affected was the fourth rib, but the sixth rib was most commonly affected ( $n = 15$  fractures). Fractures were bilateral, only left, or only right in 7 (27%), 12 (46%), and 7 (27%) subjects, respectively. Of the 62 fractures, the position of the fracture was posterior in 29 (47%), posterolateral in 19 (31%), lateral in 13 (21%), and anterior in 1 (2%). In children with multiple fractures, all fractures were in the same position on multiple ribs. Fractures were described as "healing" in all but 1 patient; this patient's fractures were considered secondary to bone disease associated with cystic fibrosis.

Clinical features that were associated with fractures included total parenteral nutrition, diuretics, conjugated hyperbilirubinemia, low calcium/phosphate levels, chronic lung disease, and high alkaline phosphatase levels (Table 1). The majority of infants had >1 of these features; only 2 of 26 (7.6%) infants had only 1 feature (Fig 1). Three infants (11.5%) had no apparent risk factors for rib fractures, and 2 of these children were investigated for NAI. Of those patients with low calcium levels, the median value was 2.0 mmol/L (range, 1.4–2.1 mmol/L). In terms of phosphate levels, the median value was 0.5 mmol/L

**TABLE 1** Clinical Features Associated With Rib Fractures in 26 Ex-preterm Infants

	<i>n</i>	%	CI, %
Total parenteral nutrition	15	57.6	36.9–76.6
Diuretics	11	42.3	23.3–63.1
Conjugated hyperbilirubinemia	11	42.3	23.3–63.1
Low serum calcium (<2.2 mmol/L)	8	30.7	14.3–51.8
Chronic lung disease	6	23.1	9.0–43.6
Low serum phosphate (<0.8 mmol/L)	5	19.2	6.5–39.4
High serum alkaline phosphatase (>120 IU/L)	4	15.4	4.4–34.9
Cystic fibrosis	2	7.6	0.9–25.1
Low serum vitamin D (<25 nmol/L)	1	3.8	0.1–19.6

CI, confidence interval.



**FIGURE 1** Number of infants with clinical features that may place them at risk for fractures.

(range, 0.4–0.7 mmol/L). The median alkaline phosphatase level was 689 IU/L (range, 483–782 IU/L).

The median number of fractures per child was 2 (1–8), and Table 2 outlines the attributable cause of the fractures according to the frequency of fractures. The outcome of clinical investigations was clearly evident in 21 (81%) of these infants. One infant died before any investigations were conducted, and 4 infants had no clear follow-up in the case notes. Of the 26 infants, rib fractures were attributed to osteopathy of prematurity in 17 (65%) and osteopathy secondary to cystic fibrosis and early hepatic dysfunction in 1 (4%).

The majority of infants (*n* = 19, 73%) were noted to have rib fractures

during their initial hospitalization. The remaining 7 (27%) infants had been discharged from the neonatal unit and had returned for follow-up or for an emergency admission at the time of the radiograph reporting the fracture. Of these 7, NAI was suspected in 4 (57%) cases; 2 (29%) infants had no follow-up, and 1 (14%) was diagnosed with metabolic bone disease. A full skeletal survey was performed in all of these infants as per standard guidance for NAI. Additional fractures of the radius, ulna, and femur were only identified in the infant with metabolic bone disease.

## DISCUSSION

This study determined the prevalence of rib fractures in ex-preterm infants by

examining all the chest radiograph reports in the preterm infants admitted to all 3 neonatal units in Glasgow. In addition, this study examined the results of any skeletal surveys performed during the study period in ex-preterm infants. It represents the largest study of fractures that has been performed in this field until now. The prevalence of 1.8% is lower than that reported in previous studies, which date from a period when neonatal nutritional care was different.<sup>13</sup> It is likely that this is an underestimate, because the chest radiographs in the current study were performed to investigate a clinical condition. The median corrected gestational age of infants with a chest radiograph that reported a fracture was around term, and most preterm infants do not have chest radiographs at that age. The timing of diagnosis of fractures also coincides with the peak incidence of osteopathy of prematurity as reflected by markers of bone mineral status.<sup>14</sup> The exact timing of when the fracture was sustained is, however, difficult to ascertain, because many of the fractures were healing, and all were identified opportunistically. There were no fractures in infants with a gestational age >34 weeks, but this study included all infants with a gestational age <37 weeks as the denominator, and this may be another reason for a lower observed prevalence. The data in the admission books from each center did not invariably record gestation, and, as a result, it was not possible to use a denominator of an earlier gestational age.

The prevalence of fractures may have also been influenced by the fact that all chest radiographs that were performed for clinical indications in this study were anteroposterior films. Studies have suggested that oblique films are more likely to yield evidence of rib fractures.<sup>2</sup> The center with the markedly higher prevalence of rib fractures was a large

**TABLE 2** Number of Rib Fractures per Child and Attributable Cause of the Fractures

	Number of Rib Fractures							Total Infants
	1	2	3	4	5	7	8	
Osteopathy of prematurity	7	7	1	—	1	1	1	18
NAI	2	1	—	—	—	—	—	3
Unknown	1	1	1	1	1	—	—	5
Total infants	10	9	2	1	2	1	1	26

pediatric teaching hospital and had the highest number of chest radiographs performed. In addition, as the regional center for neonatal surgery, it would have admitted the more severely ill preterm infants. Almost all radiographs in all 3 centers were interpreted by pediatric radiologists, so it is unlikely that the differences in incidence are due to variable expertise in identifying rib fractures. However, because of the retrospective nature of this study, it is difficult to truly ascertain why there is such a marked difference in incidence in the 3 centers. We suggest that future studies should explore differences in the management that is targeted at improving bone health of the preterm infant. Although osteopathy of prematurity is a multifactorial problem,<sup>15</sup> it is clear from the current study that fractures can be encountered in infants with just 1 risk factor.

The finding that, in almost half of the cases, the rib fractures were located posteriorly is important to note. Of these, NAI was only suspected in 2 infants. In cases of NAI, rib fractures

have been reported at many locations,<sup>2</sup> but posterior rib fractures are thought to be much more common in cases of child abuse in comparison with other causes of fractures.<sup>4</sup> The current study suggests that this may not apply in the context of prematurity. In nearly half (46%) of the affected ex-preterm infants, the posterior rib fractures were attributed to osteopathy of prematurity. This is consistent with a previous report that examined rib fractures in 39 infants.<sup>5</sup> The investigators found that there was no significant difference in the position of fractures in abused versus nonabused infants.<sup>5</sup> Previous studies have also suggested that infants with rib fractures secondary to abuse have more rib fractures than those who had not been abused.<sup>2</sup> Of the 3 infants in whom NAI was suspected and standard NAI investigations were undertaken, 2 had only 1 fracture and 1 had 2 fractures. In comparison, infants with osteopathy of prematurity had up to 8 rib fractures. It can be argued that, in the current cohort, more cases of fractures could

have been associated with NAI. Of note, NAI was only suspected and investigated in a subset of infants who had been discharged from the hospital before the fractures were identified. There is, therefore, a need for clearer guidance for investigating fractures in this group of infants.

## CONCLUSIONS

The prevalence of rib fractures in a group of ex-preterm infants managed in contemporary tertiary neonatal centers is at ~2%, and the peak timing for their diagnosis coincides with that for osteopathy of prematurity. In these infants, rib fractures are often multiple and located posteriorly. Obtaining a careful history that investigates the neonatal course is critical in the evaluation of the ex-preterm infant with a coincidental finding of rib fractures.

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