

Humeral fracture in non-ambulant infants—a possible accidental mechanism

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Abstract

Background Humeral fracture in a non-ambulant infant younger than 1 year is suspicious for a non-accidental injury unless there is a credible accidental explanation. A previously unrecognised accidental mechanism was described in 1996 whereby a 5-month-old infant was rolled by a 3-year-old sibling from a prone to a supine position.

Objective To investigate the widely accepted view that an infant with limited mobility cannot sustain a fracture of the humerus by his or her own actions in the absence of the intervention of an external party.

Materials and methods We present seven cases of non-ambulant infants between 4 and 7 months of age in whom an isolated humeral fracture was the only injury present.

Results In each case the caregiver described the fracture occurring when the child rolled over, trapping the dependent arm, without the intervention of another party.

Conclusion There is no proof for this mechanism in the form of an independent witness or video recording. However, we propose that this mechanism is worthy of further consideration as a rare and unusual cause for the injury. Further study is required.

Keywords Child abuse · Fracture · Humerus · Injuries · Infant · Radiography

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Introduction

In 1996 Hymel and Jenny [1] published a case report of a 5-month-old who sustained a fracture of the humerus whilst being rolled from prone to supine by a 3-year-old sibling. The incident was recorded on video, complete with audio recording of the fracture occurring. This provided incontrovertible proof of a previously unrecognised mechanism for a humeral fracture in a non-ambulant infant in a domestic setting. This mechanism will be referred to as the Hymel manoeuvre.

The authors of this paper are all experienced paediatric radiologists in the field of non-accidental injury and have acted as expert witnesses to the courts in the United Kingdom in several hundred cases of alleged non-accidental injury. Since Hymel's paper, we have become aware, as a result of acting as expert witnesses appointed by the court, of a number of cases in which caregivers gave a history that an infant sustained an isolated humeral fracture rolling from prone to supine, or vice versa, without the intervention of an external party. Is this a credible explanation?

Materials and methods

Between 2007 and 2013 the authors encountered seven cases of a recent isolated humeral fracture with a history from the caregiver that the child rolled over, causing the fracture. The cases were derived from our combined experience as court-appointed expert witnesses. We reviewed the available clinical records and court documents, including statements from caregivers and all radiographs for these cases.

We recognise that because these cases have come to our attention through the court process, they are a highly selected and retrospective cohort, which may be regarded as a weakness due to selection bias.

Results

None of the infants sustained any cranial or intracranial injury or had evidence of retinal haemorrhages. None of the infants had any evidence of underlying metabolic or genetic bone disease.

Skeletal surveys were performed according to departmental protocols at the treating institutions. There was some variation in technique and quality, but all were considered diagnostically acceptable by the authors acting as court-appointed experts. Because of the timetable of the court process the authors had no influence over the radiographic technique or quality. None of the cases had follow-up skeletal survey (this is not and was not standard practice in the UK). Follow-up of the humeral fractures was determined by local orthopaedic practice.

The histories have been adjusted to preclude any possibility of identification. In particular, the gender of the infants and the side of injury has not been given. We do not believe that the absence of these details alters the discussion or debate in any important respect. No significant factual issues have been altered. Below we illustrate the cases (Fig. 1).

Case 1

A previously well 7-month-old term-delivery infant was lying prone on a play mat. The parents, who were in the room, heard the infant scream and the infant was then lying supine with the arm underneath the body. The arm was floppy and the infant screamed when it was handled. The parents went immediately to the hospital, where radiographs revealed a recent, minimally angulated transverse fracture of the mid-shaft of the humerus. There were no other injuries on skeletal survey.

Case 2

A previously well 4-month-old was lying prone on a play mat with the mother watching from a couch. The infant had recently learned to roll from supine to prone and was attempting to roll from prone to supine, but up until this time was prevented from doing so by the dependent arm. On this occasion the infant rolled over into supine position and the mother reported hearing a crack. The arm was trapped underneath the body. The arm was floppy and the infant was crying. The infant was taken immediately to the hospital, where radiographs revealed a recent spiral and undisplaced mid-shaft fracture of the humerus. There were no other injuries on skeletal survey.

Case 3

A previously well 4-month-old was lying prone on a play mat with the mother watching TV. The mother described the infant trying to roll from prone to supine. The infant started

screaming and the mother said the dependent was arm stuck underneath the body. The infant was taken immediately to the hospital, where radiographs revealed a recent, transverse fracture of the mid-shaft of the humerus. There were no other injuries on skeletal survey.

Case 4

A previously well 7-month-old term-delivery infant was lying prone on the floor whilst the mother prepared food. The infant was able to roll from supine to prone but not from prone to supine. Mother heard a scream and found the infant lying supine with the arm trapped beneath the body. The arm was floppy but the infant settled on feeding. Over the following 2 days the infant appeared to be in pain and the parents went to the hospital, where radiographs revealed a recent, undisplaced, spiral fracture of the mid-humeral shaft with soft-tissue swelling. There were no other injuries on skeletal survey.

Case 5

A previously well 7-month-old was lying supine on the floor and the mother went into another room. When she returned the infant was prone, with the arm beneath the body. The infant was screaming and the arm was floppy. The infant was immediately taken to the hospital, where radiographs revealed a recent, mildly angulated, transverse fracture of the mid-shaft of the humerus. There were no other injuries on skeletal survey. Developmentally, the infant was able to roll in both directions.

Case 6

A previously well 5-month-old was observed by the parents to be rolling on a bed from supine onto the right side, catching the arm underneath the body. They heard a popping sound, following which the infant cried and stopped moving the arm. The infant was taken immediately to the hospital, where radiographs revealed a recent, undisplaced spiral fracture of the distal third of the humeral shaft. There were no other injuries on skeletal survey.

Case 7

A previously well 7-month-old was put to sleep supine in a cot. A few minutes later the infant let out a piercing cry. Both parents returned to the bedroom and found the child prone. The infant was inconsolable and the arm was limp. The infant was taken immediately to the hospital, where radiographs demonstrated a recent, minimally displaced, transverse fracture of the mid-shaft of the humerus. There were no other injuries on skeletal survey.



Fig. 1 Radiographs of the seven humeral shaft fractures are shown. Mid-shaft transverse fractures are present in case 1, a 7-month-old (a), case 3, a 4-month-old (b), case 5, a 7-month-old (c), and case 7, also a 7-month-old (d). There are minimally displaced spiral fractures of the mid-shaft of the

humerus in case 2, a 4-month-old (e), case 4, a 7-month-old (f), and case 6, a 5-month-old (g). The gender and side of fracture in these children is being withheld to protect their identity

Discussion

Humeral shaft fracture along with femoral fracture and skull fracture are the commonest single fractures seen in infancy [2]. A study of 930 skeletal surveys by Karmazyn et al. [3] found that long-bone fractures were the most common fracture, occurring in 22% of children and accounting for 42% of all fractures detected. The cause can be accidental or non-

accidental. In non-ambulant infants non-accidental causes predominate. A study of fracture patterns in Nottingham children showed no accidental humeral fractures in infants. The same study of 28 children with non-accidental injury revealed 7 (25%) with humeral fracture [4].

However, the determination of cause in an individual case is entirely dependent on the explanation given by caregivers. No radiologic feature of the fracture can determine cause.

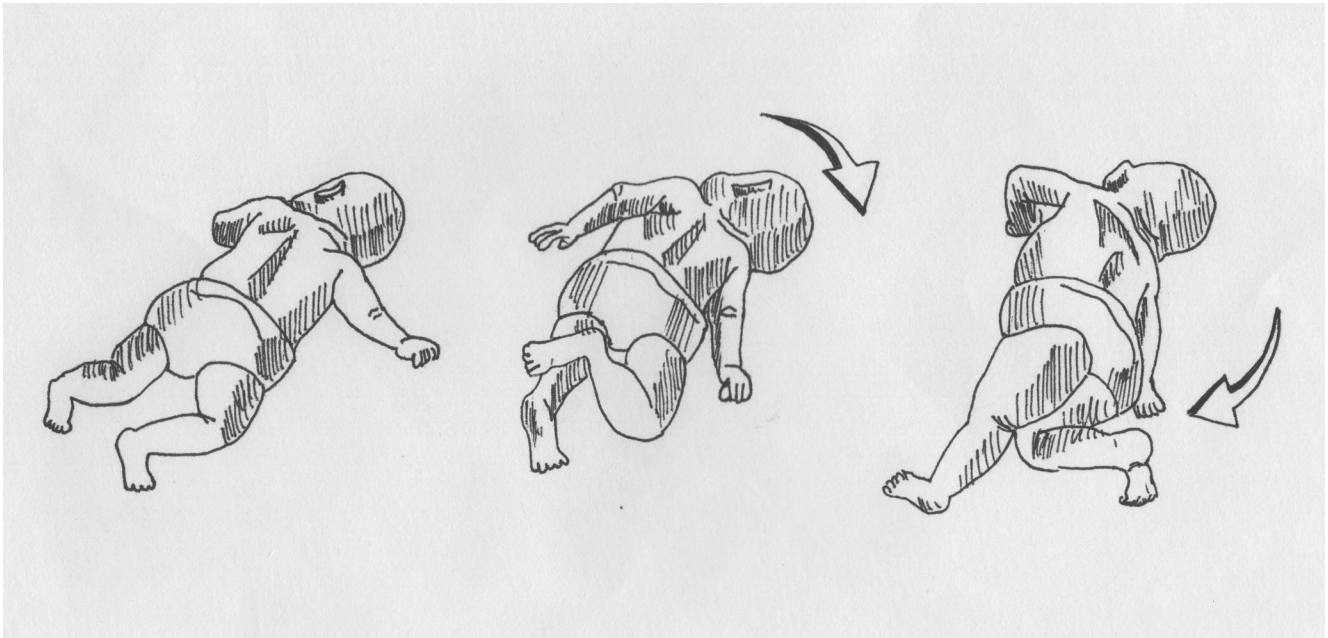


Fig. 2 A drawing made from a video recording of an infant a short time before the child presented with an undisplaced spiral fracture of the right humerus. The illustration depicts the rolling mechanism and the position

of the arm reported by the mother. Until the incident the infant was unable to roll completely onto his back. The first time the infant did so the fracture is said to have occurred

Therefore, in the absence of any other injury or social or medical concerns, the credibility of the mechanism proffered is crucial to the determination of accidental versus non-accidental causation [5, 6].

In non-ambulant infants one would expect a clear and credible traumatic event to provide an accidental account for such a fracture. For example, a parent falling down stairs whilst carrying a child [5–8] or a road traffic accident. It is widely accepted that non-ambulant infants cannot sustain such a fracture by their own actions or from minor domestic accidents [9–13]. Explanations such as the infant sustaining the injury by trapping the arm in cot bars or falling out of bed are usually dismissed as not credible [14–16].

The common features of the cases are: the ages and stage of development of the infants are very similar. None of the infants was crawling, but all were attempting or able to role from prone to supine or supine to prone. All the caregivers gave very similar histories that the injured arm was trapped beneath the body during the roll. We accept that in only three cases (2, 3 and 6) did the caregiver(s) directly witness the roll. All the caregivers gave the same history consistently throughout the proceedings. Medical attention was sought immediately in six cases and within 2 days in the remaining case (case 4). In four cases only one adult was present at the time of the fracture (cases 2, 3, 4, 5). There were no other fractures detected or any other significant injuries to support a diagnosis of non-accidental injury. The cases were also notable for the lack of concern by social services regarding the family dynamics.

The manoeuvre described in four cases was similar to the Hymel case in that it was a roll from prone to supine. Because

the range of movement of the shoulder–scapula complex is limited in this direction, it is easier to understand how the humerus may become fixed in position as the trunk passes through 90°, thus resulting in a fracture. The roll was described as supine to prone in three cases. Because the shoulder–scapula complex has a greater freedom of movement in this direction it is more difficult to understand how in this scenario the humerus could become trapped sufficient to cause a fracture.

In only three cases was the fracture spiral, as was the case in the Hymel paper. In two of the four cases where the roll was alleged to be from prone to supine the fracture was spiral. However, it is known that in infants the same mechanism can give rise to spiral, oblique or transverse fracture and the type of fracture cannot be used to differentiate accidental from non-accidental aetiology [3].

In two cases during the investigation of the fracture parents provided a video of how the child, prior to the fracture, attempted to roll from prone to supine. The dependent arm is extended out to the side along the floor, while the other pushes the body into a lateral position. Below is a drawing made from one of the videos (Fig. 2). This recording was made a few days prior to the child presenting with the fracture.

The question then arises, given the known Hymel mechanism: can a child carry out the Hymel manoeuvre without the intervention of another person to operate the lever? Without the benefit of videotape it is impossible to say definitively one way or the other. However, before Hymel's paper that mechanism was not commonly accepted as possible.

If this mechanism is possible, then why has it not been recognised before, given that most infants go through this stage of development without sustaining any injury? These issues form the crux of the debate, which is the purpose of this report.

Conclusion

The authors have independently and through the court process recognised this conundrum. We are open to the concept that it may be possible, but we also accept that without definitive proof it remains a contentious issue in that it is unproven theory rather than accepted fact.

We do not claim that any of these injuries was either accidental or non-accidental. Such a determination is for the court and is not based solely on radiographic evidence, but is a complex decision based upon careful assessment of medical and social factors. We would like to stress that this case series alone should not be used in the court process as indicative of any form of proof that this mechanism is a credible explanation for a humeral fracture. Our hope is that a wider debate and the experience of others may help to clarify this issue.

Conflicts of interest None.

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