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Assessment of interpretation of paediatric skeletal radiographs in the emergency room

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ARTICLE INFORMATION

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AIM: To assess the performance of paediatric skeletal radiography interpretation in the emergency department.

MATERIALS AND METHODS: In a large paediatric referral centre, data from trauma patients with initially misdiagnosed skeletal radiography was collected from October 2014 to June 2015. Data analysis focused on demographic data, region of the injury and clinical consequences as well as outcome of treatment.

RESULTS: In 125 of 2,316 patients aged from 1–17 years an initial misdiagnosis was documented (5.4%). Misdiagnosis was detected and corrected the next day in a routine review attended by an experienced paediatric radiologist. False-negative interpretation (missed fracture) was found in 62 and false-positive (overdiagnosis) interpretation in 63 patients. The highest error rate was found in elbow radiography (12%) followed by wrist (8%), fingers (4.5%), metacarpus (4.2%), and toes (3.5%). The most frequently missed fracture was supracondylar elbow fracture (n=12).

In case of initially missed fractures treatment was adjusted delayed the next day. In none of these patients, were repositioning or open surgical procedures necessary. No misdiagnosis resulted in additional morbidity.

CONCLUSION: Misinterpretation of paediatric skeletal radiography by paediatric emergency physicians occurred frequently. The majority of diagnostic errors occurred in a few regions. None of these misdiagnoses negatively affected patients' health. A routine review by an experienced paediatric radiologist is mandatory, but may suffice the next day.

Introduction

In the majority of cases paediatric traumatic injuries cannot be diagnosed by physical examination alone. Especially extremity pain necessitates radiography to differentiate fracture from contusion. Unfortunately, the interpretation of skeletal radiographs in paediatric trauma patients is challenging. Physicians must be aware of the normal developmental anatomy of growth plates and ossification centres. Discrete epiphysiolysis and fracture lines close to growth plates may easily be overseen.

Moreover, in the paediatric emergency department the initial interpretation of radiographs is often performed by physicians in training with lesser experience concerning the specifics of paediatric skeletal radiography. Basically, it is clear that diagnostic errors are inevitable, but they may cause serious problems: overlooked fractures result in delay of optimal treatment whereas overdiagnosis may create unnecessary morbidity, patient uncertainty, and costs.

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It is mandatory to assess the performance of radiograph interpretation and to evaluate the frequency of misdiagnosis. To specify which injuries, bones, and patients cause the most diagnostic difficulties and to clarify the most important question: do these diagnostic errors have a significant clinical impact or not?

Materials and methods

In a large paediatric referral hospital, data from all trauma patients with primarily misdiagnosed skeletal radiographs was collected prospectively between October 2014 and June 2015. The Ethics Committee was consulted and ethical approval was deemed not necessary. Emergency room staff performed initial radiography interpretation. Misdiagnosis was detected within 24 hours in a routine second interpretation by a senior paediatric radiologist. During this 9-month period, site of injury, age of patient, initial diagnosis, and corrected diagnosis were documented. Two types of diagnostic errors were noted: missed fractures (false negative) and overdiagnosis of a fracture that did not exist (false positive). The clinical significance and therapeutic consequences of diagnostic errors were evaluated.

Results

Of 2,316 trauma patients aged from 1–17 years, 125 (58 girls/67 boys) were initially diagnosed incorrectly from their skeletal radiographs (Fig 1). In 112 cases, junior doctors, in seven cases residents, and in six cases consultants (paediatric surgery) made diagnostic errors that were corrected the next day. Most of the diagnostic problems by absolute numbers occurred in interpretation of finger radiographs (n=35; Fig 2). In 21 finger radiographs, fractures were diagnosed incorrectly (false positive). The epiphyseal lines at the base of the phalanges mainly caused diagnostic confusion. Eight errors occurred from misinterpretation of toe radiographs: in four cases of overdiagnosis the epiphyseal line at the base of the first metatarsal bone was misinterpreted as a fracture line. Finger, wrist, and elbow injuries counted for two-thirds of all diagnostic errors (70/125). The remaining third included toes, midfoot, ankle, metacarpus, knee, skull, upper arm, shoulder, nose, and ribs (Fig 3).

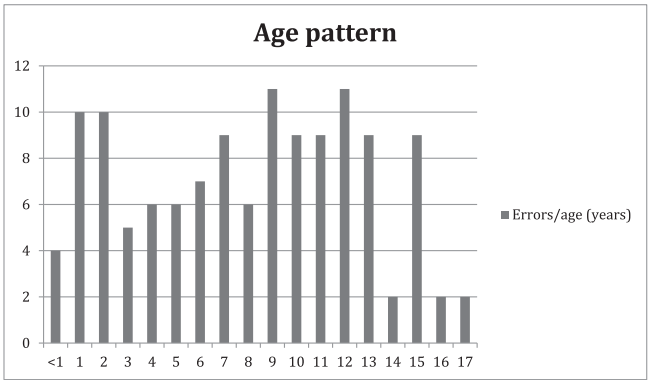

Figure 1 Age pattern of the patients with diagnostic errors by absolute numbers. There is an irregular distribution of numbers of errors without a peak age.

The highest error rate was found in elbow trauma: in 12% of the cases radiography was misinterpreted initially (Table 1). Elbow injuries counted for a high rate of misses: in 14 of 20 errors fracture (12 supracondylar fractures, one lateral condyle fracture, one processus coronoideus fracture) was overseen initially (Fig 4). Subtle supracondylar fracture was mistaken as pronatio dolorosa (n=5) and contusion (n=7).

In seven cases of wrist injuries, distal radial fracture was diagnosed correctly, but concomitant distal ulnar fracture was overseen. This problem of overseeing a second fracture occurred only in this region.

Fractures were missed in the first interpretation of radiography in 60 of 125 patients. Parents were contacted and informed via telephone the next day. In these children, misdiagnosis led to a 1-day delay in cast application. None of the initially overseen fractures required repositioning or a surgical procedure. Overdiagnosis occurred in 65 patients. All of these patients also were contacted the next day. An unnecessary cast was removed in 57 patients. In eight patients, cast immobilisation was continued for 1 week because of painful contusions. Despite the discomfort of an unnecessary cast fixation, no morbidity resulted from delay in the correct diagnosis in this patient group.

Discussion

Errors in interpretation of radiography are inevitable. Generally, for adult radiologists error rates of 4% have been reported.[1,2] A recent retrospective study found a rate of 2.7% interpretive errors by paediatric radiologists in musculoskeletal radiographs.[3] In the paediatric emergency room, trauma radiographs are often initially interpreted by paediatric surgeons or traumatologists in training and not by experienced radiologists. Therefore, higher error rates can be expected.[4,5] The most important question is whether these errors result in significant harm to the patients or not. In the present study, a high error rate was found in some skeletal regions, but all these errors did not negatively affect patient health. This finding corresponds with the published literature on this subject.[4–6] Walsh-Kelly *et al.*[4] found no morbidity resulting in 20 radiographs with clinically significant false-negative misinterpretation.

Although one might suspect a higher number of diagnostic problems in children under the age of 3 years due to their specific radiographic anatomy, this was not the case in the present study. Generally, no age group demonstrated a higher rate of diagnostic confusion.

It is no surprise, that the complex and changing anatomy of the developmental elbow is a challenge for radiological interpretation.[3] In relation to the number of obtained radiographs, elbow radiography showed the highest error rate. Therefore, special attention should be paid to the supracondylar region of the elbow. Comparison radiography of the opposite side is not an option, as radiation exposure in children has to be strictly limited.

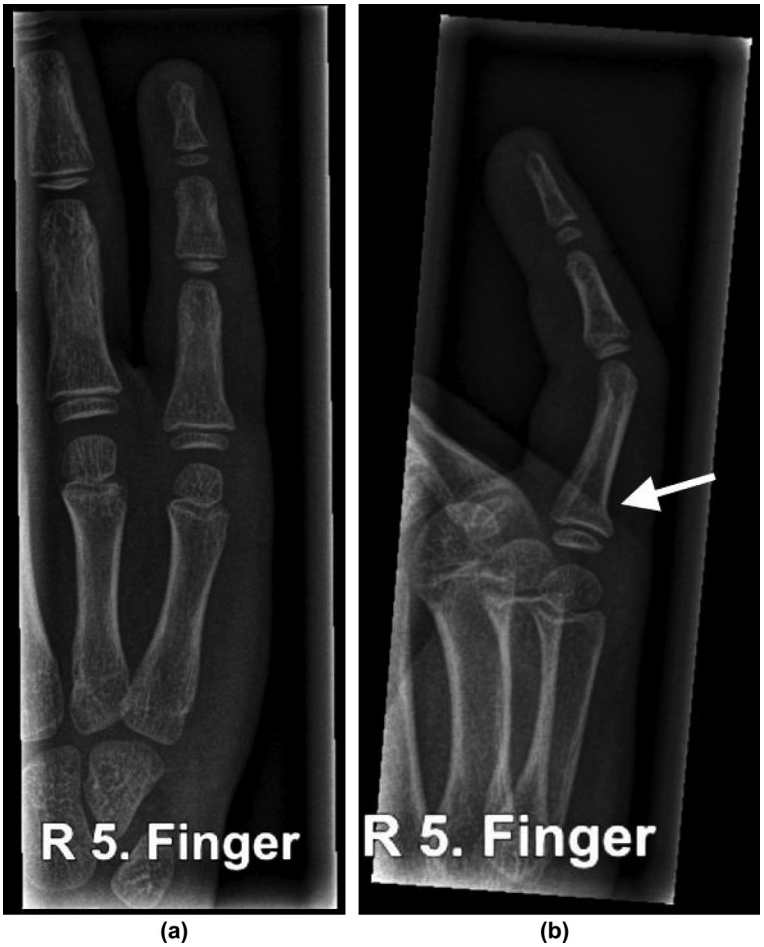

Figure 2 (a) Anteroposterior view of the fifth finger of the right hand after trauma. No clear fracture signs. (b) The lateral view unravels the missed base fracture of the fifth proximal phalanx (epiphysiolysis Salter–Harris II; white arrow).

Mounts *et al.* identified in their study fractures of the phalanges of the hand as the most commonly missed fractures in a paediatric emergency department: in the study period, 220 extremity fractures were missed, 58 were fractures of the hand phalanges.[7] In the present study, this region was also a hotspot of diagnostic error: by absolute numbers the most diagnostic errors occurred in finger radiography.

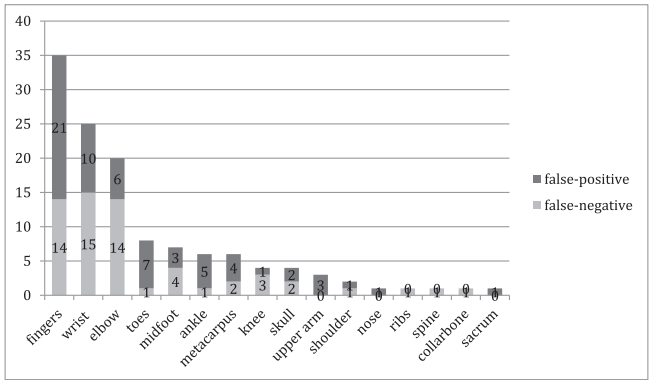

Figure 3 Location of diagnostic error by absolute numbers where a false positive indicates diagnosis of a non-existent fracture and false negative indicates a missed fracture.

There was a marginal trend towards overdiagnosis (65/125 misdiagnosed cases). In some situations overdiagnosis may appear reasonable: in case of uncertainty, more generous interpretation for an osseous lesion requiring cast fixation is likely to occur. In addition, in severe contusion a short period of immobilisation of an extremity can be appropriate as a physical pain-relieving measure. Interestingly, in cases of overdiagnosis, parents were more unpleased and less understandingly than in cases of a missed fracture.

Table 1
Error rate in selected regions from October 2014 to June 2015 (backwards sorted) calculated based on the total number of each type of radiograph.

	Total no. of examinations	No. of missed diagnoses	Error rate
Elbow	166	20	12%
Wrists	302	25	8%
Fingers	762	35	4.5%
Metacarpus	142	6	4.2%
Toes	228	8	3.5%
Knee	196	4	2%
Midfoot	316	6	1.9%
Ankles	328	6	1.8%
Skull	1,888	4	0.2%

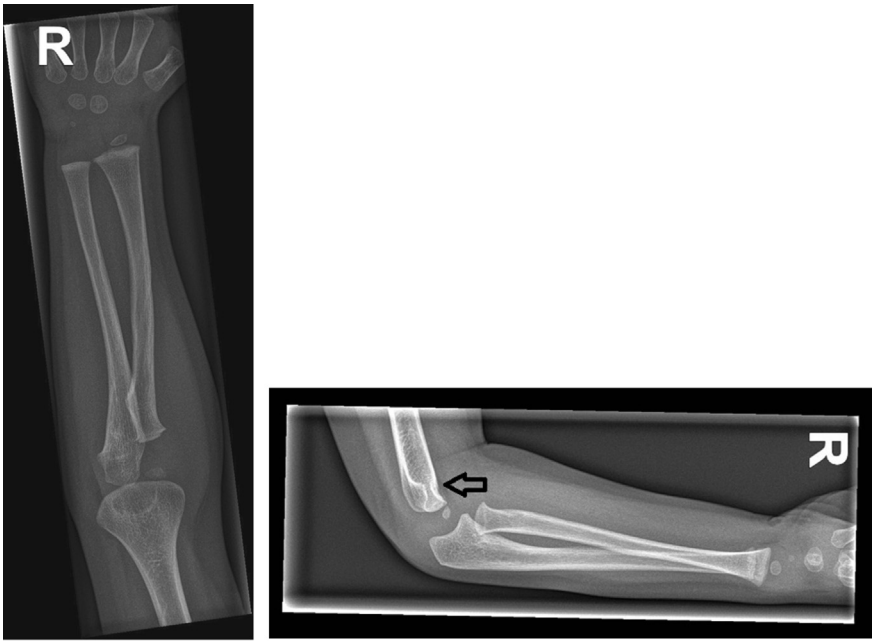

Figure 4 (a) Missed supraconylar elbow fracture. In the anteroposterior view, no signs of a fracture are visible. (b) The lateral view shows a subtle lucency visible at the anterior cortex and an anterior fat-pad sign (black arrow).

Not surprisingly, junior doctors made the vast majority of diagnostic errors as they had the least experience of interpretation of paediatric skeletal radiographs; however, approximately 10% of all diagnostic errors in the present study were committed by more experienced physicians, suggesting that paediatric fractures are challenging even in this group.

The majority of diagnostic errors were restricted to few skeletal regions. Therefore, this analysis may be used as a foundational analysis to develop specific training programmes focusing on these areas of uncertainty.

This study demonstrates that radiograph misinterpretation by paediatric emergency staff occurs regularly. Therefore, routine review by experienced paediatric radiologists is necessary; however, due to the absence of adverse sequelae of diagnostic errors in the present cohort, a review by an experienced paediatric radiologist the following day seems to be sufficient.

Conflict of interest

The authors declare no conflict of interest.

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