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ORIGINAL ARTICLE

Rapid screening for the posterior fat pad sign in suspected pediatric elbow fractures using point-of-care ultrasound: a "FAST exam" for the traumatized elbow

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Abstract
Purpose Children with elbow injuries frequently present to the emergency department for evaluation. Fractures of the elbow are sometimes not visualized on plain radiographs and the only sign of an occult fracture is an elevated posterior fat pad that normally sits within the olecranon fossa. The elevated posterior fat pad sign is highly sensitive and its absence likely rules out fractures of the elbow and can be readily visualized by ultrasound. Lipohemarthrosis within an elevated fat pad can also be visualized by ultrasound, but not by X-ray. This finding with an elevated posterior fat pat adds additional specificity to rule in elbow fractures.
Methods We report the use of point-of-care ultrasound to rapidly screen for the presence of the posterior fat pad sign and lipohemarthrosis in a series of children presenting with elbow injuries to the emergency department.
Results Point-of-care ultrasound identified elevated and normal posterior fat pads that correlated with X-ray. Lipohemarthrosis within an elevated fat pad was also detectable by ultrasonography.
Conclusions Knowledge of whether a posterior fat pad is elevated or not and noting the presence of lipohemarthrosis by using point-of-care ultrasound may be helpful to expedite diagnosis and treatment of these patients, especially in settings with no access to plain radiography.

Keywords Ultrasound · Diagnosis · Elbow fracture · Posterior fat pad · Pediatric

Background

Point-of-care ultrasound is a versatile and an increasingly important diagnostic tool for emergency physicians, pediatric emergency physicians, and pediatricians [1–3]. Children with elbow injuries frequently present to emergency departments for evaluation of suspected fracture. Fractures of the elbow are sometimes not visualized on plain radiographs, and the only sign of an occult fracture is an elevated posterior fat pad that normally sits within the olecranon fossa [4]. Thus, the posterior fat pad sign, which implies joint effusion, is highly sensitive for fracture in the setting of elbow trauma [5–7]. The posterior fat pad sign seen on radiography can also be rapidly and easily identified by ultrasound at the point-of-care [8]. The finding of lipohemarthrosis with an elevated posterior fat pad by ultrasonography may also provide further evidence of fracture [9]. Furthermore, ultrasound can be performed without discomfort to the patient and without exposure to ionizing radiation [10–15]. We describe the incorporation of point-of-care ultrasound into the clinical and physical examination in a series of children with elbow injuries in the emergency department.

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Case reports

Case 1

An 18-year-old male presented to the emergency department with right elbow pain. He fell on his right elbow after colliding with another person while playing soccer.

His vital signs were normal in the emergency department. Physical examination revealed slight swelling of the right elbow when compared to the normal elbow. The range of motion at the elbow was normal. There were no neurovascular deficits in the injured extremity.

A point-of-care ultrasound examination was performed at emergency department triage on the right and left elbows, which were flexed at 90° during scanning with a 10–5 MHz linear transducer (Figs. 1, 2a, b). The ultrasound examination was completed within a minute. An elevated homogeneous posterior fat pad was immediately visualized on the right elbow (clips 1 and 2). On the normal left elbow the posterior fat pad was situated within the olecranon fossa (clips 3 and 4). The patient was then given a non-steroidal anti-inflammatory analgesic. Approximately a half hour later, plain radiographs of the right elbow revealed an elevated posterior fat pad (Fig. 2c) but no other evidence of fracture on preliminary read. Orthopedic consultation was obtained, and the teenager was discharged home in a posterior splint with sugar tong and instructed to follow-up in orthopedic clinic in a week.

The next day, the final reading of the radiograph by the radiology attending was corrected to a non-displaced fracture of the radial head. One week later, the mother stated the patient had taken off the splint, was reporting no difficulty using the elbow, and had resumed normal activity.

Case 2

A 6-year-old boy who fell onto an outstretched left hand presented to the emergency department complaining of left elbow pain. There was no head injury or other trauma. He denied pain of the left wrist or anywhere else. The child was able to ambulate normally after the fall.

At triage, his vital signs were normal. Physical examination revealed normal range of motion of the affected elbow. However, there was tenderness to palpation over the lateral epicondyle. There were no neurovascular deficits in the injured extremity.

With X-ray orders delayed for more than 30 min, the treating physician elected to perform a point-of-care ultrasound on bilateral elbows flexed at 90°. The ultrasound examination was completed within a minute. An elevated posterior fat pad with lipohemarthrosis was immediately visualized on the left elbow (Fig. 3a, b). The child was then treated with a non-steroidal anti-inflammatory analgesic. A half hour later, plain radiographs of the left elbow revealed an elevated posterior fat pad (Fig. 3c) but no other evidence of fracture on preliminary reading. Orthopedic consultation was obtained, and the child was discharged home in a posterior splint with sugar tong to return to pediatric orthopedic clinic in a week.

The next day, the final reading of the radiograph was corrected to a non-displaced Salter-Harris 2 fracture of the radial head. At orthopedic clinic 1 week later, the child was reporting no discomfort of the affected elbow. Repeat radiographs at that time revealed no evidence of a healing fracture. However, the patient's splint was changed to a long-arm cast.

Case 3

An 8-year-old male fell off the monkey bars, onto an outstretched right hand, and experienced immediate pain and swelling of the right forearm. He denied head trauma or any other significant injuries. On presentation to emergency department triage, his vitals signs were normal. There were no neurovascular deficits in the right upper extremity. Physical examination revealed tenderness to palpation and swelling of the right proximal forearm, but there was no wrist or elbow pain.

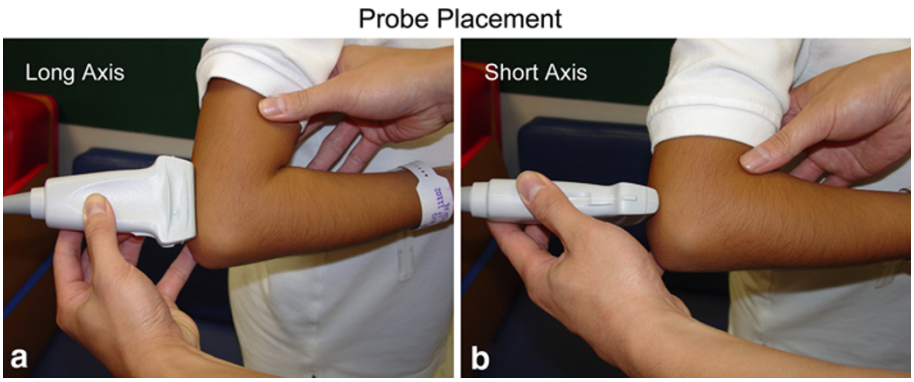

Fig. 1 Linear array probe placement for posterior fat pad: **a** long-axis view, **b** short-axis view

Fig. 2 **a** Case 1: long-axis view of the distal humerus at the olecrenon fossa; *FP* posterior fat pad. Elevated posterior fat pad on right elbow compared to left elbow. Note homogeneous echotexture of fat pads. **b** Case 1: short-axis view of the distal humerus at the olecrenon fossa; *FP* posterior fat pad. Right posterior fat pad elevated compared to normal left. Note homogeneous echotexture of right fat pad. **c** Case 1: X-ray correlation

With X-ray orders delayed for an hour, the treating physician elected to perform a point-of-care ultrasound examination that identified fractures of the diaphysis of the radius (Fig. 4a) and ulna. Furthermore, the posterior fat pad was noted in the normal position on ultrasound (Fig. 4b). The ultrasound examination took approximately 3 min to identify these findings. The child was given acetaminophen for his pain. Pediatric orthopedic consultation was obtained, and preparations were made to perform procedural sedation prior to the child receiving his plain radiographs.

Plain radiographs were requested (Fig. 4a), which confirmed the fractures of both right radius and ulna and was negative for the posterior fat pad sign. The child subsequently received procedural sedation for closed fracture reduction and casting.

Case 4

A 14-month-old healthy baby girl was brought into the emergency department by her mother for refusing to move her right arm since the previous night. The mother had given the child acetaminophen at bedtime, but she was still not moving the right arm the next morning. The mother could not recall the child falling or any trauma to the right arm. The mother denied any sudden pulling on the child's arms.

At triage her vital signs were normal. Physical examination revealed no swelling or redness of the right arm, which was hanging limp with the elbow in extension and in slight pronation. However, the child would cry softly when her right elbow was touched. A quick point-of-care

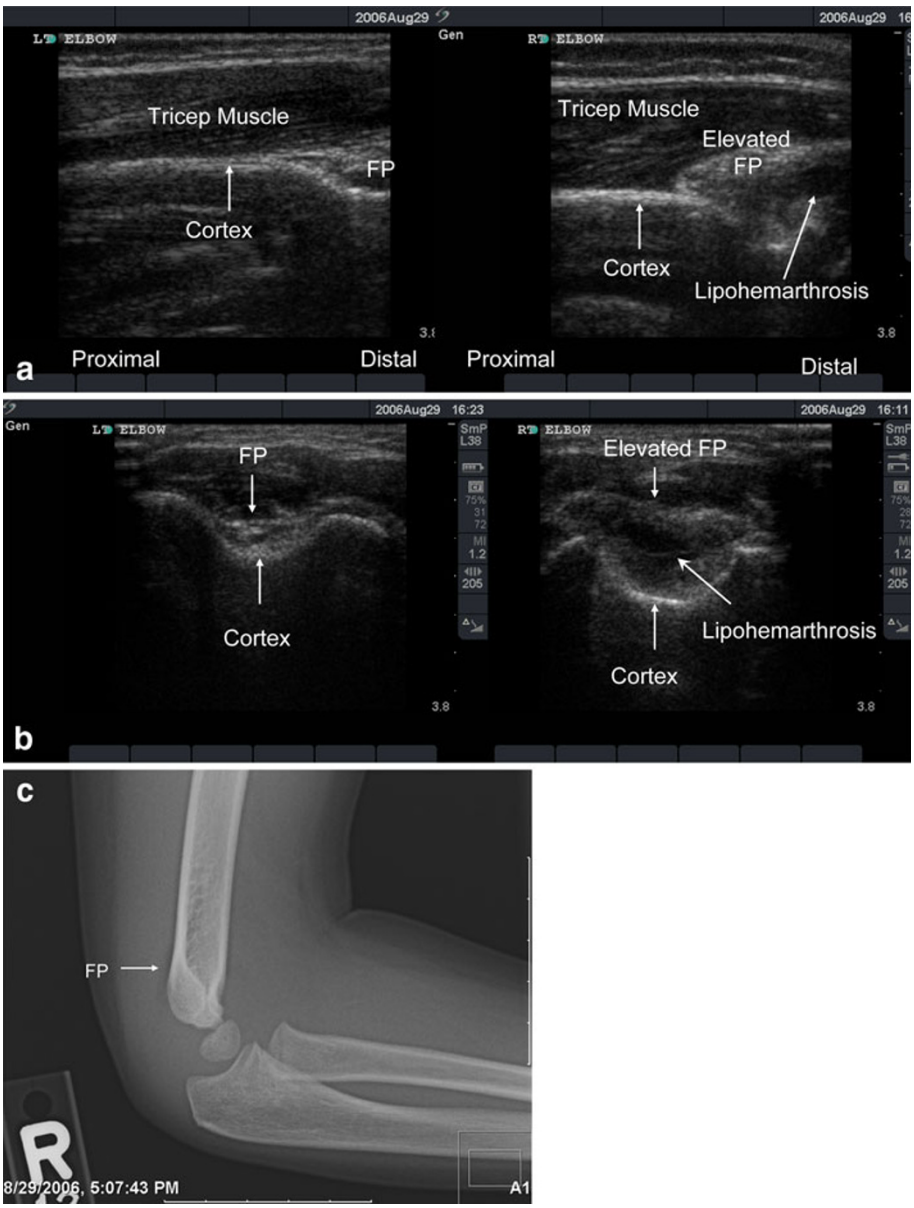

Fig. 3 **a** Case 2: long-axis view of the distal humerus at the olecrenon fossa; *FP* posterior fat pad. Elevated posterior fat pad on right elbow compared to left elbow. Right fat pad with heterogeneous echotexture consistent with lipohemarthrosis. **b** Case 2: short-axis views of the distal humerus at the olecrenon fossa; *FP* posterior fat pad. Right fat pad elevated compared to normal left. Right fat pad with heterogeneous echotexture consistent with lipohemarthrosis. **c** Case 2: X-ray correlation

ultrasound performed with the elbow in 90° of flexion revealed that the posterior fat pad was not elevated. No fractures were seen on ultrasound when her radius, ulna, and humerus were scanned in long and short axes.

A nursemaid's elbow reduction was performed, and the child began using the right arm to play with toys a few moments afterwards. The child and mother were subsequently discharged from the emergency department.

Discussion

In children, the majority of elbow fractures involve the distal humerus (81%), of which the majority is supracondylar (60%), followed by the ulna (10%) and radius (9%) [16]. In skeletally mature teenagers and adults with no radiographic evidence of fracture other than an isolated posterior fat pad sign, fractures of the radial head or neck make up the majority of occult elbow fractures (86%), followed by the lateral epicondyle and olecranon (6.7% each) [7]. The presence of an elevated posterior fat pad with no other evidence of injury on plain radiographs of the traumatized elbow is highly sensitive and predictive of an occult fracture [5–7]. Thus, the standard of care is to treat these patients with an isolated posterior fat pad sign as if they have a non-displaced fracture of the elbow by splinting and with timely orthopedic follow-up [5–7].

While plain radiography is the standard of care, immediate and convenient access to X-ray imaging may not be under the control of the treating physician in most cases

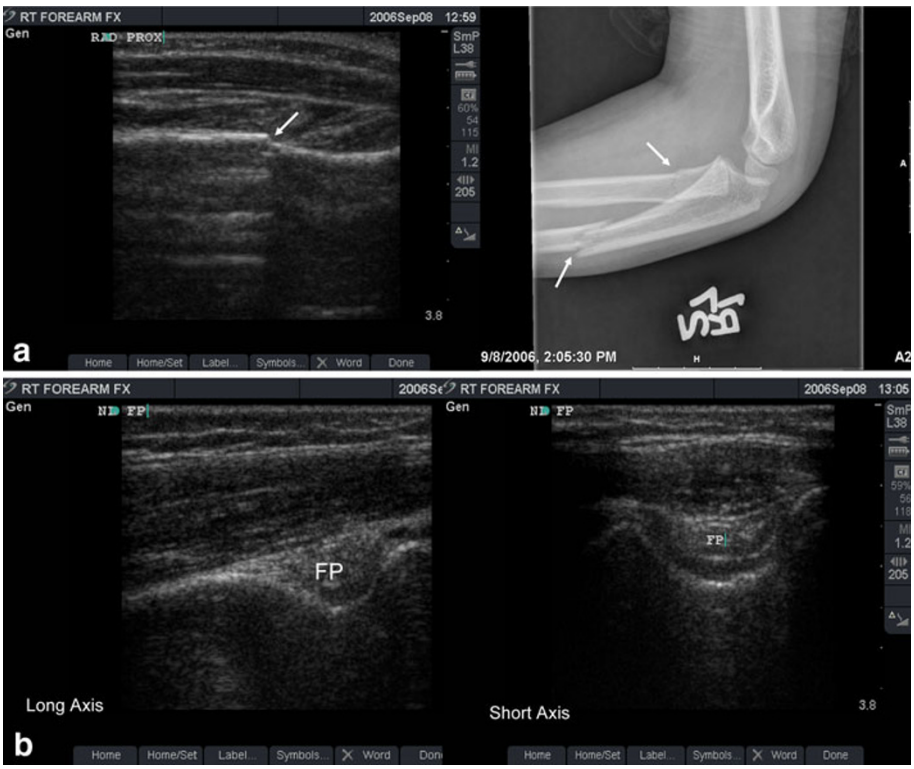

Fig. 4 **a** Case 3: ultrasound of radius fracture and lateral elbow radiograph. *Arrows* point to fracture. No posterior fat pad seen on radiograph. **b** Case 3: long- and short-axis views of posterior fat pad in normal position

and in a large, busy emergency department delays may be prevalent. Point-of-care ultrasound, however, is ideal for rapid evaluation and readily visualizes the posterior fat pad of the elbow [8]. We have made the observation that the posterior fat pad is much more conspicuous on ultrasound than it is on radiography (Fig. 3). The posterior surface of the distal humerus and olecranon fossa allows for easily obtained longitudinal and transverse views to determine the position of the posterior fat pad and look for signs of elevation. With the elbow flexed at 90°, the ultrasound transducer is placed parallel and perpendicular to the axis of the distal humerus to obtain longitudinal and transverse views of the posterior fat pad and the olecranon fossa (Fig. 1). The time to scan and identify the posterior fat pad was less than a minute in all four cases. The posterior fat pad can be visualized to determine displacement and elevation above the olecranon fossa or compared with the contralateral posterior fat pad in the uninjured elbow.

The accuracy of ultrasound for fracture diagnosis has been shown to be best at the diaphyseal (shaft) portion of long bones with decreased sensitivity at the ends or epiphyses of bones [10–15]. Using ultrasonography to visualize the epiphyses of distal humerus, proximal radius, and ulna which constitute the elbow joint with its irregular and curved contours can be difficult and may add to exam times, especially when comparing injured bone to contralateral normal side. Looking for the elevated posterior fat pad sign using point-of-care ultrasound can save time in lieu of directly visualizing suspected fracture at the ends-of-bones of the elbow joint [15]. Preliminary data on the accuracy of an elevated posterior fat pad for diagnosing fractures about the elbow demonstrated a sensitivity of 80% (95% CI 51–95), and a specificity of 87% (95% CI 58–98), LR+ = 6 (1.2, 22) and LR− = 0.23 (0.08–0.65) [15]. The prevalence of elbow fracture in this study was 50% using X-ray as a gold standard, and comprised of novice sonologists whom received a 1-h focused training session on fracture ultrasound. The study was limited by a small sample size ($N = 30$) and did not include lipohemarthrosis evaluation. However, all errors ($n = 5$) occurred in the first quartile of the study suggesting a steep learning curve, with no errors in the remainder of the study. When present, lipohemarthrosis (clip 5 and 6) within an elevated fat pad increases the likelihood of an elbow fracture [9], and is not identifiable by X-ray. In a small study of 14 patients by Zuazo [9], finding lipohemarthrosis correlated to elbow fractures (7 out of 7) seen on magnetic resonance imaging (MRI) but not seen by X-ray; when only an elevated fat pad or elbow effusion without lipohemarthrosis was visualized, only one out of seven of these cases had an elbow fracture detected by MRI.

Rapidly acquired sonographic evidence of a potential elbow fracture may prompt clinicians to immediately treat pain with higher potency analgesics, and efficiently arrange further evaluation and treatment without delay. Thus, screening for the posterior fat pad sign with or without

lipohemarthrosis in a patient with a suspected elbow fracture at emergency department triage or in the other settings may expedite care of patients with elbow injuries.

However, it is uncertain if a normal non-displaced posterior fat pad, as illustrated in cases 3 and 4, definitively rules out fracture in the setting of elbow trauma—although our clinical experience and the limited series by Zuazo et al. [8] seems to suggest this. In case 4, an infant not using her right arm, a normal posterior fat pad would make the possibility of occult elbow fracture less likely, thus encouraging us to proceed with a nursemaid's elbow reduction maneuver. Sonographic findings for nursemaid's elbow have been reported [17]; however, in our experience, we have found these findings to be more technically challenging to acquire than scanning for the posterior fat pad sign.

The posterior fat pad sign may have limited usefulness in non-traumatic conditions such as hemophilia, gout, rheumatoid arthritis, and osteoarthritis (the last three conditions primarily affecting adults); however, presence of lipohemarthrosis would likely be more consistent with fracture in the setting of trauma. Additionally, the evaluation of the anterior fat pad in elbow trauma has been incompletely addressed in the literature, and its usefulness needs to be further defined. Further research using prospective studies with clinical outcomes is needed to answer these and other questions regarding the use of the sonographic posterior fat pad sign as a "FAST exam" for the traumatized elbow.

Conclusion

Our preliminary experience suggests that focused ultrasound to detect occult fractures in children with elbow trauma by evaluating the posterior fat pad sign and when present, looking for lipohemarthrosis, is rapid, simple, and feasible. A larger study will need to determine the test performance characteristics of the sonographic posterior fat pad sign with or without lipohemarthrosis for detecting elbow fractures.

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Conflict of interest None.

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