Ultrasound Findings of the Elbow Posterior Fat Pad in Children With Radial Head Subluxation

Joni E. Rabiner, MD,* Hnin Khine, MD,* Jeffrey R. Avner, MD,* and James W. Tsung, MD, MPH†

Objective: The aim of this study was to determine whether elbow ultrasound findings of the posterior fat pad (PFP) are present in patients with diagnosis of radial head subluxation (RHS).

Methods: This was a prospective study of children presenting to an urban pediatric emergency department diagnosed clinically with RHS. Physicians received a 1-hour training session on musculoskeletal ultrasound including the elbow. Before performing reduction for RHS, the physicians performed a brief, point-of-care elbow ultrasound using a high-frequency linear transducer probe in both longitudinal and transverse views to evaluate for PFP elevation and lipohemarthrosis (LH). Successful clinical reduction with spontaneous movement of injured extremity served as the criterion standard for RHS. Clinical telephone follow-up was performed to ascertain outcomes.

Results: Forty-two patients were enrolled with a mean age of 22.3 (11.8) months. The mean time to presentation was 7 (9.2) hours, and 9/42 (21%) had an elevated PFP and LH. Clinical telephone follow-up was performed to ascertain outcomes. Reduction maneuvers for RHS may be attempted in patients with a normal elbow ultrasound when the diagnosis of RHS or elbow fracture is uncertain.

Key Words: radial head subluxation, ultrasonography, elbow trauma

Radial head subluxation (RHS) is the most common elbow injury in children. However, in young children with a nonmobile elbow, it can be difficult to differentiate RHS from elbow fracture by history and physical examination alone.1,2 Data demonstrate that the presence of an elevated posterior fat pad (PFP) or lipohemarthrosis (LH) of the PFP on ultrasound is highly sensitive for fracture at the elbow,3 but it is not known whether these findings are present in children with RHS.

In RHS, the annular ligament slips over the radial head and becomes trapped in the radiohumeral joint. Case reports and series by radiologists have shown that it is possible to use ultrasound to diagnose RHS by examining the position of the radial head and annular ligament,4–7 but this can be technically difficult to perform. However, elevated PFP and LH are easily identified on point-of-care ultrasound by clinicians and have been shown to be highly sensitive for fracture at the elbow.8 While case reports have shown normal PFP findings in RHS,8 it is not known whether PFP elevation or LH are present in children with RHS. A normal PFP on point-of-care ultrasound, which makes the possibility of fracture at the elbow unlikely,3 may direct clinicians to proceed with reduction maneuvers in children with suspected RHS when the etiology of injury is uncertain.1,2

Our objective was to determine the elbow PFP findings on point-of-care ultrasound performed by clinicians in children with RHS.

METHODS

This was a prospective, observational study conducted from January 1, 2011 to May 31, 2012 in an urban pediatric emergency department (ED). A convenience sample of patients with the clinical diagnosis of RHS, presenting when a trained study physician was available, were eligible for enrollment into the study. Written informed consent was obtained from the parent/guardian. Approval for this study was granted by the hospital's institutional review board. The methods used were similar to those published previously.3

Inclusion criteria included clinical diagnosis of RHS requiring reduction as determined by the attending pediatric emergency medicine (PEM) physician. Patients were excluded for arrival at the ED with an x-ray of the injured elbow already performed.

Before the start of the study, all participating PEM attending physicians and fellows attended a 30-minute didactic session to teach the basics of how to use ultrasound to evaluate the elbow PFP followed by a 30-minute hands-on practical session with live models. Study sonologists were mostly novice to ultrasound and new to this technique. A reference manual complete with instructions and images was available throughout the duration of the study.

The PEM physicians completed a data collection sheet and recorded the number of previous RHS episodes, time to presentation to the ED (in hours), and the mechanism of injury (pull, fall, twist, minor trauma, or unknown).

Using a SonoSite MicroMaxx ultrasound machine (SonoSite Inc, Bothell, Wash) with a 5 to 10 MHz linear transducer probe, a focused ultrasound was performed by the PEM physician. With the patient's elbow flexed to 90°, the gel on the ultrasound probe was placed over the posterior aspect of the distal humerus to obtain images, with the probe in contact with the gel but not the underlying skin. Both longitudinal and transverse views of the elbow were obtained. Ultrasound imaging of the contralateral normal, uninjured side was performed as needed for comparison and was encouraged for novice sonologists, especially if there was any uncertainty in determining normal from abnormal. A positive elbow ultrasound was defined as the enrolling PEM physician's determination of elevation of the PFP and/or presence of LH of the PFP. Elevation of the PFP was defined as rise of the PFP above the line connecting both lips of the olecranon fossa in transverse view or rise of the PFP above the extension of the distal humeral line on longitudinal view, and LH was defined as heterogeneous echodensity with hypoechoic areas of the PFP (Figs. 1, 2).

From the *Department of Pediatrics, Division of Pediatric Emergency Medicine, Children's Hospital at Montefiore, Albert Einstein College of Medicine, Bronx, and †Department of Emergency Medicine, Division of Pediatric Emergency Medicine, Mount Sinai Medical Center, Mount Sinai School of Medicine, New York, NY.

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Reprints: Joni E. Rabiner, MD, Department of Pediatrics, Division of Pediatric Emergency Medicine, Children's Hospital at Montefiore, Albert Einstein College of Medicine, 3315 Rochambeau Ave, Bronx, NY 10467 (e-mail: jrrabiner@montefiore.org).

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After completion of the point-of-care ultrasound, all patients had reduction of the RHS as per the standard of care treatment. Successful reduction was defined as spontaneous movement of the affected arm with full range of motion in the ED and was used as the criterion standard for diagnosis of RHS. The reduction maneuver performed, number of reduction attempts, and success of reduction were recorded. Clinical follow-up consisted of structured telephone calls at least 1 week after the ED visit.

Our primary outcome was to describe the ultrasound findings of the elbow PFP in children with RHS.

Data were analyzed using SPSS Statistics (IBM, Armonk, NY) and are described using descriptive statistical analyses for categorical data.

**RESULTS**

Forty-two patients were enrolled with a mean age of 22.3 months (SD, 11.8 months; range, 4–51 months). Twenty-six (62%) patients were female. Nine (21%) patients had a history of previous RHS, with 8 patients having 1 previous episode and...
1 patient having 3 previous episodes. The mechanism of injury was pull in 15 (36%), fall in 8 (19%), minor trauma in 5 (12%), twist in 2 (5%), and unknown in 12 (29%). The mean time to presentation to the ED was 7 hours (SD, 9.2 hours), with a median time of 4 hours (interquartile range, 2–7 hours).

Point-of-care ultrasound was performed by 11 PEM physicians, performing between 1 and 13 scans each. Thirty-five (83%; 95% confidence interval [CI], 69%–92%) patients had a normal point-of-care elbow ultrasound (Fig. 1). An elevated PFP was found in 6 (14%; 95% CI, 6%–28%) patients by the treating PEM physician, and LH was found in 2 (5%; 95% CI, 0.5%–17%) patients (Figs. 2, 3). One patient had both an elevated PFP and LH as determined by the PEM physician. There was no correlation between duration of symptoms or number of reduction attempts and positive findings on elbow ultrasound.

Reduction of RHS was performed with supination–flexion in 27 (64%), hyperpronation in 4 (10%), as well as both supination–flexion and hyperpronation in 6 (14%). Five (12%) patients had self-reduction of their RHS in the ED. One reduction attempt was made in 31 (74%) patients, with multiple attempts made in 7 (17%) (data missing in 4 [10%]). Radial head subluxation was confirmed by successful reduction in the ED in 100% of patients. Clinical telephone follow-up was available for 36 (86%) patients, and there were no fractures or other complications reported on follow-up. Follow-up was available for all patients with positive ultrasound findings; all were asymptomatic at follow-up.

DISCUSSION

The majority of children with RHS in our study had normal elbow PFP findings on point-of-care ultrasound performed by the PEM physicians. However, 7 (17%) patients were found to have an elevated PFP and/or LH.

Point-of-care ultrasound for elevated PFP and LH performed by clinicians has been shown to have a sensitivity of 98% for elbow fracture in children, with a negative elbow ultrasound significantly decreasing the likelihood of fracture. The clinical diagnosis of RHS may be difficult in children with an immobile elbow, especially with an unknown mechanism of injury. Therefore, a negative point-of-care elbow ultrasound may facilitate diagnosis by providing reassurance of the absence of elbow fracture so that the clinician may proceed with reduction of RHS.

Our study was performed to evaluate whether the patients with RHS, diagnosed clinically by the treating PEM physicians, can have an elevated PFP or LH on point-of-care ultrasound. Only 17% of patients were found to have an elevated PFP and/or LH on point-of-care ultrasound. Elevated PFP was defined as rise of the PFP above a line connecting both lips of the olecranon fossa on transverse view or above the distal humeral line on longitudinal view. On poststudy review of images, many of those PFPs that were read as elevated by PEM clinicians were minimally elevated, as compared with elevated PFPs with elbow fracture that are significantly and grossly elevated (Fig. 3). Ultrasound imaging of the contralateral normal elbow may help distinguish normal from abnormal PFPs when there is minimal PFP elevation or LH, especially for novice sonologists.

We had hypothesized that patients with longer duration of RHS before presentation to the ED or those requiring multiple reduction attempts may be more likely to have positive PFP findings on point-of-care ultrasound; however, there was no correlation between duration of symptoms or number of reduction attempts and positive findings on ultrasound in our study.

Upon review of the subset of patients from Rabiner et al with a final diagnosis of RHS after point-of-care ultrasound and x-ray imaging for suspected supracondylar fracture, we found that 3 of 18 (17%; 95% CI, 5%–40%) patients with RHS and no supracondylar fracture had abnormal elbow ultrasound findings, 1 with an elevated PFP, and 2 with LH. These results are similar to our findings in the patients diagnosed clinically with RHS and no radiographic imaging in this study. Overall, a minority of patients with RHS may have abnormal elbow ultrasound findings.

Elbow ultrasound may be helpful in scenarios when there is clinical uncertainty between RHS and supracondylar fracture in determining which patients should receive radiography. In these cases with clinical uncertainty, elbow ultrasound may reduce unnecessary radiographs by encouraging the clinician to proceed with RHS reduction when the elbow ultrasound is negative for PFP elevation and LH.

Our study had several limitations. First, this was a prospective study of patients clinically diagnosed and treated for RHS presenting when a trained study physician was available with a small number of patients enrolled. In addition, the patients were only included in this study if they were clinically diagnosed with RHS and the PEM physician was sufficiently confident with the diagnosis to proceed directly to RHS reduction. The patients in whom the diagnosis was in question or who received x-rays of the elbow before reduction were not included in this study; however, review of the patients with RHS who received x-ray evaluation showed a similar prevalence of abnormal elbow ultrasound findings. Another limitation is that successful clinical reduction as evidenced...

FIGURE 3. Elbow ultrasound interpreted as elevated PFP by the enrolling PEM physician in transverse (A) and longitudinal (B) views with minimal PFP elevation.
by spontaneous movement of the injured arm was used as the cri-
teron standard for RHS; however, on clinical follow-up, no com-
plications were reported.

In summary, the majority of children with RHS will have a
normal PFP on point-of-care elbow ultrasound, but elevated PFP
and LH are possible findings. Negative point-of-care ultrasound
findings may reassure and encourage the clinician to proceed with
reduction of RHS in the ED.

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REFERENCES

1. Kraus R, Dongowski N, Szalay G, et al. Missed elbow fractures
misdiagnosed as radial head subluxations. Acta Orthop Belg. 2010;76:312–315.
2. Kurdy NM, Saab M, Birkinshaw R. Traumatic radial head dislocation in
children—a missed injury. Eur J Emerg Med. 1997;4:39–41.
3. Rabiner JE, Khine H, Avner JR, et al. Accuracy of point-of-care
ultrasonography for diagnosis of elbow fractures in children. Ann Emerg Med. 2013;61:9–17.
4. Diab HS, Hamed MMS, Allam Y. Obscure pathology of pulled elbow:
dynamic high-resolution ultrasound-assisted classification.
J Child Orthop. 2010;4:539–543.
5. Kim MC, Eckhardt BP, Craig C, et al. Ultrasonography of the annular
ligament partial tear and recurrent “pulled elbow”. Pediatr Radiol. 2004;34:999–1004.
6. Kosuwon W, Mahaisavariya B, Saeungpanthkul S, et al. Ultrasonography
of pulled elbow. J Bone Joint Surg Br. 1993;75:421–422.
7. Shabat S, Folman Y, Mann G, et al. The role of sonography in detecting
radial head subluxation in a child. J Clin Ultrasound. 2005;33:187–189.
8. Tsung JW, Blaivas M. 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. Crit Ultrasound J. 2010;1:111–116.