Ultrasonographic findings in pediatric fractures

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The aim of this study was to document and analyze ultrasonographic (US) findings in different types of pediatric fractures. Thirty-nine patients, aged between 1 and 14 years, with a fracture were included in the study. Patients were classified as complete or incomplete fractures. Greenstick fractures, torus fractures and plastic deformations were considered as incomplete fractures. Ultrasonographic findings (subperiosteal hematoma, bending, cortical disruption, and reverberating echo) were analysed for each type of fracture. Subperiosteal hematoma was present in all patients in the study. Bending sign was present in all patients in the incomplete fracture group, but not present in complete fractures. Cortical disruption and reverberating echo were present in all patients with complete and greenstick fractures.

In conclusion, whether the fracture is complete or incomplete, subperiosteal hematoma, together with a cortical disruption, bending sign, or reverberating echo shown on US can confirm the fracture diagnosis in children.

Key words: ultrasonography, children, fractures.

Evaluation of an extremity trauma with clinical and roentgenographic examinations is mandatory for the diagnosis of fractures. However, ionized radiation can be hazardous to the epiphyses in pediatric patients. The ability to diagnose fractures by ultrasonography (US) in ossified and unossified regions of the bone has been reported in the literature[1-9]. In some of the studies, US was found to be even more sensitive than radiography for detecting fractures in such regions as the sternum and ribs[10-15]. US has been receiving considerable attention in assessment of fractures, due to its ease of use and lack of radiation.

Interruptions of cortical bone, paraosseous hematomas, bending signs, and reverberating echoes have been defined as US findings in fractures[5,7]. However, the validity of US findings in different types of pediatric fractures has not been clearly established. The aim of this study was to document and analyze ultrasonographic findings in pediatric fractures.

Material and Methods

Thirty-nine patients, aged between 1 and 14 years (28 male, 11 female, mean 7.9 years) were enrolled in the study. Inclusion criteria were local tenderness over the bone following a trauma and X-ray confirmation of a fracture in that area. Patients with open wounds were not included.

After the fractures were verified with an antero-posterior and lateral X-ray, US examination was performed. Patients were classified according to the X-ray findings as complete or incomplete fractures. Incomplete fractures included greenstick and torus fractures, and plastic deformations. Permanent deformation without any disruption of bone continuity was considered as plastic deformation, metaphyseal fractures with bulging of the cortex as torus fractures, and fractures with one part of the cortex and periosteum remaining intact on the compression side as greenstick fractures on X-ray evaluations. Fractures of non-ossified parts of the bone were excluded.

Ultrasonographic examination was performed with General Electric (G.E.) Logic 400 M.D. Milwaukee, U.S.A. using 7.5-MHz linear high frequency transducer. The region with tenderness was evaluated in transverse and sagittal planes. Uninjured contralateral bone was also examined

Table I. Ultrasonographic Findings and Definitions of a Fracture

Ultrasonographic findings	Definition
Subperiosteal hematoma	Periosteal elevation
Bending	Deformation of the cortex without gapping
Cortical disruption	Gapping in cortical continuity
Reverberating echoes	Increase in medullar echogenicity

with US. The US findings and definitions are shown in Table I.

Results

There were nine patients with complete fractures and 30 patients with incomplete fractures. Table II shows the distribution of the fractures by bone and by number of cases. Incidences of the US findings in different fractures are shown in Table III.

Table II. Frequency of Fractured Bones to the Number of Patients

	Number of patients	%
Fibula	2	5.1
Humerus	4	10.3
Clavicle	12	30.8
Radius	19	48.7
Tibia	2	5.1
Total	39	100.0

Table III. Incidences of the Ultrasonographic Findings in Different Fracture Groups

Fracture group	Number of cases	Average age (range)	Subperiosteal hematoma (%)	Bending (%)	Cortical disruption (%)	Reverberating echo (%)
Complete fracture	9	11.3 (6-14)	9 100	0 0	9 100	9 100
Plastic deformation	8	4 (1-9)	8 100	8 100	4 50	4 50
Torus fracture	14	7.29 (1-14)	14 100	14 100	14 100	2 14.3
Greenstick fracture	8	9.25 (5-13)	8 100	8 100	8 100	8 100
Total	39	7.95 (1-14)	39 100	30 77	35 89.7	23 59

In complete fractures, we observed all the defined US findings of a fracture except bending (Fig. 1a, 1b, 1c). In patients with plastic deformation, subperiosteal hematoma and bending were seen in all the patients, while cortical disruption and reverberating echo were seen in only 50% of the patients (Fig. 2a, 2b). Subperiosteal hematoma, bending, and cortical disruption were the most valuable finding (100%) in torus fractures (Fig. 3a, 3b),

Fig. 1a: Complete fracture of a clavicle is shown in anteroposterior X-ray examination.

Fig. 1b: Subperiosteal hematoma (open arrow), cortical disruption (asterisk), and reverberating echoes (short arrows) are seen in sagittal US examination.

Fig. 1c: On the right side, subperiosteal hematoma (open arrow), cortical disruption (asterisk), and reverberating echoes (short arrows) are seen in axial US examination. The contralateral clavicle (left side) shows no US findings of the fracture.

Fig. 2a: Lateral X-ray examination shows plastic deformation of radius.

Fig. 2b: Subperiosteal hematoma (open arrow), cortical disruption (asterisk), and reverberating echoes (short arrows) of radial plastic deformity are depicted in sagittal US examination.

Fig. 3a: Anteroposterior (A-P) X-ray examination shows a torus fracture of the distal metaphyseal region of radius.

Fig. 3b: Subperiosteal hematoma (open arrow), cortical disruption (asterisk), and bending (long arrow) are detected on sagittal US examination.

Fig. 4a: Anteroposterior (A-P) X-ray examination shows a greenstick fracture of the clavicle.

Fig. 4b: Subperiosteal hematoma (open arrow), cortical disruption (asterisk), and reverberating echoes (short arrows) are obvious in axial US examination.

Fig. 4c: Bending (long arrows) is shown on sagittal US examination of the same patient.

while reverberating echo was seen infrequently (14.3%). All the US findings of a fracture were observed in patients with greenstick fractures (Fig. 4a, 4b, 4c).

Discussion

In this study, we analysed and documented the US findings of some of the common pediatric fractures. To do so, groups of patients with incomplete and complete fractures were studied.

A child's periosteum is thickerthan an adult's, stronger and more readily elevated from the diaphyseal and metaphyseal bone[16]. For this reason, in children the periosteum is usually injured to some extent in all fractures, and subperiosteal hematoma at the fracture site is frequently seen. As US has the advantage of demonstrating soft tissue pathologies better than X-ray, subperiosteal hematoma can be clearly documented[7,9,10]. In our study the most valuable finding was subperiosteal hematoma in all pediatric fracture types.

Bending finding was present in all incomplete fracture types. Bending stress in developing tubular bone can cause incomplete fracture through only part of the cortical circumference. The remaining cortex is grossly intact but probably has microfractures[16]. In our study, any deformation of the cortex without gapping could be easily demonstrated by US in incomplete fractures.

Several authors have reported that the fracture line could be better visualized by US than X-ray[1,2,4,6,10]. We found that if US evaluation is targeted to the area of tenderness, precise domucentation of cortical disruption is possible. Cortical disruption was detected in 100% of complete, greenstick, and torus fractures. In children, the major characteristic of the metaphyseal region is a decrease in

cortical bone thickness[16]. Our study revealed that in addition to bending, US could clearly show cortical disruption in torus fractures. Furthermore, US was able to demonstrate cortical disruption in 50% of the patients with plastic deformation. It can be speculated that microfractures can cause cortical disruption, and that this technique can demonstrate it in some patients. Cortical disruption was a valuable US finding in pediatric fracture types.

Reverberation echo can be due to reflection of US waves from medullary bone instead of cortical bone. This finding was present in 100% of complete had greenstick fractures. However, in 50% of plastic deformations where cortical disruption was not seen, reverberating echo was also not detected. Reverberating echo was seen in only two (14.3%) of the patients with torus fractures. The spongy nature of the metaphyseal region may limit echo reverberation. This may explain why we infrequently detected reverberating echo in torus fractures.

In complete fractures, all defined US findings except bending were detected. Because of the complete breaking of each cortex in a complete fracture, bending was not seen. In this group US could diagnose complete fractures as accurately as X-ray.

In conclusion, US is areliable diagnostic tool for the evaluation of pediatric fractures. Whether the fracture is complete or incomplete, subperiosteal hematoma, together with a cortical disruption, a bending sign, or a reverberating echo shown on US can confirm the fracture diagnosis in children. US can provide valuable information in the evaluation of fractures, especially in the pediatric age group, and it can be expected that US will be used routinely for diagnosis of pediatric fractures in the future.

REFERENCES

1. Lazar RD, Waters PM, Jaramillo D. The use of ultrasonography in the diagnosis of occult fracture of the radial neck. J Bone Joint Surg 1998; 80-A: 1361-1363.
2. May DA, Disler DG, Jones EA, Pearce DA. Using sonography to diagnose an unossified medial epicondyle avulsion in a child. AJR 2000; 174: 115-1117.
3. Vocke-Hell AK, Schmid A. Sonographic differentiation of stable and unstable lateral condyle fractures of the humerus in children. J Pediatr Orthop B 2001; 10: 138-141.
4. Dithcfield A, Sampson MA, Taylor GA. Ultrasound diagnosis of sleeve fracture of patella. Clin Radiol 2000; 55: 721-722.
5. Hubner U, SchlichtW, Outzen S, Barthel M, Halsband H. Ultrasound in the diagnosis of fractures in children. J Bone Joint Surg Br 2000; 82: 1170-1173.
6. Williamson D, Watura R, Cobby M. Ultrasound imaging of forearm fractures in children: a viable alternative? J Accid Emerg Med 2000; 17: 22-24.
7. Rathfelder FJ, Paar O. Possibilities for using sonography as a diagnostic procedure in fractures during the growth period. Unfallchirurg 1995; 98: 645-649.
8. Katz R, Landman J, Dulitzky F, Bar-Ziv J. Fracture of the clavicle in the newborn. An ultrasound diagnosis. J Ultrasound Med 1988; 7: 21-23.
9. Blab E, Geibler W, Rokitansky A. Sonographic management of infantile clavicular fractures. Pediatr Surg Int 1999; 15: 251-254.
10. Bitschnau R, Gehmacher O, Kopf A, Scheier M, Mathis G. Ultraschhalldiagnostik von rippen- und sternumfrakturen. Ultraschall in Med 1997; 18: 158-161.
11. Griffith JF, Rainer TH, Ching AS, Law KL, Cocks RA, Metevelli C. Sonography compared with radiography in revealing acute rib fracture. AJR 1999; 173: 1603-1609.
12. Malghem J, Vande Berg B, Lecouvet F, Maldague B. Costal cartilage fractures as revealed on CT and sonography. AJR 2001; 176: 429-432.
13. Mahlfeld A, Franke J, Mahlfeld K. Ultrasound diagnosis of sternum fractures. Zentralbl Chir 2001; 126: 62-64.