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Point-of-Care Ultrasound for the Diagnosis of Skull Fractures in Children Younger Than Two Years of Age

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Objectives To determine the accuracy of skull point-of-care ultrasound (POCUS) for identifying fractures in children younger than 2 years of age with signs of head trauma, and the ability of POCUS to identify the type and depth of fracture depression.

Study design This was a multicenter, prospective, observational study of children younger than 2 years of age with nontrivial mechanisms of injury and signs of scalp/skull trauma. Patients were enrolled if they underwent computed tomography (CT). Patients underwent clinical evaluation, in addition to a cranial POCUS in the emergency department (ED). From the POCUS examinations, we documented whether fractures were present or absent, their location, characteristics, and depth. POCUS and CT findings were compared to calculate the diagnostic accuracy.

Results We enrolled a convenience sample of 115 of 151 (76.1%) eligible patients. Of the 115 enrolled, 88 (76.5%) had skull fractures. POCUS had a sensitivity of 80 of 88 (90.9%; 95% CI 82.9-96.0) and a specificity of 23 of 27 (85.2%; 95% CI 66.3-95.8) for identifying skull fractures. Agreement between POCUS and CT to identify the type of fracture as linear, depressed, or complex was 84.4% (97 of 115) with a kappa of 0.75 (95% CI 0.70-0.84).

Conclusions POCUS performed by emergency physicians may identify the type and depth of fractures in infants with local physical signs of head trauma with substantial accuracy. Emergency physicians should consider POCUS as an adjunct to clinical evaluation and prediction rules for traumatic brain injuries in children younger than 2 years of age. *(J Pediatr 2018;196:230-6)*.

Blunt head trauma is a common pediatric presentation to emergency departments (EDs) worldwide, with 25% of patients younger than 24 months of age.[1-5] Of children with documented traumatic brain injury (TBI) by computed tomography (CT), many have histories of minor blunt head trauma, defined by Glasgow Coma Scale (GCS) scores of 14-15 at ED evaluation, and no abnormal findings on neurologic examination.[2]

The risk of skull fracture (and TBI) after head trauma is inversely proportional to age.[4,6-9] Identifying skull fractures in young children is important as they are known risk factors for TBI[2,5,9,10] and are also associated with nonaccidental trauma necessitating investigation.[4,5,10] Isolated linear skull fractures, which are typically not clinically relevant in acute management,[8] may predispose younger children to future uncommon but serious complications such as expanding fractures and leptomeningeal cysts[5,9,11,12] and depressed or complicated skull fractures may require further neuro-imaging studies and/or surgical intervention.[6,9,12-15] Skull fractures uncommonly present without physical signs such as scalp hematomas or palpable step-offs.[9,16]

Currently, CT is the reference standard for emergently diagnosing both skull fractures and TBIs in children.[2,10,14] However, CT exposes children to ionizing radiation that increases the lifetime excess risk of lethal cancer.[17-21] As a consequence, clinicians must weigh the trade-offs between identifying TBIs and the risk of radiation-induced malignancies from CT.[17,18,22,23] Several single-center studies of point-of-care ultrasound (POCUS) for the evaluation of skull fractures in children show promising results.[24-27] If validated, the use of POCUS to diagnose skull fractures may help risk-stratify children for TBI following blunt head trauma.

The purpose of this study was to determine the accuracy of POCUS in identifying skull fractures in children younger than 2 years of age with local signs of

CT	Computed tomography
ED	Emergency department
NPV	Negative predictive value
POCUS	Point-of-care ultrasound
PPV	Positive predictive value
TBI	Traumatic brain injury

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head trauma. We also investigated the ability of POCUS to discriminate between linear, depressed, and complex skull fractures and to quantify the depth of the depression, if present.

Methods

This was a multicenter, prospective, observational study conducted from May 2013 to April 2015 to determine the accuracy of POCUS in identifying skull fractures in children younger than 2 years of age after minor blunt head trauma, defined by GCS scores of 14-15. This study adhered to the Standards for Reporting of Diagnostic Accuracy criteria for research[28] (**Figure 1**).

We enrolled children who had nontrivial mechanisms of injury, associated with physical signs of head trauma (ie, scalp hematomas or scalp abrasions, deformities or focal cranial pain) and were scheduled to receive a head CT per the treating physician. Patients with trivial mechanisms of injury and external signs of trauma were included only if a cranial CT was performed. Participating centers and inclusion criteria are listed in **Table I** (available at www.jpeds.com) and **Table II**. The study

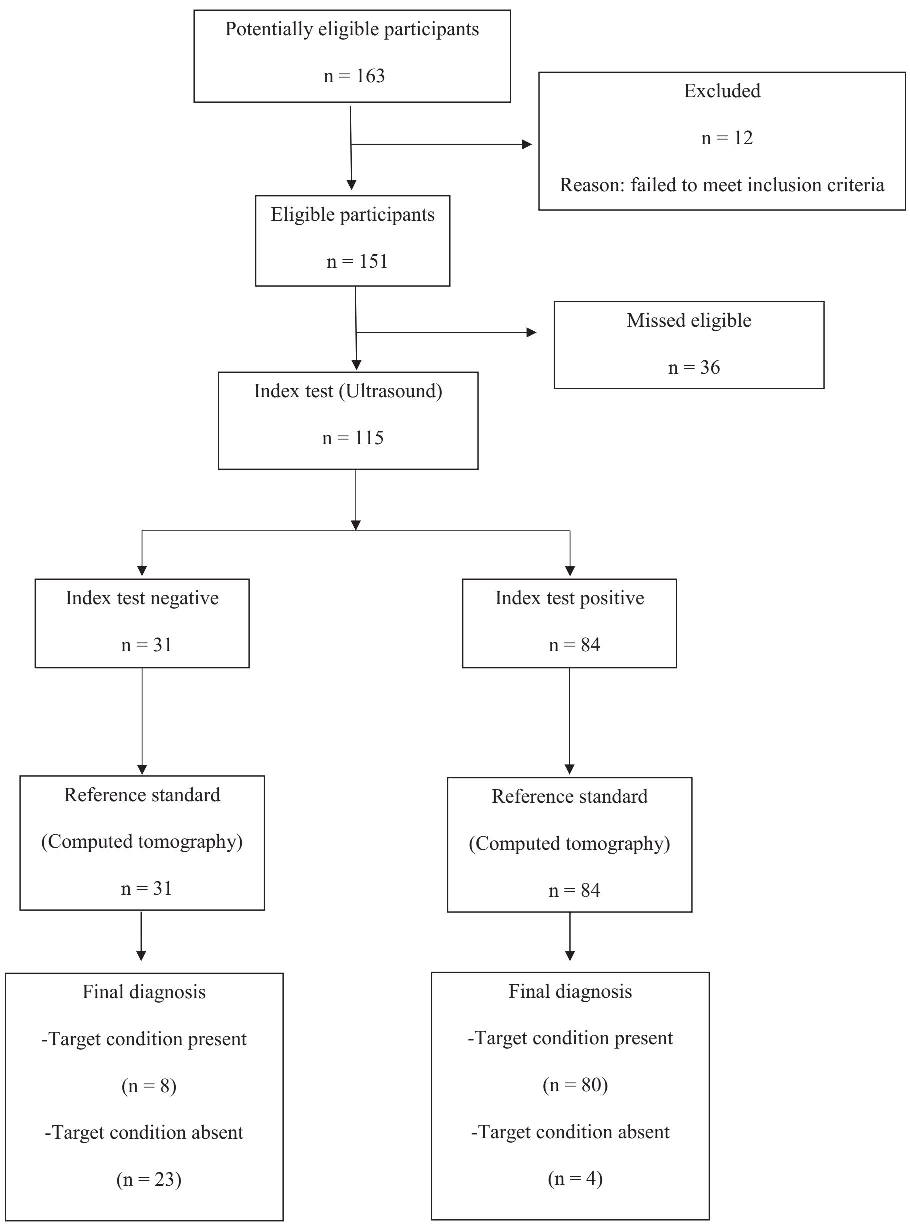

Figure 1. Standards for Reporting of Diagnostic Accuracy Studies flow diagram.

Table II. Inclusion criteria

Inclusion criteria	Age <2 y
	GCS score of 14-15 after blunt head trauma resulting from nontrivial mechanisms
	Localizing evidence of scalp trauma (cephalohematoma, focal pain, deformity)
	Undergoing cranial CT determined by the attending physician
Exclusion criteria	Hemodynamic instability
	Children with trivial mechanisms of injury (ground-level falls or walking or running into stationary objects) and no signs of TBI
	Open skull deformity/fracture or penetrating trauma
	Known brain tumors
	Pre-existing neurological disorders complicating assessment
	Ventricular shunts
	Bleeding disorders

was pilot-tested at the lead investigator's site. All sites obtained institutional review board approval. Written, informed consent was obtained from all parents/guardians.

Patients were enrolled in 1 general and 5 pediatric EDs in Italy and the US with a combined annual census of 179 000 patients. Eligible children underwent clinical evaluations by one of the general ED or pediatric ED attendings at the enrolling center, in addition to POCUS of the skull. To standardize the decision-making, all participating sites were encouraged to use the Pediatric Emergency Care Applied Research Network clinical prediction rules for CT use.[2] This limited our enrollment to patients presenting within 24 hours of head trauma.

After the decision was made to obtain a head CT, the treating physician either performed the skull POCUS, or requested a physician ultrasonographer blinded to the clinical scenario to perform POCUS. If the treating physician performed the POCUS, the physician was instructed to perform the POCUS prior to the CT scan, and no clinical decisions were made based on POCUS findings.

Uncommonly, POCUS was performed after the CT scan as not to delay patient care, with the physician ultrasonographer blinded to the CT results. Physician ultrasonographers were general or pediatric emergency physicians, pediatricians, or residents with varying levels of POCUS training (with supervision by the attending physician). All participating clinicians received 2 video didactic training sessions in skull POCUS techniques, and hands on training done locally at each site. They also had to demonstrate 10 successful skull POCUS examinations on patients younger than 2 years who were judged by the site POCUS lead. All participating clinicians except for 2 were novices to skull POCUS, with varying degrees of general POCUS training prior to study training.

To overcome training differences, we created 2 video tutorials describing techniques for detection of skull fractures to train participating clinicians. Members of our team also developed homemade, low-cost ultrasound phantoms for instruction and practice, which improved our ability to train clinicians.[29]

POCUS examinations were performed with the available ultrasound system at each site, using a high-frequency linear, transducer over the focal area of concern and the immediate surrounding area when a skull fracture was not visualized directly beneath the area of concern.[26] This targeted POCUS examination is what is most consistent with current emergency medicine practice.[25] The clinicians performing the POCUS examinations looked for cortical skull irregularities visible in multiple orientations to be considered a true positive fracture.[25] The contralateral skull area was used for comparison when fractures were identified to differentiate these from suture lines.

All clinicians performing the POCUS examinations documented whether fractures were present or absent, their location, and further characterized the fractures as linear, depressed, or complex. Fracture size was estimated by measuring the outer cortices of the 2 fracture fragments. Fracture depth was classified as ≤3 mm, 4-6 mm, 7-10 mm, or ≥11 mm. All ultrasound images were recorded and stored and then compared with head CT scans findings.

Primary endpoints of sensitivity, specificity, positive (PPV) and negative predictive values (NPV) of POCUS compared with CT results were calculated. Secondary endpoints included the accuracy of POCUS for fracture classification as linear, depressed, or complex and depth measurement.

Data analysis was performed using Stata statistical software (v 13.0; StataCorp, College Station, Texas). We performed descriptive analyses for the variables evaluated, and demographic information was stratified by outcomes. Continuous variables were reported as means ± SD. Categorical outcomes were reported with frequencies and 95% CIs. To determine the accuracy of POCUS to identify skull fractures (using CT as the reference standard) we calculated the sensitivity, specificity, PPV, and NPV. We also calculated the percent agreement in the classification and measurement of fractures as well as the Cohen unweighted k statistic based on published standards for the k point estimates.[30,31] We performed the Bowker test[32] for table symmetry and the Stuart–Maxwell test[33,34] for marginal homogeneity. When appropriate, we performed the calculations using the exact likelihood 95% CI. Level of significance was set to 5%. All tests of significance were 2-sided.

Sample size was calculated using available literature for anticipated sensitivity and specificity, absolute precision, and prevalence. Of note, the reported prevalence of skull fractures in children with minor blunt head trauma ranges from 24% to 63.3% and the reported sensitivity and specificity of POCUS is broad, ranging from 82% to 100% and 94% to 95%, respectively.[25,26] In calculating the sample size, we desired a high NPV to exclude skull fractures. Using the average reported sensitivity of 0.92 (the average between Parri[25] and Riera[26]), the corresponding specificity of 0.95, and an estimated point prevalence of 0.25, the estimated sample size needed for a 1-sided $\alpha = 0.025$, and half-width 0.075 (ie, lower bound of the 95% CI of 0.875) was 107 patients.

Results

During the study period, a total of 163 patients and their families were approached for enrollment. We excluded 12 potential subjects because they failed to meet inclusion criteria.

Patients were enrolled when any of the participating physicians were available. This resulted in 36 missed eligible patients during the study period. Twenty physicians enrolled a total of 115 patients who were included in the analysis (**Figure 1**).

Mean age of enrolled patients was 7.9 months (±6.2) with 62 (54%) male patients. Falls from elevations (N = 86, 74.8%) or down stairs (N = 11, 9.6%) were reported to be the most common injury mechanisms. In 10 of 115 (8.7%) patients, the mechanism of injury was unknown, while in a few patients, the reported mechanism of injury was motor vehicular crash occupancy or an object striking the patient's head (both 3 of 115, 2.6%). Other mechanisms were reported in 2 of 115 (1.7%) patients.

A raised scalp hematoma or swelling was documented on the case report forms in 106 (93.8%) patients. Scalp examination findings are described in **Table III** (available at www.jpeds.com). The diameter of each patient's largest scalp hematoma or swelling was categorized as medium (1-3 cm) or large (>3 cm) in 80 (93%) patients. The quality of the hematoma was boggy in 70 of 102 (68.6%) The frequency of skull fractures on CT scan was 76.5% (88 of 115), and the prevalence of any type of traumatic intracranial finding was 33.9% (39 of 115). Most (87.8%) CT scans were performed at the enrolling centers. In 14 of 115 (12.2%), patients were transferred from a referring hospital with CT imaging already performed. In all 14 cases, the physician ultrasonographer was blinded to the CT results when performing the POCUS examinations. **Tables IV** and **V** (**Table V**; available at www.jpeds.com) describe the types and frequency of POCUS and CT findings, respectively.

Table IV. Findings and test characteristics of skull POCUS

Fractures		n = 115
Yes (%)		84 (73.0)
No (%)		31 (27.0)
Fracture description		**n = 84**
Linear (%)		54 (64.3)
Depressed (%)		25 (29.8)
Complex (%)		5 (5.9)
Number of fractures		**n = 84**
Single (%)		72 (85.7)
Multiple (%)		12 (14.3)
Location of fractures		**n = 87**
Frontal		4
Parietal		66
Temporal		3
Occipital		14
Depth of fractures		**n = 84**
≤3 mm (%)		75 (89.3)
4-6 mm (%)		5 (5.9)
7-10 mm (%)		3 (3.6)
≥11 mm (%)		1 (1.2)
Test characteristics of POCUS	**CT positive for fracture**	**CT negative for fracture**
POCUS positive for fracture	80	4
POCUS negative for fracture	8	23
Total	88	27
Sensitivity	90.9% (95%CI 82.9-96)	
Specificity	85.2% (95%CI 66.3-95.8)	
PPV	95.2% (95%CI 88.3-98.7)	
NPV	74.2% (95%CI 55.4-88.1)	

The sensitivity of POCUS for skull fractures was 80 of 88 (90.9%; 95% CI 82.9-96.0) and the specificity for skull fractures was 23 of 27 (85.2%; 95% CI 66.3-95.8) (**Table IV**). None of the 8 patients with false-negative POCUS results had clinically important TBIs. All 8 patients were found to have isolated, linear skull fractures on CT scan, not directly underneath the imaged area per protocol. Among these 8 patients, 6 (75%) were admitted for short-stay hospitalizations or observation; one was discharged home from the ED. One of the patients with a false-negative POCUS examination was a 12-month-old male patient who presented with a frontal, firm scalp hematoma after a fall from >10 feet. This patient had a single linear occipital fracture on CT, was admitted to the intensive care unit, and did not require any intervention.

A total of 10 patients underwent surgery for clinically important injuries. Nine patients required fracture elevations for depressed skull fractures, and 1 patient underwent surgical drainage of an extradural hematoma. The latter was a 7-month-old male patient who fell from an elevation of 110 cm. The patient presented to the ED with a GCS of 15 and a 3 × 3 cm boggy parietal scalp hematoma and no other symptoms or signs of TBI. He was admitted for observation and after 3 hours, he showed signs of drowsiness and agitation, with a GCS of 14. POCUS showed a linear skull fracture beneath the scalp hematoma. The head CT scan confirmed a parietal linear skull fracture and revealed an extradural hematoma with mild midline shift. The patient had prompt neurosurgical evacuation of the hematoma that resulted in an excellent outcome.

The agreement between the reference standard CT scan and POCUS to classify the type of skull fracture as linear, depressed, or complex was 84.4% (97 of 115), with a k statistic of 0.75 (95% CI 0.70-0.84, **Table VI**). **Table VI** also demonstrates that the disagreement between CT and POCUS in the classification of skull fractures was due to 8 false negative and 4 false positive skull fractures by POCUS and 6 fracture misclassifications on POCUS. The highest agreement between CT and POCUS in fracture classification was reached for depressed (4-6 mm depth) skull fractures. Both the symmetry test and the marginal homogeneity test were not significant (**Table VI**).

Three case images are included to demonstrate linear and depressed skull fractures diagnosed on POCUS with their corresponding CT scans (**Figure 2**; available at www.jpeds.com).

Discussion

In this large, multicenter study we demonstrated that among children younger than 2 years of age with minor blunt head trauma and local physical signs of scalp trauma, POCUS of

Table VI. Agreement between POCUS and CT in the classification of fracture type and depth

A. Overall agreement between POCUS and CT in the classification of fracture type

	CT (reference standard)				
POCUS	No fracture	Linear	Depressed	Complex	Total
No fracture	23	8	0	0	31
Linear	2	51	0	1	54
Depressed	2	3	20	0	25
Complex	0	1	1	3	5
Total	27	63	21	4	115

Agreement 84.4%, k 0.75 (95% CI 0.70-0.84)
Symmetry test $\chi^2_5 = 9.6$ $P = .087$
Marginal homogeneity test $\chi^2_3 = 6.35$ $P = .096$

B. Agreement between POCUS and CT in the classification of fracture by CT when depth was ≤3 mm

	CT (reference standard)				
POCUS	No fracture	Linear	Depressed ≤3 mm	Complex	Total
No fracture	0	2	2	0	4
Linear	0	51	3	1	55
Depressed ≤3 mm	0	0	12	1	13
Complex	0	1	0	2	3
Total	0	54	17	4	75

Agreement 86.7%, k 0.69 (95% CI 0.52-0.85)
Symmetry test $\chi^2_5 = 8$ $P = .156$
Marginal homogeneity test $\chi^2_3 = 5.5$ $P = .139$

C. Agreement between POCUS and CT in the classification of fracture by CT when depth was 4-6 mm

	CT (reference standard)		
POCUS	Depressed 4-6 mm	Complex	Total
Depressed 4-6 mm	4	0	4
Complex	0	1	1
Total	4	1	5

Agreement 100.00%, k 1.0 (CI not calculable)
Symmetry test and Marginal homogeneity test not calculable

the skull identified skull fractures with very good accuracy (against a CT reference standard). The POCUS evaluation was well tolerated by patients, and could serve as an important adjunct to clinical prediction rules to help make decisions regarding the use of CT scans after minor head trauma in young children.[26,27] Prior single-center studies have demonstrated the feasibility of POCUS as an approach to the evaluation for potential skull fractures,[24-27] with varying test accuracies.[26,27] However variability in physician ultrasonographers' POCUS training (ranging from 1 hour[24,27] to 1 month[27]) and experience may have affected the diagnostic accuracy in previous studies.[35] We demonstrated here that skull POCUS for the detection of fractures takes little training.[29]

Another source of variability in previous research studies regarding POCUS of the skull may be attributed to the wide reported range of skull fracture prevalence, potentially affecting the test accuracies. The prevalence of skull fractures in the current study was higher than those noted in previous literature, including the Pediatric Emergency Care Applied Research Network study population.[2] This is not unexpected, given the younger age of our study, and the requirement of local signs of head trauma, which allowed us to evaluate a higher-risk population.[6,10,36]

Several studies have demonstrated the association between skull fractures and TBI in both children and adults.[10,37-39] However, these and other studies have demonstrated that TBI occur in the absence of skull fractures.[11,37-39] The quandary for emergency physicians is that the youngest patients with blunt head trauma often have no symptoms or signs of TBI other than large isolated scalp hematomas.[6,10,40-42] These otherwise asymptomatic infants are at noninconsequential risk for skull fractures and, more importantly, for intracranial injuries.[10,40,42,43] Although the main goal in evaluating children with head trauma is the diagnosis of TBI, there is also value in diagnosing skull fractures, in part because of the potentially related complications. Dural tears with growing skull fractures are an uncommon but important complication that could develop even from linear fractures occurring in the first few years of life.[12,44,45] The detection of skull fractures also helps inform discharge instructions for parents. On the other hand, complicated skull fractures (eg, fractures that are depressed or widely diastatic), should also be promptly identified, as they may need neurosurgical intervention irrespective of the presence of underlying intracranial injuries.

In our study sample, POCUS was not only more than 90% sensitive for detecting skull fractures, but also demonstrated substantial agreement between the classification and depth of the fractures by CT scans. These results suggest that implementing skull POCUS in addition to using head trauma clinical prediction rules for pre-verbal children with scalp trauma may increase further the accuracy of prediction rules and decrease resource allocation and radiation risk by mitigating unnecessary CT use in the absence of skull fractures by POCUS. Skull POCUS could also help prioritize the evaluation of infants with head trauma or influence the decision to transfer to a pediatric center. Skull POCUS could also assist with the earlier detection of depressed or complex skull fractures, help prioritize patients for CT scanning, and lead to earlier neurosurgical consultation. More importantly, if used appropriately, POCUS could help reduce unnecessary CT imaging in young patients after head trauma in the setting of a well-appearing child with a negative POCUS examination. POCUS of the skull may represent another method to reduce radiation exposure in the infant with head trauma, along with the use of other imaging modalities, when needed, such as rapid magnetic resonance imaging.[46]

Our study has limitations. Our study consisted of a convenience sample of patients enrolled when a trained physician ultrasonographer was available, and we did not assess the interobserver agreement between enrolling physicians. Although we did not assess the accuracy of POCUS to detect TBIs or basilar skull fractures, POCUS is not meant for those purposes; nevertheless, it identifies an important predictor of TBI. We tested POCUS only in patients with local physical signs for whom the treating physician was planning to obtain a cranial CT scan. We could not ethically justify exposing children to radiation if the clinician did not think CT was indicated. Finally, knowledge of suture line anatomy is another important component of the POCUS evaluation of newborn and infant skulls.[25-27] It may be difficult to distinguish sutures from fractures if the separation of bone underneath a hematoma is due to a nondepressed linear fracture from simply a normal suture line.[26] Skull fractures not located under the area of scalp trauma are also not reliably identified by focused POCUS examination. This limitation has also been reported by other investigators.[26] The approximate 90% sensitivity and 85% specificity that we found, however, likely represents an acceptable accuracy for this simple, noninvasive diagnostic tool, particularly because a period of observation is appropriate for all preverbal children with head trauma and scalp hematomas, even in the absence of other symptoms or signs of head trauma.[47,48]

In summary, POCUS of the skull performed by physicians with dedicated training identifies skull fractures in infants with external signs of head trauma with substantial accuracy. Skull POCUS is able to detect the type and depth of fractures as identified on CT scan. POCUS allows rapid bedside assessment of the fracture and, in conjunction with head trauma clinical prediction rules, has implications for the escalation of care or further imaging if positive, and the possibility of obviating CT scanning if negative. The information provided by POCUS is easy to obtain and clinically meaningful, even if only to counsel parents that the child has a skull fracture and potentially establish closer follow-up. Clinicians working in ED settings should consider skull POCUS as an adjunct to clinical evaluation and clinical prediction rules for TBI to correctly risk stratify patients, identify those at risk of TBIs early, and reduce unnecessary exposure to radiation for those not at significant risk. ■

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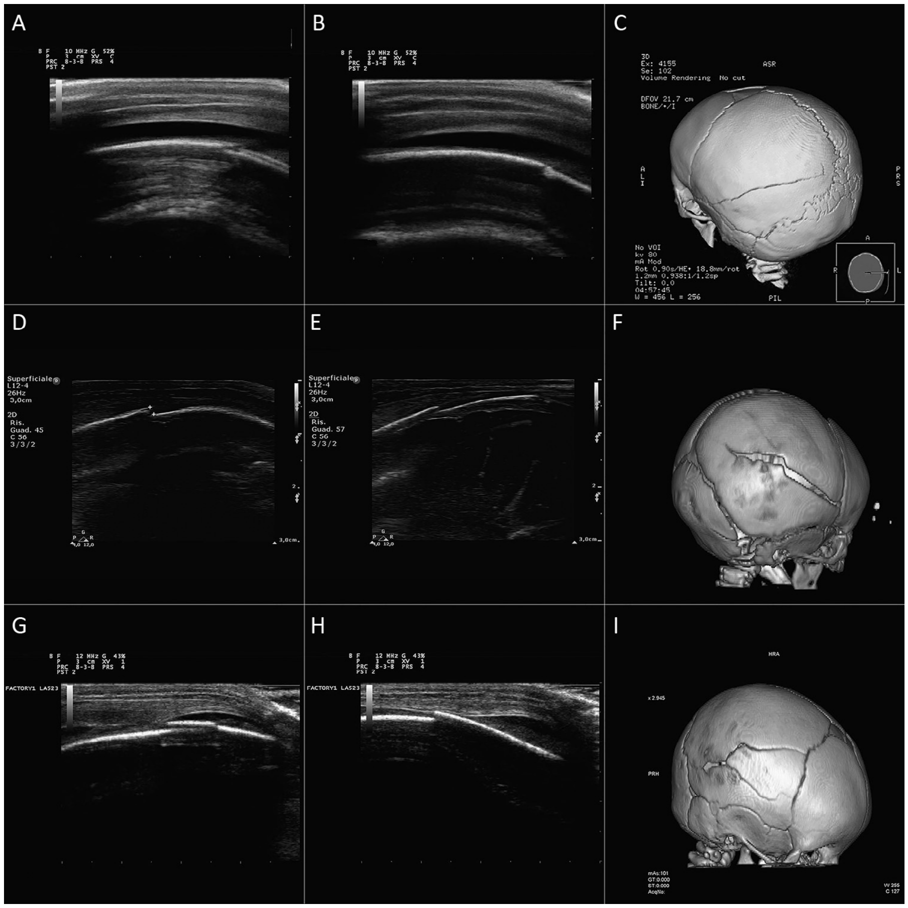

Figure 2. Examples of skull fracture types detected by POCUS. **A,** Linear skull fracture longitudinal view. **B,** Transverse view. **C,** corresponding CT scan. **D,** Depressed skull fracture longitudinal view. **E,** Transverse view. **F,** Corresponding CT scan. **G,** Complex skull fracture longitudinal view. **H,** Transverse view. **I,** corresponding CT scan.

Table I. Enrolling centers

Centers	Number of enrolled patients
Emergency Department, Anna Meyer Children's Hospital, Florence, Italy	62
Emergency Department, Bambino Gesù Children's Hospital, IRCCS Rome, Italy	17
Department of Pediatrics, University of Padova, Treviso, Italy	8
Department of Emergency Medicine, University of California Davis Health, Sacramento, California	17
Emergency Department, Dixie Regional Medical Center, St. George, Utah	5
Emergency Department, Cohen Children's Medical Center, New Hyde Park, New York	6

Table III. Scalp examination findings for enrolled patients

Findings	Enrolled patients (n = 115)
Palpable skull fracture	
Yes (%)	21 (18.3)
No (%)	84 (73.0)
Unclear (%)	10 (8.7)
Palpable fracture - depressed	
Yes (%)	15 (71.4)
No (%)	5 (23.8)
Unclear examination (%)	1 (4.8)
Raised scalp hematoma(s), swelling(s), focal pain	
Yes (%)	106 (93.8)
No (%)	7 (6.2)
Parietal (%)	72
Temporal (%)	7
Frontal (%)	21
Occipital (%)	24
Size of largest scalp hematoma or swelling	
Small (<1 cm barely palpable) (%)	6 (7.0)
Medium (1-3 cm) (%)	43 (50.0)
Large (>3 cm) (%)	37 (43.0)
Quality of largest scalp hematoma or swelling	
Boggy/depressible (%)	70 (68.6)
Firm/nondepressible (%)	27 (26.5)
Not documented (%)	5 (4.9)

Table V. Findings on cranial CT

Where CT performed	
At the study site ED (%)	101 (87.8)
At referring hospital (%)	14 (12.2)
CT results: normal or abnormal	
Normal (%)	27 (23.5)
Abnormal (%)	88 (76.5)
CT findings (of 127 abnormal findings in the 88 patients with abnormal CT scans)	
Skull fracture (%)	88 (76.5)
Extradural hematoma (%)	12 (10.4)
Subdural hematoma (%)	8 (7.0)
Cerebral contusion (%)	8 (7.0)
Subarachnoid hemorrhage (%)	7 (6.1)
Cerebral hemorrhage (%)	3 (2.6)
Intraventricular hemorrhage (%)	1 (0.9)
Pneumocephalus	0
Cerebral edema	0
Midline shift	0
Number of CT traumatic findings per patient in the 88 patients with abnormal CT scans	
Fracture alone (%)	**56 (63.6**)
Fracture + 1 finding (%)	**27 (30.7)**
Fracture + epidural hematoma	11 (12.5)
Fracture + cerebral contusion	6 (6.8)
Fracture + subarachnoid haemorrhage	4 (4.6)
Fracture + subdural hematoma	4 (4.6)
Fracture + cerebral haemorrhage	2 (2.3)
Fracture + 2 findings (%)	**4 (4.5)**
Fracture + subdural hematoma + subarachnoid haemorrhage	2 (2.3)
Fracture + subdural hematoma + cerebral contusion	1 (1.1)
Fracture + cerebral hemorrhage + epidural hematoma	1 (1.1)
Fracture + 3 findings(%)	**0**
Fracture + 4 findings(%)	**1 (1.1)**
Fracture + subdural hematoma + subarachnoid hemorrhage + cerebral contusion + intraventricular hemorrhage	1 (1.1)
Type of skull fracture on CT in the 88 patients with abnormal CT scans	
Linear(%)	63 (71.6)
Depressed(%)	21 (23.9)
Complex(%)	4 (4.5)