JOURNAL SCANNING LIST – August 9th, 2023

Point-of-Care Ultrasound for the Diagnosis of Pediatric Foreign Body Ingestion: A Narrative Review and Illustrative Case Report

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Abstract
Purpose: Foreign body ingestion (FBI) is a frequent concern in emergency departments. Clinical guidelines recommend performing plain x-rays as the primary modality of diagnosis. Although point-of-care ultrasound (PoCUS) has increasingly been integrated into the daily practice of emergency medicine, it has been poorly investigated in the diagnostic approach for FBI.This review aims to highlight the current state of PoCUS use for pediatric FBI.The following research question was considered in this narrative review: Is PoCUS useful for FBI management? Methods: A literature search was conducted to identify articles reporting PoCUS use for the management of FBI. All articles were assessed for quality by 2 reviewers.

Main results: The 14 selected articles reported 52 FBI cases in which PoCUS successfully identified and located the ingested FB. Point-of-care ultrasound was used either as the primary imaging technique or after positive or negative x-ray findings. In 5 cases (9.6%), PoCUS was the only modality used for the diagnosis. Of these cases, 3 (60%) underwent a successful procedure to remove the FB and 2 (40%) received conservative treatment without complications.

Conclusions: This review suggests that PoCUS might be a reliable modality for the initial management of FBI. PoCUS can locate, identify, and evaluate the size of the FB in a wide range of materials and gastrointestinal locations. Point-of-care ultrasound could eventually become the go-to modality in the case of radiolucent FB, thus avoiding the use of radiation. Further studies are nevertheless required to validate PoCUS use for FBI management.

CATCH IT: The Effect of Bladder Ultrasound in Decreasing the Time to Collect a Clean-Catch Urine Sample in the Nontoilet-Trained Child: A Randomized Control Trial

Richard Lennon, Anirudh Krishnamohan , Lesley Fitzpatrick , Mark Gillett

Abstract
Objectives: Clean-catch urine is essential in the investigation of an unwell child but can unfortunately be difficult to obtain in nontoilet-trained children. To this end, we compared the difference in time taken to collect clean-catch urine in nontoilet-trained children via the use of point-of-care ultrasound and traditional methods.

Methods: A single-center randomized controlled trial was conducted at an urban pediatric emergency department, recruiting 80 patients, of which 73 underwent data analyses. Participants were randomized to either the control arm, which consisted of the traditional "watch and wait" method of collecting a clean-catch sample, or to the intervention arm, which used point-of-care ultrasound to assess bladder volume and to stimulate the micturition reflex. The primary outcome measured was the mean time taken to collect a clean-catch urine sample. Results: Eighty patients (ultrasound, n = 41; standard care, n = 39) underwent randomization using a random number generator. Seven patients were removed from final analysis due to loss to follow-up for various reasons. Seventy-three patients (ultrasound, n = 37; standard care, n = 36) underwent statistical analysis. The ultrasound group had a median time to clean-catch urine of 40 minutes (interquartile range, 52) and mean time of 52 minutes (standard deviation, 42), and the control group had a median time of 55 minutes (interquartile range, 81), and mean time of 82 minutes (standard deviation, 90). This reached statistical significance (1-tail t test, P = 0.033). The baseline characteristics were similar between both groups for sex and age distribution; however, the mean ages were significantly different (2-tail t test, P = 0.049) with 8.4 months in the control group, and 12.3 months in the ultrasound group.

Conclusions: We found that there was a statistically and clinically significant reduction in mean time taken to collect clean-catch urine in nontoilet-trained children using point-of-care ultrasound compared with the traditional watch and wait method.

Minor head trauma in infants - how accurate is cranial ultrasound performed by trained radiologists?

Claudia Peter , Enno Stranzinger , Johannes T Heverhagen , Kristina Keitel , Fabrizio Romano , Jasmin D Busch , Nedelina Slavova

Abstract
Correct management of infants after minor head trauma is crucial to minimize the risk to miss clinically important traumatic brain injury (ciTBI). Current practices typically involve CT or in-

hospital surveillance. Cranial ultrasound (CUS) provides a radiation-free and fast alternative. This study examines the accuracy of radiologist-performed CUS to detect skull fracture (SF) and/or intracranial hemorrhage (ICH). An inconspicuous CUS followed by an uneventful clinical course would allow exclusion of ciTBI with a great certainty. This monocentric, retrospective, observational study analyzed CUS in infants (< 12 months) after minor head trauma at Bern University Children's Hospital, between 7/2013 and 8/2020. The primary outcome was the sensitivity and specificity of CUS in detecting SF and/or ICH by comparison to the clinical course and to additional neuroimaging. Out of a total of 325 patients, 73% (n = 241) had a normal CUS, 17% (n = 54) were found with SF, and ICH was diagnosed in 2.2% patients (n = 7). Two patients needed neurosurgery and three patients deteriorated clinically during surveillance. Additional imaging was performed in 35 patients. The sensitivity of CUS was 93% ([0.83, 0.97] 95% CI) and the specificity 98% ([0.95, 0.99] 95% CI). All false-negative cases originated in missed SF without clinical deterioration; no ICH was missed. Conclusion: This study shows high accuracy of CUS in exclusion of SF and ICH, which can cause ciTBI. Therefore, CUS offers a reliable method of neuroimaging in infants after minor head trauma and gives reassurance to reduce the duration of in-hospital surveillance. What is Known: • Minor head trauma can cause clinically important traumatic brain injury in infants, and the management of these cases is a challenge for the treating physician. • Cranial ultrasound (CUS) is regularly used in neonatology, but its accuracy after head trauma in infants is controversial. What is New: • CUS performed by a trained radiologist can exclude findings related to clinically important traumatic brain injury (ciTBI) with high sensitivity and specificity. It therefore offers reassurance in the management of infants after minor head trauma.

Point-of-Care Ultrasound for the Diagnosis of Pediatric Testicular Torsion: A Retrospective Case Series Analysis
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Abstract
Objectives: Acute testicular torsion is a surgical emergency that warrants prompt treatment. The diagnosis is typically confirmed by ultrasonography interpreted by a radiologist (RADUS); however, in this study, we describe the clinical course of 23 patients for whom point-of-care ultrasound (POCUS) was performed by pediatric emergency medicine physicians during the initial assessment for testicular torsion in the pediatric emergency department (PED).

Methods: A retrospective case series analysis of patients aged 0 to 18 years who were diagnosed with acute testicular torsion after undergoing scrotal POCUS through our PED.

Results: Between June 2015 and December 2020, 155 boys received an International Classification of Diseases-9 code of Torsion of Testis after presenting to our PED. Seventy-three patients were imaged preoperatively, of which 50 (68.5%) were diagnosed via RADUS alone. Twenty-three patients (31.5%) underwent POCUS (median age 14.1 years [interquartile range {IQR}: 11.4-15.9 years]), of which 14 (60.9%) were imaged by POCUS alone, whereas the remaining 9 patients (39.1%) underwent POCUS before RADUS. Thirteen of the 23 patients (56.5%) who underwent POCUS had intraoperative findings consistent with acute testicular torsion, whereas another 3 patients (13.0%) required manual detorsion in the PED before orchiopexy. Six patients required orchiectomy. All patients for which POCUS findings were suggestive of acute testicular torsion were correctly classified.The median length of stay from time to admission to orchiopexy for those who received RADUS only versus POCUS only was 184 minutes (IQR: 136-255), and 121 minutes (IQR: 80-202), respectively (P = 0.036). Among the patients who experienced POCUS, the median length of stay for those who underwent RADUS in addition to POCUS compared with those who underwent POCUS alone was 202 minutes (IQR: 136-338.4) (P = 0.031).

Conclusions: Point-of-care ultrasound performed by pediatric emergency medicine physicians can be used to expedite surgical management and streamline the management of pediatric patients suspected of acute testicular torsion.

Can Medical Students Learn and Perform POCUS in the Pediatric Emergency Department? Implementation of a Short Curriculum

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Abstract
Purpose: To determine medical student ability to accurately obtain and interpret POCUS exams of varying difficulty in the pediatric population after a short didactic and hands-on POCUS course. Methods: Five medical students were trained in four POCUS applications (bladder volume, long bone for fracture, limited cardiac for left ventricular function, & inferior vena cava collapsibility) and enrolled pediatric ED patients. Ultrasound-fellowship-trained emergency medicine physicians reviewed each scan for image quality and interpretation accuracy using the American College of Emergency Physicians' quality assessment scale. We report acceptable scan frequency and medical student vs. Ultrasound-fellowship-trained emergency medicine

physician interpretation agreement with 95% confidence intervals (CI). Results: Ultrasound-fellowship-trained emergency medicine physicians graded 51/53 bladder volume scans as acceptable (96.2%; 95% CI 87.3-99.0%) and agreed with 50/53 bladder volume calculations (94.3%; 95% CI 88.1-100%). Ultrasound-fellowship-trained emergency medicine physicians graded 35/37 long bone scans as acceptable (94.6%; 95% CI 82.3-98.5%) and agreed with 32/37 medical student long bone scan interpretations (86.5%; 95% CI 72.0-94.1%). Ultrasound-fellowship-trained emergency medicine physicians graded 116/120 cardiac scans as acceptable (96.7%; 95% CI 91.7-98.7%) and agreed with 111/120 medical student left ventricular function interpretations (92.5%; 95% CI 86.4-96.0%). Ultrasound-fellowship-trained emergency medicine physicians graded 99/117 inferior vena cava scans as acceptable (84.6%; 95% CI 77.0-90.0%) and agreed with 101/117 medical student interpretations of inferior vena cava collapsibility (86.3%; 95% CI 78.9-91.4%). Conclusions: Medical students demonstrated satisfactory ability within a short period of time in a range of POCUS scans on pediatric patients after a novel curriculum. This supports the incorporation of a formal POCUS education into medical school curricula and suggests that novice POCUS learners can attain a measure of competency in multiple applications after a short training course.

Point-of-care ultrasound diagnosis of skull fracture in Chinese children 0-6 years old with scalp hematoma from minor head trauma: A preliminary prospective observational study

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Abstract
Background: Previous studies have suggested that point-of-care ultrasound could help to evaluate and diagnose pediatric skull fracture for the closed scalp hematoma from blunt trauma. However, relevant data in Chinese children are missing, especially in children 0-6 years old.

Objectives: Our study aimed to evaluate the efficacy of point-of-care ultrasound to diagnose skull fracture in children 0-6 years old with scalp hematoma in China.

Methods: We performed a prospective observational study and screened children 0-6 years old with closed scalp hematoma and a Glasgow coma scale of 14-15 at Hospital in China. Enrolled children (N = 152) were first evaluated for skull fracture with point-of-care ultrasound by the emergency physician and then received a head computed tomography scan.

Results: The point-of-care ultrasound examination and computed tomography scan revealed skull fracture in 13 (8.6%) and 12 (7.9%) children, respectively. The kappa test showed a satisfactory agreement between two examinations (P < 0.0001), with kappa = 0.87 (95% confidence interval, i.e., 95% CI, [0.69, 1.00]) and area under the curve = 0.95 (95% CI [0.86, 1], P < 0.0001). The point-of-care ultrasound examination had the sensitivity of 91.7% (95% CI [62.5%, 100%]), specificity of 98.6% (95% CI [94.6%, 100%]), positive predictive value of 84.6% (95% CI [56.5%, 96.9%]), negative predictive value of 99.2% (95% CI [95.6%, 100%]), and accuracy of 98.0% (95% CI [94.1%, 99.6%]).

Conclusions: While our study is preliminary in nature, our findings may guide future larger studies in assessing the utility of point-of-care ultrasound examination in diagnosing skull fractures in children with scalp hematoma from minor head trauma.

Identification of Papilledema in Pediatric Patients With Meningitis Using Ocular Point-of-Care Ultrasound
Kathryn Schissler, Kayla Gonzalez, Henry Chicaiza

Abstract
Ocular point-of-care ultrasound is used by physicians for an array of diagnoses. In this case series, we describe how pediatric emergency medicine physicians utilized ocular point-of-care ultrasound in the management of patients with papilledema secondary to meningitis or its treatment.

Competency Standard Derivation for Point-of-Care Ultrasound Image Interpretation for Emergency Physicians
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Abstract

Study objective: Because number-based standards are increasingly controversial, the objective of this study was to derive a performance-based competency standard for the image interpretation task of point-of-care ultrasound (POCUS).

Methods: This was a prospective study. Operating on a clinically-relevant sample of POCUS images, we adapted the Ebel standard-setting method to derive a performance benchmark in 4 diverse pediatric POCUS applications: soft tissue, lung, cardiac and focused assessment with sonography in trauma (FAST). In Phase I (difficulty calibration), cases were categorized into interpretation difficulty terciles (easy, intermediate, hard) using emergency physician-derived data. In Phase II (significance), a 4-person expert panel categorized cases as low, medium, or high clinical significance. In Phase III (standard setting), a 3x3 matrix was created, categorizing cases by difficulty and significance, and a 6-member panel determined acceptable accuracy for each of the 9 cells. An overall competency standard was derived from the weighted sum. Results: We obtained data from 379 emergency physicians resulting in 67,093 interpretations and a median of 184 (interquartile range, 154, 190) interpretations per case. There were 78 (19.5%) easy, 272 (68.0%) medium, and 50 (12.5%) hard-to-interpret cases, and 237 (59.3%) low, 65 (16.3%) medium, and 98 (24.5%) cases of high clinical significance across the 4 POCUS applications. The panel determined an overall performance-based competency score of 85.0% for lung, 89.5% for cardiac, 90.5% for soft tissue, and 92.7% for FAST.

Conclusion: This research provides a transparent chain of evidence that derived clinically relevant competency standards for POCUS image interpretation.

Need of Point of Care Ultrasound Training in Pediatric Emergency Medicine Practice: A Wake-Up Call for the Low-Income Countries

Noman Ali , Erum Shakeel , Salman Muhammad Soomar

Abstract
POCUS is the acquisition, interpretation, and rapid clinical integration of ultrasonographic imaging performed by the treating physician at the patient's bedside. It is used in the field Emergency Medicine to assist in diagnosing and managing various clinical conditions ranging from undifferentiated shock, respiratory failure, and cardiac arrest, which have shown a positive impact on clinical decision-making, resulting in a decreased emergency department and hospital length of stay. POCUS is also a valuable diagnostic tool in managing pediatric patients for whom radiation exposure is a significant concern. It is used to aid in diagnosing and

managing various pediatric medical and surgical emergencies. Despite the evident literature regarding the utility of POCUS in Pediatric Emergency Medicine (PEM) practice, there is a lack of specialized training for pediatric emergency physicians, especially in low-income countries. Therefore, this comment emphasizes the need for POCUS training in PEM.

The Evolution of Cardiovascular Ultrasound: A Review of Cardiac Point-of-Care Ultrasound (POCUS) Across Specialties

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Abstract
The use of cardiac point-of-care ultrasound (POCUS) is now widespread in clinics, emergency departments, and all areas of the hospital. Users include medical trainees, advanced practice practitioners, and attending physicians in many specialties and sub-specialties. Opportunities to learn cardiac POCUS and requirements for training vary across specialties, as does the scope of the cardiac POCUS examination. In this review, we describe both a brief history of how cardiac POCUS emerged from echocardiography and the state of the art across a variety of medical fields.

Finding the most suitable puncture site for intraosseous access in term and preterm neonates: an ultrasound-based anatomical pilot study

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Abstract

The purpose of this prospective ultrasound-based pilot study was to identify the most suitable tibial puncture site for intraosseous (IO) access in term and preterm neonates, describe tibial dimensions at this site, and provide anatomical landmarks for rapid localization. We measured the tibial dimensions and distances to anatomical landmarks at puncture sites A (proximal: 10 mm distal to the tibial tuberosity; distal: 10 mm proximal to the malleolus medialis) and B (chosen by palpation of the pediatrician), in 40 newborns in four weight groups (< 1000 g; 1000-2000 g, 2000-3000 g, and 3000-4000 g). Sites were rejected if they fell short of the assumed safety distance to the tibial growth plate of 10 mm. If both A and B were rejected, puncture site C was determined sonographically at the maximum tibial diameter while maintaining the safety distance. Puncture site A violated the safety distance in 53% and 85% (proximally and distally, respectively) and puncture site B in 38% and 33%. In newborns weighing 3000-4000 g, at median (IQR), the most suitable puncture site at the proximal tibia was 13.0 mm (12.0-15.8) distal to the tuberosity and 6.0 mm (4.0-8.0) medial to the anterior rim of the tibia. The median (IQR) diameters at this site were 8.3 mm (7.9-9.1) (transverse) and 9.2 mm (8.9-9.8) (anterior-posterior). The diameters increased significantly with increasing weight. Conclusion: This study adds concise, practical information on the implementation of IO access in neonatal patients: the tibial dimensions in newborns in four different weight groups and initial data on anatomical landmarks to easily locate the IO puncture site. The results may help implement IO access in newborns more safely. What is Known: • Intraosseous access is a feasible option for emergency administration of vital drugs and fluids in newborns undergoing resuscitation when an umbilical venous catheter is impossible to place. • Severe complications of IO access due to malpositioned IO needles have been reported in neonates. What is New: • This study reports the most suitable tibial puncture sites for IO access and the tibial dimensions, in newborns of four weight groups. • The results can help to implement safe IO access in newborns.

Bedside lung ultrasound for the diagnosis of pneumonia in children presenting to an emergency department in a resource-limited setting

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Abstract
Background: Lung ultrasound (LUS) is an effective tool for diagnosing pneumonia; however, this has not been well studied in resource-limited settings where pneumonia is the leading cause of death in children under 5 years of age.

Objective: The objective of this study was to evaluate the diagnostic accuracy of bedside LUS for diagnosis of pneumonia in children presenting to an emergency department (ED) in a resource-limited setting.

Methods: This was a prospective cross-sectional study of children presenting to an ED with respiratory complaints conducted in Nepal. We included all children under 5 years of age with cough, fever, or difficulty breathing who received a chest radiograph. A bedside LUS was performed and interpreted by the treating clinician on all children prior to chest radiograph. The criterion standard was radiographic pneumonia, diagnosed by a panel of radiologists using the Chest Radiography in Epidemiological Studies methodology. The primary outcome was sensitivity and specificity of LUS for the diagnosis of pneumonia. All LUS images were later reviewed and interpreted by a blinded expert sonographer.

Results: Three hundred and sixty-six children were enrolled in the study. The median age was 16.5 months (IQR 22) and 57.3% were male. Eighty-four patients (23%) were diagnosed with pneumonia by chest X-ray. Sensitivity, specificity, positive and negative likelihood ratios for clinician's LUS interpretation was 89.3% (95% CI 81-95), 86.1% (95%CI 82-90), 6.4, and 0.12 respectively. LUS demonstrated good diagnostic accuracy for pneumonia with an area under the curve of 0.88 (95% CI 0.83-0.92). Interrater agreement between clinician and expert ultrasound interpretation was excellent (k = 0.85).

Conclusion: Bedside LUS when used by ED clinicians had good accuracy for diagnosis of pneumonia in children in a resource-limited setting.