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Utility of Inpatient Cranial Ultrasound for Surveillance of Pediatric Traumatic Brain Injury

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Abstract

Introduction: Although CT and MRI remain gold standards for pediatric traumatic brain injury (TBI) surveillance imaging, radiation, sedation, and cost limit their use. Cranial ultrasound (CUS) offers a radiation-free bedside alternative. This study evaluated inpatient surveillance CUS utility for pediatric patients with CT-confirmed mild-to-moderate TBI.

Methods: This retrospective chart review (2014–2024) evaluated children aged 0–2 with Glasgow Coma Scale (GCS) scores of 9–15 and CT-confirmed skull fracture and/or intracranial hemorrhage (ICH). Collected data included demographics, hospital course, TBI characterization, and 30-day readmission. Charts of patients undergoing CUS were reviewed for utility, defined as a CUS-attributed change in management (e.g., additional imaging, escalation of care, neurosurgical consultation, or discharge alterations). Data were analyzed using chi-square and Fisher's exact tests ($p < 0.05$).

Results: Of the 247 patients, 94 (38.1%) underwent surveillance CUS; only 4 (4.3%) had a change in management. All utility cases involved isolated ICH ($p = 0.008$) and bilateral ICH ($p = 0.003$), and correlated with longer ICU ($p = 0.010$) and hospital lengths of stay ($p = 0.006$). Overall, the CUS group was younger (0.2 vs 0.7 years, $p < 0.001$), had longer hospital stays ($p < 0.001$), and more frequent ICU admissions ($p < 0.001$). 30-day readmission rates did not differ ($p = 0.372$).

Conclusion: Inpatient surveillance CUS demonstrates low overall clinical utility for mild-to-moderate TBI. Management changes were confined to patients with higher-burden ICH. Selective rather than routine CUS, combined with clinical monitoring, may better guide imaging strategies. Multicenter studies are needed to validate these findings.

Introduction

Traumatic brain injury (TBI) is a leading cause of pediatric hospitalization and death in the United States [17]. Accurately assessing injury through clinical examination and imaging is critical for management and reducing complications. However, the selection of imaging modalities in pediatric patients requires careful consideration. Computed Tomography (CT), while highly effective, exposes children to higher levels of potentially harmful ionizing radiation [2, 4, 11, 15, 23]. Magnetic Resonance Imaging (MRI) avoids ionizing radiation but is time-intensive, resource-demanding, and often requires sedation in young patients [9]. Low-dose CT and rapid MRI protocols have reduced these limitations; however, CT still imparts radiation [27], and rapid MRI is not universally available [18]. Despite its pitfalls, CT remains the preferred imaging modality because of its rapid detection of acute intracranial hemorrhage (ICH) and skull fractures (SFs) [28].

To streamline decision-making and reduce unnecessary imaging, the Pediatric Emergency Care Applied Research Network (PECARN) introduced head injury prediction rules in 2009. These rules use clinical criteria including Glasgow Coma Scale (GCS) score, presence of a palpable SF, and altered mental status to guide the use of CT imaging. When imaging is pursued, clinicians primarily evaluate for SF and ICH

[16]. Although PECARN guidelines have reduced unnecessary CT utilization, they do not address imaging strategies for inpatient surveillance once an injury has been identified. Consequently, management of clinically stable patients with known injuries remains unclear. Cranial ultrasound (CUS) has been proposed as a potential adjunct or alternative imaging modality to further mitigate risks associated with repeated CT or MRI, particularly for patients with open fontanelles where the acoustic window allows for bedside evaluation.

Studies evaluating the diagnostic performance of CUS for pediatric head trauma have reported variable results. In detecting pediatric (< 18 years old) SF, one prospective study found 100% sensitivity and 95% specificity [21]. However, studies assessing CUS detection of ICH in infants have reported more modest performance, with one study demonstrating 67% sensitivity, including 81% sensitivity for significant hemorrhage [6], and another reporting substantial interobserver variability [19]. When excluding clinically important TBI, as defined by PECARN criteria, one study found that CUS achieved 93% sensitivity and 98% specificity, with all false-negative cases attributable to missed SFs without subsequent clinical deterioration [24]. This discrepancy suggests that while CUS may be excellent for identifying bony injury, its role in monitoring hemorrhagic progression is less certain. Similarly, compared to MRI, CUS reliably identifies severe brain abnormalities, but may miss subtle findings detected on MRI that have little prognostic significance [3].

Overall, data regarding the ability of CUS to consistently detect traumatic findings remains variable when compared with CT and MRI. Prior studies have focused on CUS in initial diagnostic evaluation rather than in inpatient surveillance. Meanwhile, research examining CT for inpatient surveillance suggests that routine repeat imaging is often unnecessary, particularly in clinically stable patients [1, 13, 22, 25]. Nevertheless, clinicians continue to seek surveillance imaging for reassurance, and CUS is generally considered a low-risk alternative. Whether CUS provides new information or alters management in this setting remains unclear. Determining the clinical utility of CUS is imperative as these studies cost patients hundreds of dollars along with upwards of 30 minutes of radiologists' and technicians' time.

This study evaluates the clinical utility of CUS as an inpatient imaging modality through a retrospective chart review. Specifically, we assess whether surveillance CUS provides new information resulting in a change in patient management, thereby clarifying its potential role in inpatient pediatric head trauma care.

Methods

We performed a single-center, retrospective cohort study of pediatric patients at a tertiary care academic medical center over a 10-year period (January 1, 2014, to January 1, 2024). This study was approved by the local institutional review board, with consent waived due to its retrospective nature.

We reviewed the electronic medical record of patients < 2 years of age who presented with mild (GCS 13–15) to moderate (GCS 9–12) scores and CT-evident TBI. This age range reflects fontanelle patency, with closure at 4–26 months [5]. TBI was defined as SF and/or ICH identified on initial CT imaging.

Additionally, patients who sustained an open and/or penetrating mechanism of TBI, had a presenting GCS score < 9, or had an intracranial mass lesion requiring surgical decompression or evacuation following the initial CT were excluded to focus on a cohort stable enough for inpatient surveillance.

Collected data included patient demographics (age, sex, and race), length of stay (days from admission to discharge), and ICU length of stay (days in the ICU, NICU, and PICU). Patient race was recorded from the electronic medical record to assess potential disparities in imaging utilization. TBI was characterized by anatomic location, laterality, and ICH type. For patients undergoing MRI after surveillance CUS, examinations were reviewed alongside the index CT for interval changes and adjudicated by a board-certified study-investigator radiologist. TBI-related 30-day readmission was determined by a board-certified study-investigator neurosurgeon.

Patients were grouped based on the presence or absence of surveillance CUS performed after the initial CT. The decision to image was made at the discretion of the attending clinical team. CUS charts were reviewed for clinical utility. For patients undergoing multiple CUS, utility was assessed at the patient level. Utility was defined as any documented change in clinical management attributable to CUS findings, including additional imaging, escalation of level of care, neurosurgical consultation, or alteration in discharge planning. Provider notes and imaging results were evaluated. CUS utility was adjudicated by a study-investigator neurosurgeon. Confirmatory negative findings without clinical suspicion were not classified as utility.

Statistical analysis was performed using SPSS. Data distribution was evaluated for normality; consequently, non-parametric Mann-Whitney U tests were employed for continuous variables, while chi-square tests were used for categorical data. Statistical significance was set at $p < 0.05$. The primary outcome was patient-level rate of clinical utility provided by surveillance CUS. Secondary outcomes included SF and ICH characteristics, median length of stay, and 30-day readmission rates.

Results

Of the 249 children screened, 247 met inclusion criteria with 94 (38.1%) having received CUS. Patient demographics and clinical presentations are depicted in Table 1, and injury characteristics are summarized in Table 2. Sex and race distributions were balanced; however, the median age was 0.2 (IQR 0.1–0.5) years in the CUS group compared with 0.7 (IQR 0.2–1.5) years in the non-CUS group ($p < 0.001$). Children who received CUS were more frequently admitted to the ICU (86.2% vs 41.2%; $p < 0.001$) and demonstrated a wider distribution for hospital length of stay (median, 2.0 [IQR 1.0–4.0] vs 2.0 [IQR 2.0–3.0] days; $p < 0.001$), while ICU length of stay was similar between groups (2.0 [2.0–3.0] days; $p = 0.475$). Injury types differed significantly between groups. Patients in the CUS cohort were more likely to present with isolated ICH (30.9% vs 12.4%; $p < 0.001$) or SF and ICH (54.3% vs 24.2%; $p < 0.001$) compared to the non-CUS group. Conversely, isolated SF was more prevalent in the non-CUS group (14.9% vs 62.7%; $p < 0.001$). 30-day readmission did not significantly differ between groups ($p = 0.372$).

Table 1: Patient Demographics and Clinical Characteristics by Surveillance Cranial Ultrasound Presence

Characteristics	Total (n = 247)	Cranial Ultrasound (n = 94)	No Cranial Ultrasound (n = 153)	p-Value
Demographics				
Age, years, median (IQR)		0.2 (0.1–0.5)	0.7 (0.2–1.5)	**< 0.001**
Legal Sex (Male), n (%)	138 (55.9%)	50 (53.2%)	88 (57.5%)	0.513
Race, n (%)				0.106
White	84 (34.0%)	29 (30.9%)	55 (35.9%)	
Black	68 (27.5%)	34 (36.2%)	34 (22.2%)	
Hispanic	60 (24.3%)	22 (23.4%)	38 (24.8%)	
Asian	4 (1.6%)	1 (1.1%)	3 (2.0%)	
Other/Unspecified	25 (10.1%)	5 (5.3%)	20 (13.1%)	
Multiple	6 (2.4%)	3 (3.2%)	3 (2.0%)	
Clinical Presentation				
GCS Category, n (%)				1.000
Mild (13-15)	232 (93.9%)	88 (93.6%)	144 (94.1%)	
Moderate (9-12)	15 (6.1%)	6 (6.4%)	9 (5.9%)	
Hospital Course				
Hospital Length of Stay, days, median (IQR)		2.0 (1.0–4.0)	2.0 (2.0–3.0)	**< 0.001**
ICU Admission, n (%)	144 (58.3%)	81 (86.2%)	63 (41.2%)	**< 0.001**
ICU Length of Stay, days, median (IQR)		2.0 (2.0–3.0)	2.0 (2.0–3.0)	0.475

Abbreviations: GCS = Glasgow Coma Scale; ICU = Intensive Care Unit; IQR = interquartile range.

Statistically significant p-values ($p < 0.05$) are typeset in boldface.

Table 2: Comparison of Initial Injury Characteristics and 30-Day Clinical Outcomes by Surveillance Cranial Ultrasound Presence

Characteristics	Total (n = 247)	Cranial Ultrasound (n = 94)	No Cranial Ultrasound (n = 153)	p-Value
Imaging Findings				
Isolated SF, n (%)	110 (44.5%)	14 (14.9%)	96 (62.7%)	**< 0.001**
Isolated ICH, n (%)	48 (19.4%)	29 (30.9%)	19 (12.4%)	**< 0.001**
SF and ICH, n (%)	88 (35.6%)	51 (54.3%)	37 (24.2%)	**< 0.001**
Skull Fracture Characteristics				
Displaced Fracture, n (%)	50 (25.3%)	18 (27.7%)	32 (24.1%)	0.604
Cross Suture, n (%)	30 (15.2%)	10 (15.4%)	20 (15.0%)	1.000
Multiple Bones Involved, n (%)	39 (19.7%)	15 (23.1%)	24 (18.0%)	0.234
Intracranial Hemorrhage Characteristics				
ICH Type, n (%)				0.490
Subarachnoid	20 (14.7%)	12 (15.0%)	8 (14.3%)	
Subdural	52 (38.2%)	34 (42.5%)	18 (32.1%)	
Epidural	9 (6.6%)	5 (6.3%)	4 (7.1%)	
Parenchymal	5 (3.7%)	2 (2.5%)	3 (5.4%)	
Extra Axial	36 (26.5%)	22 (27.5%)	14 (25.0%)	
Multiple	13 (9.6%)	5 (6.3%)	8 (14.3%)	
ICH Location, n (%)				0.220
Frontal	24 (17.6%)	13 (16.3%)	11 (19.6%)	
Temporal	3 (2.2%)	2 (2.5%)	1 (1.8%)	
Parietal	37 (27.2%)	23 (28.7%)	14 (25.0%)	
Occipital	4 (2.9%)	1 (1.3%)	3 (5.4%)	
Cerebellar	3 (2.2%)	0 (0.0%)	3 (5.4%)	
Multiple	65 (47.8%)	41 (51.2%)	24 (42.9%)	
Bilateral, n (%)	36 (26.5%)	20 (25.0%)	16 (28.6%)	0.695
Post-Discharge Outcomes				

30-Day Readmission, n (%)	5 (2.0%)	3 (3.2%)	2 (1.3%)	0.372

Abbreviations: ICH = intracranial hemorrhage; SF = skull fracture.

Statistically significant p-values ($p < 0.05$) are typeset in boldface.

Table 3 presents comparisons of primary and secondary outcomes. Among the 94 children who underwent CUS, clinical utility was documented in 4 patients (4.3%). Age was not associated with CUS utility ($p = 0.275$). However, the utility group experienced significantly greater hospital (median, 6.0 [IQR 4.0–8.8] vs. 2.0 [IQR 1.0–3.0] days; $p = 0.006$) and ICU lengths of stay (median, 3.5 [IQR 3.0–8.5] vs. 2.0 [IQR 2.0–3.0] days; $p = 0.010$).

Within the CUS cohort, clinical utility was exclusively observed in patients with isolated ICH (100% vs 27.8%; $p = 0.008$), all of which were bilateral (100% vs 21.1%; $p = 0.003$). No management changes occurred in patients presenting with SF, whether in isolation (0% vs 15.6%; $p = 1.000$) or when combined with an ICH (0% vs 56.7%; $p = 0.040$). CUS utility was not associated with 30-day readmission ($p = 0.124$).

Table 3: Analysis of Clinical Utility Among Patients Undergoing Surveillance Cranial Ultrasound

Characteristics	Utility n = 4 (4.3%)	No Utility n = 90 (95.7%)	p-Value
Demographics			
Age, years, median (IQR)	0.4 (0.3–0.6)	0.2 (0.1–0.4)	0.275
Legal Sex (Male), n (%)	2 (50.0%)	48 (53.3%)	1.000
Race, n (%)			0.422
White	0 (0%)	29 (32.2%)	
Black	2 (50.0%)	32 (35.6%)	
Hispanic	2 (50.0%)	20 (22.2%)	
Other	0 (0%)	9 (10.0%)	
Clinical Presentation			
GCS Category, n (%)			0.235
Mild (13-15)	3 (75.0%)	85 (94.4%)	
Moderate (9-12)	1 (25.0%)	5 (5.6%)	
Hospital Course			
Hospital Length of Stay, days, median (IQR)	6.0 (4.0–8.8)	2.0 (1.0–3.0)	**0.006**
ICU Length of Stay, days, median (IQR)	3.5 (3.0–8.5)	2.0 (2.0–3.0)	**0.010**
Imaging Findings			
Isolated SF, n (%)	0 (0%)	14 (15.6%)	1.000
Isolated ICH, n (%)	4 (100%)	25 (27.8%)	**0.008**
SF and ICH, n (%)	0 (0%)	51 (56.7%)	**0.040**
Intracranial Hemorrhage Characteristics			
ICH Type, n (%)			0.875
Subarachnoid	1 (25.0%)	11 (14.5%)	
Subdural	2 (50.0%)	32 (42.1%)	
Extra Axial	0 (0%)	5 (6.6%)	
Multiple	1 (25.0%)	26 (34.2%)	
Other	0 (0%)	2 (2.6%)	
ICH Location, n (%)			1.000

Frontal	1 (25.0%)	12 (15.8%)	
Parietal	1 (25.0%)	22 (28.9%)	
Multiple	2 (50.0%)	39 (51.3%)	
Other	0 (0%)	3 (3.9%)	
Bilateral, n (%)	4 (100.0%)	16 (21.1%)	**0.003**
Post-Discharge Outcomes			
30-Day Readmission, n (%)	1 (25.0%)	2 (2.2%)	0.124

Abbreviations: GCS = Glasgow Coma Scale; ICH = intracranial hemorrhage; ICU = Intensive Care Unit; IQR = interquartile range; SF = skull fracture.

Statistically significant p-values ($p < 0.05$) are typeset in boldface.

The utility cohort was further analyzed to determine case chronology and patient specifics. The first patient was an 8-month-old who presented with bilateral parietal subdural hematomas extending toward the convexity following a fall from elevation. Surveillance CUS was obtained on hospital admission days 2 and 3 to monitor interval progression. MRI was performed on hospital admission day 4 due to concern for an acute-on-chronic hemorrhage. MRI demonstrated stable findings without new or active bleeding.

The second patient was a 4-month-old with moderate acute-on-chronic bilateral subdural intracranial hemorrhages in the superior frontal region attributed to physical abuse. During hospitalization, this patient suffered from seizures, respiratory failure, and acute altered mental status. Serial CUS examinations were performed on hospital admission day 6 for interval monitoring, and days 8 and 9 for seizures and increased agitation, with one demonstrating enlargement of the subdural collections, prompting neurosurgical recommendation for shunt placement at an outside facility.

The third patient was a 5.5-month-old who presented with 2.3 × 0.7 × 0.8 cm acute intraparenchymal and chronic subdural hemorrhages in the superior frontal region concerning for nonaccidental trauma. This patient received CUS on hospital admission day 2 with recommendation of MRI for further characterization.

The fourth patient was a 3-month-old who presented with trace bilateral parietal subdural hemorrhages following a fall from one level to another. CUS was performed on hospital admission day 2 to assess hemorrhage stability prior to discharge. Imaging findings raised concern for chronic hemorrhage and possible non-accidental head trauma, prompting Child Abuse Research Education and Services (CARES) consultation and follow-up MRI evaluation, which demonstrated no interval progression.

Discussion

Limited literature evaluates surveillance CUS in pediatric TBI, making direct comparisons challenging. We therefore compared our findings with repeat CT studies evaluating the impact of routine surveillance imaging on clinical management [13, 22, 25]. Our study design and outcome definitions align with repeat-CT studies, with clinical utility defined as a change in management, including escalation of care, neurosurgical consultation, or intervention. We also examined escalation from ultrasound to CT or MRI, a pathway not captured in CT-focused studies.

In our cohort, inpatient surveillance CUS infrequently resulted in clinical utility. Our observed utility rate of 4.3% aligns with retrospective repeat-CT data showing neurosurgical intervention in 5.2% of cases, and prospective data showing management changes in 2.3% of mild TBI patients [25]. Thus, routine surveillance in neurologically stable patients yields limited clinical benefit.

Patients who underwent surveillance CUS differed from those who did not across several baseline characteristics. Patients undergoing CUS were generally younger and demonstrated more severe clinical courses, reflected by higher ICU admission rates and hospital length of stay. The CUS cohort less frequently presented with isolated SF, instead demonstrating ICH with or without SF. These differences likely reflect selection bias from clinician-directed imaging. CUS may be preferentially used in younger patients due to patent fontanelles permitting adequate acoustic windows, and in patients with more complex injury patterns where clinicians seek additional bedside monitoring. Hemorrhage location may also influence CUS use because certain regions are better visualized through available ultrasound windows. Despite this bias towards younger, potentially higher-risk patients, CUS-related management changes remained low.

Of the four patients with management changes, CUS prompted MRI in three cases and identified interval enlargement of subdural collections in one case, prompting hospital transfer for definitive subspecialty surgical management. While CUS changed management by leading to MRI, this may represent a diagnostic cascade in which low-risk bedside imaging triggers high-resource testing for findings of little prognostic significance. Our radiologist-investigator's confirmation that escalation to MRI in 75% of these utility cases yielded no additional clinically significant information beyond the initial CT provides direct evidence of this phenomenon. This aligns with findings by Rivero et al., who demonstrated that patients undergoing imaging despite not meeting PECARN head injury criteria are frequently subjected to redundant follow-up studies that rarely necessitate intervention [26].

By contrast, most surveillance CUS were performed for routine monitoring without new clinical indications, serving as confirmatory imaging rather than diagnostic tools. Similarly, 90.9% of repeat CTs were performed for routine surveillance rather than clinical change [13]. Clinical utility in our study was exclusively observed in patients with more complex hospital courses, specifically those presenting with bilateral ICH. These findings suggest that routine surveillance imaging in the absence of clinical deterioration or high-risk imaging features may be unnecessary and that careful clinical monitoring remains the primary driver of management decisions [22]. Similarly low 30-day TBI-related readmission rates suggest that omitting routine CUS did not result in clinically significant missed deterioration.

Despite the low rate of management changes, CUS offers distinct value-based advantages in pediatric trauma care. The absence of ionizing radiation and avoidance of pharmacological sedation, required for CT and MRI respectively, allows clinicians to establish a diagnostic 'safety net' during the observation period without compounding patient risk [23]. Additionally, transport required for advanced neuroimaging carries risks, including accidental displacement of invasive lines or monitors and impaired clinical surveillance during transit [7]. As a portable bedside modality, CUS mitigates these risks while preserving transport staff and advanced imaging availability for more acute indications [14].

While logistical benefits justify CUS use broadly, our data suggest that its clinical impact is maximized when targeted toward a specific clinical phenotype. Notably, 100% of the utility cohort presented with bilateral ICH. In our study, ICH bilaterality served as a proxy for increased hemorrhage burden and anatomic complexity, as granular volumetric measurements were not captured for all patients. Prior research supports that diagnostic yield and clinical impact of bedside modalities correlate with hemorrhage complexity and extent. Elkhunovich et al. observed sensitivity rising from 33% in minor bleeds to 81% in clinically significant hemorrhages [6], indicating that CUS is more likely to influence management in larger or more complex bleeds. This relationship is further emphasized by the pediatric Brain Injury Guidelines (pBIG), which categorize patients into three tiers based on injury severity. A 2025 validation found that 98.4% of patients requiring neurosurgical intervention were classified as pBIG 3 (high-risk) on arrival, with the remaining 1.6% upgraded to pBIG 3 within 24 hours [8]. In our utility cohort, three of four patients met pBIG 3 criteria, while one patient presented with only trace subarachnoid hemorrhage. Collectively, these findings support surveillance imaging targeted to patients with high-burden, anatomically complex ICH. While bilaterality emerged as a dominant phenotype in our utility cohort, it likely represents one component of a broader high-risk imaging profile.

Beyond hemorrhage burden, anatomic accessibility to CUS windows may explain the observed pattern of clinical utility. The anterior fontanelle window utilizing coronal and sagittal planes provides visualization of supratentorial hemorrhage but limited views of the posterior fossa. Cerebellar hemorrhage requires the mastoid fontanelle for adequate detection, while the posterior fontanelle provides access to the periventricular white matter and occipital lobe [12]. These windows inadequately visualize the temporal lobe, deep sulci, and the cortical/superficial surface due to acoustic shadowing and beam geometry limitations [10, 29]. Thus, hemorrhages that are larger, bilateral, or extend into acoustically favorable regions are more likely to be detected as interval change, potentially explaining why clinical utility in our cohort was confined to high-burden, bilateral ICH.

The primary clinical implication of this study is a transition from routine to selective surveillance for pediatric TBI. This shift could be facilitated by standardized guidelines parallel to the PECARN head injury rules, which demonstrate that risk-stratification is a cost-effective and safe method for reducing unnecessary acute imaging [20]. While PECARN effectively triages patients in the acute setting, inpatient surveillance requires a similar evidence-based framework to prevent redundant testing. Given that management changes were exclusive to patients with high-burden, bilateral, isolated ICH, clinicians may consider prioritizing serial CUS for this phenotype while favoring close clinical observation for lower-risk

injuries such as isolated SF, which demonstrated no utility in our cohort. This approach maintains the radiation-sparing and logistical benefits of bedside imaging while mitigating diagnostic cascades leading to redundant high-resource testing.

These implications must be considered within the limitations of the study. As there are no other studies investigating CUS in a surveillance capacity, our findings lack a direct benchmark for modality-specific comparison. The retrospective, single-center design limited our sample to a specific tertiary-care population, resulting in few cases with demonstrated clinical utility (n = 4). This small sample size restricts statistical power, particularly the ability to identify subtle predictors of utility, and carries a high risk of Type II error. Furthermore, ultrasound is operator-dependent with high interobserver variability [19]. Because individual sonographers were not tracked over the 10-year study period, we could not account for variations in technical proficiency or evolution in ultrasound technology since 2014. The absence of a standardized institutional protocol meant that CUS imaging was obtained at clinician discretion, introducing selection bias and confounding by indication; notably, the CUS cohort was significantly younger and more acutely ill than the non-CUS group. Finally, while clinical utility was adjudicated by a neurosurgeon, the lack of standardized documentation regarding the rationale for every management change may have under-attributed the role of imaging findings relative to the patient's evolving clinical exam.

Future studies should evaluate the potential diagnostic cascade associated with surveillance CUS. Multicenter investigations with larger sample sizes would improve generalizability and allow more robust assessment of how TBI characteristics influence CUS clinical utility. Future studies could also incorporate granular data collection including qualitative measurements of ICH size, defined clinical utility subgroups, and objective, timestamp-based outcomes to better capture management changes attributable to surveillance imaging.

Among pediatric patients younger than 2 years old presenting with CT-evident TBI and mild-to-moderate GCS scores, inpatient surveillance CUS provides minimal clinical utility. While CUS offers a safe, radiation-free, and cost-effective bedside imaging modality, its routine application in low-risk or clinically stable injury patterns rarely alters management. Diagnostic yield was concentrated among patients with higher-burden, bilateral ICH. These findings support a transition from routine surveillance to a selective, risk-stratified approach. Prioritizing CUS for patients with complex or bilateral ICH can optimize institutional resource allocation without compromising pediatric trauma patient safety.

Declarations

Declaration of Generative AI and AI-Assisted Technologies in the Manuscript Preparation Process:

During the preparation of this work the authors used ChatGPT (GPT 5.4) and Google Gemini (Gemini 3) to edit formatting, punctuation and sentence flow. Additionally, Open Evidence was used for assistance with literature review. After using these tools/services, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Competing Interests

Dr. Corey Mossop has previously served as a peer reviewer for Child's Nervous System. The authors declare that they have no other relevant financial or non-financial competing interests to disclose regarding the content of this article.

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Author Contribution

NG: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. CT: Data curation, Writing – original draft, Writing – review & editing. IA: Data curation, Software. AGS: Conceptualization, Methodology, Writing – review & editing. AK: Conceptualization, Data curation, Methodology, Supervision, Writing – review & editing. RO: Conceptualization, Methodology, Writing – review & editing. ES: Conceptualization, Data curation, Methodology, Writing – review & editing. CM: Conceptualization, Data curation, Methodology, Writing – review & editing. All authors read and approved the final manuscript.

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Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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