Validation of the Sainte-Justine Head Trauma Pathway for children younger than two years of age

Sarah Spénard

Serge Gouin, MDCM

Marianne Beaudin, MD

Jocelyn Gravel, MD, MSc

Correspondence to:
J. Gravel
Section d'Urgence, Département de
  Pédiatrie
CHU Sainte-Justine
3175 Chemin Côte Sainte-Catherine
Montréal QC H3T 1C5
graveljocelyn@hotmail.com

SUMMARY

The Sainte-Justine Head Trauma Pathway helps physicians' decision-making in the evaluation of head trauma in young children. We evaluated the pathway to identify clinically important traumatic brain injury (ciTBI) among children younger than two years who presented to a pediatric emergency department for a head trauma. The primary outcome was ciTBI, defined as a TBI complicated by death, neurosurgery, intubation or hospitalization for more than one night. Among 2258 children, we reviewed the charts of all hospitalized children (*n* = 100) and a random sample of nonhospitalized children (*n* = 101) and found a ciTBI in 26 patients. The Sainte-Justine Head Trauma Pathway and the Pediatric Emergency Care Applied Research Network Pediatric Head Injury Prediction Rule both had a sensitivity of 96% (95% confidence interval 81%–100%). We found that the Sainte-Justine Head Trauma Pathway does not improve the identification of ciTBI among young children with head trauma.

Head trauma is a common chief complaint among children visiting the emergency department (ED). The Pediatric Emergency Care Applied Research Network (PECARN) Head Injury Prediction Rule is the decision tool currently used in many institutions.[1] Its main limitation is that 33% of children younger than two years fall in the moderate-risk category, which entails the physician selecting further investigations based on various factors.[1] Identification of a skull fracture would modify the management decisions of approximately half of Canadian pediatric emergency physicians.[2] In 2015, a new clinical decision rule was reported to identify children at risk of skull fracture following head trauma: the C-3PO rule.[3] Merging the C-3PO rule with the PECARN rule might facilitate the management of traumatic brain injury (TBI) in all children younger than two years while minimizing the limitations of each individual rule. With this aim in mind, the Sainte-Justine Head Trauma Pathway was proposed. Following its development, we aimed to measure the impact of the pathway in identifying children with clinically important TBI (ciTBI).

We conducted a retrospective study of all children younger than two years with a chief complaint of head trauma visiting our university-affiliated pediatric hospital between 2013 and 2015. Children were dichotomized in two groups: all hospitalized children and a 5% random selection of all nonhospitalized children. We reviewed the complete medical chart of each eligible participant. Information was collected by a single coauthor (S.S.) using the standardized case report form, while a second coauthor (J.G.) evaluated a random sample of 5% of health records to assess data accuracy. We measured the interrater reliability using a κ score. The primary outcome was the presence of a ciTBI, defined as a TBI complicated by death, neurosurgery, intubation of more than 24 hours or hospitalization for more than one night.[1]

Our primary analysis sought to determine the proportion of children with ciTBI that would have been accurately identified using the Sainte-

Justine Head Trauma Pathway and the PECARN rule.[1] For this analysis, participants were distributed in high-, moderate- and low-risk categories according to their baseline characteristics and radiological investigations. In a secondary analysis, results were extrapolated to the full population of all eligible children. We included all children admitted to hospital with a chief complaint of head trauma in order to include all cases of ciTBI. This was expected to yield a sample of approximately 100 children and at least 20 children with a ciTBI. It was estimated that a random sample of 5% of nonhospitalized patients would need to be recruited to have at least 100 nonhospitalized patients.

Our institutional review board approved the study, and we obtained a waiver of consent from the patients or their guardians for this project.

RESULTS

During the study period, a total of 2258 children were eligible, including 101 children admitted to hospital. Table 1 shows baseline characteristics of participants. Among them, a ciTBI was reported in 26 participants. All children were hospitalized for more than 24 hours, three had a neurosurgical intervention (including one who was intubated for more than 24 hours), and an additional three were intubated for more than 24 hours.

Figure 1 shows the distribution of the 201 participants according to the pathway and the PECARN rule alone. Both strategies showed a sensitivity of 96% (95% confidence interval 81%–100%) and specificities of approximately 41% (Table 2). Applying the distribution to the entire population would yield a rate of ciTBI in each risk category using the clinical pathway: approximately 33% in the high-risk category, 1% in the moderate-risk category and < 0.1% in the low-risk category for both the Sainte-Justine pathway and the PECARN rule (Figure 2).

We evaluated 10 charts in duplicate to assess interrater reliability on the 10 baseline characteristics and items of the pathway. Among them, a perfect agreement was met for five characteristics. An intraclass correlation coefficient (ICC) between 80% and 99% was met for three characteristics, and an ICC less than 50% was calculated for two characteristics ("not acting normally" and "high velocity").

DISCUSSION

The Sainte-Justine Head Trauma Pathway allowed identification of more skull fractures than the PECARN rule, but it did not improve identification of ciTBI among young children.

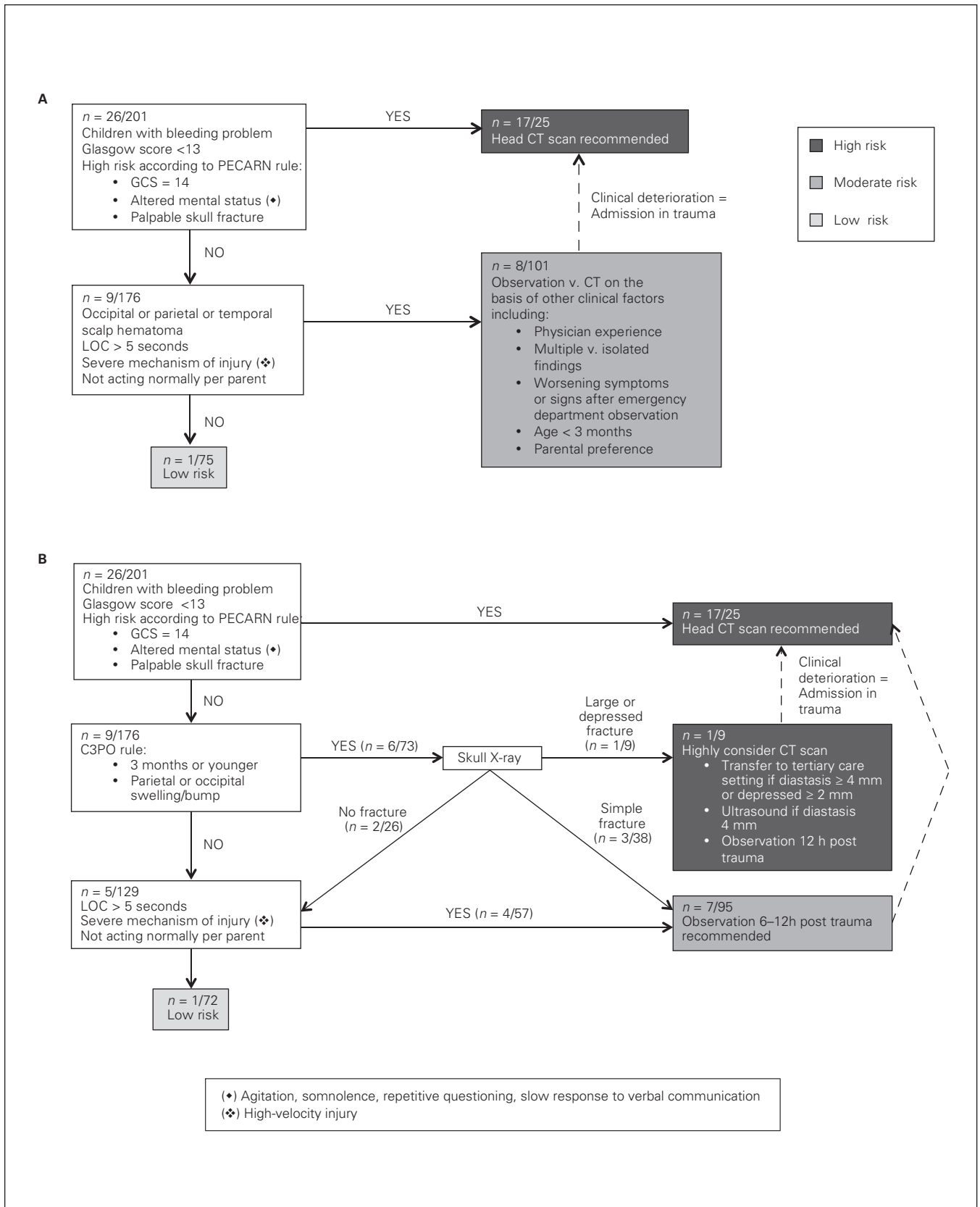Local modifications to the PECARN rule have been suggested in various settings to ease adherence and sat-

isfaction among physicians[4] or to improve diagnostic capacity.[5,6] The Sainte-Justine pathway was designed to help emergency physicians to stratify the risk among children at moderate risk for ciTBI according to the PECARN rule. Even if more than 33% of our sample still falls in the moderate-risk category, the inclusion of the C-3PO rule allows a better identification of skull fracture, which could improve ciTBI diagnosis. To our knowledge, our study was the first to integrate skull radiography with the PECARN rule. Notably, use of bedside ultrasonography to detect pediatric skull fractures is a growing imaging modality for children at risk of skull fracture. Therefore, incorporation of ultrasonography into a minor head trauma decision rule is promising for diagnosis of skull fractures and warrants further investigation.

Our study was limited by its small sample size, and the low frequency of ciTBI led to a large confidence interval, resulting in a lack of power in our results. Our study didn't collect information on previous medical experience and parental preference, which are clinical factors used by physicians when selecting further investigations

Table 1. Baseline characteristics of study participants			
Characteristic	Hospitalized, $n = 101$	Not hospitalized, $n = 100$	All not hospitalized, $n = 2158$
Age, mo, median (IQR)	6 (2–14)	10 (6–18)	—
Age group, mo, %			
1–2	29	4	8
3–11	36	54	46
> 11	36	42	46
Male sex, %	64	63	—
Falls, %			
Any fall	79	84	—
From his/her height	8	19	—
From 1–3 feet	46	48	—
From > 3 feet	25	17	—
Fall from arms of a parent	24	2	—
Fall on the stairs	7	14	—
Loss of consciousness, %	8	0	—
Head CT scan, %			—
Not done	42	100	—
Normal	8	—	—
Not normal	50	—	—
Skull radiograph, %			—
Not done	38	75	—
Normal	13	25	—
Not normal	50	—	—
Final disposition, %			—
Hospitalized	100	0	—
Observation then home	—	19	—
Directly home	—	81	—
CT = computed tomography; IQR = interquartile range.			

A

n = 26/201
Children with bleeding problem
Glasgow score <13
High risk according to PECARN rule:
- GCS = 14
- Altered mental status (♦)
- Palpable skull fracture

YES → n = 17/25 Head CT scan recommended

NO ↓

Clinical deterioration =
Admission in trauma

n = 9/176
Occipital or parietal or temporal scalp hematoma
LOC > 5 seconds
Severe mechanism of injury (❖)
Not acting normally per parent

YES → n = 8/101
Observation v. CT on the basis of other clinical factors including:
- Physician experience
- Multiple v. isolated findings
- Worsening symptoms or signs after emergency department observation
- Age < 3 months
- Parental preference

NO ↓

n = 1/75
Low risk

High risk
Moderate risk
Low risk

B

n = 26/201
Children with bleeding problem
Glasgow score <13
High risk according to PECARN rule:
- GCS = 14
- Altered mental status (♦)
- Palpable skull fracture

YES → n = 17/25 Head CT scan recommended

NO ↓

n = 9/176
C3PO rule:
- 3 months or younger
- Parietal or occipital swelling/bump

YES (n = 6/73) → Skull X-ray

Large or depressed fracture (n = 1/9) → n = 1/9
Highly consider CT scan
- Transfer to tertiary care setting if diastasis ≥ 4 mm or depressed ≥ 2 mm
- Ultrasound if diastasis 4 mm
- Observation 12 h post trauma

Clinical deterioration = Admission in trauma

No fracture (n = 2/26)

Simple fracture (n = 3/38)

NO ↓

n = 5/129
LOC > 5 seconds
Severe mechanism of injury (❖)
Not acting normally per parent

YES (n = 4/57) → n = 7/95
Observation 6–12h post trauma recommended

NO ↓

n = 1/72
Low risk

(♦) Agitation, somnolence, repetitive questioning, slow response to verbal communication
(❖) High-velocity injury

Fig. 1. Distribution of the 201 participants according to (**A**) the Sainte-Justine Head Trauma Pathway and to (**B**) the Pediatric Emergency Care Applied Research Network (PECARN) Head Injury Prediction Rule. The numerators refer to the number of clinically important traumatic brain injuries (ciTBI). CT = computed tomography; GCS = Glasgow Coma Scale; LOC = loss of consciousness.
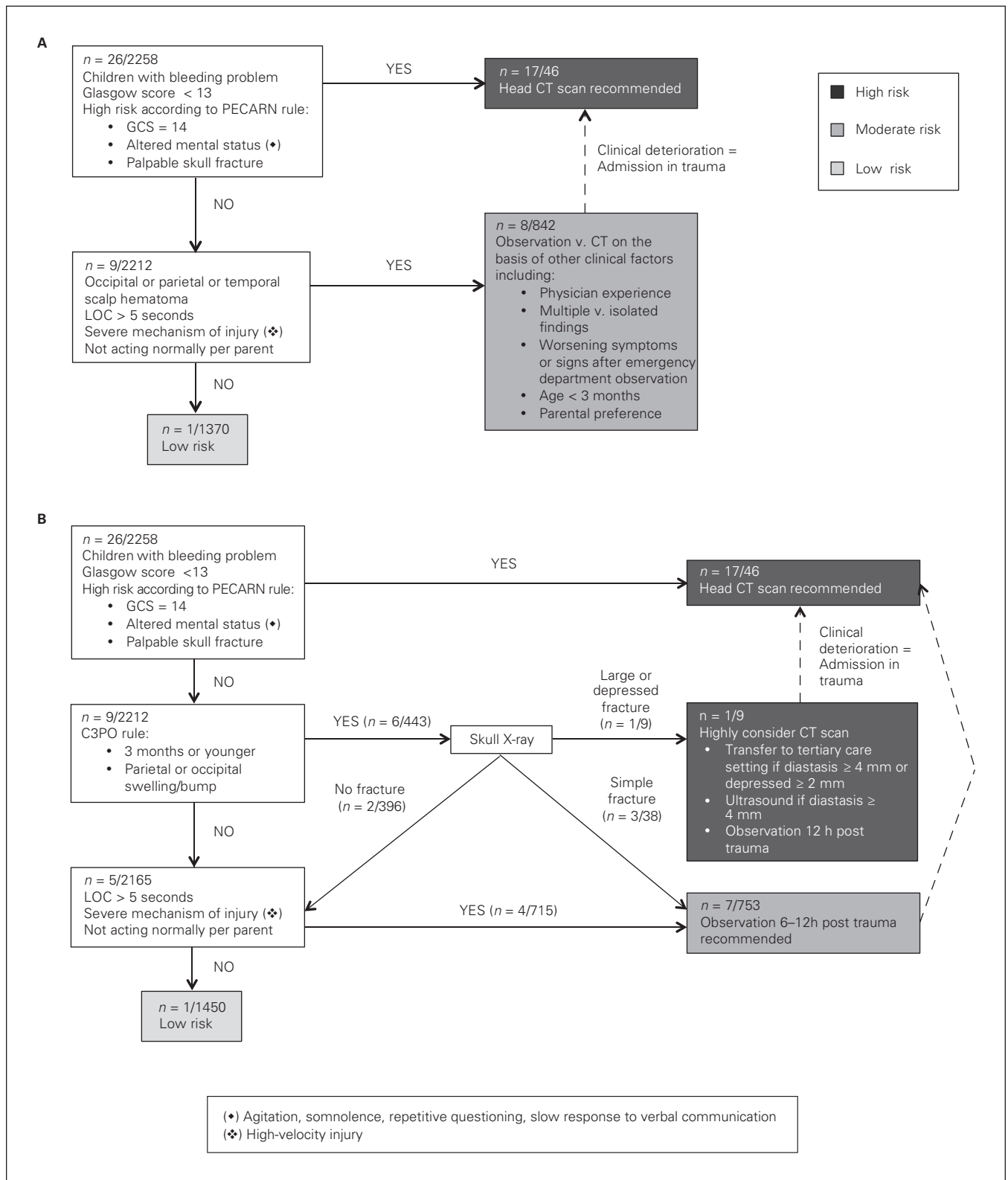
Fig. 2. Distribution of the full population (extrapolated) according to (**A**) the Sainte-Justine Head Trauma Pathway and to (**B**) the Pediatric Emergency Care Applied Research Network (PECARN) Head Injury Prediction Rule. The numerators refer to the number of clinically important traumatic brain injuries (ciTBI). CT = computed tomography; GCS = Glasgow Coma Scale; LOC = loss of consciousness.

Table 2. Accuracy in identification of patients using Sainte-Justine Pathway and PECARN rule

Variable	Sainte-Justine Pathway				PECARN rule			
	High risk	Moderate risk	Low risk	Total	High risk	Moderate risk	Low risk	Total
Study sample								
ciTBI	18	7	1	26	17	8	1	26
No ciTBI	16	88	71	175	8	93	74	175
Total	34	95	72	201	25	101	75	201
Sensitivity (95% CI), %	96 (81–99)				96 (81–99)			
Specificity (95% CI), %	41 (33–48)				42 (35–50)			
Positive predictive value (95% CI), %	19 (17–22)				19 (17–22)			
Negative predictive value (95% CI), %	99 (91–100)				99 (91–100)			
Positive likelihood ratio (95% CI)	1.6 (1.4–1.9)				1.6 (1.4–1.9)			
Negative likelihood ratio (95% CI)	0.09 (0.01–0.65)				0.09 (0.01–0.65)			
All population								
ciTBI (% of risk category)	18 (0.33)	7 (0.01)	1 (0.0007)	26	17 (0.37)	8 (0.01)	1 (0.0007)	26
No ciTBI	37	746	1449	2232	29	834	1369	2232
Total	55	753	1450	2258	46	842	1370	2258
Sensitivity (95% CI), %	96 (80–100)				96 (80–100)			
Specificity (95% CI), %	65 (63–67)				61 (59–63)			
Positive predictive value (95% CI), %	3.0 (2.7–3.3)				2.8 (2.3–3.3)			
Negative predictive value (95% CI), %	99.9 (9.59–99.9)				99.9 (9.59–99.9)			
Positive likelihood ratio (95% CI)	2.7 (2.4–3.0)				2.5 (2.3–2.7)			
Negative likelihood ratio (95% CI)	0.06 (0.01–0.40)				0.06 (0.1–0.4)			

CI = confidence interval; ciTBI = clinically important traumatic brain injury; PECARN = Pediatric Emergency Care Applied Research Network.

in patients at moderate risk for ciTBI. Finally, our study was conducted in a single tertiary care pediatric hospital. Before incorporating the Sainte-Justine Head Trauma Pathway into local practice, it should be validated in a multicentre prospective cohort.

CONCLUSION

The Sainte-Justine Head Trauma Pathway effectively identifies children younger than two years at risk for ciTBI following head trauma while effectively triaging children at low risk. However, while improving skull fracture detection, the pathway was not a better screening tool than the PECARN rule to identify children at risk for ciTBI.

Affiliations: From the Université de Montréal, Montréal, Que. (Spénard, Gouin, Beaudin, Gravel); the Department of Pediatrics, Division of Pediatric Emergency Medicine, CHU Sainte-Justine, Université de Montréal, Montréal, Que. (Gouin, Gravel); and the Department of Surgery, Division of Pediatric Surgery, CHU Sainte-Justine, Université de Montréal, Montréal, Que. (Beaudin).

Competing interests: None declared.

References

1. Kuppermann N, Holmes JF, Dayan PS, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. *Lancet* 2009;374:1160-70.
2. Carriere B, Clement K, Gravel J. Variation in the use of skull radiographs by emergency physicians in young children with minor head trauma. *CJEM* 2014;16:281-7.
3. Gravel J, Gouin S, Chalut D, et al. A clinical decision rule to identify skull fracture among young children with isolated head trauma. CMAJ 2015;187:1202-8.
4. Bressan S, Romanato S, Mion T, et al. Implementation of adapted PECARN decision rule for children with minor head injury in the pediatric emergency department. *Acad Emerg Med* 2012;19:801-7.
5. Bressan S, Daverio M, Martinolli F, et al. The use of handheld near-infrared device (Infrascanner) for detecting intracranial haemorrhages in children with minor head injury. *Childs Nerv Syst* 2013;e-pub online.
6. Simon-Pimmel J, Lorton F, Guiziou N, et al. Serum S100beta neuroprotein reduces use of cranial computed tomography in children after minor head trauma. *Shock* 2015;44:410-6.