

# Skull x-ray scans after minor head injury in children younger than 2 years of age

Abdullah Nour MD   Ran D. Goldman MD FRCPC

## Abstract

**Question** A 1-year-old child presented to my clinic after falling from a couch and landing on his head. In the clinic, the child was asymptomatic and acting normally. Does this child need imaging of his head? If so, how do I decide between sending the child for a skull x-ray scan and sending him to the hospital for a computed tomography (CT) scan?

**Answer** The Pediatric Emergency Care Applied Research Network clinical decision rule for CT scans helps identify children younger than 2 years of age at high risk of intracranial injury. Application of the rule, which has 100% sensitivity and 53.8% specificity for clinically important traumatic brain injury in children, is the first step to assessing children with minor head injury. If a CT scan is not needed urgently, it is recommended that children younger than 2 years get a skull x-ray scan only if a skull fracture is suspected. The presence and type of skull fracture can determine if a CT scan of the head and consultation with a neurosurgeon is warranted.

**T**raumatic brain injury is a substantial cause of morbidity and mortality in the pediatric population.<sup>1</sup> In the United States, head trauma leads to more than 470,000 emergency department (ED) visits and 35,000 hospital admissions annually.<sup>2</sup> Data from the World Health Organization suggest 70% to 90% of all treated head injuries are minor, with an annual rate of 100 to 300 cases per 100,000 population.<sup>3</sup> *Minor* is defined as isolated blunt trauma to the head that occurred during the previous 24 hours in a patient with a Glasgow Coma Scale (GCS) score of 13 to 15 in the ED (scores <13 indicate more severe head injury).<sup>3,4</sup>

The high frequency of head injuries among children and the theoretical risks associated with exposure to radiation for those having a cranial computed tomography (CT) scan led the scientific community to find ways to limit the use of CT scanning in children.<sup>4</sup>

The Pediatric Emergency Care Applied Research Network (PECARN) is the largest collaboration thus far to derive a clinical decision rule for CT scans and to help identify children at high risk of clinically important traumatic brain injury (CITBI), which includes intracranial injury (ICI).<sup>5</sup> The PECARN rule has 100% sensitivity and 53.8% specificity for CITBI in children younger than 2 years of age, without missing cases requiring neurosurgical intervention. The PECARN findings suggested that a head CT scan is warranted for children who present to the ED with a GCS score of less than 15, signs of altered mental status, or palpable skull fracture. Furthermore, the PECARN rule suggests that if there is no history of loss of consciousness (LOC) for 5 seconds or more; no occipital, parietal, or temporal scalp hematoma; no severe mechanism of injury; and no abnormal behaviour as reported by the parent, then no head CT scan is needed. The PECARN rule recommended observation in the ED or a head CT scan based on other clinical factors including physician experience, how many findings are observed

on examination (such as more than 1 hematoma), worsening symptoms or signs during observation, infant age younger than 3 months, and parental preference.<sup>5</sup>

Despite advancing the understanding of risk factors for CITBI, the PECARN rule has low specificity, which may lead to ordering unnecessary head CT scans.<sup>5,6</sup> Of note, children with suspected nonaccidental head trauma can undergo a head CT scan without having a skull x-ray scan, as they may have an ICI without evidence of head injury or skull fracture.<sup>7</sup>

## Skull fractures and the risk of ICI

Skull fractures can develop in young children owing to their larger head-to-body ratio, thinner cranial bones, and less myelinated neural tissue.<sup>8</sup> Children younger than 2 years of age with minor head injuries have a 6% to 30% chance of developing a skull fracture.<sup>9-12</sup> However, most of these studies are older and were done before the PECARN rule was created, meaning that this range could be overestimated. In a more recent study, Gravel et al from Canada conducted a prospective study in 1667 children younger than 2 years of age and excluded children with high-risk minor head trauma as per the PECARN rule (GCS score <15, altered mental status, or palpable skull fracture) or with suspected nonaccidental head injuries.<sup>13</sup> Only 5.6% of children had a skull fracture on an x-ray scan, and none of the children in the study, including those who did not have head imaging done, developed complications or needed neurosurgical intervention.<sup>13</sup> The risk of skull fracture was substantially reduced when high-risk patients were excluded from the study.

In general, the risk of developing an ICI in children younger than 17 years of age with a minor head injury is 4.1%, as reported by the Pediatric Emergency Research Canada Head Injury Study Group,<sup>14</sup> but the incidence range of ICI associated with skull fracture following minor head trauma is wide—between 4% and 50%.<sup>9-12,15</sup>

A prospective study in asymptomatic infants up to 2 years of age presenting to the ED with a minor head injury reported that 11% (45 of 422) had skull fractures and 28.8% of them had an associated ICI.<sup>12</sup> The study included children with mechanisms of injury such as motor vehicle accidents, falls, and direct blows to the head by an object; however, they did not report the severity of the mechanisms of injury.<sup>12</sup>

The PECARN rule considers a *severe* mechanism of injury to be a fall of more than 0.9 m (3 ft); a strike to the head by a high-impact object; a motor vehicle collision with patient ejection, death of another passenger, or rollover; or a pedestrian or bicyclist without a helmet being struck by a motorized vehicle. With any of those, a head CT scan should be considered.<sup>5</sup>

A study by Erlichman et al including children with a GCS score of less than 15 and no documented LOC, or LOC of less than 5 minutes found that one-quarter of the children with a skull fracture had an ICI.<sup>11</sup> Nonetheless, ICI associated with an isolated linear skull fracture was almost always clinically insignificant and rarely required neurosurgical intervention.<sup>11,12</sup>

This finding was supported by a recent systematic review evaluating the number of adverse outcomes associated with isolated skull fractures in children younger than 18 years of age.<sup>16</sup> Twenty-one studies of 6646 children with isolated skull fractures were included and only 1 child needed emergency neurosurgery, with no reported deaths.<sup>16</sup>

The variation in the risk of developing a skull fracture or an ICI related to a skull fracture in these studies could be attributed to including children who would be considered at high risk, as per the PECARN clinical rule (GCS score <15 and altered mental status), or who had a high-risk mechanism of injury. Nevertheless, most of these studies were retrospective, which may have affected the selection of patients.

### Skull x-ray scan versus head CT scan

The Canadian Paediatric Society suggests screening for skull fractures in children with minor head trauma who are younger than 2 years of age and have a large, boggy hematoma.<sup>17</sup> Skull x-ray scans have been preferred for this purpose for many years in the management of head injury, as they expose children to a minimal amount of radiation.<sup>17</sup> In a study comparing head imaging methods to detect skull fractures in cadavers of children, high-resolution CT scans with 3D projections and “conventional CT” had a sensitivity of 71% and skull x-ray scans had a sensitivity of 63% for a single linear fracture. For multiple fractures, all 3 imaging methods had 50% sensitivity.<sup>18</sup>

Two Canadian studies evaluated skull x-ray scans in children younger than 2 years of age with minor head injuries in the ED.<sup>13,19</sup> In one study, none of the patients with a skull fracture needed neurosurgical intervention after assessment and follow-up. Although head imaging

was not done and skull fracture was not excluded in 1022 patients, complications secondary to skull fracture were excluded.<sup>13</sup> In the other study, patients with asymptomatic linear skull fractures on x-ray scans were followed; it was determined that they could have been safely discharged after 3 to 6 hours of observation in the ED instead of being admitted to the hospital.<sup>19</sup>

Using a skull x-ray scan to identify a linear fracture with a diastasis greater than 4 mm, a depressed skull fracture, open fractures, or comminuted fractures can help stratify patients for risk of CITBI and the need for an urgent head CT scan and neurosurgical consultation.<sup>19</sup> This contributes to resource management and radiation reduction.<sup>20</sup>

Finding a skull fracture and monitoring children clinically as outpatients for rare complications such as growing skull fracture, also known as an arachnoid (leptomeningeal) cyst, can help expedite referral for treatment to avoid complications such as brain herniation.<sup>21-23</sup>

### Clinical decision rules with skull x-ray scans

There is variability in identifying skull fractures using x-ray scans (1.3% to 10%).<sup>19,24,25</sup> In a retrospective study of 5217 children with minor head trauma, only 1.3% had a skull fracture on an x-ray scan. For children younger than 2 years, the rate was 3%. It was unclear what the indications were for skull x-ray scans.<sup>24</sup> A retrospective study from Quebec included 417 children up to 3 years of age who presented to the ED with minor head injury.<sup>19</sup> More than one-third (37%) of them had a skull x-ray scan, and 3.6% had a skull fracture. The investigators included children who fell from less than 1 m, which is a nonsevere mechanism of injury. However, only a few patients had a cephalhematoma on examination, and the study did not specify the location of the hematoma. These patients had a lower probability of having a fracture identified on an x-ray scan.<sup>19</sup>

Members of the Pediatric Emergency Research Canada group responded to an e-mail questionnaire (response rate of 54%) about ordering skull x-ray scans for 11 clinical case scenarios of children younger than 2 years with minor head trauma. Substantial variation among practices was apparent, as 20% to 80% of respondents would have ordered x-ray scans for 6 of 11 case scenarios. Most (95%) participants said they would apply a validated clinical decision rule for detecting skull fractures if it had a sensitivity of 98%.<sup>26</sup>

To reduce unnecessary imaging in the ED, Gravel et al developed a clinical decision rule limiting skull x-ray scans to children younger than 2 years of age with occipital or parietal hematoma and all children 2 months of age or younger with any hematoma. The sensitivity was 98% and specificity was 82%, and the clinical decision missed severe injury in only 1 infant. None of the patients in the study developed complications or needed a neurosurgical intervention.<sup>13</sup> A larger cohort study and external validation are yet to be done.

## Conclusion

Despite considerable variation in practice among providers, skull x-ray scans are helpful to identify skull fractures without missing children who need neurosurgical intervention. After a minor head injury in children younger than 2 years of age, providers should apply the validated PECARN rule and if a CT scan is not recommended, skull x-ray scans in selected groups may be ordered. More research is needed to validate this proposition in a prospective cohort of children.

### Competing interests

None declared

### Correspondence

Dr Ran D. Goldman; e-mail [rgoldman@cw.bc.ca](mailto:rgoldman@cw.bc.ca)

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