CJEM Journal Club

Review of the CATCH study: a clinical decision rule for the use of computed tomography in children with minor head injury

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Clinical question
In children with minor head trauma, which elements of the history and physical examination, combined as a clinical decision rule, can be used to rule out clinically significant brain trauma?
Article chosen
Osmond MH, Klassen TP, Wells GA, et al. CATCH: a clinical decision rule for the use of computed tomography in children with minor head injury. *CMAJ* 2010;182:341-48.
Objective
To prospectively derive a sensitive and reliable clinical decision rule for the use of computed tomography in children with minor head injury.

Keywords: brain trauma, clinical decision rule, computed tomography, minor head injury, pediatrics, review

BACKGROUND

Computed tomography (CT) has become an important tool for clinicians during the evaluation of children with minor head trauma. Its use has increased dramatically, so much so that despite a low yield, many children who enter the emergency department (ED) following minor head trauma receive a CT scan, with one study documenting up to 28.6% of pediatric patients receiving CT following head trauma.[1] CT scans are not benign interventions; they are associated with significant radiation exposure and risks related to procedural sedation when needed.[2–5] There can be considerable impact on the system as well, with costs related to unnecessary CT use and prolonged lengths of stay that can worsen ED crowding.[6–11] As a result, there is a need for a sensitive clinical decision rule (CDR) that would aid clinicians in determining which children with minor head injury require CT.

POPULATION STUDIED

Children 0 to 16 years of age presenting to the ED at 1 of 19 Canadian pediatric teaching institutions were enrolled if they met all three of the criteria listed in Table 1. Exclusion criteria are listed in Table 2.

STUDY DESIGN

After enrolment in this prospective cohort study, clinicians (emergency physicians and second-year residents or higher) prospectively collected findings from the history and physical examination on a standardized data collection sheet. When possible, a second physician independently completed the same form to allow for measurement of interobserver agreement. CT scans were ordered at the treating physician's discretion. A staff radiologist who was blinded to the clinical data interpreted the CT. For patients who were discharged directly from the hospital without a CT scan, a follow-up telephone interview by a study nurse unaware of the patient's predictor clinical variables was conducted 14 days after discharge. Patients who were unable to be reached

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Table 1. CATCH study inclusion criteria

1. Blunt trauma to the head with any one of witnessed loss of consciousness, definite amnesia, witnessed disorientation, persistent vomiting, or persistent irritability (children under 2 years)
2. Initial Glasgow Coma Scale score of at least 13, as determined by the treating physician
3. Injury within the past 24 hours

Study participants must have met all three of the listed criteria.

Table 2. CATCH study exclusion criteria

1. Obvious penetrating skull injury or depressed skull fracture
2. Focal neurologic deficit
3. Chronic developmental delay
4. Child abuse suspected as a mechanism of injury
5. A pregnant patient
6. Patient returning for reassessment of a previously treated head injury

Study participants were excluded if any of the listed criteria were present.

were excluded from the analysis. Symptomatic patients were asked to return for reassessment and CT. Univariate analyses were used to determine which factors had the highest associations with brain injury or the need for neurologic intervention. Recursive partitioning was used to develop a CDR that was calibrated toward maximal sensitivity by combining variables that were significantly associated with the outcome and had acceptable interobserver agreement (kappa > 0.5).

Table 3. Performance of the four high-risk factors in the CATCH rule in relation to need for neurologic intervention in children with a minor head injury

Result	Needed neurologic intervention	Did not need neurologic intervention
Positive (≥ 1 high-risk factor)	24	1,144
Negative (no high-risk factors)	0	2,698
Sensitivity, % (95% CI)	100 (86.2–100.0)	
Specificity, % (95% CI)	70.2 (68.8–71.6)	
Patients who would undergo CT if rule were applied, %	30.2	

Adapted from Stiell IG and Wells GA.[13]
CT = computed tomography.

Table 4. Performance of all seven factors in the CATCH rule in relation to the presence of brain injury on CT scan in children with a minor head injury

Result	Brain injury present	Brain injury absent
Positive (≥ 1 risk factor)	156	1,851
Negative (no risk factors)	3	1,856
Sensitivity, % (95% CI)	98.1 (94.6–99.4)	
Specificity, % (95% CI)	50.1 (48.5–51.7)	
Patients who would undergo CT if rule were applied	51.9	

Adapted from Stiell IG and Wells GA.[13]
CT = computed tomography.

OUTCOMES MEASURED

The primary outcome was the need for neurologic intervention, defined as either death within 7 days (secondary to the head trauma), craniotomy, elevation of skull fracture, monitoring of intracranial pressure, or intubation for management of head injury. The secondary outcome was defined as brain injury visible on a CT scan and attributable to the acute injury. This included closed, depressed skull fractures and pneumocephalus but excluded nondepressed skull fractures and basilar skull fractures.

RESULTS

Of the 3,866 patients enrolled in the study, 2,043 (52.8%) patients underwent CT of the head. There were 159 enrolled patients (4.1%) with a brain injury and 24 (0.6%) requiring neurologic intervention. There were no deaths among the patients enrolled in the study. See Table 3 and Table 4 for analyses of the diagnostic accuracy of the high- and medium-risk factors.

STUDY CONCLUSION

In children presenting to the ED with minor head injury, investigators identified four high-risk factors associated with the need for neurologic intervention, as well as three additional medium-risk factors associated with radiographic evidence of a brain injury on CT (Table 5).

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Table 5. Canadian Assessment of Tomography for Childhood Head Injury: the CATCH rule

High risk (need for neurologic intervention)
1. Glasgow Coma Scale score < 15 2 hours after the injury
2. Suspected open or depressed skull fracture
3. History of worsening headaches
4. Irritability on examination
Medium risk (brain injury on CT scan)
5. Any sign of basal skull fracture
6. Large, boggy hematoma of the scalp
7. Dangerous mechanism of injury (e.g., motor vehicle crash, a fall from elevation ≥ 3 feet [91 cm] or 5 stairs, a fall from a bicycle with no helmet

CT = computed tomographic.
Minor head injury is defined as injury within the past 24 hours associated with witnessed loss of consciousness, definite amnesia, witnessed disorientation, persistent vomiting (more than one episode), or persistent irritability (in a child under 2 years of age) in a patient with a Glasgow Coma Scale score of 13 to 15.

Using the CATCH rule (Canadian Assessment of Tomography for Childhood Head Injury), 30.2% of patients in this study would have undergone head CT by virtue of having one or more of the four high-risk factors. For patients with any one of the seven risk factors, 51.9% of patients would have received head CT. In terms of accuracy, the four-component rule had a sensitivity of 100% and a specificity of 70.2% for identifying those patients who underwent a neurologic intervention. Using any one of the seven risk factors for detecting a brain injury on a CT scan had a sensitivity of 98.1% and a specificity of 50.1%.

COMMENTARY

The use of CT has steadily increased,[1,12] despite the risks and costs associated with this imaging modality.[2–5] Although there is a role for CT following minor head injury, there is also a need for a reliable, valid CDR to aid clinicians in avoiding neuroimaging. The difficulty is balancing the desire to perform fewer head CT scans without missing clinically significant head injuries.

The strengths of this study include a large sample size from multiple centres (including a sufficient number of patients with the positive outcomes for developing the model), training sessions for physicians participating in the study, an objective definition for what constitutes a minor head injury, and the inclusion of clinically relevant outcomes. Furthermore, the CDR demonstrated 100% sensitivity for predicting neurologic intervention and as such is a potentially effective rule-out strategy. The rule is also highly sensitive for CT-identified brain injuries.

Despite the strengths of the study and the potential for widespread clinical use, the study has limitations. One of the important limitations is its (lack of) applicability to children under 2 years of age. Of the 277 children in that age range, 23 (8%) had brain injury revealed by CT, or nearly twice the incidence of that found in the total population. This is a significant limitation as these data imply that children 2 years of age and under may be a unique population compared to those older than 2 years of age and may be more prone to brain trauma following minor head injury. Age stratification may alter the specificity and sensitivity of the CDR for children over the age of 2 years. Additionally, most other research and CDRs in the area of neuroimaging following head trauma recognize children under the age of 2 years as a distinct population, which makes comparison with other studies difficult. It is important to note that the authors of the CATCH study indicate that further studies are required to determine the robustness of the rule in this age group.

A major limitation was the inability to enrol more than half of the patients approached (2,178 eligible patients). The authors claim that these patients were similar to the enrolled patients in terms of age, rate of arrival by ambulance, transfer from another hospital, and mechanism of injury, suggesting that no selection bias occurred with respect to the missing patients.

With respect to the sample size, Stiell and Wells discuss the rule of 10 outcomes per independent variable in the prediction rule as the "rule of thumb" for sample size in CDRs to avoid overfitting the data in the multivariate models.[13] As such, with the four variables in the high-risk factor group, the ideal sample size should be approximately 40 patients who have undergone a neurosurgical intervention. Despite the large number of patients enrolled, only 24 patients had neurosurgical interventions, resulting in wider confidence intervals (86.2–100%). For the secondary outcomes, 159 patients had brain injuries identified on a CT scan, well above the 10:1 ratio, resulting in tight confidence intervals around the sensitivity for the medium-risk factors (94.6–99.4%).

The cutoff for good interobserver agreement recommended by Stiell and Wells is a kappa value > 0.6,[13] although the authors state that acceptable agreement is somewhat dependent on the nature of the clinical problem. In this study, the kappa values for the included variables ranged from 0.55 to 0.77. Kappa

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values of 0.5 to 0.6 are generally recognized to represent only moderate agreement. Insufficient interobserver agreement would significantly limit the ability to generalize these results.

One debatable issue of the study is how to incorporate the medium-risk criteria into the clinical decision to perform CT. If a clinician were to order CT scans for all patients with any of the seven risk factors, CT use would essentially stay the same as the baseline CT rate in this study (52.8% versus 51.9%). This conservative approach would identify all patients in need of neurologic intervention and the vast majority of CT-identified injuries, but at the expense of lower specificity. Reserving CT scans for patients with only high-risk features would ensure that all clinically important brain injuries are identified and would result in a reduction of CT imaging rates (down to 30.2%). The downside would be that some intracranial lesions (of questionable significance) would be missed. In light of the risks associated with ionizing radiation and sedation for CT, a cogent argument could be made for reserving CT for patients with high-risk features, whereas patients with medium-risk factors may warrant a period of observation and discharge with clear "return to ED" instructions.

Importantly, the CATCH rule has been developed from this derivation set. It has yet to be validated and so should not be considered for general clinical practice. As a derivation set, the rule would be considered a low level of evidence (level 4) in the hierarchy of quality for CDRs.[14]

Prior to the CATCH study, numerous studies have attempted to derive a CDR for pediatric minor head injury.[15–20] A recent study by the Pediatric Emergency Care Applied Research Network (PECARN) in the United States derived and validated a CDR for children with minor head injuries.[21] This study was similar to the CATCH study in study design and inclusion criteria, but the PECARN study analyzed children under 2 years of age separately from those aged 2 to 16 years. Although methodologically sound, the PECARN study does differ in the way clinicians decide when to order head CT. The PECARN decision tree states that for any child with a Glascow Coma Scale (GCS) score of less than 14[13], an altered mental status, or a palpable skull fracture, CT is recommended. The rule further states that CT may be warranted in children less than 2 if there are findings of a scalp hematoma, loss of consciousness greater than 5 seconds, or a severe mechanism of injury or if the child is acting abnormally. For children older than 2 years of age, additional indications for CT include loss of consciousness, emesis, a severe mechanism of injury, or the presence of a severe headache. In both age groups, CT may also be warranted if there are multiple findings, if the patient worsens with observation, or if the patient's parents prefer to have their child undergo the test (Table 6). In contrast, the CATCH study provides a less ambiguous indication of when a clinician should use CT, potentially reducing the chances of misinterpretation.

Table 6. PECARN algorithm for CT of the head

Age $<$ 2 years
1. CT if GCS score is 14 or less, or if other signs of altered mental status present, or if palpable skull fracture present
2. Consider CT (versus observation) if occipital, parietal, or temporal scalp hematoma, if LOC is $>$ 5 seconds, if severe mechanism of injury, or if acting abnormal per parent
3. No CT if above criteria absent
Age $>$ 2 years
1. CT if GCS score is 14 or less, or if other signs of altered mental status present, or if signs of basilar skull fracture
2. Consider CT (versus observation) if history of LOC, or vomiting, or headache or severe mechanism of injury
3. No CT if above criteria absent

CT = computed tomography; GCS = Glasgow Coma Scale; LOC = loss of consciousness; PECARN = Pediatric Emergency Care Applied Research Network. Observation versus CT is based on clinical factors such as physician experience, isolated versus multiple findings, worsening signs and symptoms, parental preference, and age less than 3 months.

CONCLUSION

The CATCH study was a prospective derivation set designed to develop a CDR for determining which pediatric patients with minor head injury require CT. Seven clinical variables were identified (four high-risk and three medium-risk factors) that, when absent, would preclude the presence of a brain injury with a high degree of certainty. Future validation studies and impact analyses are necessary steps before we can use this rule with confidence.

Competing interests: None declared.

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