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Which emergency department patients with minor head injuries require computed tomography?

Clinical question

Can a highly sensitive clinical decision rule be developed to determine which patients presenting to the emergency department (ED) with minor head injuries require computed tomography (CT)?

Article chosen

Stiell IG, Wells GA, Vandemheen K, Clement C, Lesiuk H, Laupacis A, et al. The Canadian CT Head Rule for patients with minor head injury. Lancet 2001;357:1391-6.

Objective

To determine if a highly sensitive and clinically sensible decision rule can be developed to guide the use of CT scanning in adults with minor head injuries.

Background

Despite an estimated one million annual ED visits in North America for minor head injuries, there is currently no methodologically sound and valid clinical decision rule to safely identify those patients not requiring a CT scan of their head. Previous studies have demonstrated up to a 4-fold variation in the ordering of CT among similar teaching facilities in Canada. In addition, the prevalence of significant intracranial lesions identified on a CT scan following minor head injury has been estimated to be between 0.7% and 3.7%. A highly sensitive clinical decision rule could improve the emergency management of patients and standardize the approach to patients with minor head injuries, therefore leading to significant cost savings.

Population studied

Inclusion criteria required all 3 of the following: 1) blunt trauma to the head resulting in definite amnesia, witnessed loss of consciousness or disorientation; 2) initial ED Glasgow Coma Scale (GCS) score of >13; and 3) injury within the past 24 hours. Exclusion criteria included age <16 years, no history of trauma as the primary event (e.g., primary seizure or syncope), obvious penetrating skull injury or depressed fracture, acute focal neurological deficit, major trauma with unstable vital signs, seizure prior to ED assessment, bleeding disorder or anticoagulant use, a return to the ED for reassessment of the same head injury, or pregnancy.

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Study design

Ten large Canadian hospitals participated in this prospective cohort study. The physician assessors were trained to assess patients for 22 standardized findings from the history, physical examination and neurological assessment. After clinical examination, patients underwent CT based on the judgement of the treating physician. CT scans were interpreted by neuroradiologists who were unaware of the defined clinical predictors. Reliability of radiographic interpretations was assessed by having all abnormal scans and 5% of randomly selected normal scans reviewed by a second radiologist who was unaware of the initial interpretation. There was 100% intrarater agreement for all scans.

Those patients who did not undergo CT were assessed using a 14-day telephone proxy outcome measure, administered by a registered nurse. Patients were classified as having no clinically important brain injury if all of the following criteria were met: headache absent or mild, no problems with memory or concentration, no seizure or focal motor findings, weighted error score of no more than 10 out of 28 on the Katzman Short Orientation–Memory–Concentration Test, and had returned to normal daily activities. Patients who did not fulfill these criteria were recalled for clinical reassessment and CT. Patients who could not be reached were excluded from the final analysis.

Outcomes measured

The primary outcome measure was the need for neurological intervention, which was defined as any of the following events within 7 days: intubation or death due to head injury, craniotomy, elevation of skull fracture or intracranial pressure monitoring. The secondary outcome measure was clinically important brain injury identified on the CT scan. This was defined as any acute brain finding revealed by CT that would normally require admission to hospital and neurological follow-up. All brain injuries were judged clinically important unless the patient was neurologically intact and the CT finding was one of the following: solitary contusion less than 5 mm in diameter, localized subarachnoid blood less than 1 mm thick, smear subdural hematoma less than 4 mm thick, isolated pneumocephaly, or closed depressed skull fracture not through the inner table. This definition was based upon results of a formal survey of 129 neurosurgeons, neuroradiologists and emergency physicians at 8 study sites.

Results

All 3121 patients enrolled during the study period were assessed for the primary outcome measure. Of these, 2078 (67%) underwent CT to assess for the secondary outcome measure. The remaining 1043 (33%) patients were discharged directly from the ED and followed up by telephone at 14 days. In total, 44 (1%) patients required neurological intervention and 254 (8%) were judged to have a clinically important brain injury. Another 94 patients (4%) were judged to have clinically unimportant brain injuries, which for the most part consisted of localized subarachnoid hemorrhage or isolated cerebral contusions less than 5 mm in diameter. A total of 363 eligible patients were excluded from the final analysis because they did not undergo CT, nor could they be reached for the 14-day telephone outcome measure. An additional 1358 eligible patients at the study sites were seen but not enrolled by the treating physicians.

Overall, 24 primary predictor variables based on the history and physical exam were assessed to determine which correlated best with the primary and secondary outcome measures. Those variables found to have good interobserver reliability ($\kappa > 0.6$) and a strong association with the outcome measures ($p < 0.05$) were combined — the objective being the pursuit of predictor variables highly sensitive for detecting the outcome measure while achieving the greatest possible degree of specificity. The final statistical model combined the most suitable variables into a clinical decision rule, entitled the Canadian CT Head Rule, which asks 7 questions and stratifies patients into either high-risk (primary outcome measure), medium-risk (secondary outcome measure) or low-risk (neither outcome measure) groups (Table 1).

This clinical decision rule had a sensitivity of 100% (95% confidence interval [CI], 92%–100%) and a specificity of 68.7% (95% CI, 67%–70%) for identifying patients requiring neurological intervention (high risk). When applied to the medium-risk group, the decision rule was 98.4% sensitive (95% CI, 96%–99%) and it was 49.6% specific (95% CI, 48%–51%) for identifying patients with clinically important brain injuries. If applied to this patient population the clinical rule would eliminate the need for CT in 382 patients (12.2%), although it would have missed 4 brain injuries classified by CT as clinically significant.

Study conclusions

The Canadian CT Head Rule represents a potentially valuable tool in the clinical assessment of minor head injuries. Its sensitivity for brain injuries requiring neurological intervention and for those requiring hospitalization and follow-up were 100% and 98.6%, respectively. If successfully

Table 1. Canadian CT Head Rule

High risk (for neurological intervention)

- GCS score <15 at 2 hours after injury
- Suspected open or depressed skull fracture
- Any sign of basal skull fracture (hemotympanum, "raccoon" eyes, CSF otorrhea or rhinorrhea, Battle's sign)
- Vomiting ≥2 episodes
- Age ≥65 years

Medium risk (for brain injury on CT)

- Amnesia before impact >30 minutes
- Dangerous mechanism (pedestrian struck by motor vehicle, occupant ejected from motor vehicle, fall from height >3 feet or 5 stairs)

CT = computed tomography; GCS = Glasgow Coma Scale; CSF = cerebral spinal fluid

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validated, this simple decision rule may lead to a more standardized approach to the ED investigation and management of patients with minor head injuries and would potentially reduce costs.

Commentary

Following unbridled enthusiasm for ordering CT for every patient with a bump on the head, investigators tried to identify patients in whom CT of the head could be safely avoided. Miller and colleagues[1] prospectively studied 2143 patients with a GCS score of 15 and a history of a minor head injury within 2 hours of ED presentation. Using severe headache, nausea, vomiting and depressed skull fracture as risk factors, the presence of any risk factor gave a sensitivity of 65% (95% CI, 57%–73%) and a specificity of 63% (95% CI, 60%–65%) for any CT abnormality, and 100% sensitivity (95% CI, 36%–100%) for identifying the 5 patients requiring neurosurgical intervention. Haydel and coworkers[2] reported a sensitivity of 100% (95% CI, 95%–100%) for detecting abnormal CT scans in alert (GCS score 15) head injured patients with any one of 7 findings: headache, vomiting, age >60 years, drug or alcohol intoxication, deficits in short-term memory, physical evidence of trauma above the clavicles, and seizure. Unfortunately, no a priori decisions were made with regard to the clinical significance of abnormal CT findings, so all were considered equally important. Further, risk factors chosen for their rule appeared to lack discriminatory power, and this was borne out by their low specificity of 25% (95% CI, 22%–28%). A prediction rule that led to CT scanning for 77% of all minor head injury patients would increase utilization in even the most aggressive Canadian ED.

Stiell and colleagues point out that successful clinical decision rules such as the Ottawa Ankle Rules have led to large reductions in imaging use at some sites,[3] while maintaining a high degree of sensitivity for injuries requiring intervention. They also suggest that the application of the Canadian CT Head Rule would decrease the ordering of CT by 25%–50% in minor head injuries. Applying the Canadian CT Head Rule to this study population, 32.2% met high-risk criteria and 54.3% met high- or moderate-risk criteria. This would have translated into a 12.2% decrease from the 66% baseline CT ordering rate among the study patients without sacrificing safety. However, if the rule is validated, individual hospitals should conduct a careful analysis before rule implementation, because Stiell and colleagues found that, prior to rule development, institutional CT rates for patients with minor head injury ranged from 16.2% to 70.4%;[4] therefore, it is possible that, in some settings, rule adoption could substantially increase CT utilization.

The value of any decision rule lies in its ability to clearly stratify patients into distinct groups, each safely managed using different strategies. A survey of emergency physicians suggests that clinical decision rules need to be 100% sensitive for severe injuries for them to feel comfortable using the instrument.[5] Based on this and the a priori consensus definition of "clinically unimportant" CT scan abnormalities, the Canadian CT Head Rule was 100% sensitive for patients requiring neurosurgical intervention — but with only 44 patients requiring intervention, the precision of this sensitivity estimate is limited (95% CI, 92%–100%). In addition, the rule was only 98.4% sensitive for "clinically important" brain injury, missing 4 cerebral contusions (although none of these required treatment or led to neurological sequelae). Unfortunately, 363 discharged patients were lost to follow-up, and it is unclear whether any of these patients suffered adverse outcomes.

The Canadian CT Head Rule is a methodologically sound, clinically useful, and highly sensitive prediction rule for detecting clinically important brain injuries. It is more specific than any previous tools, but could increase utilization in some centres. If applied to the wrong patients or used incorrectly, it may lead to unnecessary referrals from smaller centres for CT. A larger validation study is currently underway to ensure these results are reproducible. Future studies should test the safety of observing medium-risk patients for a short time period (i.e., 4–6 hours) prior to discharge, and re-evaluate the "age >65" high-risk criterion, which seems to be responsible for a significant proportion of normal CT scans.

Competing interests: None declared.

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