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Review article

Indications for CT scanning in minor head injuries: A review

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ABSTRACT

Background and objective: To determine indications for performing head CT following minor head injuries, which allow reducing number of imaging.
Materials and methods: Based on 15 articles dedicated to this topic, the clinical decision rules were systematically analysed.
Results: The Canadian Computed Tomography Head Rule was found to be the most reliable instrument meeting these criteria, characterised by excellent sensitivity of 100% and fairly good specificity of 48–77%. Remaining scales, although very sensitive, showed poor ability to reduce number of "unnecessary" CT scans. Features most predictive for intracranial injuries included: disorientation, abnormal alertness, somnolentia and neurological deficits. Patients with no loss of consciousness and in normal physical condition need only clinical assessment. Indications to head CT scanning are determined by decision rules presented in the article.
Conclusion: Use of clinical decision rules may have effect on reducing number of head CT scanning performed "just in a case".
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1. Introduction

Head injuries, both isolated and accompanying to the multi-trauma are very common. Estimated data from the USA show that as many as 2 million persons are diagnosed annually following head trauma, of these 90% being classified as "minor" [1]. Likewise, in our country general and surgical Emergency Departments are visited everyday by hundreds such patients. The commonest cause of admission to the hospital a person with a history of head injury is so called "brain concussion", which diagnosis is mainly based on patient's report on a transient loss of consciousness related to the trauma and lack of pathological findings at neurologic examination. Symptoms and signs associated to brain concussion include headache, nausea, sporadic vomiting and feeling unwell, but they are not required to make the diagnosis. Brain concussion is considered indication to the two-three days in-patient observation, mainly for revealing conceivable intracranial lesions such as brain contusion,

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haematoma, subarachnoideal bleeding, which may be poorly- or asymptomatic directly after trauma. The risk that intracranial haematoma would develop later than two days after injury is regarded as minimal [2]. Other findings, such as skull fracture visible at X-ray, history of a loss of consciousness related to the trauma or neurological abnormalities (anizocoria, nystaxis, meningeal irritation, pathological reflexes, unilateral muscle weakness or paresis) are usually indication to extend diagnostics, firs of all by a CT. Alcohol abuse, seizure or faint episode prior to head injury constitute circumstances in which it is difficult to distinguish whether loss of consciousness was actually a consequence of the trauma.

At present, most of hospitals are equipped with CT scanners, what allows excellent and precise diagnosing head injuries such as skull fractures and brain lesions. Routine ordering CT in almost all cases of head traumas, frequently without history of loss of consciousness or neurological abnormalities, would result in large number of normal CT scans being performed, with associated risks of radiation exposure, waste of health care resources and significant burden of radiographic units. Estimated data from the USA show that as many as 400 thousands CT scans are performed annually only in children who sustained minor head injuries [3]. Ordering of a head CT in patient without history of loss of consciousness or neurological abnormalities is motivated by self-assurance, fear of legal and ethical consequences of missing of the intracranial lesion, which may (but not need) be associated with patient's life- or health threat [4]. Data from the literature suggests that if there is no history of the loss of consciousness related to the trauma, the presence of intracranial lesions is minimal and such patients need only clinical assessment and skull X-ray.

There is no precise guidelines in textbooks regarding diagnostic and therapeutic procedures in patients diagnosed with ''brain concussion'' or ''minor head injury'', who show neither neurological abnormalities nor skull fractures, but who present only with self-reported loss of consciousness (not confirmed by a witness). The commonest practice in these cases includes two-three days in-patient care, frequently extended by head CT imaging.

Being everyday involved in diagnosing head injuries, we attempted to answer a question about scientific grounds of routine ordering of CT in each case of minor head injury and of necessity of further patient's hospitalisation in case of negative (no abnormalities) head tomography. These questions were analysed based on the literature.

2. Clinical decision rules estimating the risk of intracranial lesion following minor head trauma

A trend towards reduction of the CT imaging in patients following minor head trauma stimulated the development of clinical decision rules (scales), which – in assumption – would allow identification patients at higher risk of serious intracranial lesion. ''Minor head injury/trauma'' is defined by a history of loss of consciousness or post-traumatic amnesia in patient who is fully conscious, awake and oriented, has a Glasgow Coma Score (GCS) of 13–15, and whose neurological examination is normal. Application of clinical decision rules in diagnosing patients following minor head injuries may result in confining ordering of computed tomography only to cases with the likelihood of intracranial lesions. This obviously would translate into reduction of costs and unnecessary radiation exposure. Below we present several clinical decision rules which have been tested in clinical practice and results of their use were reported.

2.1. *The Canadian Computed Tomography Head Rule [5]*

One of the most popular scales is The Canadian Computed Tomography Head Rule, showed in Table 1 [5]. According to this rule, CT scanning is only required in patients who sustained minor head injury, present with GCS of 13–15 and meet at least one of the 7 criteria listed in the table. Patients who do not meet any of the CCTHR criteria have a minimal (but not equal zero) risk of having serious intracranial injury.

Stiell et al. analysed the usefulness of the CCTHR in identification subjects at risk of intracranial injury and prediction of necessity of CT scanning. A total of 2700 patients meeting the criteria of minor head injury, with GCS score of 13–15 were included. CT scans were performed in 2170 patients (80%), revealing in 328 (15%) one or more clinically important brain injury, such as contusion, intracranial haematoma, subarachnoideal haemorrhage or depressed skull fracture. Of these 328 patients, 41 (1.9%) of the total amount required neurosurgical intervention. All patients diagnosed on CT with intracranial lesion, met the CCTHR criteria, thus showing 100% sensitivity of the scale in detection of important brain injuries. Its specificity has been estimated on 76%, but there is no precise explanation, how this figure was derived (simple calculation shows that in 88% of patients CT scans were normal). Of clinical features used in the scale, the greatest predictive value for detecting intracranial lesions showed GCS score <15, signs of basal skull fracture and anterograde amnesia >30 min [6]. Other authors reported the sensitivity of the scale of 99–100% and specificity of 48–77% in diagnosing intracranial injuries requiring neurosurgical intervention [1,7].

Table 1 – The Canadian CT Head Rule [5].

Inclusion criteria: Patient with minor head injury who present with a GCS score of 13–15, after winesssed loss of consciousness, amnesia or confusion. CT is only required for patients with any of the following findings

High risk of neurosurgical intervention

1. Glasgow Coma Score lower than 15, at 2 h after injury
2. Suspected open or depressed skull fracture
3. Any sign of basal skull fracture[a]
4. Two or more episodes of vomiting after trauma
5. Age 65 years or older

Medium risk of brain injury detection by CT

6. Amnesia before impact of more than 30 min
7. ''Dangerous'' mechanism of injury[b]

[a] Signs of basal skull fracture: raccoon eyes, cerebrospinal fluid rhinorrhea or otorrhea, blood otorrhea, hemotympanum.

[b] Dangerous mechanism: a pedestrian struck by a car, an occupant ejected from the motor vehicle, fall from an elevation of >1 m or 5 stairs.

2.2. *New Orleans Criteria [1,6]*

This is a next clinical decision rule, which has attracted popularity, particularly in the United States (Table 2) [1,6]. This scale was developed – likewise CCTHR – in order to identify minor head injury patients with higher risk of intracranial lesions. Unlike in previous scale, the prerequisite to use this rule is patient being fully conscious, with GCS of 15 at presentation. According to this scale, CT scanning is only required in patients who sustained minor head injury and meet at least one of the 7 criteria listed in Table 2.

Stiell et al. assessed the usefulness of New Orleans Criteria in prediction of the intracranial lesions (and the necessity of CT) in the same group of 2700 patients with minor head injuries. Likewise in case of CCTHR, all patients diagnosed on CT with brain injuries or skull fractures met the New Orleans Criteria (sensitivity100%), but the ability of the scale to detect patients with minimal risk of intracranial lesion was much lower, amounting 12% [6].

The authors assessed also the perceived influence of the use of both scales in clinical practice on the reduction of ordering CT in minor head injury patients. For the entire cohort of 2700 patients, the CT imaging rate according to CCTHR would have been 62% and the actual CT rate for these cases (ordered according to clinical experience of Emergency Departments doctors) was 80% (reduction of 18%). Among the patients with GCS score of 15 ($n = 1820$) the rate of CT imaging would have been 52%, which gives substantial reduction of 28%. In contrast, use of the New Orleans Criteria would result in increase of ordering of CT scans of 8% (they would be required in 88% of patients). Therefore use of this scale shows no benefit in comparison to diagnosis based on ''common sense'' [6]. Results of this study show that Canadian Computed Tomography Head Rule is useful and relatively safe instrument for identification patients who are at minimal risk of clinically important head injury and, thus, its use may result in reducing imaging rates. However, one must be aware that use of this scale in clinical practice does not warrant100% safety and there is always a minimal risk of missing intracranial lesion. However, even it would be a case, this injury almost never requires neurosurgical intervention and its consequences for patient's health are of minimal importance [1].

Some limitations should be considered when using the CCTHR in clinical practice. It is not applicable for patients younger than 16 years and it ignores some important determinants/factors such as coagulopathy, pregnancy, seizure post-injury or presence of focal neurological deficit. However, for experienced clinician occurrence of the latter two situations is an obvious indication for CT imaging. On the other hand, the use of the most popular anticoagulant – aspirin is not associated with increased risk of post-traumatic intracranial bleeding [1,8].

Table 2 – The New Orleans Criteria [6].

CT is required for patients with minor head injury and with any of the following findings. These criteria apply only to patients who present with a GCS of 15
1. Headache following trauma
2. Vomiting
3. Age >60 years
4. Drug or alcohol intoxication
5. Persistent anterograde amnesia (deficits in short-term memory)
6. Visible trauma above the clavicle
7. Seizure

2.3. *Other clinical decision rules*

Falmirski et al. analysed significance of the following symptoms and signs as predictors of post-traumatic intracranial lesions: headache, somnolence, altered alertness/confusion, nausea/vomiting, seizure post trauma, preservation, neurological abnormalities (muscle strength, sensation, reflexes), blurred/double vision, vertigo and hemotympanum. Inclusion criteria required a history of witnessed loss of consciousness or post-traumatic amnesia and GCS score of 14–15 suggesting minor head injury. Of 331 patients meeting the inclusion criteria, 195 (59%) had at least one of the mentioned features and 195 (59%) had not any. All patients received a head CT imaging. In the former group, the imaging showed presence of intracranial lesions in 29 patients (21%), in the latter group in 11 (6%). The most frequently diagnosed pathology was subarachnoideal haemorrhage in 18 cases, brain contusion in 17, intracerebral bleeding in 10 and subdural haematoma in 8 cases. Only two of all 40 patients having intracranial injuries required neurosurgical intervention. The greatest predictive value for post-traumatic intracranial lesion showed somnolence, which was present in 25 patients, of whom 10 (40%) had pathological CT findings, followed by altered alertness/confusion, present in 39 patients, of whom 13 (33%) had pathological CT, and seizure post-trauma (3 patients, one with pathological CT). The remaining variables showed weaker (<10%) significance as determinants of intracranial lesions. Authors conclude that post-traumatic loss of consciousness alone is not predictive of significant head injury and is not an absolute indication for head CT. They suggest that ordering tomography only in patients meeting requirements of their rule is relatively safe, although not without a minimal risk of missing the intracranial lesion. They also showed that no increase in morbidity or mortality is incurred despite pathological CT findings in some patients [9].

Mower et al. analysed results of the multicentre trial conducted in the USA in which more than 13.7 thousands patients with minor and moderate head injuries were enrolled (GCS 12–15). All patients received head CT which showed clinically important post-traumatic injuries in 917 (6.6%), the most frequently intracranial haematoma, brain contusion and subarachnoideal haemorrhage. A comparison of prevalence of the individual criteria (clinical features) in patients with- and without intracranial lesions showed that the abnormal findings at neurological examination had the greatest predictive value for identification patients with intracranial lesions, as they were found in 65% patients having abnormal CT vs 28% patients having normal CT. Almost the same value had clinically meaningful altered awareness (disorientation, somnolence, confusion), found in 64% patients with abnormal CT vs 28% in patients with normal CT. The further difference

concerned a history of loss of consciousness (63% vs 48%), lasting longer than 5 min (29% vs 8%), abnormal behaviour (irritation, aggression, non-compliance) (43% vs 22%) and presence of skull fracture (21% vs 4%). Interestingly, a severe or progressive headache was more frequently present in the group without intracranial lesions (17% vs 12%). Authors suggest these criteria to be the most predictive for presence of intracranial lesions, thus being indications for performing head CT. However, applying these criteria would allow accurate identification 901 of 917 patients with positive CT (sensitivity of 98%), but only 1750 of 12,720 patients with negative CT (negative predictive value of 14%) [10]. Thus, the ability of these criteria to reduce unnecessary imaging in patients with minor head trauma is rather modest.

Arienta et al. analysed the risk of intracranial injuries (and necessity of CT scanning) in a cohort of 10 thousands patients with head injuries of various severity. They selected 4 groups, according to severity of the trauma: (a) the first ($n = 8950$) comprised patients with minor injuries (GCS of 15), with no history of loss of consciousness, amnesia or vomiting and with no abnormalities at simple neurological review performed by Emergency Department doctor. Skull X-rays were performed in 65% of these patients (all negative) and they were dismissed home after few hours. (b) The second group ($n = 800$) consisted of patients scored GCS of 13–15 and having at least one of the following symptoms and signs: transient loss of consciousness, post-traumatic amnesia, single episode of vomiting and significant subgleal swelling or head wound. These patients were fully conscious, oriented and without abnormalities at neurological examination. All these patients received skull X-rays which revealed 73 fractures (9%). In 592 persons CT was performed which revealed post-traumatic intracranial lesions in 21 (3.5%), of which 3 (0.4%) required neurosurgery. All patients were admitted, but none of those with negative CT or skull X-ray developed neurological complications during a hospital stay. (c) Third group comprised patients scored GCS 9–12 and presenting more alarming symptoms such as impaired consciousness, disorientation, somnolence, repeated vomiting, neurological deficits, signs of basal skull fracture, seizure post-trauma and history of neurosurgical operations. All these patients had CT imaging which showed in 85 (41%) intracranial lesions, of which 23 (11%) required neurosurgical intervention. (d) The last group consisted of patients who were delivered to the hospital unconscious [11]. Based on this analysis authors conclude, that patients with trivial injuries (group a) need only a general physical examination, do not require skull X-ray and may be safely dismissed home under the care of relatives. For patients with minor injuries (group b) authors suggest CT imaging, as there is a minimal risk of intracranial injuries being asymptomatic at presentation. An alternative for tomography can be 2–3 days hospitalisation, followed by dismissal home, unless other, alarming symptoms will appear. Authors indicate routine CT scans in patients older than 60 years, as they are at higher risk of intracranial lesions (they composed 24% of this group). Those with no abnormalities in CT can be safely sent home without hospitalisation, as the risk of development later complications is almost zero [11]. We most frequently follow this algorithm in our clinical practice and we found it very useful.

3. Some other aspects of routine CT scanning patients with minor head trauma

It is obvious benefit from the head CT in patients who present with clinical symptoms or signs suggesting post-traumatic brain injury or skull fracture. This imaging allows making correct diagnosis with almost 100% accuracy. However, its routine uses in each patient with head injury, regardless its severity, circumstances and clinical symptomatology entails substantial additional costs and radiation exposure. Particularly in children, CT-mediated radiation has been associated with increased cancer risk. Paediatric patients typically are more sensitive to radiation secondary to their growing body. This increased sensitivity along with long life expectancy after exposure makes children more likely to experience negative effects of radiation. It was shown that in the USA, annually as many as 700 patients die of CT-related cancer, with 170 of them being children [3]. As a consequence, the paediatric CT recommendations are published, addressing this risk. All this data suggest that abuse of CT imaging, particularly in young patients, may be associated with serious and potentially health-threatening consequences.

First of all, however, routine use of CT in each, even trivial head trauma generates substantial costs. The tendency to ordering of tests, treatments and procedures with the primary aim of protecting the doctor form liability rather than of clear benefit for the patient is called ‘‘defensive medicine’’ [12]. In case of head injuries it concerns CT scanning performed ‘‘just in a case’’ because of fear of missing a traumatic intracranial lesion, but without clear indications and support by clinical findings. Defensive medicine may be practised not only at decision making (diagnosing), but also at therapeutic interventions. The primary reason of this behaviour seems to be ‘‘a fear of the own's skin’’ of the physician, but not a real benefit for the patient. However, data from the literature based on studies involving almost 1 million patients show, that, although CT reveals trauma-related intracranial pathologies in 6–12% of patients with minor head injuries, but these are mostly cranio-facial fractures suitable for conservative therapy. Incidence of injuries requiring neurosurgical intervention is about 0.13–0.3%, thus occurring at the very most in three of 1000 patients with minor head trauma who had performed CT [1,7,8,13,14]. So rare occurrence of potentially dangerous brain injuries indicates a high level of assurance of doctors ordering this examination, what excellent meets the criteria of ‘‘defensive medicine’’ [12].

On the other hand, a fear of physicians of being sued and of patients' malpractice claims is not without rationale, even if missed intracranial injury had no consequences on patient's health or life (which is the most commonly observed). This is because of frequent prosecutions of doctors in our country, who are accused of malpractice by poorly qualified medical law-experts and further sentenced by ‘‘solicitous’’ judges because of missing, i.e. focal brain contusion or small subdural haematoma. This may occur even if the physician's choice of not performing head CT imaging was consistent with recognised clinical decision rules and evidence based medicine. It has been shown that early diagnosis of intracranial injury requiring surgical treatment is obviously beneficial and

improves prognosis of recovery. In contrast, this is not a case in clinically less important pathologies which are typically treated conservatively (i.e. quoted above). Immediate or delayed diagnosis is in these situations usually meaningless and it has little (if any) translation on the prognosis of recovery [1]. The problem is that both law-experts and judges are not aware of this evidence and, therefore, self-assurance inclines the physician to order CT imaging even without clear and meaningful indications. It was also shown that avoiding use of recognised clinical decision rules or institutional guidelines for minor head injuries is frequently motivated by psychological factors, such as fear of missing brain injury, fear of being sued and pressure form patient or his relatives. Practising defensive medicine protects physicians from prosecution and patients' malpractice claims, but is very expensive. It was calculated that it ''assurance behaviour'' costs US health care system up to an estimated 50–100 billion dollars annually [12,15]. It seems justifiable to open not only physicians' eyes to this problem, but – first of all – insurance companies, health-care providers and lawyers, that routine use of well recognised guidelines in diagnosing minor head trauma patients is based on scientific grounds. These clinical decision rules allow considerable reduction of unnecessary (''just in a case'') CT imaging and hospitalizations, without increasing risk of harm for the patient.

However, everyday clinical practice reveal, other, less scientifically evidenced determinants of decision-making in patients with minor head injuries. They are related to specific (and sometimes peculiar) reimbursement system with National Health Fund, not necessary consistent with Evidence Based Medicine. Although scientific evidence shows that patients with minor head injury and negative CT can be safely dismissed home, the economical calculation suggests their admission to the hospital for 3 days. This is because reimbursement form NHF for minor head injury (procedure A76, according to Homogenous Patients Groups guide, reimbursed of 1500 zł) is only possible when the patient is ''stored'' in for a minimum 3 days. Patient's dismissal home directly from the Emergency Department (after CT scanning), results in no reimbursement forms NFH, because most of these departments are paid globally (not for individual procedures).

4. Summary

In this paper we intended to determine rational indications for performing computed tomography following minor head injuries, which allow reducing number of both imaging and hospitalizations, but not increasing a risk of missing clinically important intracranial lesion. We found the Canadian Computed Tomography Head Rule to be the most reliable instrument meeting these criteria, which was characterised by excellent sensitivity of 100% and fairly good specificity of 48–77%. Remaining scales, although enough sensitive, showed poor ability to reduce number of ''unnecessary'' CT scans. The following symptoms and signs were the most predictive for intracranial injuries: disorientation, abnormal alertness, somnolentia and neurological deficits. Patients with no loss of consciousness after accident and in normal physical condition need only clinical assessment. Indications to head CT scanning are determined by decision rules presented in the article. The subjects who had transient loss of consciousness after trauma, but with negative CT do not need hospitalisation, because the risk of the later development of complications related to the sustained trauma is minimal.

Conflict of interest

None declared.

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REFERENCES

[1] Harnan SE, Pickering A, Pandor A, Goodrace SW. Clinical decision rules for adults with minor head injury: a systematic review. J Trauma 2011;71:245–51.
[2] Yamaki T, Hirakawa K, Ueguchi, Tenjin H, Kuboyama T, Nakagawa Y. Chronological evaluation of acute traumatic intracerebral haematoma. Acta Neurochir (Wien) 1990;103:112–5.
[3] Goldberg J, McClaine RJ, Cook B, Garcia VF, Brown RL, Crone K, et al. Use of a mild traumatic brain injury guideline to reduce inpatient hospital imaging and charges. J Pediatr Surg 2011;46:1777–83.
[4] Rohacek M, Albrecht M, Kleim B, Zimmerman H, Exadaktylos A. Reasons for ordering computed tomography scans of the head in patients with minor brain injury. Injury 2012. http://dx.doi.org/10.1016/j.injury.2012.01.001
[5] 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.
[6] Stiell IG, Clement CM, Rowe BH, Schull MJ, Brison R, Cass D, et al. Comparison of the Canadian CT Head Rule and the New Orleans Criteria in patients with minor head injury. JAMA 2005;294:1511–8.
[7] Stippler M, Smith C, McLean AR, Carlson A, Morley S, Murray-Krezan C, et al. Utility of routine follow-up head CT scanning after mild traumatic brain injury: a systematic review of the literature. Emerg Med 2012. http://dx.doi.org/10.1136/emermed-2011-200162
[8] Miller EC, Derlet RW, Kisner D. Minor head trauma: is computed tomography always necessary. Ann Emerg Med 1996;27:290–4.
[9] Falmirski ME, Gonzales R, Roidriguez A, Wilberger J. The need for head computed tomography in patients sustaining loss of consciousness after mild head injury. J Trauma 2003; 55:1–6.
[10] Mower WR, Hoffman JR, Herbert M, Wolfson AB, Pollack CV, Zucker MI. Developing a decision instrument to guide computed tomographic imaging of blunt head injury patients. J Trauma 2005;59:954–9.
[11] Arienta C, Caroli M, Balbi S. Management of head injured patients in the emergency department: a practical protocol. Surg Neurol 1997;48:213–9.
[12] Studdert DM, Mello MM, Sage WM, DesRoches CM, Peugh J, Zapert K, et al. Defensive medicine among high-risk specialist physicians in a volatile malpractice enviroment. JAMA 2005;293:2609–17.

[13] Haydel MJ, Preston CA, Mills TJ, Luber S, Blaudeau E, DeBlieux PM. Indications for computed tomography in patients with minor head injury. N Engl J Med 2000;343:100–5.
[14] Ibanez J, Arikan F, Pedraza S, Sanchez E, Poca MA, Rodriguez D, et al. Reliability of clinical guidelines in the detection of patients at risk following mild head injury: results of a prospective study. J Neurosurg 2004;100:825–34.
[15] Mello MM, Chandra A, Gawande AA, Studdert DM. National costs of the medical liability system. Health Aff (Millwood) 2010;29:1569–77.