ORIGINAL ARTICLE

Mild head injury: reliability of early computed tomographic findings in triage for admission

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Emerg Med J 2005;**22**:103–107. doi: 10.1136/emj.2004.015396

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Accepted for publication 28 June 2004

Objective: To search the literature for case reports on adverse outcomes in patients with mild head injury where acute computed tomography (CT) findings had been normal.
Methods: Mild head injury was defined as head trauma involving amnesia or loss of consciousness, but where neurological findings are normal on arrival at hospital (GCS 15). The scientific literature was systematically searched for case reports where an early CT was normal and the patient deteriorated within two days. In these cases, early discharge despite a normal CT head scan would have been hazardous.
Results: Two prospective studies were found that investigated the safety of early CT in 3300 patients with mild head injury, as were 39 reports on adverse outcomes describing 821 patients. In addition, 52 studies containing over 62 000 patients with mild head injury were reviewed. In total, only three cases were deemed to have experienced an early adverse outcome despite a normal CT and GCS 15 on initial presentation. In another eight cases with incomplete descriptions, the interpretation was doubtful. Many reports of complications were not relevant to our question and excluded. These reports included cases with more severe head injury/not GCS 15 at presentation, complications that occurred after more than two days, or initial CT findings that were not fully normal.
Conclusion: Very few cases were found where an early adverse event occurred after normal acute CT in patients with mild head injury. The strongest scientific evidence available at this time shows that a CT strategy is a safe way to triage patients for admission.

Mild head injury is a common reason for hospital admission after trauma. Traditionally, the management of these patients has been based on in-hospital observation.[1–4] An increasing number of patients currently receive computed tomography (CT) in addition to in-hospital observation.[4 5] It has been suggested that patients can be triaged for admission with an early CT scan,[6] thereby avoiding unnecessary admissions when findings are normal. At the same time, better care could be provided for the estimated 8% of patients with abnormal CT findings and a higher risk for complications.[7] Early CT for these patients could result in better supervision and more rapid access to treatment, possibly yielding a better prognosis.[8–11]

A strategy based on CT to triage for admission depends heavily on the ability of an early CT scan to identify abnormal changes associated with the risk for later deterioration. If unsuccessful, the patient could deteriorate after having been transferred home instead of during in-hospital observation, which might be more hazardous. Many clinicians in emergency medicine express uncertainty about the safety of an early CT scan in patients with mild head injury. They have heard of cases where rapid and dramatic deterioration occurred despite normal findings on the CT scan.[12–14] Do these anecdotal accounts reflect scientific findings? One way of obtaining reliable evidence on rare adverse events is large prospective trials and another is to systematically review case reports.[15] This paper reviews the literature on cases of mild head injury that deteriorate within two days after a normal CT scan performed in conjunction with a visit to the emergency ward.

METHODS

Ideally, our study question should be answered in a large, prospective clinical trial with proper patient follow up. Many studies have investigated the optimal use of CT in managing mild head injury.[16] However, few prospective studies are specifically designed to answer the question posed in this review.[17] Hence, based on the available evidence, it is not possible in this review to calculate formal quantitative estimates of risk/outcome. The second best option, therefore, is to identify relevant cases through three sources:

(1) Prospective studies that investigate the safety of CT for early discharge after mild head injury.
(2) Publications that specifically address and describe head injury cases having a complicated course.
(3) A manual search of all publications for mild head injury (cohort studies/patient series) including descriptions of cases with complications that detailed findings and outcome.

The cases identified are purely descriptive and are presented without a pooled estimate of the outcome.

DEFINITIONS

Mild head injury

The term ''mild head injury'' is used to denote a short term loss of consciousness and/or amnesia from a closed head injury.[16 18] Upon presenting in the emergency department, the patient should have regained a normal level of consciousness—that is, 15 on the Glasgow coma scale (GCS),[19] and should have normal neurological findings. Some definitions of mild head injury include GCS 13–15.[20] There is evidence that patients with GCS 13–14 have a significantly higher overall risk compared with patients with GCS 15.[21] Hence, the situation for patients with GCS 13–14 is more serious. The best group in which to initially apply the home care strategy is therefore GCS 15. These patients also constitute the vast majority with mild head injury.[22] For these reasons, only GCS 15 cases were included as relevant in this review.

Abbreviations: CT, computed tomography; GCS, Glasgow coma scale

Abnormal CT

The definition of abnormal CT findings often varies among studies. Our review covers all abnormal CT findings that could be attributed to head trauma. This includes intracranial bleeding (which is most common), skull fractures, and oedema.

Early CT

No a priori definition of what constitutes early CT was stated. In clinical practice, early CT probably means anything between around 30 minutes up to several hours after injury. Instead, we carefully extracted and presented all facts on the timing of the initial CT scan in the relevant case reports.

The review process

Medline and the Cochrane library were searched from 1966 to October 2003. Regarding our specific research question, it was concluded that searches in these major bibliographical databases would produce similar results to additional searches in for instance Embase and CINAHL.[23] Database definitions and indexing for mild head injury have changed over time. We conducted a broad search using multiple keywords in different combinations (see appendix for complete list of search terms). No limitations were placed on study design, study language, or patient age. Reference lists of key studies and review articles were screened. Two reviewers independently reviewed all publications.

All sources were reviewed for information about patients, initially in a good clinical state with a normal CT scan, who later developed a severe complication (requiring transfer to more intensive care or surgery) or died. To be assessed as relevant, reports needed to include both the post-trauma time frames and findings of the initial CT scan. However, partially incomplete descriptions (for instance, missing the exact timing of the first CT) were included in order not to diminish risks. Cases were not considered to be relevant if the early CT scan was normal and the patient deteriorated later than two days after the initial injury. Under standard practice, these patients would have been discharged from the hospital after an initial course of observation. Papers rejected for these reasons are discussed further in the ''Results'' section.

RESULTS

In total, 2187 abstracts were evaluated, whereof 410 were judged to be of possible interest and were carefully reviewed in full text. The excluded publications contained obviously non-relevant studies, letters, comments, recommendations, and guidelines. After careful review, 93 of the 410 publications were deemed relevant to our question. These publications included two large prospective studies (3300 patients) that systematically addressed our study question,[24 25] 39 studies of 821 cases with serious adverse events, and 52 publications on patient series containing 62 000 patients with mild head injury.

The two prospective studies, both from the United States and published in 1999/2000, included 1170 and 2152 patients respectively.[24 25] Both studies had a short follow up period (23 and 20 hours). No relevant cases for our study question were identified in either study. In one study, four patients had injuries that were missed on the preliminary CT reading and later required intervention (two received intensified neurological monitoring and two received ICU admission and anticonvulsant/antioedema medications). All recovered without sequelae.[25] However, the study included patients with GCS 14–15, but did not present the results separately. No additional data were delivered upon request to the authors. The authors of both studies concluded that ''patients with a cranial CT scan, obtained on a helical CT scanner, that shows no intracerebral injury and who do not have other body

Table 1 Summary of case reports of mild head injury patients with GCS 15 where an early CT scan might have been normal and the patient still deteriorated within two days

Author, year, country, reference	Type of study	Patient, history	Time of first CT, result	Reason for new CT	Time for new CT, result	Intervention, outcome	Number of cases, remarks
Hemphill, 1999 USA,[26]	Retrospective case series of 194 patients with late complications	74 year old male, fall, salicylate therapy, no LOC or amnesia, no other symptoms	Early, normal	Returns 23 hours later, comatose, GCS 3	After 25 hours, subdural hematoma	Unclear, died	1 ''false negative'' case, symptom free at start, salicylate therapy
Domenicucci, 1995, Italy,[27]	Review article with 5 original and 45 earlier published cases	31 year old woman, normal neurology after car accident	After 4 hours, normal	Depressed level of consciousness, anisicoria, right sided weakness	After 21 hours, intracranial bleeding	Surgery, discharged to home after10 days	1 ''false negative'' case, few details given
Ciquini Junior, 1992 Brazil,[28]	Case report of two cases	10 year old boy, fell from >2 metres, normal neurology	After 3 hours, normal	GCS lowered to 14	After 21 hours, extradural haematoma	Surgery, discharged to home after 5 days	1 ''false negative'' case, had both skull radiograph and CT, unclear why admitted after first CT
Culotta, 1996 USA,[21]	Retrospective case series of 3370 patients with GCS 13–15	Six cases, no other history given, GCS 15	''Early'', normal	Not stated	Not stated	Surgery, unclear	6 possible cases, few details given, unclear time intervals. No further data delivered on request.
Keskil, 1995 Turkey [29]	Retrospective case series of 257 children with GCS 14–15	6 year old boy, GCS 15	Unclear, not stated	Clinical deterioration after 2 days	After 2 days, diffuse cerebral swelling	Unclear, died	1 possible case, unclear if initial CT was carried out
Arienta, 1997 Italy,[30]	Retrospective case series of10000 head injuries	Patient with epilepsy admitted for observation, GCS 15	Early, normal	Clinical deterioration	Unclear, intracranial haemorrhage	Unclear, unclear	1 possible case, few details given, unclear time intervals
Total							11 cases

system injuries or a persistence of any neurological findings can be safely discharged from the ED without a period of either inpatient or outpatient observation''.[25]

Among the 821 cases with complications, we detected three confirmed cases of deterioration within 48 hours where an early CT had been normal.[26–28] The three cases—a man aged 74 years, a woman aged 31 years, and a boy aged 10 years—underwent their initial CT scan ''early'', three hours and four hours after injury (table 1). The repeated CT scans were performed after 23 hours, 21 hours, and 21 hours respectively, showing a subdural haematoma, an extradural haematoma, and intracranial bleeding respectively. The older male patient subsequently died while the young child and female patient were discharged home five and 10 days postoperatively, both were reported to have had a good outcome.

In the series of 62 000 patients, we found another eight possible cases of this type, also described in table 1.[21 29 30] The eight cases were briefly described, but lacked important information—that is, about whether a first CT scan was actually performed and found completely normal, about the timing of the CT scans, about the time for deterioration and about the outcome for the patient. Therefore, they were labelled as not possible to rule out.

The remaining case descriptions in the 39 studies on complications and in the 52 publications of patient series were deemed irrelevant to our question regarding the risk of a CT strategy with home care. Our judgement was based on two categories of reasons:

(1) 19 studies/674 cases—these patients presented with a head injury more severe than our definition (GCS $\leqslant$14) or had other severe, associated injuries.[31–47] None of the patients would have been discharged under a strategy for mild head injury requiring a score of GCS 15.

(2) 13 studies/126 cases—the complications occurred long after the head injury (mean 34 days, range 2 to 120 days).[12–14 48–57] The most common lesion was subdural haematoma, followed by epidural haematoma and a single case of a facial fracture that needed operation. One case mentioned anticoagulant treatment (a 3 year old receiving warfarin treatment because of heart valve replacement). Patients in this category would probably have been discharged from hospital even if admitted initially and observed one or two days.

In addition, 26 cases in eight studies were labelled ''false negative'', but the first CT scan was not fully normal.[25 58–64] What is often described is the presence of a skull fracture, or a small intracranial bleeding and a second scan showing significant deterioration. Such cases are not really normal and therefore cannot be safely discharged without observation and follow up.

DISCUSSION

The aim of this review has been to identify case descriptions of complications in mild head injury within two days despite normal early CT findings. We identified a large number of studies on the use of CT in managing mild head injury. Two prospective studies (together including more than 3300 patients with mild head injury) were found that systematically studied the question investigated in this review. These two large studies are pertinent to the findings of this review. Both had short follow up periods (20 and 23 hours) and one included patients with GCS 14–15. Still, they concluded that CT is a safe way to triage for admission. Among more than 65 000 cases of mild head injury described in other prospective studies, patient series, and case reports, not more than three showed an adverse outcome within two days despite a normal initial CT. In another eight cases, a similar course could not be ruled out because documentation was insufficient. Thus, this literature review on mild head injury would suggest that the risk for developing an intracranial lesion after an early normal CT seems very low.

We chose to use a two day cut off for deterioration after an initial normal CT head scan because patients with mild head injury normally have short hospital stays. It could be argued that subtle neurological deterioration might be detected more quickly in the hospital. On the other hand, studies have shown that in-hospital observation of the large group of patients with mild head injury is no guarantee for early detection of serious complications.[9 17]

A possible clinical concern regarding a CT strategy is the need for experienced clinicians or radiologists to report emergency CT scans before discharge of A&E patients. Previous studies have shown a high to moderate concordance when comparing head CT readings made by emergency physicians with those made by radiologists.[65–67] This question needs to be prospectively studied in clinical practice to assess the significance of such misinterpretations on patient outcome.

The generalisability of our findings to all populations of mild head injury is not fully known. Arguments could be put forward that the result either overestimates (interesting cases are more likely to be reported) or underestimates (underreporting because of medicolegal implications) the true incidence. In our opinion, the results of this review probably underestimate the true incidence. Searching for single case reports in the vast and ever growing medical literature in no easy feat. We cannot exclude the possibility that, despite our efforts, we have failed to identify a number of relevant cases. Nevertheless, our data suggest that significant complications in mild head injury are very rare when an initial CT is normal.

Numerous guidelines concerning the management of mild head injuries have been published.[21 68–70] A recently published study validated guidelines proposed by the NCWFNS (The Neurotraumatology Committee of the World Federation of Neurosurgical Societies),[18] and found the variables suggested (Glasgow coma score, clinical findings, risk factors, neurological deficits, and skull fracture) to be accurate for predicting clinically significant outcomes in patients with mild head injury.[71] No relevant cases for this review (early normal CT that developed a severe complication within two days) were presented in the study, and the authors come to a similar conclusion as this review regarding the safety of early negative CT.[72] An underlying problem for all the proposed guidelines is the scarcity of well designed studies of mild head injury management.[16 17 73] This fact seriously weakens the strength of recommendations for any proposed guideline. Hopefully, future research will provide more conclusive evidence on which to base recommendations for mild head injury care.

The studies in this review rarely specify time frames, and most case descriptions are brief, giving them limited value for assessing risk of early CT in mild head injury. Even if sparse and incomplete, such case reports can have a strong influence on practice.[74] Still, management of mild head injury must be based on solid clinical evidence. The strongest scientific evidence available at this time would suggest that a CT strategy is a safe way to triage patients for admission.

ACKNOWLEDGEMENTS

This review was originally carried out for The Swedish Council on Technology Assessment in Health Care (SBU) and published in a Swedish governmental report in December 2000. The report has been updated, shortened, rewritten and focuses more on scientific aspects. The SBU Project Group on Mild Head Injury included Mona Britton (project chair), Jörgen Borg, Mia Colliander, Jean-Luc af Geijerstam

(project coordinator), Kaj Ericson, Lars-Åke Marké, Johan Nathorst Westfelt, Sven Oredsson, and Elisabeth Ronne-Engström.

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Funding: this study was supported by The Swedish Council on Technology Assessment in Health Care (SBU).

Conflicts of interest: none declared.

APPENDIX

SEARCH TERMS

Brain concussion; brain injuries; case reports; cerebral haemorrhage; closed head injuries; CT; diagnosis; diagnostic errors; emergency service, hospital; follow up studies; haematoma (epidural, subdural); head injuries; mild brain injury; mild head injury; minimal brain injury; minimal head injury; minor brain injury; minor head injury; monitoring, physiological; mortality; radiography; review, guidelines; risk assessment; risk factors; sensitivity, specificity; survival rate; tomography, x-ray computed; triage.

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