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Clinical Article

Mild head injury – mortality and complication rate: meta-analysis of findings in a systematic literature review

J.-L. af Geijerstam[1,2] and **M. Britton**[1,2]

[1] The Swedish Council on Technology Assessment in Health Care (SBU), Stockholm, Sweden
[2] Department of Medicine, Unit of Clinical Epidemiology, Karolinska Hospital, Stockholm, Sweden

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Summary

Background. Whether the strategy for care of mild head injury should be in-hospital observation or computed tomography (CT) investigation and home care has been discussed lately. A necessary requirement for guidelines and the design of clinical trials would be knowledge about the risks of the condition. These have not been reliably summarised. The study aims to estimate as accurately as possible the mortality, the complication rates, and the frequency of pathological findings on CT in patients with mild head injury.

Methods. Mild head injury was defined as head trauma involving loss of consciousness or amnesia, but where neurological findings on arrival at hospital are normal (GCS 15). Large databases were searched to find relevant scientific literature, and the retrieved studies were critically appraised. Findings were used from all representative patient data sets that met predefined standards for minimum quality. Meta-analysis using the random-effects model was performed on the data collected.

Findings. The search yielded 24 studies on 24249 patients fulfilling the requirements. The mean mortality of patients was low, 0.1% (CI 0.05–0.15). Complications, mostly requiring surgery, occurred in 0.9% (CI 0.6–1.2) of the cases. In approximately 8% (CI 6.1–9.5), pathological CT findings, dominated by haemorrhages, were identified in the acute phase.

Conclusions. Of 1000 patients arriving at hospital with mild head injury, 1 will die, 9 will require surgery or other intervention, and about 80 will show pathological findings on CT. At least these 8% of patients will probably need in-hospital care.

Keywords: Mild head injury; computed tomography; in-hospital observation; clinical management; meta-analysis.

Introduction

Annually, millions of people worldwide suffer head injuries, most of which are considered mild. In Sweden, 17000 patients require admission to hospital for mild head injury each year (191/100000 inhabitants) [15]. There are neither widely accepted criteria for the definition or degrees of severity of this diagnosis nor uniform guidelines for its care [43]. In recent years, several clinical guidelines and protocols have been published and proposed. Nevertheless, recent systematic reviews of the literature reveal that the current evidence is generally methodologically weak and lacunae regarding key questions exist [1, 23, 58]. The common management strategy has been in-hospital observation, but a proposed option is computed tomography (CT) followed by home care when findings are normal. There are no studies actually comparing these two strategies and important questions still need reliable answers [23]. For example, would it be possible to identify patients at risk with an early CT or is hospital observation safer? This can only be answered in a prospective randomised trial with proper follow up of patients. To design such a trial, as well as for planning care, precise risk estimates of outcomes like mortality, complication rate and frequency of pathological findings on CT are necessary. Despite using all available observations, no such data were found. Hence, this study aims to present a systematic review and meta-analysis of results from all representative, high-quality studies.

Methods and materials

Definitions

Mild head injury

The definition of mild head injury used in this report is short-term loss of consciousness and/or amnesia as a result of skull trauma. Upon presenting in the emergency department, the patient should have regained a normal level of consciousness as measured by the Glasgow Coma Scale [55] and have normal neurological findings. Only studies using these inclusion criteria were considered as relevant. Some definitions of mild head injury include GCS 13–15 [5]. There is now evidence that patients with GCS 13–14 have a significantly increased overall risk compared to patients with GCS 15 [6]. This was also noted at the outset of this review. Aggregated data from initially retrieved studies showed that, e.g., the rates of pathological CT findings in GCS 13–14 were 32% and 17% respectively as compared to less than 10% for GCS 15. Hence, the situation for patients with GCS 13–14 is more serious. The best group in which to initially try the home care strategy is therefore GCS 15. They also constitute the vast majority of patients with mild head injury [56]. For these reasons, only GCS 15 was included in our meta-analysis. The chosen definition of mild head injury is in agreement with recent proposals as elicited by clinical expertise [23, 43].

Pathological CT

The frequency of pathological findings on CT can vary among studies depending on the definition used. Our review covers all abnormal CT findings that could be attributed to the head trauma. This includes intracranial bleeding (which dominates), skull fractures, and oedema. Collapsing such a wide variety of pathological findings might seem inappropriate. The reason for doing this is not only the mentioned problem of different definitions in use. From the clinician's perspective in the emergency department, any pathological finding on CT most probably will influence the management of the patient, and thereby be of relevance for practical decision-making.

Complications

Complications are defined broadly to include neurosurgical procedures (which dominate), medical treatment of brain oedema, start of intracranial pressure monitoring, and transfer to more intensive care, i.e. a definition that includes any intensification and deviation from routine care in a patient with mild head injury.

The review process

MEDLINE was searched from 1966 to May 2001. There are no generally accepted definitions for mild head injury, and indexing in the databases has changed over time. Hence, we conducted a broad search using multiple keywords in different combinations (see appendix for a full list of search terms). For the period up until October 2002, MEDLINE was searched for any larger recent study, using mild- and minor head injury as keywords.

The Cochrane Library was also screened, as were reference lists of key studies and review articles. Studies written in all languages were accepted.

Three different reviewers checked the publications from our search in three phases. Disagreement was resolved by consensus. First, all clearly irrelevant publications were sorted out from the 1143 abstracts initially retrieved. Thereafter, the remaining 410 full-text articles were carefully reviewed, whereof 322 were excluded. The excluded publications included letters, comments, recommendation, guidelines and case histories. A total of 88 patient studies were thus further appraised.

Grading the evidence

To find reliable answers to clinical questions, evidence-based medicine puts emphasis on a complete literature search and critical appraisal of relevant studies. A synthesis, preferably quantitative, then has to be made of all available data. Our questions could only be answered in representative patient series with proper follow up of patients, at least during the acute stage. For this reason, we developed a checklist that graded the studies according to a set of predetermined criteria. The overall purpose of the checklist was to ensure representativity to allow for a high external validity of the results. The checklist graded the studies according to: 1. the use of inclusion criteria (studies should have clearly defined head injury, loss of consciousness/amnesia); 2. use of GCS to estimate the level of consciousness; 3. ordinary case-mix (mild head injury and not only referral patients with complications or severe head injury, a substantial part of the patients should be less than 20 years old and there should be a male predominance); 4. completeness of follow-up; 5. study design (prospective/retrospective); 6. study size. Based on the score received from the checklist, studies were graded as high, medium or low quality of evidence for our purpose.

As regards the rate of pathological CT findings, only patient series where CT had been performed in more than 90% were included. The frequency of pathological findings was calculated among the investigated patients.

Statistical analysis

Two statistical methods, viz, the fixed effects model and the random effects model, can be used for meta-analysis [13]. The fixed effects model assumes that the different studies have selected their patients from a single population. The random effects model takes these studies as representing samples from different populations. The relatively large variation between the different studies indicated that the latter is more appropriate, and hence it was chosen here. The difference between the two models in this case would be that the random effects model chosen, yields more uncertainty and larger 95% confidence intervals (CI).

Results

In total, 88 studies were further appraised that presented results concerning mortality, complications, or pathological CT findings in patients with mild head injuries. Of these, 40 were rated as low quality of evidence, i.e. not representative for mild head injury of the type in focus for this study. These studies had severe shortcomings in most regards for the study questions, indicated by a very low score ($\leq$4 of 11) on our checklist for grading the evidence. They often lacked clear definitions or description of the patient material. Some papers included patients with severe head injuries, or were case series of patients with complications. The studies were not necessarily of a low quality per se, but lacked relevance for our questions and were hence excluded from further analysis.

Thus, 48 high and medium quality studies remained for analysis. Twenty-four of these were not used due to: multiple publication [8, 29, 41, 42, 44, 46, 47, 50–52]; the results of patients with GCS 15 were not reported separately but only as GCS 13–15 or 14–15 [16, 20–22, 25, 31, 40, 54]; the loss of consciousness/amnesia was not reported to be a criterion for selection [10, 17, 19, 32, 34, 35]. Of the remaining 24 studies, 10 were classified as of high quality and 14 of medium quality. There

Table 1. *Studies used for calculations of mortality, complications, and pathological CT findings in patients with mild head injury. Frequencies are based on patients with GCS 15. LOC/amnesia = loss of consciousness and/or amnesia (– = missing data)*

Author, publ. year, country, ref. nr.	Prospective/ retrospective	Patients total no.	Patients with GCS 15, no.	LOC/ amnesia (%)	CT perform. (%)	Mortality (%)	Complications (%)	Pathological CT (%)	Comments
Dacey 1986 USA [7]	retro.	610	533	100	–	0.2	1.5	–	unclear CT rate among GCS 15, 1 death (subdural hematoma)
Feuerman 1988 USA [12]	retro.	373	236	68	25	0	0.8	34	low CT rate, patients with neurological signs and other severe injuries included
Livingston 1991 USA [26]	prosp.	111	91	82	100	0	0	9.9	small no. of cases
Mikhail 1992 USA [28]	prosp.	112	110	22	30	0.9	2.7	24.2	small no. of cases, patients with neurological signs included, 1 death (subdural hematoma)
Shackford 1992 USA [45]	retro.	2766	1899	100	77	–	6.8	19.4	multicenter study, varying management, mortality not reported
Stein 1992 USA [48]	retro.	1538	1117	100	100	–	–	13.2	unclear if associated injuries were included, mortality not reported
Jeret 1993 USA [24]	prosp.	712	712	100	100	0.1	0.3	9.4	1 death (78-year-old male with subarachnoid hemorrhage)
Reinus 1993 USA [36]	retro.	373	276	65	100	–	0.4	5.1	only CT-scanned patients included, mortality not reported
Schnyoll 1993 USA [39]	prosp.	264	213	27	100	–	1.4	7	only CT-scanned patients included, patients with neurological signs included
Davis 1994 USA [9]	retro.	168	168	100	100	–	1.2	7.1	only CT-scanned patients included, mortality not reported
Borczuk 1995 USA [4]	retro.	1448	1211	64	100	0	0.08	5.9	only CT-scanned patients included, mainly elderly
Stein 1995 USA [49]	prosp.	24 841	3558	100	100	0	–	–	GCS 14 and 15 not presented separately (except for mortality)
Schunk 1996 USA [38]	retro.	313	313	26	100	0	0.9	28	children, only CT-scanned patients included
Culotta 1996 USA [6]	retro.	3370	2398	100	91	0.08	0.4	4.4	good representativity. Two deaths (one subdural hematoma, other unclear)

(*continued*)

Table 1 (*continued*)

Author, publ. year, country, ref. nr.	Prospective/ retrospective	Patients total no.	Patients with GCS 15, no.	LOC/ amnesia (%)	CT perform. (%)	Mortality (%)	Complications (%)	Pathological CT (%)	Comments
Dunham 1996 USA [11]	retro.	2252	1631	100	100	–	0.1	3.6	mortality not reported
Arienta 1997 Italy [3]	retro.	1052	799	100	74	0	0.4	3.5	no clear definition of pathological CT.
Miller 1997 USA [30]	prosp.	2143	2143	100	100	0	0.2	6.4	associated severe injuries were included
Roddy 1998 USA [37]	retro.	62	62	50	100	0	0	0	62 children with MHI, GCS 15 and normal CT. No one deteriorated or died.
Nagy 1999 USA [33]	prosp.	1170	1170	100	100	0	1.8	3.3	good representativity
Haydel 2000 USA [18]	prosp.	1429	1429	100	100	–	0.4	6.5	good representativity, mortality not reported
Vilke 2000 Italy [59]	prosp.	58	58	100	100	–	1.7	5	only CT-scanned patients included, mortality not reported
Viola 2000 Italy [60]	prosp.	4536	600	100	100	0	0.3	10	majority of patients had no LOC/amnesia
Adams 2001 USA [2]	retro.	1033	1033	100	37	0	0	–	rate of pathological CT not reported
Stiell 2001 Canada [51]	prosp.	3121	2489	100	–	–	0.8	4.8	mortality not reported, unclear CT rate among GCS 15
Total	*24 studies*	*53855*	*24249*						

Table 2. *Meta-analysis of mortality and complications in the studies presented in Table 1 for patients with GCS 15. For pathological CT findings, the basis was studies where more than 90% underwent this investigation*

No. studies	Patients with GCS 15, no.	Mortality % (CI) n = 14969	Complications % (CI) n = 19512	Pathological CT findings % (CI) n = 13311
24	24249	0.1 (0.05–0.15)	0.9 (0.6–1.2)	7.8 (6.1–9.5)

n The number of patients available for each calculation; *percent* mean values, random effects model; *CI* 95% confidence intervals.

was no significant difference between the two quality groups as regards the mean for adverse outcomes. Therefore, results from all the studies were pooled in the meta-analysis.

Our findings are based on the 24 studies presented in Table 1 [2–4, 6, 7, 9, 11, 12, 18, 24, 26, 28, 30, 33, 36–39, 45, 48, 49, 53, 59, 60]. All studies had a fair representativity regarding age and gender. Most materials included patients of all ages and a few focused on the paediatric population or mainly the elderly. All together, the cohort well represented a patient population of mild head injury normally seen in emergency departments. Eleven studies used a prospective, and 13 a retrospective, design. They were published between 1986 and 2001 and collectively included 53855 patients. Of these, only the 24249 patients clearly defined as having GCS 15 could be included in our calculations. Some studies presented data only on mortality or only on other complications. In consequence, the numbers of patients vary between the outcomes according to what data could be obtained from the different studies (see Table 1). One study came from Canada, two from Italy, and the remaining 21 from the United States.

Table 2 presents a meta-analysis of the 24 studies, including 24249 patients. The findings show a low mortality rate, 0.1% (CI 0.05–0.15), in patients with mild head injury. Complications occurred in 0.9% (CI 0.6–1.2) of the cases. The most common interventions were (based on 19 studies that reported the complications separately): Neurosurgical operations (75%), transfer to intensive care unit (23%) and intracranial pressure monitoring (2%). The distribution of complications is not ideal, since definitions and reporting varied between the studies.

Based on findings from 15 studies (13311 patients) with high CT rates, 7.8% (CI 6.1–9.5) of the patients were found to have pathological findings identified in the acute phase. The most frequent CT findings were (based on 11 studies that differentiated the pathological findings): Skull fracture (3.2%), intracranial haemorrhage/contusion (2.8%), subdural- (1.3%), epidural- (1.0%) and subarachnoid haemorrhage (1.0%). These frequencies should be interpreted with some caution since definitions and categorizations were not uniform.

Discussion

This is the first meta-analysis of mortality and complications that includes all relevant studies of patients with mild head injury. Of 1000 patients arriving at hospital with mild head injury, 1 will die, 9 will require surgery or other intervention, and about 80 will show pathological findings on CT. At least these 8% of patients will need in-hospital care. Presumably, a few more are likely to require admission due to other medical, social, ethical, or practical reasons.

The studies included in the meta-analysis showed a substantial variation. For instance, complications varied from zero to an occasional 6.8% but mostly occurred in around 1% of cases. The frequency of pathological CT findings shifted more importantly, from 3.3–34%. Many possible factors could explain the variation: Case-mix (US-based studies from specialized clinics), differences of definitions, selection bias (often more common in retrospective studies), different study populations (variations between countries/areas) or differences in clinical practice (varying use of intracranial pressure monitoring or treatment of brain oedema). Still, the studies met our predetermined criteria for representativity and the data were thereby included to create the most fair meta-analysis of the collected knowledge. One consequence of the large variation was that the random effects model was deemed to be most appropriate for the statistical analysis.

The presence of a skull fracture is a well-known indicator for the risk of a traumatic haematoma after a mild head injury. It has been estimated that a patient with GCS of 15 and no skull fracture has a risk of a haematoma of approximately 1 in 8000 for an adult and 1 in 12000 in a child [57]. However, the routine use of skull x-ray to triage patients with mild head injury has been shown to be of less diagnostic value at a cost roughly equal to CT [14, 23, 27]. Therefore, the main questions regarding clinical guidelines for mild head injury today probably involve the optimum use of CT, home care and in-hospital observation.

The aim of a systematic review and meta-analysis is to increase precision by minimizing bias and random error. We cannot exclude the possibility that, despite our efforts, we may have failed to identify and include a few studies of potential relevance. However, the number of high-quality studies actually found, covering several thousands of patients, makes it unlikely that a few missing cases would substantially alter our findings. The results of this analysis therefore represent the best possible estimate of risk for mild head injury currently available. This knowledge is of great importance for any discussion about strategies and planning for the care, as well as for studies, of mild head injury patients.

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Appendix

Search terms

Brain concussion	Minimal brain injury
Brain injuries	Minimal head injury
Case reports	Minor brain injury
Cerebral haemorrhage	Minor head injury
Closed head injuries	Monitoring, physiological
CT	Mortality
Diagnosis	Radiography
Diagnostic errors	Review, guidelines
Emergency service, hospital	Risk assessment
Follow-up studies	Risk factors
Hematoma (epidural, subdural)	Sensitivity, Specificity
Head injuries	Survival rate
Mild brain injury	Tomography, x-ray computed
Mild head injury	Triage

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Comment

A substantial number of patients are seen in Emergency Rooms and sometimes are admitted to the Hospital in Europe following a mild head injury. A few cases will have intracranial abnormalities on CT scan and even a smaller number will be submitted to neurosurgical procedures. A number of papers have been recently published containing protocols, guidelines, and suggestions. Each paper claimed that the suggested procedures were "the final solution" to identify these few complicated cases on admission and on a clinical basis. Unfortunately there has always been a subsequent report [1, 2] discussing how impractical the previous suggestions were, even if published in high impact journals. In this scenario, any attempt to provide the readers with a systematic literature review is welcomed. Therefore, I believe that this is a valuable paper.

Franco Servadei

Correspondence: Jean-Luc af Geijerstam, Department of Medicine N4:01, Unit of Clinical Epidemiology, Karolinska Hospital, SE-171 76 Stockholm, Sweden. e-mail: jean-luc.af.geijerstam@medks.ki.se