

Minor Head Trauma: One of the Most Common Reasons for Emergency Department Care and Neurosurgical Referral: A Chronological Overview about the Management and Major Issues from the Advent of CT Scan

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Abstract

Traumatic brain injury is one of the most common reasons for emergency department care; over 1 million visits per year in both the USA and UK have been reported. The majority of these affected patients present minimal, mild or moderate head injury. Herein a historical overview is reported from the advent of the CT scan about the management of patients after mild head injury and the major issues. Finally it results that anamnesis and GCS are the key factors in selecting patients for CT scan and only their accurate evaluation can reduce the amount of requested CT scans without risks.

Keywords: Mild head injury; Guidelines for mild head injury; Compliance to guidelines; Head CT scan

Introduction

Traumatic brain injury is one of the most common reasons for emergency department care [1], over 1 million visits per year in both the USA and UK have been reported [2]. The majority of these affected patients present minimal, mild or moderate head injury [3].

Among the definitions one reports that mild or moderate head injury is any traumatic event that affects the cranial-encephalic region in subjects over 14 years of age, with a Glasgow Coma Scale score of 15 and 14 [4].

The initial management of these patients is particularly important; they are usually admitted and firstly assessed by emergency doctors with basic neurological and neurosurgical competencies.

It is important to have basic and standard details in the management, this improves the care. A wrong management would determine catastrophic results as a late neurosurgical treatment or discharge of patients at risk.

Nowadays CT scan is widely used, it is very useful in the assessment of these patients, many guidelines have been developed in order to give the appropriate indications and reduce its use and costs (**Table 1**), but the compliance in the clinical practice is only partial.

Herein a historical overview is reported from the advent of the CT scan about the management of patients after mild head injury and the major issues (**Table 2**).

The advent of the CT scan

The first commercially viable CT scanner was invented by Sir Godfrey Hounsfield in UK in 1967 [5]. The first patient brain-scan was done in 1971 and it was publicly announced in 1972 [6].

In 1971 Jennett [7] raised some issues in using X-rays for mild head trauma. He reported that better doctoring in casualty departments would result in fewer x-rays, because these were often taken by inexperienced doctors. Furthermore he considered unacceptable the difficulties in interpretation on a 24 hours a day basis and uneconomic to suggest that all patients with scalp lacerations and possible underlying fracture to be admitted, because of the very scale of this problem.

The introduction of the Glasgow Coma scale

In 1974 Teasdale and Jennett [8] introduced the Glasgow Coma Scale (GCS), a clinical scale for assessing depth and duration of impaired consciousness and come. The aim was to obtain a consistent evaluation by doctors and nurses and record on a simple chart which was proven practical both in a neurosurgical unit and in general hospital. The scale was considered to facilitate consultations between general and special units in cases of recent brain damage, and in defining the duration of prolonged coma.

Issues in the management of mildly injured patients

In 1975 Jennett [9] reported that the crux of the problem at the acute stage was which mildly injured patients should be admitted to hospital and to which wards both they should go. Management in the casualty departments depended on the local admission policy. He reported that in most British centres care by primary surgeons with secondary referral to neurosurgeons was the system. Head-injured patients were therefore often scattered around many wards, and neither surgical nor nursing staff had the opportunity to develop particular expertise or interest in their problems. The degree of involvement of neurosurgeons varied, usually inversely with distance from the regional unit. The primary care needed for mild injuries required facilities for the assessment of conscious level, for x-ray examination of the skull, for suture of scalp lacerations, and, when deemed necessary, for continuing observation. Skull radiography and echoencephalography were the only tools available for general use, but neurosurgical units often used carotid angiography and some of them intracranial pressure monitoring.

The use of skull X-ray in selecting patients for CT scanning

In 1980 Jennett [10] reported the importance of the findings and exclusion of a fracture at skull X-ray. He stated that the failure to detect a linear fracture of the vault was a common reason for delayed diagnosis of intracranial haematoma, with resultant mortality and morbidity. Detection of fracture was also important in selecting patients for CT scanning, which was considered to be made available only to a minority of patients.

Guidelines to Reduce Unnecessary Skull X-Rays

In 1981 the Royal College of Radiologists analyzed the costs and benefits of skull radiography for head injury reporting that the radiological cost of identifying 1 patient with unsuspected clinical intracranial haematoma is 43200 pounds [11].

In 1983 the same group presented six different patient-selection guidelines for skull radiography permitting the reader to explore his own preference and become aware of the implications of his choice [12].

In 1984 Fowkes et al. [13] reported a fall by 51% on the proportion of new accident-and-emergency attenders having skull radiographs after the introduction of the guidelines by the Royal College of Radiologists' Working Party.

Role of the skull X-ray vs CT scan

In 1987 Jennett [14] reported that X-rays played an important role in Britain in selecting patients for admission, for neurosurgical referral and for scanning after head injury. Skull X-ray was considered an important component of triage for mild head injury.

On the same year Masters et al. [15] reported a prospective study of 7035 patients with head trauma at 31 hospital emergency rooms to validate their management strategy. They distinguished two main groups of patients: those at high risk of intracranial injury and those at low risk of such injury. The high risk group was candidates for emergency CT scanning, neurosurgical consultation, or both. The low-risk group included patients who were asymptomatic or who had one or more of the following: headache, dizziness, scalp hematoma, laceration, contusion, or abrasion. Radiographic imaging was not recommended for the low-risk group and was considered to be omitted. An intermediate moderate-risk group was less well defined, and skull radiography in this group was considered to be appropriate. They concluded that use of the management strategy was safe and that it would result in a large decrease in the use of skull radiography, with concomitant reductions in unnecessary exposure to radiation and savings of millions of dollars annually.

In 1990 Stein and Ross [16] assessed the importance of the addition of a CT scan to the history and physical examination because it greatly improved patient assessment. Abnormalities on CT scans were common in patient with a GCS score of 13 that head injuries in that patient was considered "moderate" rather than "mild" in severity and risk. Patients with normal CT scans were considered for observation at home, allowing hospital personnel to devote full attention to the more seriously injured patients. They reported for patients with a GCS score of 13, 40% of abnormalities on the CT scan and 10% required surgery. None of the patients with normal CT scans on admission showed subsequent deterioration and none needed surgery.

Guidelines from the Italian Society of Neurosurgery

In 1996 the study group on Head Injury of the Italian Society for Neurosurgery suggested guidelines basing on GCS, anamnestic and clinical information. They distinguished three groups of patients. Patients in Group 0 (GCS 15, without loss of consciousness, amnesia, diffuse headache and/or vomiting) could be sent home after at least 6 hours of observation with an information sheet. Patients in Group 1 (GCS 15, with loss of consciousness and/or amnesia and/or diffuse headache and/or vomiting) require clinical observation (6 hours) and neuroradiological assessment. According to hospital availability, either skull-X rays or CT scan was obtained. In the presence of a skull fracture a CT scan was mandatory. In the presence of intracranial lesions, neurological consultation was requested. In the absence of skull fractures or intracranial lesions the patient was admitted for observation (24 hours). Patients in Group 0 and in Group 1 with a risk factor (coagulopathies, alcoholism, drug abuse, epilepsy, previous neurosurgical treatments and disable elderly patients) were admitted to the hospital (24 hours) and submitted to a CT scan. In patients with coagulopathies or in treatment with anticoagulants a CT scan was considered to be repeated before discharge even in the absence of intracranial lesion on the first

CT. In patients in Group 2 (GCS 14) a CT scan was obtained in all cases independent of the presence of a risk factor.

Guidelines by the Scandinavian Neurosurgical Society

In 1999 Bellner et al. [17] addressed the need for guidelines for minor head injury in Sweden. They performed a cross-sectional mail survey including all 76 hospitals treating head-injured patients. The outcome showed a variation in the management of mild head injury. Routines for assessment of consciousness level were satisfactory, but CT scan for detection of skull fracture and early diagnosis of intracranial complications were usually not performed.

In the same year a study reported the management protocols for minor head injury in 63 Norwegian hospitals [18]. Considerable interhospital variations were described. The use of skull radiography was reported for 18 (29%) hospitals and assessment according to the GCS in 27 (43%). The conclusions were that quality of care for minor head injury patients in Norwegian hospitals can be improved through extended use of routine early CT and consistent evaluation according to GCS.

In 2000 the Scandinavian Neurotrauma Committee was initiated by the Scandinavian Neurosurgical Society to develop evidence-based guidelines to improve the care of neuro-traumatic patients. [10] Implementation of the Head Injury Severity Scale was advocated. Patients with minimal injuries (no loss of consciousness, GCS score of 15) were considered to be safely discharged. Routine early CT scan was recommended in cases with mild injuries (history of loss of consciousness, GCS score=14-15) and patients with normal scans considered to be discharged. CT scan and admission was considered mandatory in moderate injuries (GCS score=13). All patients harboring additional risk factors considered to be scanned and admitted. A flow-chart for clinical decision making and a Head Injury Instruction card was introduced.

Guidelines to Reduce Unnecessary Head CT Scan

In 2000 the New Orleans Criteria established the first successfully validated clinical decision rule for selective use of CT in minor head injury. Haydel et al. [19] reported a study to develop and validate a set of clinical criteria to identify patients with minor head injury who do not need to undergo CT. All patients with positive CT scans had one or more of seven findings: headache, vomiting, an age over 60 years, drug or alcohol intoxication, deficits in short-term memory, physical evidence of trauma above the clavicle, and seizure. The sensitivity of the seven findings combined was 100 percent. All patients with positive CT scans had at least one of the findings.

In 2001 Stiell et al. [20] developed the Canadian CT Head Rule, a high sensitive decision rule for use of CT. He carried out a prospective color study in the emergency departments of ten large Canadian hospitals including adults who presented with a GCS score of 13-15 after head injury. Standardised clinical

assessment was executed before the CT scan in order to evaluate the main outcome measures in need for neurological intervention and clinically important brain injury on CT. Five high-risk factors were derived: failure to reach GCS of 15 within 2 hours, suspected open skull fracture, any sign of basal skull fracture, vomiting >2 episodes, or age >65 years. Two additional medium-risk factors: amnesia before impact >30 minutes and dangerous mechanism of injury.

In 2003 the Guidelines from NICE in UK reported very similar recommendations [21]. The CT scan was considered not to be required if the patient had GCS 15, no signs of skull fracture, no post-traumatic seizure, no focal neurological deficit, no more than one episode of vomiting since the head injury, was not on warfarin treatment, no loss of consciousness or amnesia. If the patient was on warfarin treatment or presented loss of consciousness associated with age >65 years, history of bleeding or clotting disorder, dangerous mechanism of injury, more than 30 minutes retrograde amnesia the CT scan should be performed within 8 hours. If the patient presented GCS<13 on initial assessment or GCS<15 at 2 hours after injury or suspected skull fracture, post-traumatic seizure, focal neurology deficit, more than one episode of vomiting the CT scan was considered to be performed within 1 hour.

In 2008, the American College of Emergency Physicians (ACEP) and the Centers for Disease Control and Prevention revised and disseminated their most recent clinical policy regarding recommendations for the management of these patients [22]. Some recommendations were given. Recommendation B: Skull film radiograph are not recommended in the evaluation of mild TBI. Although the presence of a skull fracture increases the likelihood of an intracranial lesion, its sensitivity is not sufficient to be a useful screening test. Indie, negative findings on skull films may mislead the clinician, level-A recommendation. A non-contrast head CT is indicated in head trauma patients with loss of consciousness or posttraumatic amnesia only if one or more of the following is present: headache, vomiting, age greater than 60 years, drug or alcohol intoxication, deficits in short-term memory, physical evidence of trauma above the clavicle, posttraumatic seizure, GCS score less than 15, focal neurologic deficit, or coagulopathy, level-B recommendations. A non-contrast head CT should be considered in head trauma patients with no loss of consciousness or posttraumatic amnesia if there is a focal neurologic deficit, vomiting, severe headache, age 65 years or greater, physical signs of a basilar skull fracture, GCS score less than 15, coagulopathy, or a dangerous mechanism of injury. No recommendations were given regarding the role for head MRI over non-contrast CT in the evaluation of a patient with acute mild TBI. Level C recommendations: in mild TBI patients without significant extracranial injuries and a serum S100B level less than 0.1 g/L measured within 4 hours of injury, consideration can be given to not performing a CT.

In 2013 an update of the Scandinavian guidelines was mandated [23]. The injury was divided in three categories: moderate (GCS 9-13), mild (GCS 14-15), minimal (GCS 15). The criteria for executing a CT scan were very similar to previous

reported guidelines with the introduction of analysis of sample serum S100B. It was proposed for mild low-risk injuries at <6 hours. Basing on its value consider if to perform CT scan (>0.10 g/L) or not (<0.10 g/L). This was the first time a brain biomarker was introduced into clinical practice guidelines. The aim was a safe reduction in CT scan in a subpopulation of patients with mild head injury. Unfortunately patients with extracranial injuries and those seeking care more than 6 hours after trauma are not good candidates for S100B sampling due to high risk of false positives and negatives, respectively.

Uden et al. demonstrated that using these guidelines could save approximately one third of CT scans in a pre-selected color of mild traumatic brain injured patients with little or no impact on patient outcome.

On the other hand because of significant subgroup variation in classification accuracy, age and race were reported in need to be considered when using S100B to classify subjects [24].

In 2014 Wolf et al. [25] reported an Austrian trial and comparison with the Canadian CT Head Rule analyzing the risk factors indicating the need for cranial CT scans in elderly patients with head trauma. The presence of at least 1 of the following was considered able to predict the necessity of cranial CT: amnesia, GCS score, age >65 years, loss of consciousness, nausea or vomiting, hypocoagulation,

dementia or a history of ischemic stroke, anisocoria, skull fracture, and development of a focal neurological deficit. The use of the suggested parameters proved to be superior in the detection of high-risk patients who sustained a mild head trauma compared with the Canadian CT Head Rules.

Compliance to Guidelines

Jones et al. [26] assessed the compliance of ACEP guidelines in two separate academic emergency medicine departments in USA creating a set of realistic clinical vignettes that described a patient encounter in the emergency department and then asked the respondents to make decision regarding whether or not to obtain a non-contrast head CT. Overall, physician decision-making was consistent with the guidelines in only 62.8% of total vignettes.

In 2001 a study from Spain analyzed the management of minor head injury in 66 Neurosurgical Departments of the Spanish National Health System between December 1999 and February 2000 through a 57-item questionnaire [27]. It emerged that cranial X-ray was routinely used in 89.1% of the departments, while only in 5.5% of them the CT scan was systematically indicated although it was completely available in 74.5% of them (**Table 1**).

Table 1: Reports some of the Guidelines developed for the management of mild head injury.

Guidelines for Mild Head Trauma	
The Italian Society for Neurosurgery	1996
Scandinavian Neurosurgical Society	2000
The New Orleans Criteria	2000
The Canadian CT Head Rule	2001
Guidelines from NICE	2003
American College of Emergency Physicians	2008
Update of the Scandinavian guidelines	2013

On the same way a low compliance to Scandinavian mild head trauma guidelines was reported [28]. This caused significant unnecessary costs, estimated as USD 2,167,000

annually in Norway. Among patients: 69% underwent over triage, 18% with unnecessary hospital admission, 27% with unnecessary CT and 24% with both (**Table 2**).

Table 2: Lists the major events from the introduction of the CT scan.

Year	Event
1971	First patient to have a brain scan
1971	Jennett raised some issues in using X-rays
1974	Introduction of Glasgow Coma Scale (GCS)
1975	Jennett reported skull radiography and echoencephalography as still the only tools available for general use and carotid angiography and intracranial pressure monitoring available in neurosurgical units
1980	Detection of fracture at skull X-ray was reported as indication for CT scanning
1983	Guidelines for skull X-ray in patients with recent head injury were introduced

1987	X-ray was still considered playing an important role for triage in mild head injury in Britain
1987	Masters et al. highlighted the role of CT scan against that of X-ray for patients at high risk of intracranial injury
1990	Stein and Ross found an high correlation of abnormalities on CT scans in patients with a GCS score of 13 against normal CT scans in asymptomatic patients
1996	Guidelines for mild head injury from the Italian Society for Neurosurgery were introduced
1999	Bellner et al. raised concerns about the need for guidelines in Sweden. A survey in 76 hospital showed that CT scan for detection of skull fracture and early diagnosis of intracranial components were usually not performed
1999	A Norwegian study involving 63 hospitals augured for the routine use of CT scan in mild head injury
2000	Scandinavian Neurosurgical Society developed guidelines to improve the care of neuro-traumatic patients
2000	The New Orleans Criteria were established for selective use of CT in minor head injury
2001	The Canadian CT Head Rule were established
2003	The Guidelines from NICE in UK were established
2008	Skull X-ray was definitely not recommended in the evaluation of mild traumatic brain injury
2013	Scandinavian guidelines introduced the use of S100B in selecting patients for CT scan
2014	An Austrian trial revised the risk factors indicating the need for cranial CT scans in elderly patients with head trauma

Discussion

The use of skull X-ray has been for a long time the only available tool for the assessment of mild traumatic patients. The invention of the CT scan in 1971 has slowly replaced the skull X-ray use. Nowadays head CT scan is widely used in the assessment of patients after a mild head injury and it is cause of important unnecessary costs for the hospitals. In the clinical practice these patients are usually admitted by emergency doctors who routinely ask for a CT scan before the neurosurgical referral without consideration of the neurological status of the patients. GCS and many guidelines have been produced in order to improve the management of traumatic patients and reduce the overspread use of the CT scan; nevertheless the compliance to the guidelines has been demonstrated to be scarce in different countries.

Conclusion

The anamnesis and GCS are the key factors in selecting patients for CT scan and only their accurate evaluation can reduce the amount of requested CT scans without risks.

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