REPORT

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health technology assessment

ROUTINE SKULL RADIOGRAPHS IN HEAD INJURY PATIENTS

HEALTH TECHNOLOGY ASSESSMENT UNIT
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EXECUTIVE SUMMARY

In recent years, with the availability of CT scans, the role of routine skull radiographs in minor neuro-trauma has been questioned. In moderate and severe head trauma, a CT scan is the investigation of choice. The effectiveness, legal and cost implications of routine skull radiographs in head trauma cases was studied. The results indicate that skull radiographs only show fractures, and do not afford visibility of either brain or blood to demonstrate an intracranial injury. The presence of a skull fracture without neurological abnormalities is of little significance. The pick-up rate of skull fractures by skull radiographs in patients with mild head injury has been reported as being very low, ranging from 1.9% to 4.3%. A skull fracture does not necessarily imply significant intracranial injury, while despite the absence of a skull fracture a patient could be having significant intracranial pathology.

However, skull radiographs are helpful in those patients suspected of non-accidental injury, depressed skull fracture, penetrating head injury by a foreign body, or head trauma in children less than 2 years of age, even without neurological symptoms.

With respect to costs, the Royal College of Radiologists Working Party on the effective use of diagnostic radiology found that about £11,000 could be saved within a year if routine skull X-rays were excluded. Legally, if a doctor omits skull radiographs in minor head trauma, he cannot be judged negligent as opinion on this matter is divided and not well established.

In conclusion, there is sufficient evidence that routine skull radiographs are not effective or useful in minor head trauma. For mild to moderate head injury, CT scan is the investigation of choice. Thus, the following is recommended

- Routine skull radiographs not recommended for minor head traumas.
- A skull radiograph is only indicated in head trauma patients where a CT scan is otherwise not clinically indicated during the initial evaluation, but in whom:
- age is less than 2 years
- a depressed fracture is suspected clinically or by the nature of the injury
- a penetrating injury by metal, glass is suspected
- a foreign body is suspected
- there is a history of loss of consciousness or post-traumatic amnesia

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1. BACKGROUND

Routine skull radiographs have been an integral part of head injury management before the advent of the Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) scans. These radiographs proved valuable in picking up the following:

- simple skull fractures
- depressed skull fractures
- fractures of other bones of the head and neck such as orbital, mastoid, maxillary, mandibular and cervical bones
- a shift of the brain from the midline suggesting a mass effect in cases where the pineal body was calcified
- any foreign body within the skull

The advent of CT scans and subsequently the MRI scans has revolutionised the management of head injuries. With these scans intracranial lesions such as extradural, subdural, intracranial, intraventricular hematomas could be accurately visualised and therefore appropriately managed.

In the early 1980's, CT scans were only available in a couple of government hospitals and a few private hospitals in Malaysia. In 1999, this scenario has totally changed. Almost every major government hospital and most private hospitals have a CT scanner. Hospital Kuala Lumpur and some of the large regional hospitals, as well as the leading private hospitals have an MRI scanner too. These accurate brain-scanning facilities are available or easily accessible to trauma and neurosurgical centers in Malaysia.

2. INTRODUCTION

Head injuries constitute the bulk of cases seen in the Accident and Emergency departments, and also make up a large portion of cases admitted for observation in hospitals. Currently, all head injury patients are seen at the Accident & Emergency department and, where necessary, than referred to specialised units for further management. It has become a routine practice in this country to obtain skull radiographs for all types of head injuries. For example, in 1998, the Diagnostic and Imaging Department of Kota Bharu Hospital performed 4,631 skull radiographs, which contributed to about 10.4% of the annual workload. Of these, 1,547 (33%) were due to head injuries. However, only 3% to 6% of all skull radiographs are positive in those patients who have sustained any degree of head trauma.

In recent years, especially with the availability of CT scans, the role of routine skull radiographs in minor neuro-trauma has been questioned, and opinion on this is divided.

However, with respect to moderate and severe head trauma there is general agreement that a CT scan is the investigation of choice.

3. OBJECTIVE

To determine the effectiveness, legal and cost implications of routine skull radiographs in head trauma cases

4. METHODOLOGY

Literature searches were conducted for the years 1980 – 1998 using the MEDLINE database. Only articles in the English language were included in the search. Search terms used include the following: *skull radiographs in head injury, skull radiographs in head trauma, CT brain in head injury, CT brain in head trauma, indications of skull radiographs in head injury, indications of CT brain in head injury, effects of skull fractures, cost-skull radiographs-head injury, skull radiographs-head injury-cost effective, economic impact-head injury-skull radiographs, skull radiographs-head injury-economy*. These terms were used singly or in various combinations.

The search generated a total of 147 articles, 85 related to effects of skull fracture, 60 on skull radiographs and CT in head trauma, and 2 related to cost. However, only 41 of these (18, 21 and 2 respectively) were found to be relevant to the issues under consideration, or where the original articles could be obtained. A systematic review of this literature was carried out.

With respect to the legal aspects, no direct publication on this issue could be obtained. Material was obtained instead from discussions with lawyers who helped with relevant legal references, and also from reviewing material from standard law books.

Literature was systematically reviewed and the evidence graded according to the Modified CAHTA scale (Appendix 1).

5. TECHNICAL FEATURES

Performing radiological examinations on head injury patients can be challenging, especially in instances where the patient may be very restless or very uncooperative. Skull radiograph examinations could be carried out by using a bucky or portable on direct exposure with or without a static grid. These three different techniques require different settings of exposures, so that producing an optimum film on the first exposure could sometimes be difficult.

Routinely, two projections are performed on head injury case i.e. frontal and lateral views. In addition, sometimes a Towne's view is requested by the clinician, especially in situations where patients have trauma to the occipital region.

6. RESULTS & DISCUSSION

The issue of routine skull radiographs in head trauma was considered from various aspects.

6.1 Role of Routine Skull Radiographs in Minor Head Trauma

In general, the overall pick-up rate of skull fractures by skull radiographs in patients following mild head injury has been generally reported as very low. It ranged from 1.9% to 4.3% (Lloyd 1997; Livingston et al. 1991; Murshid 1998; Chan et al. 1990; Masters 1990).

6.1.1 Skull fractures and head injury

The presence of a skull fracture cannot accurately predict whether or not a patient with a minor head injury has sustained significant intracranial injury. The presence of a skull fracture does not necessarily imply significant intracranial injury, and conversely, despite the absence of a skull fracture, a patient could be having significant intracranial pathology, some necessitating neurosurgical intervention (Sharman et al. 1992; Lloyd, 1997; Livingston et al. 1991; Murshid, 1998; Chan et al. 1990; Masters 1990; Miller et al. 1990; Sarvadei et al. 1988). It would be a mistake to be reassured about the severity of a head trauma because skull radiographs are normal (Frush et al. 1998). In a study by Pasman et al. (1995), 1218 patients who had skull radiographs done for head trauma were studied. These patients were divided into 3 risk groups. It was found that not a single haematoma or skull fracture was identified in the low risk group. Hence, skull radiographs had no significance in this group. In the moderate risk group only one patient had skull fracture and one patient had intracranial haematoma. Here negative skull radiographs did not fully exclude intracranial complications. In the high-risk group there were many with intracranial haematoma, in the presence or not of a skull fracture. The study concluded that plain skull radiographs were of little value in patients with acute head trauma.

6.1.2 Skull fractures and intracranial injury

Depressed fractures are usually associated with some primary injury to the underlying brain but paradoxically the process of fracture may absorb some of the energy of impact and protect the brain. While most skull fractures can be diagnosed on skull radiographs, basal fractures can be difficult to demonstrate. It is easier to order skull radiographs for every patient with head injury however trivial but this policy is expensive and time consuming. Severe intracranial injuries occur without a skull fracture, and skull radiographs cannot be justified as a tool for diagnostic exclusion (Lloyd 1998). In a population based study (Wiederholt et al. 1989) of residents who experienced brain

injury, skull fractures were observed in 28.0%. Mortality was lowest in subjects without skull fracture and it increased with fracture severity. Associated neurological injuries, complications and deficits were more common in patients with skull fracture than those without. The types of neurologic deficits differed little between those with and without fractures.

6.1.3 Skull fractures and neurological abnormalities

Skull radiographs only show fractures and do not afford visibility of either brain or blood to demonstrate an intracranial injury. The presence of a skull fracture without neurological abnormalities is of little significance. Sixty percent of children with extradural haematoma, 85.0% of children with subdural haematoma and 35.0% of children with brain damage did not have any associated skull fracture (Toupin et al. 1996). The presence of neurological abnormalities is a more reliable indicator of intracranial injury than the presence of a skull fracture (Lloyd et. al, 1997). However, the possibility of a patient harbouring significant intracranial pathology increases in the presence of a skull fracture detected on a skull radiograph. This is especially so when there is a history of loss of consciousness or if the Glasgow Coma Score (GCS) is less than 15 (Teasdale et al. 1990; Chan et al. 1990; Masters 1990; Sarvadei et al. 1988; Gomez et al. 1996).

Thus, there is no evidence to show that skull radiographs are effective in skull trauma.

6.2 Risks Related to Skull Fractures

6.2.1 Significance of skull fractures

Patients with skull fractures are 30 times more likely to develop secondary brain damage. Significant brain injury is often present with a skull fracture (Frush et al. 1998, Lloyd et al. 1997). It therefore follows that all patients with skull fractures merit hospital admission for close observation, even if fully conscious. In a retrospective study by Gomez PA et al. 1996, patients with a GCS of 13-14, and the presence of skull fracture and focal signs, showed significantly increased incidence of abnormal CT findings, than those patients with a GCS of 15. The study suggests that CT scan be done on patients with a GCS of 13-14 and not improving within 4-6 hours of injury. Skull radiographs then become unnecessary in this group. On the other hand, 183 patients who apparently had minor head injuries (10-year period) developed acute intracranial haematoma, with 54.0% had extradural haematoma. A skull fracture was present in 60.0% of patients, including 52.0% of those not clinically suspected of having an intracranial lesion. Miller et. al. (1990) feel that a skull radiographs retains a useful place in the investigation of selected patients with minor head trauma.

6.2.2 Children with skull fractures

It has been suggested that all children with skull fractures require urgent CT scanning to exclude intracranial injury. In addition, a study by Read et al. (1995) concludes that all children with a diminished level of consciousness need to undergo an urgent CT scan, while children with skull fractures and a normal conscious level may be managed conservatively without the need for a CT scan. Despite this, there is a scarcity of

literature that dealt directly with the indications of skull radiographs in minor head trauma. Only two relevant articles that dealt with the indication of skull radiographs following head injury were able to be retrieved, and both these dealt with head injury in children (Lloyd , 1998; Frush et al. 1998).

6.2.3 Association of haematomas with skull fracture

Haematomas occur more frequently in association with lateral and occipital fractures, than with frontal fractures. Linear fractures are more often associated with extra- and subdural haematomas than are depressed fractures. Intracranial damage associated with depressed fractures are localized more frequently than with linear fractures (Macpherson et al. 1990). Despite this, intracranial injury is found to be rare in children with uncomplicated linear parietal fractures (Lloyd et al. 1997).

6.2.4 Morbidity associated with skull radiographs

The role of skull fracture in affecting morbidity following head injury has received attention from researchers. There is widespread agreement that skull fractures increase the risk of complications such as haematoma. The role of skull fracture in predicting neuropsychological dysfunction following head injury was studied. The results obtained from the study (Smith-Seemiller et al. 1997) suggested that the presence of a skull fracture is predictive of additional neuropsychological dysfunction, even in the absence of intracranial pathology.

6.2.5 Use of CT scans versus skull radiographs

In a retrospective study (Jend et al. 1995), patients with skull fractures (without intracranial injuries) showed just as many symptoms as patients without skull fractures. Patients with intracranial injuries showed unconsciousness, neurological deficits, and, or required intubation. Any one of these criteria or a combination of these indicated the presence of intracranial injury with a high degree of probability. These criteria permit the use of other diagnostic means like CT scan in the first instance rather than a plain skull radiographs followed by CT scan.

The skull radiograph is not diagnostic of intracranial injury or of neurological damage. In patients where these are suspected, a CT scan is indicated.

6.3 Indications for skull radiographs

Plain skull radiographs are indicated in the following instances:

i. Penetrating skull injuries
ii. Clinical suspicion of skull fracture e.g. depressed fracture, even without neurological symptoms
iii. Foreign bodies in the scalp
iv. Head trauma in children less than 2 years, even without neurological symptoms.

6.4 Cost-effectiveness of Skull Radiographs in Minor Head Trauma Cases

The Royal College of Radiologists (RCR) Working Party on the effective use of diagnostic radiology (RCR 1981) found that only 1 in 4 800 skull radiographs contributed to the detection of intracranial haemorrhage. The cost for this detection was £43 000. They also compared the benefits of current practice with that without skull radiography. Using specific criteria and through consensus, it was found that about £11 000 could be saved within a year. Another study done by Clarke et al. (1990) found that the rate of skull radiography fell by 40.0% post implementation of guidelines in the use of skull radiography in the accident and emergency department. In this process almost £10 000 was saved.

6.4.1 Local cost-implications

Local costing data on skull radiographs is not readily available in Malaysia. Information regarding the life span of radiograph facilities is also very varied. An attempt to calculate the cost of doing skull radiograph was made using information gathered from an equipment supplier using the workload of Kota Bharu Hospital as reference, in which 10.35% of the total radiographs done in 1998 were for skull radiographs. The estimated cost per skull examination is about RM 5.47 (Appendix 2).

An attempt was made to estimate the total number of skull radiographs carried out annually in hospitals under the Ministry of Health by sampling three hospitals as follows:

Table 1: Number of Skull Radiographs Done in 3 Hospitals, 1997

Hospital	Total radiographs	Skull radiographs	Percentage
Hospital Taiping	38 501	2 432	6.3
Hospital Ipoh	82 581	4 745	5.7
Hospital Seremban	56 838	4 515	7.5
Total	177 920	11 692	-

Percentage of skull radiographs done in 3 hospitals = (11 692 / 177 920) X 100
= 6.6 %

Total number of x-rays for the whole country, 1997 = 1 818 587
Skull radiographs done for the whole country, 1997 = 1 818 587 X 6.6 %
= **120 026**

Thus, based on the approximate cost of RM 5.47 per skull examination, and taking into account the estimated annual skull radiograph workload of 120 026, there could be a potential savings of RM 656 542.22 if routine skull radiographs in minor head trauma were not performed.

6.5 Medico-Legal Aspects of Skull radiographs in head trauma

An attempt was made to study the legal implications of not carrying out skull radiographs as a routine practice. The concern was whether this could be construed as negligence. In

medical practice, negligence has been agreed to mean failure to act in accordance with the standards of a reasonably competent medical doctor (Bolam vs. Friern Hospital Management Committee, 1957; Chin Keow vs. Government of Malaysia & Anor, 1965; Elizabeth Choo vs. Government of Malaysia & Anor, 1970; Hunter vs. Hanky, 1981). Thus, if there were differing views on management, as long as the doctor acts in accordance with one view, he is judged not to be negligent even if there is a body of opinion that takes a contrary view (Dr. Chin vs. Ng EK & Ors, 1998; Bolam vs. Friern Hospital Management Committee, 1957; Hughes vs. Waltham Forest Health Authority, 1991; 1 All England Report 635, 1985; Luxmoore-May vs. Messenger May Barerstock 1990).

The law recognizes that differences of opinion and practice exist in the medical profession and that there is seldom one answer exclusive of all others to problems of professional judgement (1 World Law Report 634, 1985; Bolam vs. Friern Hospital Management Committee, 1957; Chin Keow vs. Govt. of Malaysia & Anor, 1965; Elizabeth Choo vs. Govt. of Malaysia & Anor, 1970).

If there should be differing professional schools of thought, a doctor only needs to show that his approach is regarded as proper by one well-established school of thought. There may exist an equally well-established school of thought to the opposite effect (Bolam vs. Friern Hospital Management Committee, 1957; Maynard vs. West Midlands Regional Health Authority, 1985; Whitehouse vs. Jordan and Another, 1981).

Apart from this, the other aspect is the damages paid out for fractures. A fracture detected in routine skull radiographs is worth approximately RM 5,000.00 - RM 6,000.00 in general damages. Two separate fractures mean RM 10 000.00 - RM 12 000.00. Thus, a patient with a cerebral concussion and a fracture detected through skull radiographs is eligible to receive approximately RM 6,000.00.

Thus, if a doctor omits skull radiographs in minor head trauma, he cannot be judged negligent as opinion on this matter is divided and not well established.

7. STUDY OF LOCAL SITUATION

7.1 Introduction

In order to determine the local practice with respect to skull radiographs in head trauma, a survey was carried out in Ministry of Health hospitals. The survey focused on the magnitude of skull radiographs in relation to head injury cases ordered from the Accident & Emergency (A & E) departments and the wards, as well as on the proportion of skull fractures detected. Four hospitals were identified for this study, one of which is a district hospital, by virtue of the fact that the members of the expert committee belong to those hospitals.

7.2 Objective

The aim of this survey was to determine whether skull radiographs were being carried out routinely in head trauma and also the pick-up rate of skull fractures from these radiographs.

7.3 Methodology

The study population of this survey was patients with head injury treated at A&E departments as well as those admitted to wards. This was a prospective observational study over a two-week period (first and third week) in October 1998.

From the A & E departments the following data on head trauma patients was collected:

- number of patients treated on an outpatient basis
- number of patients admitted

Data collected from the Diagnostic Imaging departments on patients from A&E departments and from wards are as follows:

- number of patients with skull radiographs done
- number of head trauma patients
- number of skull fractures

7.4 Results and Discussion

The results of this survey are as shown in Table 2.

Table 2: Head trauma cases and skull radiographs at A+E Department and Wards, in four hospitals.

	Location							
	A & E Department				Ward			
Hospital	Skull radio-graphs ordered	Skull radio-graphs for head injury cases	Head trauma with outpatient treatment	Skull radio-graphs with fracture skull	Total skull radio-graphs ordered	Skull radio-graphs for head injury cases	Head trauma cases from A + E	Skull radio-graphs with fracture skull
Alor Setar	39	39	30	1	12	12	25	0

Taiping	10	10	13	0	22	18	4	1
Ipoh	197	197	188	1	0	0	9	0
Seremban	47	33	12	0	42	24	32	0
Kota Bharu	42	42	4	1	11	0	35	0

In all these hospitals, skull radiographs seem to be done routinely in the Accident and Emergency Department on all head trauma cases. The number of skull radiographs is higher than the number of head trauma cases possibly due to radiographs being done for patients other than head trauma like ear-nose-throat, oral-maxillary and ophthalmology conditions, as well as for patients who are subsequently admitted. However, for inpatients in three hospitals, skull radiographs do not seem to be done as a routine, and in fact in Ipoh and Kota Bharu hospital no skull radiographs were ordered at all.

The pick-up rate of skull fractures from these four hospitals in patients attending the A & E Departments who sustained head injury, range from 0% to 2.6%. This pick-up rate was higher, that is, 0% to 4.6% for in-patients. The availability of CT scans in all three of the hospitals (with the exception of Taiping hospital) may also contribute to the differences in these hospitals.

7.5 Conclusions

Skull radiographs are being carried out routinely for head injury cases in all four hospitals, but less so for inpatients. There is a low pick-up rate of skull fractures among head trauma patients undergoing skull radiographs.

8. CONCLUSIONS

- The positive pick-up rates of skull fracture by skull radiographs are low.
- A skull radiograph by itself is not a reliable indicator of the severity of intracranial injury. However, the presence of a skull fracture increases the likelihood of significant intracranial injury. Skull radiographs are helpful in patients with suspected non-accidental injury, suspected depressed skull fracture and suspected penetrating head injury by foreign body.
- A reasonable amount of savings could be made if skull radiographs were omitted in head injury cases.
- A medical practitioner, who omits skull radiographs in minor neuro-trauma cases, cannot be deemed negligent since opinion in this matter is divided and not well established.

There is sufficient evidence to conclude that routine skull radiographs are not useful in minor head trauma. Thus, for mild to moderate head injury, CT scan is the investigation of choice.

9. RECOMMENDATIONS

A skull radiograph is only indicated in patients where a CT scan is otherwise not clinically indicated during the initial evaluation, but in whom:

- age is less than 2 years,
- a depressed fracture is suspected clinically or by the nature of the injury,
- a penetrating injury by metal, glass is suspected,
- a foreign body is suspected,
- there is a history of loss of consciousness or post-traumatic amnesia

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11. EVIDENCE TABLE

RISKS RELATED TO SKULL FRACTURES

No	Title. Author, Journal, Year	Type of Study, Sample size, Follow-up	Characteristics & outcome	Comments Grade of Evidence
1	Pasman P, Twijnstra A et al The value of skull radiography in patients with head trauma. J Belge Radiol 78(3): 169-71 1995	Retrospective. 1218 patients. Patients divided into 3 risk groups, based on history and clinical findings.	No skull fracture or haematoma in low-risk group. Moderate risk group, one patient had skull fracture and one patient had intracranial haematoma. Many patients had intracranial haematomas in the high risk group, in the presence or not of a skull fracture. Plain skull x-rays are of little value in patients with acute head trauma.	Poor
2	Read HS, Johnstone AJ Scobie WG *Skull fractures in children: altered conscious level is the main indication for urgent CT scanning.* Injury, 26(5): 333-4 1995	Retrospective. 7 year period.	140 children with skull fractures. 13 had diminished level of consciousness. Scan done in 9 and 7 showed intracranial injuries. 127 children with normal level of consciousness recovered fully. Of these 8 had CT scans and only one had subarachnoid haemorrhage. All children with diminished level of consciousness need to undergo urgent CT scan. Children with skull fractures and a normal level of consciousness may be managed conservatively.	Poor
3	Jend HH, Helkenberg G. The value of conventional skull x-rays after head injuries. Rofo Fortschr Geb Rontgenstr	Retrospective study.	78 (1.5%) had skull fractures. 41(0.8%) suffered intracranial injuries. Of 57 patients with skull fractures, only 23 showed intracranial injuries.	Poor

No	Title. Author, Journal, Year	Type of Study, Sample size, Follow-up	Characteristics & outcome	Comments Grade of Evidence
	Neuen Bildgeb Verfahr, 162(1): 7-12 1995		Of 41 patients with intracranial injuries, 18 did not show any skull fractures. Patients with skull fracture (without intracranial injuries) showed just as many symptoms as patients without skull fracture.Patients with intracranial injuries showed neurological deficits, unconsciousness and or required intubation. Any one of these criteria indicated when to use CT scan.	
4	Moreea S, Jones S, Zoltie N. Radiography for head trauma in children: what guidelines should we use. J Accid Emerg Med, 14(1): 13-15 1997	Retrospective audit.	569 children presenting to a large teaching hospital A&E department. American and British Guidelines for indications of radiography were compared with the actual requests for radiography. 50% of children had skull radiography. If British guidelines were followed then 63% of children should have had x-rays done. If American guidelines were used then only 18% would have required x-rays. All the fractures identified were in this 18%. British guidelines over-investigate children with head injury.	Poor
5	Wallace SA, Bennett J et al. Head injuries in the accident and emergency department: are we using resources effectively? J Accid Emerg Med, 11(1): 25-	Retrospective criterion based audit. 158 patients.	132 (84%) satisfied the three key areas of recommended head injury management. Failure to satisfy recommended guidelines present in 19 patients for SXR and 3 for CT scanning.	Poor

No	Title. Author, Journal, Year	Type of Study, Sample size, Follow-up	Characteristics & outcome	Comments Grade of Evidence
	31 1994		Three skull fractures would have been missed if the criteria had been strictly followed.	
6	Miller EC, Derlet RW, Kinser Minor head trauma: Is computed tomography always necessary? Ann Emerg Med, 27(3): 290-4 1996	Prospective study in a Level I trauma centre. 1 382 patients. Followed to discharge.	To determine clinical value of routine CT of head in patients with normal mental status after minor head trauma. Intracranial abnormality identified in 84(6.1%). Nausea and vomiting and signs of head trauma more common in group with abnormal CT findings. Routine CT of head in patients with history of LOC/amnesia but no symptoms or signs of depressed skull fractures has minimal clinical value and is not warranted.	Fair
7	Ingebrigtsen T, Romner B. Routine early CT-scan is cost saving after minor head injury. Acta Neurol Scand, 1996 93(2-3): 207-10	Study focuses on economic aspects of minor head injury management. Sample size = 88.	88 patients underwent routine early CT scan and at least 24 hours admission. CT demonstrated intra-cranial lesion in 8 (9%) patients. This management was compared to routine early CT scan and discharge of patients, and was found to be reliable and cost saving.	Poor
8	Macpherson BC, MacPherson P, Jennet B. *CT evidence of intracranial contusion and haematoma in relation to the presence, site and type of skull fracture*.	Review article. 850 patients with skull fractures	71% had contusion or haematoma. 533 patients with no fracture – 46% had contusion or haematoma. Haematomas occur more frequently in association with lateral and occipital fractures, than with frontal fractures. Linear fractures associated with extra- and subdural haematomas than were depressed fractures.	Poor

No	Title. Author, Journal, Year	Type of Study, Sample size, Follow-up	Characteristics & outcome	Comments Grade of Evidence
	Clin Radiol, 42(5): 321-6 1990			
9	Miller JD, Murray LS, Teasdale GM *Development of a traumatic intracranial haematoma after a minor head trauma*. Neurosurgery, 27(5): 669-73 1990	Retrospective analysis of 183 patients.	These were the patients who had surgery for acute intracaranial haematoma. Initially they were well during admission. Skull fracture was shown in 60% of these patients. Skull x-ray retains a useful place in the investigation of selected patients with minor head injury.	***Poor***
10	Stein SC, Ross SE. Mild head injury: a plea for routine early CT scanning. J Trauma, 33(1): 11-3 1992	Review article.	1 538 mild head injured patient admitted during a 41/2 year period. Routine urgent cranial CT scans in all patients. Correlation between skull fractures and intracranial lesions investigated. 265 patients (17.2%) had lesions on CT scans of which 131 were fractures, and 209 were intracranial abnormalities. Clinical observation with or without skull x-rays is inadequate to rule out potentially dangerous intracranial lesions in mild head injuries. With history of LOC immediate CT scan is indicated.	***Poor***
11	Smith-Seemiller L, Lowell MR et al. Impact of skull fracture on neuropsychological functioning following closed head injury.	Prospective study. Number of patients not known.	To investigate the role of skull fracture in predicting neuropsychological dysfunction following head injury. Patients who had skull fractures were compared to those who had not suffered skull fractures. Multivariate analysis revealed that the presence of a	***Fair***

No	Title. Author, Journal, Year	Type of Study, Sample size, Follow-up	Characteristics & outcome	Comments Grade of Evidence
	Brain Inj, 11(3): 19-6 1997		skull fracture is predictive of additional neuro-psychological dysfunction.	
12	Toupin JM, Lechevallier J et al Selective indication of skull radiography after head injury in children. Rev Chir Orthop Reparatrice Appar Mot 82(3): 210-7 1996	Prospective study.	Since Feb 1994 only children with possible skull penetration, depressed fracture or presenting signs of basilar fracture had X-rays done. CT scan was done in those with focal neurologic signs An average of 241 children were seen after head trauma., each month. An average of 21 x-rays were performed each month, representing a decrease of 2000 x-rays a year. The presence of a skull fracture without neurological abnormalities is of little significance. It would be a mistake to be reassured about the severity of a head trauma because skull x-rays are normal. Routine skull x-rays after head trauma are not justified either for financial or radioprotection reasons.	***Good to Fair***
13	Sevadai F, Ciucci G et al. Diagnosis and management of minor head injury: a regional multicenter approach in Italy. J Trauma, 39(4): 696-701 1995	Multicenter trial.	Liberal use of CT scans in asymptomatic patients with skull fractures produced an earlier identification of patients with extradural haemotomas. CT scans are obtained in patients with a GCS of 13 or less. Skull x-rays are obtained in patients older than 10 years old with a GCS of 14/15.	***Good***
14	G'omez PA, Lobata RD et al. *Mild head injury: difference in prognosis among patients with*	Retrospective study of 2484 consecutive	94% scored 15, 3.5% scored 14 and 1.3% 13.Patients with initial GCS of 13-14 had a significantly increased incidence of skull fractures and abnormal CT findings,	Poor

No	Title. Author, Journal, Year	Type of Study, Sample size, Follow-up	Characteristics & outcome	Comments Grade of Evidence
	GCS score of 13 to 15 and analysis of factors associated with abnormal CT findings. Br J Neurosurg, 10(5): 453-60.1996.	patients with mild head injury, seen over a 18 month period.	than those with a GCS of 15. Recommend separating patients with a GCS of 13-14 into a different category and to perform CT in all those not improving within 4-6 hours of injury. Such a policy would make skull x-rays unnecessary in this group. Skull radiographs may be useful for triage of patients with a GCS of 15.	
15	Lloyd DA Skull radiographs and children with blunt head injury. Br J of Surgery 85(5) 580-581 1998	Leading article. Review of 2 published reports on children with head injury.	Skull radiographs are not justified as a tool for diagnostic exclusion of intracranial injuries. Skull radiographs do not contribute to the care pathway of head injury management.	Poor
16	Frush et al Pediatric imaging perspective: Acute head trauma - Is skull radiography useful. J of Pediatrics. 132(3) 553-554 1998	General article.	Absence of skull fracture gives a fall sense of security that no significant injury is present. Skull radiographs can detect fractures, but are not useful in the management of head injury.	Poor
17	Lloyd et al Predictive value of skull radiography for intracranial injury in children with blunt head injury. Lancet 349(9055) 821-824 1997	Prospective study of 9 269 children with head injury over a 2 year period.	6 011 had skull x-rays. 162 had fractures. Of the 162, CT scan was done in 106 and 12 had intracranial injury. Serious intracranial injury can occur in the absence of skull fractures. Reliance on skull radiography alone has the risk of failing to recognise potentially severe intracranial injury. The presence of neurological	Good to Fair

No	Title. Author, Journal, Year	Type of Study, Sample size, Follow-up	Characteristics & outcome	Comments Grade of Evidence
			abnormalities is a more reliable indicator of intracranial injury than the presence of a skull fracture on the radiograph	
18	Stein SC, O'Malley KF, Ross SE Is routine CT too expensive for mild head injury? Ann Emerg Med, 20(12): 1286-9. 1991.	Retrospective record review. 658 patients with mild head injury. Hypothetical costs were calculated based on actual length of hospitalisation, surgical intervention.	Average cost if every patient had been admitted for observation, given a skull radiograph, with CT scans done on those exhibiting fractures or later deterioration was $1.207. If CT scan had been used to identify patients with intracranial lesions and others had been discharged, costs would have been almost 10% less. If skull radiography had been used to screen admissions, costs would have been 22% below those of routine CT scanning. However, this savings is likely to be reduced by additional expenses related to miss intracranial lesions.	Poor
19	Lloyd D.A Skull Radiographs and Children with blunt Head Injury. B.J. Surgery 1998. 85: 580 – 581	Review article.	Routine skull X-Ray does not contribute to the care pathway in children with blunt head injury.	Fair
20	.Pasman P, Twijnstra A, Wilmink, J, Leffers P. *The value of skull radiographs in patients with head trauma.*	Retrospective study involving 1218 patients.	1. Low risk group- Skull X-Ray had no significance. 2. Moderate risk group- Negative skull radiography did not fully exclude intracranial complications. 3. High- risk group - There were many patients with	Fair

No	Title. Author, Journal, Year	Type of Study, Sample size, Follow-up	Characteristics & outcome	Comments Grade of Evidence
	J. Belgenian Radiology 1995. Jun; 78 (3): 169 - 171.		intracranial hematoma in the PRESENCE OR ABSENCE of a skull fracture.	
21	Toupin JM,.Leche Vallier J, Chaput E, Dacher JN, Le-Dosseur P, Proust B,.Mitrofanoff, P.. *Selective indications of skull radio-graphy after head injury in children*. Rev-Chir-Orthop-Reparatrice-Appar-Mot.1996; 82(3): 201 .07. French.	Prospective study since Feb.94 till 1996	1. Since Feb. 1994, no skull X-Rays were performed in children after head injuries except in those with possible skull penetration, depressed fracture or basilar fracture. 2. This resulted in a decrease of 2000 X-Ray examinations per year. 3. There was no undiagnosed neurological complication. 4. Routine skull X-Rays after head trauma are NOT JUSTIFIED either for financial or radio protection reasons.	Fair
22	Moreea S., Jones S, Zoltie N. *Radiography for head trauma in children: What guidelines should we use?* J. Accid - Emer- Med. 1997 Jan; 14 (1): 13 - 5.	Audit study of 569 children attending a large teaching hospital A & E department.	1. 50% of Children presenting with head injury actually had skull radiography. 2. If British guidelines for the use of skull radiography had been complied with, 63% of Children would have radiography. 3. If American guidelines had been used, 18% would have required radiography. All actual fractures identified were in this 18%.	Fair
23	Lloyd D.A, Carty H, Patterson M., Butcher CK,.Roe D. Predictive value of skull radiography for intracranial injury in children with blunt	A 2 year Prospective study of 9 269 children. 6 011children were	1. The presence of neurological abnormalities had a sensitivity for identification of intracranial injury of 91%, and a negative predictive value of 97%. 2. The corresponding values for skull fracture on radiography were 65% and 83%.	Fair

No	Title. Author, Journal, Year	Type of Study, Sample size, Follow-up	Characteristics & outcome	Comments Grade of Evidence
	head injury. Lancet.1997 Mar. 22; 349 (9055): 821 - 4.	referred for skull radiography.	<u>Interpretation:</u> 1. In children severe intracranial injury can occur in the absence of skull fracture. Skull radiography is NOT a reliable predictor of intracranial injury. 2. Skull X-Rays are indicated in the following instances:- (i) To confirm or exclude a suspected depressed fracture. (ii) In penetrating head injuries. (iii) When non-accidental injuries is suspected, including in all infants younger than 2 years. 3. Clinical neurological abnormalities are a reliable predictor of intracranial injury. 4. If imaging is required it should be with CT and not skull radiography.	
24	Clarke J.A, Adams JE. The application of clinical guidelines in the skull radiography in the accident and emergency department: theory and practice Clinical Radiology 1990 March; 41(3): 152 -5.	Prospective Study.	1. Pre- implementation of guidelines - 94 skull X-Rays per 1000 new casualty cases. 2. Post implementation of guidelines - Rate of skull radiography fell by 40% initially, but gradually increased to pre-implementation levels in 12 months. 3. In the process almost 10,000 was saved. 4. Clinical guidelines for skull radiography can reduce the number of skull radiographs without detriment to the care of the head injured patient.	Fair

No	Title. Author, Journal, Year	Type of Study, Sample size, Follow-up	Characteristics & outcome	Comments Grade of Evidence
			5. The application of these guidelines needs to be strongly motivated and regularly monitored.	
25	Duus B.R. *An audit on guidelines used for the initial management of patients with minor head injuries in Denmark.* Acta - Neuro Chir - Urien 1997; 139 (8): 743 - 8.	Audit study. Population Covered = 5,146,000. 895,000 patients received questioners. 94% response.	1. More than 80% of the participating hospitals recommended admission if the patient reported unconsciousness, significant headache, dizziness or nausea and vomiting. 2. Skull X-Rays were always used in only 2/64 hospitals.	Fair
26	Miller E.C, Holmes JF, Derlet R.W *Utilizing clinical factors to reduce head* *CT Scan ordering for minor head* trauma patients. J. Of Emergency Medicine 1997 Jul - Aug; 15 (4): 453 - 7.	Prospective study of 2143 patients.	1. All patients sustained acute minor head injury with L.O.C. The risk factors studied were: severe headache, nausea, vomiting and depressed skull fracture. 2. CT Scan abnormalities in the NO RISK factor group were not clinically significant. 3. All 5 patients who required operative intervention had at least ONE of the risk factors present. The use of 4 simple clinical criteria in minor head trauma patients would allow a 61% reduction in no. of head CT Scans performed, and still identify all patients who required neurosurgical intervention and the majority of patients with an abnormal CT Scan.	Fair

No	Title. Author, Journal, Year	Type of Study, Sample size, Follow-up	Characteristics & outcome	Comments Grade of Evidence
27	Arienta C, Caroli M,. Balbi S. Management of head injured patients in the emergency department: a practical protocol. Surg- Neurol. 1997 Sept; 48(3): 213-9.	Retrospective analysis of 10,000 head injured patients in a A&E Dept. over a 21 month period.	1. Group A -- No LOC, no vomiting or amnesia, normal neurological examination, minimal if any sub-galeal swelling. RX:- Sent home. Special instruction sheet to relative. NO X-RAYS. Out come: No complications. 2. Group B -- Patient had at least one of the following features: Transient LOC, Post-traumatic amnesia, Single episode of vomiting and significant subgaleal swelling. RX: - Do CT Scan. If normal, give short period of observation. If NO CT Scan, do SKULL X-RAY. If fracture, send for urgent CT Scan. Outcome:- No patient with NORMAL SKULL X-RAY developed intracranial lesions. 3. Group C --Patients had at least one of the following symptoms:- Impaired consciousness, repeated vomiting, neurological deficits, ottorrhagia, otorrhea, rhinorrea, signs of basal skull fracture, seizures , penetrating or perforating wounds, lacks of co-operation, had previous intracranial operations, having coagulopathy or on anticoagulation rx., epileptic or alcoholic patients. RX: - Receive immediate CT Scan. 4. Group D -- Comatose patients. RX: - immediate resuscitation followed by CT Scan. CONCLUSION: - The above protocol stresses the importance of the patient's clinical	Fair

No	Title. Author, Journal, Year	Type of Study, Sample size, Follow-up	Characteristics & outcome	Comments Grade of Evidence
			and amnestic evaluation upon arrival in an A & E Dept. especially in minor head injuries.	
28	Stiell I.G, Wells GA, K. Vandemheen A,. Laupacis,. Brison R, Eisen Hauer MA. *Variation in Emmergency Dept. Use of CT for patients with minor head injury*. Ann. Emerg - Med. 1997 July: 30(1): 14 - 22.	Retrospective study over a 12-month period. 1 699 patients were seen.	There was considerable variation among institutions and individual physicians in the ordering of CT for patients with minor head injury. Yield of radiography was VERY LOW at all hospitals. Patients may be managed safely with a selective approach to CT Scan use. There is a great potential for more standardized and efficient use of CT of the head.	Fair

ROLE OF ROUTINE SKULL RADIOGRAPHS IN MINOR HEAD TRAUMA

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
1.	Harrad FT, Kerstein, M.D. *Inadequacy of Bedside Clinical Indicators in Identifying Significant Intracranial Injury in Trauma Patients*. J. Of Trauma, 1998; 32(3): 359-63.	Review of 1 875 consecutive patients at a Level 1 trauma center from 1987 and 1988.	Four hundred and ninety seven consecutive CT scans were done. Criteria for CT scan: 1. LOC 2. Amnesia 3. GCS < 13 4. Depressed or open skull fracture 5. Deteriorating mental status 6. Pupillary inequality Abnormal CT's in 43/251(17%) patients with GCS 15; 9/40(23%) patients with GCS 14; 3/11(27%) with GCS 13. In patients with GCS of 13 or greater, 4% required craniotomy, 1% needed medical treatment to maintain ICP. Emergency Dept. CT scan should be performed in all patients with LOC or amnesia regardless of GCS score. In patients with GCS> 13, 18% will have abnormal CT and 4% will require craniotomy.	**Poor**

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
2.	Harad FT et al. Inadequacy of Bedside Clinical Indicators in Identifying Significant Intracranial Injury in Trauma Patients. J. Of Trauma, 1992; 32(3): 359-63.	Review of 1875 consecutive patients with possible head trauma admitted to a Level I trauma center.	Four hundred and ninety seven CT scans were done in the Emergency Dept. to evaluate intracranial trauma. Of these 497 patients with CT scans, 251 had GCS 15, 40 had GCS 14, 11 had GCS 13 and the rest had GCS < 13. Abnormal CT scans were seen in 17% of patients with GCS 15; 23% with GCS 14; and 27% with GCS 13. Overall, abnormal CT scans were seen in 18% of patients with GCS 13 or higher. In these groups of patients, 11 (4%) required craniotomy, 3(1%) required medical treatment to control ICP, 6(2%) needed repeat CT scans only. Emergency department CT scans should be done for all patients with LOC or amnesia regardless of GCS.	POOR.
3.	Sherman CS et al. Mild head injury: A plea for routine early CT scanning *J .of Trauma 1992; 33(1): 11-13.*	Review of 1 538 patients with GCS 13-15, LOC or amnesia and no focal neurological deficit during a 4 to 5 year period.	Routine CT scans were obtained on all patients. Two hundred and sixty five patients (17.2%) harbored 340 lesions on CT: 131 fractures and 209 intracranial abnormalities. Fifty-eight patients (3.8%) needed operations for intracranial lesions of which 23 had no skull fractures. None of the 1 339 patients with normal CT deteriorated under observation. Clinical observation with or without skull x-rays is inadequate to rule out potentially dangerous	Poor

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
			intracranial lesions. If there is history of LOC or amnesia, immediate CT scan is indicated. If CT is normal, and there are no other indications for admission, the patients may be safely discharged.	
4.	Vincent PC et al. *Clinicopathological Heterogeneity in the Classification of Mild Head Injury*. Neurosurgery 1996; 38(2): 245-50.	Retrospective study of 3370 patients with non-missile head injury, loss of consciousness, and GCS 13-15 from 1990-1992.	Head CT scans were done for 3 107 patients within the first 24 hours. GCS 15: 95 / 2 179 (4%) abnormal CT; 10 / 2 398 (0.4%) required Neurosurgical intervention. GCS 14: 118 / 755 (16%) abnormal scans. 13 / 796 (1.6%) required neurosurgical intervention. GCS 13: 48 / 173 (28%) had abnormal scans. 8 / 176 (4.5%) needed neurosurgical intervention. The implicit assumption of clinical pathological homogeneity among patients with GCS 13-15 is challenged. Statistically significant differences between the frequency of positive CT scans and need for neurosurgical intervention between patients with GCS 15 and 14; 14 and 13 and 15 versus 13.	Poor
5.	Lloyd DA et al Predictive value of skull	Over a 2 year period, 9 269	CT scans were done for all children with skull fractures and in those without fractures if there were	Fair

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
	radiography for intracranial injury in children with blunt head injury. Lancet; 349 March 22, 1997	who attended the A&E with head injury. 6 011 were referred for skull x-ray.	neurological indications. All patients who had skull fracture or were admitted to hospital (n=883) were included into the study. Radiographs showed 162 fractures (2.7% of all radiographs and 18% of study group radiographs). Presence of neurological abnormality had sensitivity of identification of intracranial injury of 91%(21 of 23) and a negative predictive value of 97%. Corresponding values for skull fracture on radiography were 65%(15 of 23) and 83%. Four children died of whom only one had a skull fracture.	
6.	Sherman CS et al. The value of CT scans in patients with low-risk head injuries. Neurosurgery 1990. 26(4): 638-40.	Retrospective review of 658 patients with head injury and GCS 13-15, who had LOC or amnesia after the injury.	Abnormalities on CT were seen in 18% of patients. 5% required surgery. Among the 32 patients with GCS 13,40% had abnormal CT and 10% required surgery. None of the 542 patients with normal CT on admission showed subsequent deterioration and none needed surgery. History and physical examination alone are inadequate to assess head injury or severity of risk and CT scans greatly improves patient assessment	***Poor***
7.	Davis RL et al Use of cranial CT scans in the	Retrospective study of all	Four children were re-admitted for neurological reason within one month of injury.	Poor

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
	Triage of Pediatric Patients with Mild Head Injury Pediatrics 95(3) March 1995:345-49.	children (n=400) with head injury and GCS 13-15who had an initial normal CT scan over a 4.5 year period. Follow-up of one month period.	One child on Warfarin developed subdural haematoma requiring drainage 5 days after head injury. One child had hemorrhagic contusion 3 days after injury requiring observation only. Two children admitted for concussive symptoms one day after injury and were discharged after observation only. No deaths among study population.	
8.	Teasdale GM et al. *Risks of Acute Traumatic Intracranial Haematoma in Children and Adults: Implications in Managing Head Injuries*. BMJ. 10 February 1990. Vol. 300: 363-67.	Prospective study of 8406 adults and children accident and emergency departments and 1007 consecutive patients who had an operation for acute traumatic intracranial haematoma.	Adults: Without skull fracture • Fully conscious 1:7866 • Impaired consciousness 1: 180 • Coma 1:27 With skull fracture • Fully conscious 1:45 • Impaired consciousness 1:5.1 • Coma 1: 3.6 Children: Without skull fracture • Fully consciousness 1:12559	Poor.

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
			• Impaired consciousness 1:580 • Coma 1:65 <u>With skull fracture</u> • Fully conscious 1:157 • Impaired consciousness1:25 • Coma 1:12	
9.	Livingston DH et al. Minimal Head Injury: Is Admission Necessary? American Surgeon. 57(1): 14-17. January 1991.	Retrospective review of 138 patients with GCS 14 and 15 after head injury.	GCS was 15 in 103 patients (74%) and 14 in 35 patients (26%). Seven percent (5/71) of skull x-rays were positive, of which only 3 were associated with CNS pathology. SXR in an additional 4 patients with positive CT findings were negative including one patient with an extradural haemorrhage. Seventeen percent (13/75) of CT scans were positive (5 contusions, 3 subdurals, 2 subarachnoid, 2 cerebral oedema, 1 extradural). Only the patient with extradural needed surgery. No patient's with normal CT scans developed subsequent neurosurgical problems.	***Poor***
10.	Moran SG et al. Predictors of Positive CT scans in	Analysis of 200 patients with head injury and	Looked at the various parameters: 1. Scene GCS (SC-GCS)	Poor

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
	Trauma Patients with Minor Head Injury American Surgeon July 1994, Vol. 60:533-35	GCS 13-15.	2. Emergency room GCS (ER-GCS) 3. Change in GCS 4. Loss of consciousness (LOC) 5. Focal neurological deficit Ninety-six patients (48%) had CT brain. CT positive in 4% of the total group (8/200) and 8.3%(8/96) of the patients who had CT scans. In patients with no LOC and ER-GCS 13-15, all CTs negative. In the 93 patients with LOC, 8 (8.6%) had positive scans. Five of the 9 patients (55.6%) with skull fractures had positive scans. Of all the patients with positive scans, 2 had craniotomy, one for depressed skull fracture and one for epidural haematoma. Both had LOC and SC-GCS and ER-GCS of 15.	
11.	Murshid WR. Management of Minor Head Injuries: Admission Criteria, Radiological Evaluation and Treatment of Complications. Acta Neurochirurgica (Wien)	Review of 633 patients admitted to King Khalid University Hospital with mild head injury	Skull x-rays were done in 616 patients (97.3%) of which a skull fracture was found in 78 patients (12.7%). CT brain was done in 131 patients (20.7%): GCS 15 : 17/112 (15.2%) had abnormal scans GCS 14 : 5/8 (62.5%) had abnormal scans	Poor

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
	(1998) 140:56-64.	(GCS 13-15). .	GCS 13: 8/11 had abnormal scans (72.7%). Overall: 30/131 (22.9&) had abnormal scans Twenty-two patients (3.5%) required neurosurgical intervention. Six patients (0.9%) required neurosurgical intervention within 24 hours. Another 6 patients (0.9%) required neurosurgical intervention within a week of the injury.	
12.	Scackford SR et al *The Clinical Utility of CT scanning and Neurologic Examination in the Management of Head Injured Patients.* J. Trauma 1992; 33(3): 385-94.	Evaluation of 2 766 patients with mild head injury (History of LOC/post-traumatic amnesia/GCS ≥ 13).	A neurological examination and a CT were done in 1 166 patients: 1. 933 patients had normal neurological examination and normal CT and none required craniotomy. 2. 1 170 patients had normal CT and none required craniotomy. 3. 2 112 patients had normal neurological examination and 59 required craniotomy. The use of CT alone would have saved 3 924-hospital days and $ 1 509 012.00 in hospital charges. Based on this, recommend that CT scanning is essential in the management of patients with mild head injury and if the neurological examination is normal and the CT is negative, the patients can be safely be discharged from the Emergency Room.	Poor

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
13.	Poon WS et al. *Traumatic Extradural Haematoma of Delayed Onset is Not a Rarity*. Neurosurgery 30(5), 1995: 681-86	4 to 5-year period (1985 to 1990). 73 consecutive patients with traumatic extradural haematoma who required surgical evacuation were reviewed.	These came from a pool of 6200 patients with head injury admitted to a neurosurgical unit where a liberal policy for early CT brain is practiced: Patients with GCS 13-15 with skull fracture, confusion/ drowsiness, deteriorating consciousness and focal neurological signs, persistent symptoms and moderate/severe head injury undergo CT brain. Twenty-two patients with delayed EDH are reported. Incidence in this study was 30%. Reported incidence in literature was 0-10%. Overall mortality was 5% and related to cases of delayed onset.	Poor
14.	Chan KH et al. *The significance of skull fracture in acute traumatic intracranial haematomas in adolescents: a prospective study*. J Neurosurgery 1990; 72:189-94.	Study of 1 178 patients with head injury. Of these, 418 were admitted and the rest discharged.	All patients had skull x-rays in three views: AP, Lateral, and Towne. Immediate CT was done if GCS was less than 15, radiological/clinical evidence of skull fracture and where clinically indicated. Of the 418 patients, 26 had skull fractures, and among these, 13 developed ICH (10 with admission GCS of 15). Found that skull fracture was the only independent risk factor for ICH in adolescence by multivariate analysis.	Fair.

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
15.	Thornbury JR et al *Imaging Recommendations for Head Injury: A new comprehensive strategy*. ARJ Oct. 1987; 149:781-783	Multi-disciplinary panel report.	**Low risk** Asymptomatic, headache, dizziness, scalp haematoma / laceration, scalp contusion or abrasion and absence of moderate or high-risk criteria: Recommendation: Observation. **Moderate risk** History of change in consciousness, progressive headache, alcohol/drug intoxication, age less than 2 years unless very trivial injury, seizures, vomiting, amnesia, signs of basilar fracture, possible skull penetration or depressed fracture, suspected child abuse: Recommendation: Extended close observation and consider CT. **High risk** Depressed level of consciousness, focal neurological signs, decreasing level of consciousness penetrating skull injury or palpable depressed skull fracture: Recommendation: Emergency CT.	Poor.
16.	Masters SJ Evaluation of Head trauma: Efficacy of skull films. AJR: 135, Sept 1980.	A review of 1845 patients to evaluate the efficacy of skull film in acute	Seventy-nine patients had skull fractures (4.3%) Thirty-three sustained significant intracranial injury but only 7 of these had fractures (21.2%). Skull fractures alone seldom indicate more serious head injury.	Poor.

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
		head trauma.	Patients with "high-yield" features e.g. LOC, altered consciousness, amnesia, should have a CT scan as the primary diagnostic procedure of choice.	
17.	Miller JD et al *Development of a traumatic intracranial haematoma after a "minor" head injury*. Neurosurgery 1990; 27(5): 669-73		Analysed patients who had initially appeared to have mild head injury (GCS 15) but who subsequently underwent an operation for intracranial haematoma. A history of altered consciousness or symptoms of headache and vomiting was present in 61%; 33% had focal neurological deficit, 43% had either focal deficit or signs of base of skull fracture. Skull fracture was detected clinically in 60% of these patients including 52% not clinically suspected of having an intracranial lesion. The possibly of developing a significant intracranial lesion in a pt who has recently sustained head injury can never be completely discounted, even when there are no abnormal clinical signs. Skull x-rays retains a useful place in the investigation of selected patients with minor head injury.	Poor
18.	Servadei F et al. Skull fractures as a factor of increased risk in minor head injuries: Indication for a broader use of cerebral computed CT scanning	Prospective study of CT scans of a total of 182 patients differing only in the presence or	Intracranial abnormalities occurred in 105(38%) of patients with skull fractures compared to with 6% of those without skull fractures. All operations were done in patients with a skull fracture, none in those without.	Fair

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
	Surg Neurol 1988; 30:364-9	absence of skull fractures.		
19.	Gomez PA et al. Mild Head Injury: Differences in prognosis among patients with a Glasgow Coma Scale of 13 to 15 and analysis of factors associated with abnormal CT findings. Br J Neurosurgery 1996; 10(5): 453-60	A retrospective study of 2 484consecutive patients with mild head injury (GCS 13-15) over a period of 18 months.	Of these, 2 351(94.6%) had GCS 15, 88(3.5%) had GCS 14 and 45(1.3%) had GCS13. A multivariate analysis showed that advanced age, a GCS 13-14, presence of a skull fracture and focal signs significantly increased the incidence of abnormal CT findings. By contrast, gender, mechanism of injury, the occurrence of LOC and post-traumatic amnesia and coagulation defects did not increase the incidence of abnormal CT findings. Patients with GCS 13-14 had a higher incidence of initial LOC, skull fracture, abnormal CT findings, need for hospital admission, delayed neurological deterioration and need for operation compared with patients with a GCS of 15. A skull fracture influenced the presence the presence of abnormal CT findings as follows: The presence of abnormal CT in patients with a skull fracture who have: 1. No LOC, no PTA: Increased from 1.2 to 76.5% ($p<0.0001$) and need for operation from 0.1 to 29.4% ($p<0.0001$)	Poor

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
			2. With LOC: Increased from 2.9 to 72.7% ($p<0.0001$) and need for operation from 0.9 to 29.5% ($p <0.0001$) 3. With PTA only: Increased from 0% to 20%. Overall, when there was a fracture present, there is a significantly higher incidence of abnormal CT findings (69.7%) and the need for operation (28.8%) compared to when a skull fracture was absent (1.6 and 0.35%, respectively; $p<0.001$). <u>Suggested:</u> 1. Separating patients with GCS 13-14 into a separate category and performing a CT in all whom did not improve within 4-6 hrs from the injury. Such a policy makes skull x-ray unnecessary in this subgroup. 2. SXR useful in triaging patients with GCS 15 and should be obtained in patients presenting with initial LOC or post traumatic amnesia as these two were associated with a significantly higher incidence of skull fractures. Patients without these two findings could be discharged home with a warning sheet, as incidence of skull fracture is very low (0.9%).	

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
20.	Lloyd DA Skull radiographs and children with blunt head injury. British J Surg, 85(5), 1998; 580-81		Recommended that skull x-rays be used only for suspected non-accidental injury in children under 2 years old, suspected penetrating injury by foreign body and in suspected depressed fracture. Concluded that skull x-rays were not reliable as a triage tool in children with blunt head trauma and that in cases where significant injury is suspected, a CT scan is indicated.	Poor
21.	*Frush DP et al* Pediatric imaging perspective: Acute head trauma – Is skull radiography useful? Journal of Paediatrics, 132(3), 1998; 553-4		Questions the justification of skull x-rays in head trauma. Suggest that SXR might be useful in suspected penetrating injury by foreign body, depressed skull fracture, to preserve patient-doctor relationship when the relatives request a SXR. Any suspicion of significant intracranial injury should be investigated with a CT scan.	Poor
22.	Wiederholt W.C. Short-term out come of skull fracture: A POP" based study of survival and neurological complications. Neurology, Vol. 39,No 1, Jan 1989.	Large (4,660) Population based - Study.	Because of the rather low yield of routine skull X-Rays, particularly in patient's with mild head injuries, the wisdom of obtaining X-Rays has been questioned.	Fair

No.	Title, Author, Journal, Year	Type of Study, Sample Size, Follow-up	Characteristics and Outcome	Comments and Grade of Evidence
23.	Chan K.H, Yue CP, Mann.KS The risk of intracranial complications in paediatric head injury. Results of a multivariate analysis. Childs- Nervous System. 1990 Jan; 6(1): 27-9.	Retrospective analysis of 12,072 paediatric head injury cases.	1. Study revealed 2 risk factors that could be recognized easily by primary care physicians that were significant in predicting the development of intrarcranial complications. a) Impairment of conscious at the time of admission. b) Clinical and / or radiological skull fracture. 2. The combination of impaired consciousness and skull fracture carried the highest risk of complication (75%). 3. Presence of impaired consciousness alone has an intermediate level of risk.(19%). 4. Presence of skull fracture alone carried a small overall risk (2%). 5. Absence of all risk factors, carried a negligible risk, provided proper skull X-Rays were taken and correctly interpreted	Fair
24.	Brisman. MH; Camins MB Radiographic evaluation of patients with head injury Mt. Sinai-J- Med. 1997, May: 64 (3): 226 - 32.	Literature Review.	A non-contrast CT of the head is the Study of Choice for patients with head injury and should be performed whenever there is reasonable suspicion of a serious injury to the brain.	Fair

COST IMPLICATIONS

No	Title, Author, Journal, Year	Type of study, Sample size, Follow-up	Characteristic & Outcome	Comments Grade of evidence
1	*Cost benefits of skull radiography for head injury. Under guidance of RCR working party of effective use of Diagnostic Radiology.* The Lancet October 10, 1981.	Prospective study. 10 weeks. 9 Accident Emergency units in England, Wales and Scotland. Questioner: 12 questions. - 10 on symptoms/ clinical signs. - 2 on how to dispose patient Sample size: 5850 divided in 3 groups: Group I: Complicated head injury (10210 Group II: Uncomplicated,	Group I: 1021 SXR: Depressed fracture 4 Basal fracture 4 Frontal fracture 3 Vault fracture 44 Radiological cost per antecedent detected: 167 Group II: 3328 SXR: Vault fracture 23 1 ICH (surgical evacuation). Radiological cost per antecedent detected: 1302 Group III: 1501 SXR: Basal fracture 2 Frontal fracture 1 Vault fracture 41 3 ICH – 1 no fracture 2 with fracture Radiological cost per antecedent detected: 307 Clinical/ Radiological outcome of uncomplicated head injury (4829): fracture present 67; no fracture 4762 Total Intra-cranial haemorrhage: 4 - 2 clinically +ve with fracture skull - 1 clinically +ve, no fracture skull - 1 clinically –ve, fracture skull (3 suspected clinically)	

No	Title, Author, Journal, Year	Type of study, Sample size, Follow-up	Characteristic & Outcome	Comments Grade of evidence
		clinically negative (3328). Group III: Uncomplicated clinically positive (1501).	Therefore, only 1 patient SXR contributed in detection of intra-cranial haemorrhage (1 in 4 800) Cost for detection: USD 43 200.00	
2	Clarke J.A, Adams J.E. *The application of clinical guidelines in the skull radiography in the accident and emergency department: theory and practice.* Clinical Radiology 1990 March; 41(3): 152-5	Prospective study	1. Pre implementation of guidelines – 94 skull x-rays per 1000 new casualty attenders. 2. Post implementation of guidelines – Rate of skull radiography fell by 40% initially, but gradually increased to pre-implementation levels in 12 months. 3. In the process almost 10 000 was saved. 4. Clinical guidelines for skull radiography can reduce the number of skull radiographs without detriment to the care of head injured patient. 5. The application of these guidelines needs to be strongly motivated and regularly monitored.	Fair

LEVELS OF EVIDENCE SCALE

Level	Strength of Evidence	Study Design
1	Good	Meta-analysis of RCT, Systematic reviews.
2	Good	Large sample of RCT
3	Good to fair	Small sample of RCT
4		Non-randomised controlled prospective trial
5	Fair	Non-randomised controlled prospective trial with historical control
6	Fair	Cohort studies
7	Poor	Case-control studies
8	Poor	Non-controlled clinical series, descriptive studies multi-centre
9	Poor	Expert committees, consensus, case reports, anecdotes

SOURCE: ADAPTED FROM CATALONIAN AGENCY FOR HEALTH TECHNOLOGY ASSESSMENT (CAHTA), SPAIN

Appendix 2

COSTING FOR PER SKULL EXAMINATION

MACHINE (1)

Table I: Capital cost (fixed and variable costs) involved in doing skull radiographs

Items	Types of direct cost	Life span (years)	Cost (RM)	Service contract (RM)/year	Cost (RM)/year
General radiographs machine	Fixed	10	250 000	8 800	33 800
Radiographs film processor	Fixed	10	80 000	3 600	11 600
Radiographs tube	Variable	4 (150 000 exposures)	70 000	-	17 500

Note: Utility cost i.e. water and electricity used for processing the films is not included in the costing

To calculate the machine cost, both fixed cost items are not taken into consideration here; and only the cost of the radiograph tube is considered. Skull radiograph in Kota Bharu Hospital represents 10.35% (4 631) of the annual workload.

Total cost for doing skull radiographs RM 70 000 x (10.35 /100) = RM 7 245.00
Cost per exposure RM 7 245 / 4 631 = RM 1.56

*Cost of machine / Case **(2 projections for every case)*** = *RM 3.13*
(*Assuming that the cost is equal, regardless of the difference in selected exposure factor*)

CHEMICAL SOLUTIONS (DEVELOPER AND FIXER) (2)

Table II: The amount of chemicals used by 3 processors for 3 months (October - December, 1998) in Kota Bharu Hospital, Kelantan

Items	Cost (RM) / set	Number of sets used	Total cost (RM)
Developer	69.49	27	1 876.23
Fixer	46.29	33	1 527.57
TOTAL	115.78	60	3 403.80

Total of 15 300 films (different sizes) were processed during the 3 months period.
Processing cost RM 3 403.80 / 15 300 = RM 0.222

Cost of chemical solution / Case = RM 0.444
(*Assuming that the cost for processing is equal for all size of film*)

COST OF FILM (3)

Film size : 12” x 10”

Film cost : RM 0.6286

*Cost of film / Case **(2 projections for every case)*** = *RM 1.257*

(*Assuming that all skull radiographs are using film 12” x 10*”)

MANPOWER (4)

Table III: Staff salary according to category

Staff category	Salary		Salary (RM)/ month for performing 10.35% skull radiograph	Total salary (RM)/ year for performing 10.35% skull radiograph	Average cost (RM)/case
	Minimum (RM)	Maximum (RM)			
U7	1 360.00	2 339.00	140.76 – 242.09	1 689.12 – 2 905.04	0.496
U8	975.00	1 943.00	100.91 – 201.10	1 210.92 – 2 413.20	0.391
U14	440.00	1 036.00	45.54 – 107.23	546.48 – 1 286.76	0.198

Note: These costs do not include other category of staff i.e. Specialist and the Consultant as well as the cost for paying overtime is also not considered

Manpower cost:

i. If the examination is done by the U8 and U14 : = RM 0.589

ii If the examination is done by the U7 and U14 : = RM 0.694

Cost of manpower/case = *RM 0.642*

AVERAGE COST OF SKULL RADIOGRAPHS / CASE = (1)+(2)+(3)+(4)

= RM 5. 47

LIST OF HEALTH TECHNOLOGY ASSESSMENT REPORT

TOPIC	**YEAR**
1. LOW TEMPERATURE STERILISATION	1998
2. DRY CHEMISTRY	1998
3. DRY LASER IMAGE PROCESSING	1998
4. ROUTINE SKULL RADIOGRAPHS IN HEAD INJURY PATIENTS	2002
5. STROKE REHABILITATION	2002