PREDICTORS OF IMPORTANT CT FINDINGS AND NEUROSURGICAL INTERVENTION IN MINOR HEAD INJURY

By

Dr. LAILI SURIANI AB. LATIP

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Supervisor:
Assoc. Prof. Dr Hj Nurul Azman Bin Ahmad Alias

To

My Husband: Dr Abd. Rahim Bin Abd. Ghani

My sons: Muhamad Luqman & Muhamad Ashraff,

My parents: Hj Abd. Latip & Hjj Maimunah

With Love

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ABBREVIATIONS

CONT.	Contusion
CT	Computed Tomography
CNS	Central Nervous System
ED	Emergency department
EDH	Extradural haemorrhage
GCS	Glasgow Coma Scale
IPH	Intra-parenchymal haemorrhage
MLS	Midline shift
MRI	Magnetic Resonance Imaging
No.	Number
PNEUMO	Pneumocephalus
SAH	Subarachnoid haemorrhage
SDH	Subdural haemorrhage

ABSTRAK

Bahasa Malaysia

Tajuk: Faktor klinikal yang meramal penemuan penting dalam imbasan tomografi berkomputer and keperluan intervensi neuro bagi pesakit kecederaan kepala ringan.

Latarbelakang: Di antara semua kecederaan kepala, kecederaan kepala ringan merupakan suatu kumpulan kecederaan kepala yang paling kerap berlaku dimana ia menyumbang sebanyak 70 – 80 % kes yang ditemui di Jabatan Kecemasan. Kecederaan kepala ringan didefinasikan sebagai seseorang yang mengalami hentakan di kepala yang mengakibatkan pengsan dan / atau hilang ingatan. Sementara itu, skala koma Glasgow pula adalah di antara 13 – 15. Penggunaan imbasan tomografi berkomputer ke atas semua pesakit yang mengalami kecederaan kepala ringan adalah suatu perkara yang kontroversi. Ini disebabkan peratusan keputusan penting yang di perolehi dari imbasan berkenaan adalah kecil berbanding dengan kos tinggi yang membabitkan penggunaan imbasan tomografi berkomputer. Peratusan pesakit yang menjalani intervensi neuro juga amat kecil untuk menjustifikasikan kegunaan rutin imbasan tomografi berkomputer. Penggunaan faktor klinikal untuk meramal samada pesakit perlu untuk menjalani pemeriksaan imbasan tomografi berkomputer dilihat sebagai suatu perkara yang berpatutan untuk mengurangkan kadar penggunan imbasan tomografi berkomputer ke atas semua pesakit kecederaan kepala ringan. Faktor-faktor klinikal ini boleh digunakan oleh para doktor untuk meramalkan penemuan penting hasil dari imbasan tomografi berkomputer and keperluan intervensi neuro.

Objectif & Kaedah: Tujuan penyelidikan ini adalah untuk mengenal-pasti faktor – faktor klinikal yang boleh meramal penemuan penting hasil daripada imbasan tomografi berkomputer dan keperluan intervensi neuro di kalangan pesakit kecederaan kepala ringan. Sebanyak 15 faktor klinikal telah di siasat hubung-kaitnya dengan penemuan penting imbasan tomografi berkomputer dan keperluan intervensi neuro. Data pesakit di rekodkan samada secara retrospektif atau prospektif. Ramalan faktor klinikal kemudian dianalisis berdasarkan kaedah analysis "univariate" yang kemudiannya dilanjutkan kepada 'Multiple Logistic Regression'.

Keputusan: 94 orang pesakit prospektif dan retrospektif yang mengalami kecederaan kepala ringan telah dikenalpasti. Daripada jumlah tersebut, 50 kes (53.2%) didapati mempunyai penemuan penting dari imbasan tomografi berkomputer manakala 19 pesakit (20.2%) telah dikenal pasti memerlukan intervensi neuro. Terdapat dua faktor klinikal yang terbukti signifikan di dalam menentukan keputusan imbasan tomografi berkomputer. Skala koma Glasgow yang kurang dari 15 boleh meramalkan keputusan penting imbasan tomografi berkomputer sebanyak 18.7 kali lebih berbanding dengan pesakit yang mempunyai skala coma Glasgow yang penuh. Begitu juga dengan kehadiran retak tempurung kepala yang boleh meramalkan keputusan penting imbasan tomografi berkomputer iaitu sebanyak 56 kali lebih berbanding dengan pesakit yang tidak mengalami retak. Kaedah kecederaan pula memainkan peranan yang penting untuk meramalkan keperluan intervensi neuro. Kaedah kecederaan selain daripada kemalangan kenderaan (yakni yang meliputi kecederaan pejalan kaki, jatuh dari ketinggian, terhentak

objek dan kes 'assault') merupakan faktor klinikal penting yang berkaitan dengan keperluan intervensi neuro.

Kesimpulan: Skala koma Glasgow kurang daripada 15 dan retak tempurung kepala merupakan dua faktor klinikal yang penting untuk meramal penemuan penting imbasan tomografi berkomputer. Saranan telah dibuat supaya kecederaan kepala ringan perlu untuk direklassifikasikan semula berdasarkan kepada skala koma Glasgow. Kecederaan kepala ringan perlu hanya untuk pesakit yang mempunyai skala koma Glasgow penuh iaitu 15 manakala kecederaan kepala ringan yang berisiko tinggi untuk pesakit yang mengalami skala koma Glasgow antara 13 dan 14. Sekiranya pesakit mengalami keretakan tempurung kepala atau pesakit yang mendapat kaedah kecederaan seperti yang tersebut diatas, pesakit adalah berisiko tinggi dan perlu menjalani imbasan tomografi berkomputer segera jika keadaannya stabil.

ABSTRACT

English

Topic: Predictors of Important CT findings and Neurosurgical Intervention in minor head injury.

Background: Of all patients with head injury, minor head injury represents the most common visitors of the emergency department. It contributed to about 70 – 80 % of all head injury cases that are seen in the Accident and Emergency department. Minor head injury is generally defined as those with history of blow to the head in which has resulted in loss of consciousness and / or amnesia with Glasgow Coma Score of 13 to 15. It is controversial whether cranial CT scan should be performed on all patients, as the yield of positive CT scan is low as opposed to its high cost. The rate of neurosurgical intervention is even lower to justify the routine use of CT scan on this patient. The use of clinical variables as a screening tool before deciding to embark on CT scan is appropriate in order to reduce the number of CT scan performed on all patients with minor head injury. The clinical variables can than be used by the attending doctors in predicting important CT findings and the need of neurosurgical intervention.

Objectives and Method: The aim of this study is to evaluate clinical variables that can be used to predict important CT findings and the need of neurosurgical intervention among patient who presented with minor head injury. A descriptive study was conducted on 94 patients who had history of blow to the head, with Glasgow Coma Score of 13 to 15 and had cranial CT scan examination. There were a total of 15 clinical variables that

were correlated with two outcomes. The outcomes were important CT findings and the need of neurosurgical intervention. The predictors of important CT findings and the need of neurosurgical intervention were derived after performing initial univariate analysis, which was then followed by Multiple Logistic Regression.

Result: There were a total of 94 retrospective and prospective patients with minor head injury. 50 patients (53.2 %) had important CT findings and 19 patients (20.2 %) had neurosurgical intervention. There were two significant predictors of important CT findings. The presence of GCS score of 14 and 13 were associated with nearly 19-fold increase in the risk of developing important CT findings compared to patients with full GCS score. 3 out of 4 patients with GCS score of 14 or 13 developed clinically important brain injury on CT scan examination. Similarly, the present of skull fracture was associated with 56-time increase risk of developing important CT findings. 8 out of 10 patients with skull fracture developed clinically important CT findings. Mechanism of injury was the only predictor of neurosurgical intervention. Non-motor vehicular accident in which included pedestrian injury, fall from height, falling object, assault cases and others were associated with four-fold increase risk of needing neurosurgical intervention.

Conclusion: Glasgow Coma Score of less of 15 and skull fractures were significant clinical variables in predicting important CT findings in patients with minor head injury. Therefore, proposal was made for reclassifying minor head injury in which it should be based on the GCS score. Patients with full GCS score of 15 were classified as mild head injury, while patients with GCS score of 13 and 14 were at higher risk of developing

brain injury and therefore categorized as "high-risk mild head injury". Those patients with skull fracture regardless of other clinical findings would automatically qualified the patient into high-risk group. The high-risk group needed urgent cranial CT scan examination. Particular mechanism of injury which included pedestrian injury, fall from height, falling object and assaulted cases predisposed the patient for neurosurgical intervention and therefore classified as high-risk mild head injury as well.

SECTION ONE

INTRODUCTION

INTRODUCTION

Head injury is common in modern society. Of all patients with head injury, minor head injury represents the most common attenders of the emergency department. Generally, minor head injury is defined as any patient with a history of blow to the head resulting in loss of consciousness and amnesia with GCS score of 13 – 15. Although minor head injury represents the majority of head trauma patients, the management of minor head injury remains controversial and confusing.

There has been much debate on whether to perform cranial CT scan on every patient with minor head injury. The decision to obtain cranial CT scan in every patient with minor head injury is due to the anxiety of the clinician missing potentially curable intracranial haematoma as well as for the medico-legal consequences. Although most patients with minor head injury can be safely discharged without sequelae after a period of observation, there is a group of patients who has significant intracranial injury that necessitate neurosurgical intervention. Early neurosurgical intervention is important in improving the prognosis of such patient. Therefore, cranial CT scan is essential to identify such patient. However, one can argue that the blanket rule of performing cranial CT scan on every patient with minor head injury is unjustifiable as the rate of positive CT findings and neurosurgical intervention are low. The low yield of CT scan findings among patients with minor head injury suggests great potential for reducing the use of CT. It is clear that CT scanning is an expensive modality used as screening tools and therefore, more selective use for patient with minor head injury could lead to large reductions in health-care cost.

There is a clear need for a valid and reliable clinical guidelines to allow doctors to be more selective in the use of cranial CT without compromising the care of the patients with minor head injury. The used of clinical variables in deciding whether to perform cranial CT scan is appropriate in order to reduce the number of performing CT scan on all patients with minor head injury. Clinical variables are identified based on history and physical examination. A patient who presented with minor head injury can be screened using the clinical variables. This set of clinical variables can be used by the attending doctors to predict which patients that need urgent cranial CT assessment. By utilizing this clinical variable, the patient that needs neurosurgical intervention can be identified. This rule will allow doctors in emergency department to order cranial CT for their patients based upon strong evidence and to provide consistent management without jeopardizing optimum patient care. Without selective guideline, there is very strong evident that the use of cranial CT for minor head injury will be markedly increase in the years to come (Stiell et al., 2001).

The aim of this study was to identify clinical variables in minor head injury that could be used to predict significant intracranial injury and the need for neurosurgical intervention. The main outcome measured the need of neurosurgical intervention and clinically important brain injury on CT scan.

SECTION TWO

LITERATURE

REVIEW

LITERATURE REVIEW

Head injury is a common problem in emergency department. It constitutes about 20 – 30% of all trauma admission (Fisher et al., 1981, Taheri et al., 1993). In the United States of America and other western countries, head injury does not only represent a serious cause of loss of life, it also adds to financial burden of the health care system. The financial burden is due to the increase in the resources in caring and treating these patients. In the United States of America, more than 500,000 Americans suffer from head injury per year (Stein et al., 1993). Similarly, head injury is also a common problem in United Kingdom where more than 150,000 patients with head injury are admitted to hospital each year (Thornhill et al., 2000).

In Malaysia, head injury is also a serious health problem. In the year 1998, the incidence rate of motor vehicle accident in Peninsular Malaysia was 112.3 per 10,000 population (KKM., 2000). The number of casualties due to motor vehicle accident in the year 1998 was estimated to be around 52,218 (KKM., 2000). From the year 1997 – 1998, accident was the third principal cause of hospitalization in MOH (Ministry of Health) hospital (KKM., 2000). Accident was the fourth principle cause of death in the year 1997 behind heart disease, septicaemia and cerebrovascular accident (KKM., 2000). In Hospital Universiti Sains Malaysia, which is a tertiary referral center with a neurosurgical unit, a total of 570 head injured patients were seen in the year 1999 (Record Office, HUSM). In the year 2001, a total of 1382 cases were reported to involve in motor vehicle accident in Kelantan in which 428 cases were fatal (Jabatan Polis Trafik, 2001). From

this number, 382 cases were reported to suffer from head injury (Jabatan Polis Trafik, 2001).

Serious head injury occurs in only 3 % of non-vehicular and 15% of vehicular injuries (Lee et al., 1999). Most cases of head injury in the emergency department are classified as minor or mild head injury. This is the biggest group of patients that will be seen by the casualty officer. The proportion of patients with minor head injury are different in different hospital with inter-study variability among different researchers depending on the population studied and the definition of minor head injury. The proportion of patients with minor head injury ranges from 70 – 90 % of all the head injured patient (Kraus et al., 1988, Livingston et al., 1991, Mittl et al., 1994, Gomez et al., 1996 and Nagy et al., 1999).

In the past 20 years, there have been a lot of controversies regarding minor head injury on the literature review. Among the controversy is in defining minor head injury (Stein et al., 1993). The authors had commented in their article that there was no consensus on the term of the least severe form of head injury – whether the least severe form should be termed as mild, minor, grade 1, low risk or class 1. Some studies defined mild head injury as a brief loss of consciousness after a blow to the head, whereas other studies graded the degree of injury by the length of posttraumatic amnesia (Hsiang., 1997).

Generally, minor head injury is defined as a patient with a blow to the head with a history of loss of consciousness, amnesia or disorientation and Glasgow Coma Score of 13 – 15 (Shackford et al., 1992, Stein et al., 1992, Mittl et al., 1994, Gomez et al., 1996, Borczuk., 1997 and Nagy et al., 1999). Therefore a patient with a Glasgow Coma Score of 13 to 15 is classified as having minor head injury. However, this term is arbitrary and misleading (Hsiang et al., 1997). This is because, the term minor head injury should not be associated with significance consequences and long-term sequelae. In reality, studies have proven that there is convincing evidence that considerable amount of disability can occur after the so-called "minor head injury" (Hsiang et al., 1997). It is misleading to label all of these patients with minor head injury because the word minor means not serious (Hsiang et al., 1997). There is heterogeneous pathophysiology among patients with GCS score of 13 to 15 (William et al., 1990, Culotta et al., 1996, Hsiang et al., 1997). The classification of minor head injury has been constantly revised and in 1997, Hsiang had proposed that the definition of minor head injury should be divided into mild head injury and high-risk mild head injury (Hsiang et al., 1997).

Patients with high-risk mild head injury may be at an increased risk of developing complications that may need neurosurgical intervention. Patients with GCS score of 13 or 14 and those with scores of 15 who exhibited acute radiographic abnormalities according to the above authors should be classified as high-risk mild head injury (Hsiang et al., 1997). This is in agreement with previous study done by William in 1990 that reclassified minor head injury into complicated and uncomplicated depending

on the GCS score and radiographic findings (which include skull fracture and focal brain lesion).

The importance of proper classification of minor head injury has implication to the management of minor head injury. Patients classified as mild or minimal head injury can be discharged home while patients with high-risk mild head injury should be admitted to the hospital (Hsiang et al., 1997). By using this system, the authors argued that tremendous amount of resources could have been saved (Hsiang et al., 1997).

Although minor head injury represents the most common group of head injury that is seen in the casualty, the management of minor head injury is still confusing. There has been a lot of argument in the literature on how to manage minor head injury. The goal of any management scheme should be to minimize mortality and morbidity at a reasonable cost and effort (Stein et al., 1993). In any head injury patient, the management is directed towards identifying which patient that need prompt surgical intervention and therefore urgent referral to the neurosurgical team. Because missed intracranial haematomas are potentially devastating, the aim is to identify these as early and as accurate as possible (Stein et al., 1993). The other factor is the severity of the medico-legal consequences should the identification of the neurosurgical candidate is not timely.

There is no argument that patient with moderate and severe head injury will need urgent Computed Tomography assessment to exclude any intracranial haemorrhage (Stein et al., 1992). However, these population only represents 10 – 15 % of all patient

with head injury (Fisher., 1981) As mentioned earlier, the main bulk of the head injured patients are those who sustained minor head injury. It is not cost effective to perform Computed Tomography on all patients with minor head injury because of the low yield in the positive intracranial findings. The rate of those with minor head injury that need neurosurgical intervention is even lower to justify the blanket rule of doing Computed Tomography on all patients. On the other hand, excess mortality from head injury actually came from the lowest risk group i.e. those patients with minor head injury (Klauber et al., 1989). The fore mention authors argued that the improvements in mortality would not come from added technology and "advance care" of patients with severe head injury, but from identifying and preventing deterioration in patients who appear to be at low risk (Klauber et al., 1989).

The rate of positive CT findings in patient with minor head injury varies in different studies. It ranges from 3 % to 41 % (Dacey et al., 1986, Feuerman et al., 1988, Livingston et al., 1991, Mohanty et al., 1991, Harad et al., 1992, Mikhail et al., 1992, Shackford et al., 1992, Stein et al., 1992, Jeret et al., 1993, Borczuk., 1995, Miller et al., 1996, Nagy et al., 1999, Haydel et al., 2000 and Stiell et al., 2001). Refer to table 2.1 for summary of the studies in minor head injury. Comparison between different studies is difficult because of the different in study design. The definition of the studied population with minor head injury is also not uniform, therefore making comparison difficult. For example, some of the authors ((Dacey et al., 1986, Feuerman et al., 1988, Harad et al., 1992, Mikhail et al., 1992, Stein et al., 1992, Shackford et al., 1992, Borczuk., 1995 and Stiell et al., 2001) included all patient with GCS score of 13 – 15 while other researchers

only included GCS score of 15 (Jeret et al., 1993, Nagy et al., 1999, Haydel et al., 2000). Similarly, another group of researchers only included GCS score of 14 –15 (Livingston et al., 1991 and Mohanty et al., 1991). Computed Tomography was not performed on all of the patients with minor head injury. The range of performing CT scan in these patients ranged from as low as 11% to 100% of their entire head injury patients. Because not all of the patients with minor head injury were studied with CT scan it might therefore under-estimated the true rate of positive CT findings.

Table 2.1: Summary of studies involving patients with minor head injury.

Series	Population	No. of patients	No. Head CT performed (%)	Prevalence Positive CT (%)	Prevalence Neurosurgery (%)
Dacey	GCS 13-15, admitted, LOC	610	68(11)	23(34)	18(3)
Mikhail	GCS 13-15, ED	95	35(37)	8(23)	3(3)
Feuerman	GCS 13-15, admitted	373	129(35)	53(41)	5(1)
Harad	GCS 13-15, ED	302	302(100)	55(18)	11(4)
Stein	GCS 13-15, admitted, LOC	1538	1538(100)	265(17)	58(4)
Mohanty	GCS 14-15, admitted, LOC	348	348(100)	12(3)	0(0)
Livingston	GCS 14-15, LOC, ED	111	111(100)	15(14)	(0)
Jeret	GCS 15, LOC	712	712(100)	67(10)	2(0.3)
Shackford	GCS 13-15, admitted	2766	2166(78)	468(22)	111(4)
Borczuk	GCS 13-15, ED	1448	1448(100)	119(8.2)	11(0.8)
Nagy	GCS 15, LOC,	1170	1170(100)	39(3.3)	4(0.003)
Haydel	GCS 15, no CNS deficit	520 first phase	520 (100)	36(6.9)	
		909 second phase	909(100)	57(6.3)	
Miller	GCS 15, LOC	2143	2143(100)	138(6.4)	5(0.002)
Stiell	GCS 13-15	3121	2078(67)	254(8)	44(1)

2.2 NEUROIMAGING AND MINOR HEAD INJURY.

In minor head injury, history and physical examination still remain the most important means of identifying those at risk for a significant head injury. However, imaging of the skull and brain can offer detail information about the anatomic site of injury and prognosis (Yealy et al., 1991). Roentgenography was first developed in 1895. Since than until 1970s, imaging of head trauma patient had been relied on plain skull radiograph. In 1920's pneumocephalography became available to help diagnose and localize intracranial lesions, although this technique was only helpful in the presence of a large mass lesions. With the start of CT era in 1970s, the utilization of plain skull radiograph has reduced and pneumocephalography has become historic.

The use of plain radiograph in minor head injury has received much attention in the literature review. Plain radiograph of the skull is widely available and relatively in-expensive than CT scan. It is a useful imaging tool with good sensitivity and specificity to diagnose bony fracture (Yealy et al., 1991). In many emergency rooms, skull radiographs are taken routinely in almost all patients who sustained acute head injury regardless of their clinical condition. Depressed or open skull fracture is often well identified by plain skull radiograph. Aside from the basilar fracture, skull radiograph can visualized most non-displaced linear fracture when interpreted by an experienced radiologist or emergency doctor. However, some researchers argued the usefulness of performing routine skull radiography on every patient with head injury. This group of researchers argued that by identifying skull vault fracture, it is often necessary to also

perform CT scan on these patients. Skull radiograph would result in delaying CT examination on these patients. Furthermore, skull radiograph does not provide details on the intracranial injury and the anatomical site to guide the neurosurgeon should the patients need neurosurgical intervention (Yealy et al., 1991).

An imaging procedure that is more rapid such as skull radiograph but insensitive to provide evident for parenchyma brain damage only delays the diagnosis and treatment of the patient (Lee et al., 1999). Although patients who sustained skull fracture are at increase risk of developing an intracranial injury, it is also common to find patients with normal skull radiograph and yet developed intracranial haematoma on CT scan. Therefore, there is limited role of skull radiography as a screening tool in head injury. Furthermore, the discovery of incidental fracture on skull radiograph in a neurologically intact patient rarely changes the treatment (Perini et al., 1984).

The reason why plain skull radiography is used in patient with minor head injury is due to the following reason. In patient with no impairment of consciousness, a normal physical examination and a normal skull series, the risk of intracranial injury is less than 0.001% (Yealy et al., 1991). This data has been used to justify the routine use of plain skull radiograph in all patients with head injury in order to identify those who can safely discharged home (Yealy et al., 1991).

After the advent of CT scan, the role of skull radiograph has become less popular. CT scan has become the imaging modality of choice in acute head injured patient. It is

highly specific for bony and intracranial lesions (Perini et al., 1984 and Yealy et al., 1991). Its role in identifying those lesions, which requires urgent referral to the neurosurgical team and urgent neurosurgical intervention, are well established. CT scan is also useful as an imaging tool to determine the prognosis of patients who involved in head injury. A normal CT scan in patients with a normal neurological examination has an excellent negative predictive value for delayed neurological complication. Another advantage of CT scan is that it showed basilar skull fracture that is not demonstrable on plain skull radiograph (Lee et al., 1999). It is also the method of choice for demonstrating fracture of the facial bones, including the paranasal sinus and orbits (Lee et al., 1999). In a typical head injury, window levels are optimized for the brain (brain window), used to assess the presence of blood adjacent to the inner table of the skull (subdural or epidural haematoma in subdural window) and lastly bone window to see if there is any skull vault fracture (Lee et al., 1999).

The role of cranial CT scan in minor head injury remains controversial and confusing. Some authors claim there should be blanket rule of performing CT scanning in all patients involved in minor head injury. This group of authors argued that because the rate of positive CT findings can be as high as 20%, CT scan must be performed on every one who presented with minor head injury. Other investigators argued that because the rate of neurosurgical intervention is actually low, the universal approached of performing CT scan is not cost effective. The increase in the demand of CT request will put an extra load to the radiology department.

There are many studies performed to look at the indication of CT scanning in minor head injury. Some of the studies are summarised in Table 2.1. The following authors have supported the notion of performing Computer Tomography on every minor head injury patients. For example, Dacey et al. in 1981 prospectively evaluated 610 patients with a transient loss of consciousness and GCS score of 13 and above. Only 11% of the patients underwent CT scanning. In the above study, 34% of the patients had positive CT findings and 3% required neurosurgical intervention. This is the largest percentage of positive CT findings, but it must be understood that it represents a selection bias in test ordering (Borczuk, 1997). The conclusion from this study was that - discharging all patients with a GCS score of 15 and a normal CT were much cheaper that routinely admitting these patients with mild head injury.

Stein et al (1991, 1992, 1993) were strong advocates for obtaining a cranial CT in patients with mild head trauma and LOC, claiming the test serves to identify the patients requiring surgery, as well as define the low-risk patients who do not need hospital admission for observation. The authors reviewed 1538 patients who were admitted to the hospital in a 2 years period (Stein et al., 1992). Contrary to Dacey et al, the above authors performed CT scanning on all patients who presented with history of LOC or amnesia, no matter how brief. Positive CT findings were identified in 17.2% of their population. The patients who had GCS score of 13 had the highest rate of positive CT findings. The rate of positive CT findings for patients with GCS score of 13, 14 and 15 were 37.5%, 24.2% and 13.2% respectively. Of these patients, 4% required neurosurgical intervention (Stein et al., 1992). The authors emphasized that because CT scan can provide more anatomic

information than radiographs, radiographs were not indicated in the evaluation of mild head injury (Stein et al., 1992). Similar to Dacey, the population of patients in the study done by Stein et al (1992) represented only those who were admitted to the hospital and therefore, may not actually reflected the true number of patients who were discharged and not admitted.

Other studies that were supportive of routinely performing CT scan on minor head injury are similar in term of the rate of positive CT findings. This study was done by Harad et al. (1992) who reported abnormal CT findings in 18 % and neurosurgical intervention in 4 % of the total patients. Similarly Livingston et al. (1991) evaluated 111 patients who had GCS score of 14 and 15, a history of LOC and underwent cranial CT scanning. 14% of the patients with minor head injury in their population had positive CT findings. Again the above authors concluded that their study supported the use of cranial CT scan on all patients with minor head injury in order to identify those who required neurosurgical intervention and those who could be safely discharged home. Because there was no predictive characteristic that could identify the 14% of their patients with positive CT findings, the author concluded that CT scan should be performed on all patients with LOC or amnesia. In addition, they recommended that patient with normal neurological examination and negative CT findings does not need admission at all. This observation is supported by Klauber et al. (1989) who found that observation in the hospital and frequent neurological checks were actually not practiced. As high as 50% of their patients admitted to the surgical floors had no records of checks being done. In addition, the

frequency of observation was frequently insufficient to detect deterioration (Klauber et al., 1989).

Jeret and colleagues in 1993 conducted a study on 712 patients with minor head injury who presented with LOC and normal GCS score. The authors concluded that regardless of age, mechanism of injury or clinical findings, intracranial lesions could not be completely excluded clinically on head-trauma patients who had loss consciousness or amnesia, even if the GCS score was normal (Jeret et al., 1993). Again the above authors advocated for a routine CT scanning in minor head injury.

Another investigator further emphasized the need of cranial CT scanning in minor head injury as a screening tool to determine which patient can be safely discharged. Shackford et al. (1992) studied 2766 patients with isolated mild head injury who presented to seven trauma centers. They concluded that because 1 in 5 patients with minor head injury developed positive CT findings, cranial CT scanning should be used routinely. CT scan was essential especially to patients with GCS score of 13 because 1 in 3 would have positive CT findings and about 1 in 10 would require craniotomy. They also supported the idea of discharging patients with normal neurological examination and negative CT scan, as it was more cost-effective than routinely admitting these patients (Shackford et al., 1992).

Contrary to the idea of performing universal cranial CT scan on all minor head injury patients, there are few others who disagree that patients with minor head injury

would require cranial CT scan at all. Mohanty in 1991 studied which group of patients with minor head injury that did not require cranial CT scanning. In the above study, patient included was limited to those with age 18 years and above, had a history of minor head injury, remains neurologically stable for 20 minutes on arrival to the casualty and had GCS score of 13 with no evident of basal skull fracture. Only 0.03% of the patients exhibited abnormal CT scan and all had uneventful hospital admission. Because CT scan did not have any prognostic or therapeutic on the above patients, the author concluded that routine CT scan for minimal head injury was an inefficient use of personnel and equipment. The above patient could have gone home, and been observed instead of undergoing CT scan, because there were no intervention other than observation. Taheri et al. (1993) also advocated discharge from the casualty department without radiologic evaluation. In the above study, all the neurosurgical patients with initial GCS score of 15 (5 out of 310 or 0.016%) were identified by abnormal neurological deficit or a positive skull radiograph. Thus, the above authors believed it would be safe to discharge a patient with GCS score of 15, a negative skull radiograph and no neurological deficit.

Duss et al. in 1994 studied a large number of patients in Denmark in which the authors concluded that it was safe to exclude neuroimaging in primary assessment of patients with minor head injury and rely instead on clinical criteria (Duss et a., 1994). Minor head injury in the above study was defined as individual who can talk and walk that presented to the hospital. This entry criterion makes it difficult to compare with other study that uses GCS score or LOC as main criteria of minor head injury.

So far, what have been discussed were two different schools of thought regarding the usage of cranial CT in minor head injury. The first half of the discussion are the group of researchers whom advocated routine cranial CT scan for every minor head injury and the second group of researchers dismissed the idea of performing routine CT scanning. In evaluating patients with minor head injury, doctors need to define the goal that they wish to achieve (Borczuk., 1997). If the goal is to identify patients who need neurosurgical intervention, than based on the low prevalence of neurosurgical intervention of $< 0.1\%$ in patients with GCS score of 15, than one can argued that there is no benefit of performing routine cranial CT scan (Borczuk., 1997). On the other hand, if the goal is to identify those patients with abnormal CT findings, with the purpose of prescribing anti-convulsant therapy or other medical therapy, clearance for general anesthesia or post-concussion rehabilitation program, then routine CT scanning will need to be performed (Borczuk., 1997).

There are other researchers who rely on clinical decision criteria to order CT scan in minor head injury. Many studies have looked into this issue in order to identify significant clinical variable that can predict positive CT findings. The clinical variables or parameters that were chosen are derived either from the history or physical examination. These clinical variables are than studied for their sensitivity or specificity in predicting positive CT findings. The summary of studies done by different researchers is shown in Table 2.2. Reinus et al. reviewed 373 head trauma patients and identified the following combination that had association with positive CT findings: 1) positive neurological examination, 2) intoxication, 3) history of amnesia and 4) history of a focal deficit. By

using these clinical variables, the author claimed that they were able to predict positive intracranial findings with sensitivity of 90.9% and specificity of 65.6% and a negative predictive value of 98.1% (Reinus et al., 1993).Jeret et al. in 1993 also looked at clinical variables that were associated with positive CT findings. The author found that older age, white race; signs of basilar skull fracture, pedestrian involved in head injury and assaulted cases were the significant risk factors that predict positive intracranial findings. In 1997, Miller et al. studied whether simple clinical criteria could be used to safely reduce the number of patients who require cranial CT with GCS score of 15. There was limited research done on patient with minor head injury and normal GCS score and therefore prompted the study. The studied risk factors include severe headache, nausea, vomiting and depressed skull fracture. With the used of these clinical variables, the author concluded that a reduction of 61% of the total number of CT scan can be achieved and yet would identify all the patients that need neurosurgical intervention. By utilizing the four criteria, the author could detect patients with abnormal CT findings with 65% sensitivity and 63 % specificity.

There are other researchers arguing that the above sensitivity and specificity of the clinical criteria are low and unacceptable. This prompted others to investigate other clinical variables that have better sensitivity value. Recently, study by Haydel et al. (2000) tried to look at clinical variables that has high sensitivity to predict positive CT findings. In the above study, there were two phases involved. In the first phase, clinical findings of 520 consecutive patients with minor head injury but with normal GCS score and neurological examination were evaluated. In the second phase of the study, the

sensitivity and specificity of the criteria for predicting a positive CT scan were evaluated in 909 patients. Patients with positive CT scans had one or more of the following seven findings: headache, vomiting, age over 60 years, drug or alcohol intoxication, physical evidence of trauma above clavicle and seizure. Using these clinical variables, the sensitivity of 100% was achieved which was far higher than the previous study. Therefore, the author concluded that in evaluating patients with minor head injury, the used of cranial CT scan could be safely limited to those who had certain clinical findings (Haydel et al., 2000).

Similar study, which showed high rate of sensitivity, was just published recently. The study was conducted in emergency department of ten large Canadian hospitals involving a large population of minor head injury patients (Stiell et al., 2001). The author had developed the Canadian CT head rule, which identified five high risk factors, associated with positive CT findings. The rule consists of failure to reach GCS of 15 within 2 hours, suspected open skull fracture, any sign of basal skull fracture, vomiting of more than 2 episodes, or age of more than 65 years. The authors also identified medium risk factors, which included amnesia before impact of more than 30 minutes and dangerous mechanism of injury. These high risk factors were 100% sensitive for predicting the need of neurosurgical intervention and would require only 32% of patients to undergo CT. Please refer to Table 2.2 for the summary of the studies investigating the clinical risk factors.

Table 2.2: Summary of studies investigating clinical risk factors in head injury / minor head injury.

Series	Population	No of patients	No of head CT performed (%)	Prevalence of positive CT findings (%)	Prevalence surgical intervention	Clinical variables associated with positive CT findings
Reinus et al., 1992	All patients presented with head trauma	373	373 (100%)	44 (12.4 %)		Positive neurological examination, intoxication, history of amnesia or focal neurological deficit.
Jeret et al., 1993	GCS 15	712	712 (100%)	67 (9.4%)	2 (0.3%)	Older age, white race, signs of basilar skull fracture, pedestrian & assault
Miller et al., 1997	GCS 15	2143	2143 (100%)	138 (6.4%)	5 (0.002%)	Severe headache, nausea, vomiting, skull
Haydel et al., 2000	GCS 15	520 (first phase) 909 (second phase)	520 (100%) 909 (100%)	36 (6.9%) 57 (6.3%)	Not mentioned	Headache , vomiting, age over 60, drugs or alcohol intoxication, deficits in long term memory, physical evident of trauma above clavicle
Stiell et al., 2001	GCS score from 13 - 15	3121	2078 (67%)	248 (8%)	31 (1%)	Failure to reach GCS of 15 within 2 hrs, suspected open skull fracture, any sign of basal skull fracture, vomiting > 2 episodes, age >65

The role of Magnetic Resonant Imaging in minor head injury deserves to be mentioned. Magnetic Resonant Imaging (MRI) in head injury has evolved since the past 10 years. It is valuable in imaging traumatic brain injury due to several reasons. The multiplanar capability of MRI is useful to separate cortex from extra-axial blood collections in the subdural and epidural spaces that lie at the vertex and the skull base. This area of bleeding can sometime be missed on axial CT scanning (Lee et al., 1999). In addition, MRI is quite useful to show non-haemorrhagic contusion that can occur in diffuse axonal injury where CT scan is less sensitive to pick up these lesions (Lee et al., 1999). MRI is also very sensitive to pick up small bleeding which can be missed on the CT scan. However, MRI is inferior to CT scan in cases of acute subarachnoid haemorrhage less than 24 hours. Skull vault fracture is also poorly detected on MRI.

Long acquisition time is another problem in acute head trauma patients. Time is a crucial factor in head injury. Image quality is degraded by motion and the scans may be uninterpretable (Lee et al., 1999). Motions can be controlled with sedation, however, sedation will eliminate the ability to assess the neurological sign. When this patients need to be intubated and paralyzed due to the head injury, monitoring equipment and intubation devices need to be compatible with the requirement of the MR scanner and this can be a problem as well (Lee et al., 1999). Electronic monitoring equipment may become a problem when it causes interference to the signal of the scanner and extraneous radio frequency source can degrades the image quality (Lee et al; 1999).

SECTION THREE

AIMS

&

OBJECTIVES

3.1 AIM OF THE STUDY

The aim of this study is to identify the clinical variables that predict positive CT findings and the need of neurosurgical intervention in patients with minor head injury who underwent cranial CT scan examination. It is not the intention of this study to analyse new factors that predict positive CT findings and neurosurgical intervention. The focus of this study is to analyse the association between various clinical variables with positive CT findings and neurosurgical intervention in reference to the local surrounding. The results obtained were then compared to other established researchers.

3.2 OBJECTIVES

1. To determine the rate of positive CT findings and the need of neurosurgical intervention among patients who presented with minor head injury.
2. To determine the association between a set of defined clinical variables and positive CT findings.
3. To determine the association between a set of defined clinical variables and neurosurgical intervention.
4. To develop a screening tool in predicting positive CT findings and the need of neurosurgical intervention among patients with minor head injury.

3.3 HYPOTHESIS

Null hypothesis

1. There is no correlation between clinical variables and significant CT findings in patients with minor head injury.

2. There is no correlation between clinical variables and the need for neurosurgical intervention in patients with minor head injury.

SECTION FOUR

METHODOLOGY

4.1 METHODOLOGY

This was a descriptive study conducted on 94 cases of minor head injury patients treated in Hospital Universiti Sains Malaysia. The period of the study was from January 1999 till June 2001. Of the 94 cases, 17 cases were retrospective cases (from 1st January 1999 to 31st August 1999) and the remaining numbers (77 cases) were prospective cases. Study period for the prospective cases were taken from 1st Sept 1999 till 30th June 2001. The study sample comprised of all patients with minor head injury, which was defined as patient with a blow to the head with initial Glasgow Coma Score of 13 – 15 and underwent cranial CT scan examination. The sampling of patients was taken according to the Non-Probability Sampling whereby all patients who met the criteria for the study population would be included in this study. Such patients were identified from the Department of Radiology database. Once identified, their medical records were traced from the medical record office for further data gathering.

4.2 CRITERIA

The inclusion criteria for this study were:

1. 12 years old and above
2. Patients with minor head injury who presented with history of blow to the head and Glasgow Coma Score of 13 to 15
3. All patients had cranial CT scanning on admission.