ASSOCIATION OF TRAUMATIC HEAD INJURIES AND MAXILLOFACIAL FRACTURES AMONG PATIENTS TREATED AT HOSPITAL UNIVERSITI SAINS MALAYSIA

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by

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LIST OF SYMBOLS, ABBREVIATIONS AND ACRONYMS

3D	Three-dimensional
AOD	Adjusted Odds ratio
CT	Computed tomography
CI	Confidence interval
DAI	Diffuse axonal injury
ED	Emergency department
EDH	Epidural haematoma
GCS	Glasgow coma scale
HUSM	Hospital Universiti Sains Malaysia
ICH	Intracranial haemorrhage
LR	Likelihood ratio
MCA	Motorcycle accident
MFF	Maxillofacial fractures
MVA	Motor vehicle accident
NOE	Naso-orbital-ethmoidal fractures
OMFS	Oral maxillofacial surgery
OR	Odds ratio
ROC	Receiver operation characteristics
RTA	Road traffic accidents
SD	Standard deviation
SAH	Subarachnoid haematoma
SDH	Subdural haematoma
TBI	Traumatic brain injuries

THI	Traumatic head injuries
UK	United Kingdom
USM	Universiti Sains Malaysia
WHO	World Health Organization

HUBUNGKAIT DI ANTARA KECEDERAAN KEPALA TRAUMATIK DENGAN PATAH TULANG MAKSILOFASIAL DI KALANGAN PESAKIT YANG DIRAWAT DI HOSPITAL UNIVERSITI SAINS MALAYSIA

ABSTRAK

Latarbelakang: Hubungkait di antara kecederaan kepala traumatik (THI) dengan kepatahan tulang maksilofasial (MFF) merupakan masalah kesihatan yang utama di seluruh dunia. Walaupun secara anatomi, tulang maksilofasial dekat dengan kranium, hubungkait di antara THI dan MFF menjadi satu kontroversi. Lazimnya, pesakit MFF berisiko tinggi untuk mengalami THI secara serentak. Dalam kes ini, mengenalpasticorak hubungkait adalah satu informasi yang penting semasa penilaian awal dan perancangan rawatan untuk mengurangkan morbiditi dan kematian oleh itu memperbaiki hasil rawatan. Objektif**:** Kajian ini menilai perkaitan di antara THI dan MFF dalam kalangan pesakit yang dirawat oleh Unit Pembedahan Oral dan Maksilofasial dan menentukan prevalennya. Tambahan lagi, faktor lain yang dikaitkan dengan THI dalam pesakit MFF (umur, jantina, sebab-sebab aetiologi, dan jenis MFF) dan skor Glasgow coma scale (GCS) bagi pesakit tersebut juga dikaji. Material dan kaedah: Kajian retrospektif berdasarkan hospital yang dijalankan di Hospital Universiti Sains Malaysia; Malaysia daripada 12 Jun, 2013 sehingga 31 Disember, 2015 telah diadakan. Sejumlah 473 rekod pesakit dengan MFF ditinjau dalam kajian ini untuk menilai hubungkait THI dan MFF. Faktor yang dikaitkan dengan THI ditentukan dengan kedua-dua univariabel dan multivariabel dengan menggunakan analisis regresi pelbagai logistik untuk mencapai tujuan tersebut. Ujian chi-square digunakan unutk menentukan perkaitan skor GCS. Keputusan: THI prevalen dalam kalangan pesakit MFF sebanyak 69.98%. Kepatahan tulang kranium (68.6%) adalah paling biasa dalam THI diikuti dengan kecederaan intrakranium dan konkusi. Kepatahan dinding orbital paling kerap dalam kalangan pesakit THI (61.0%), diikuti dengan kepatahan maksilari dinding sinus (36.9%), tulang hidung (30.5%), dan tulang mandibel (25.4%). Perkaitan jelas terdapat di antara skor GCS dan THI diikuti dengan MFF sebanyak hampir separuh daripada pesakit (55.0%) yang mengalami kecederaan kepala yang ringan (skor GCS 13-15). MCA merupakan sebab paling utama kecederaan (75.8%), diikuti dengan MVA (10.9%) dan jatuh (4.5%). RTA sebagai etiologi dan tulang hidung, zygomatik kompleks, lengkung zygomatic, dinding orbital, dinding sinus maksilari dan kepatahan proses mandibular alveolar sebagai jenis MFF berkait secara statistiknya berkait dengan pesakit THI yang mengalami MFF [nisbah ganjil terlaras (AOR) = 4.65, 2.13, 2.37, 2.77, 3.38, 2.05, dan juga 0.48]. Kesimpulan: Prevalen tinggi dalam kalangan pesakit THI dengan MFF (69.98%) dianggap sebagai salah satu peratus tertinggi seluruh dunia. Walaupun kebanyakan pesakit mengalami kecederaan kepala yang ringan dengan skor GCS (13-15), peluang THI masih kuat disyaki dalam kalangan pesakit dengan skor GCS bebas. Tulang hidung, zygomatik kompleks, lengkung zygomatik, dinding orbital, dinding sinus maksilari dan kepatahan proses mandibular alveolar mewakili jenis MFF yang secara statistiknya signifikan berkait dengan THI dalam kalangan pesakit MFF sedangkan dikalangan etiologi hanya RTA yang berkait secara signifikan dengan THI.

ASSOCIATION OF TRAUMATIC HEAD INJURIES AND MAXILLOFACIAL FRACTURES AMONG PATIENTS TREATED AT HOSPITAL UNIVERSITI SAINS MALAYSIA

ABSTRACT

Background: The association of traumatic head injury (THI) with maxillofacial fractures (MFF) is major health concern worldwide. In spite of the close anatomical proximity of maxillofacial bones to the cranium, the association of THI with MFF is remained controversial as the patients with MFF are at high risk to sustain THI simultaneously. In such cases, recognition of the pattern of that association is an important information during initial assessment and treatment planning to reduce morbidity and mortality therefore improve the outcome of treatment. Objectives: This study assesses the association between THI and MFF among patients treated by Oral & Maxillofacial Surgery Unit and determine its prevalence. In addition, the other factors associated with THI in patients with MFF (age, sex, etiological causes, and types of MFF) and the Glasgow coma scale (GCS) score for those patients were also investigated. Materials and methods: A hospital-based retrospective study at Hospital Universiti Sains Malaysia, Malaysia from June 12, 2013, to December 31, 2015 was conducted. A total of 473 patient records with MFF were reviewed in this study to evaluate the association of THI and MFF. The factors associated with THI were determined at both univariable and multivariable by using simple and multiple logistic regression analysis respectively to achieve that aim. The chi-square test was used for determining the association of GCS score. Results: Prevalence of THI among the patients with MFF was 69.98%. Cranial bone fractures (68.6%) being commonest of THI followed by intracranial injuries and concussion. Orbital wall fracture was the most frequent amongst patients with THI (61.0%), followed by fractures of maxillary sinus wall (36.9%), nasal bone (30.5%), and mandible bone (25.4%). A significant association exists between the GCS score and THI accompanying MFF with almost half of the patients (55.0%) had a mild head injury (GCS score 13-15). Motorcycle accident (MCA) was the most common cause of injury (75.8%), followed by motor vehicle accident (MVA) (10.9%) and fall (4.5%). The aetiology road traffic accident (RTA) and types of MFF (nasal bone, zygomatic complex, zygomatic arch, orbital wall, maxillary sinus wall and mandibular alveolar process) were statistically significantly associated with THI in patients with MFF [Adjusted odds ratio (AOR) = 4.65, 2.13, 2.37, 2.77, 3.38, 2.05, and 0.48 respectively]. Conclusion: A high prevalence of THI among patients with MFF (69.98%) considered as one of the highest percentagesworldwide. Although the majority of patients sustained mild head injuries of GCS score (13-15), the chance of THI still strongly suspected in those patients independent of GCS scores. Nasal bone, zygomatic complex, zygomatic arch, orbital wall, maxillary sinus wall and mandibular alveolar process fractures representing types of MFF which found statistically significant associated with THI in the patient sustained MFF while among the etiologies of injury only RTA was found statistically significant associated with THI.

CHAPTER 1

INTRODUCTION

1.1 Background of the study

The complete speed progress of modern life has made maxillofacial trauma a form of social disease from which no one is immune. Moreover, the increasing pace of modern life, high-speed travel, growing frequency of violence, crowded society, the magnitude of traffic accidents, sports injuries, wars, and industrial trauma all contribute to exposure to maxillofacial trauma (Batnitzki and McMillan, 1990). Traumatic head injuries (THI) are usually concomitant with maxillofacial fractures (MFF), and the MFF can be considered as significant indicators for THI (Holmgren *et al.*, 2004; Pappachan and Alexander, 2006; Salentijn *et al.*, 2014). These types of injuries require usually combined interventions from both of maxillofacial and neurosurgical specialists during the same admission day (Salentijn *et al.*, 2014).

There is controversy in the literature in different countries about the association of THI with MFF, some studies had reported the prevalence of THI in patient with MFF ranging from 5.4 – 45.5% (Lim *et al.*, 1993; Tung *et al.*, 2000; Alvi *et al.*, 2003; Mulligan *et al.*, 2010; Arslan *et al.*, 2014); while in other studies the percentage can be reached to 86% in more serious MFF (Hayter *et al.*, 1991; Alves *et al.*, 2014). Head injuries may involve closed head trauma (brain contusion or laceration), skull fracture and intracranial haemorrhages.

Usually, if the presence of important findings such as emesis, loss of consciousness and vomiting, the strong suspicion of a cranial injury raised but sometimes these positive findings are not present although there is head injury seen in a patient with maxillofacial trauma. The head trauma is considered as a life threatening problem and increases the mortality if it accompanied with maxillofacial trauma. Early detection of these injuries may improve the outcome and prognosis. Hence the high suspicious feelings must be present in any healthcare specialist when dealing with MFF patients with or without any GCS score disturbances (Hohlrieder *et al.*, 2004; Kanno *et al.*, 2008; Isik *et al.*, 2012).

Due to the close anatomic proximity of maxillofacial bones and the cranium, there is a potential risk to the patients, especially if the diagnosis of THI missed. It is common that the patients with MFF are at increased risk of and suffer from THI simultaneously which can lead to primary or secondary brain damage in case of a missed or late diagnosis in such cases (Pappachan and Alexander, 2006; Grant *et al.*, 2012; Zandi and Hoseini, 2013).

The MFF accompanied with THI are considered complex in nature as they might involve serious esthetic and functional problems, and thus they are clinically described as consequential. Those accompaination makes accurate diagnostic evaluation essential, especially in acute stage to clarify emergent injuries, to pre-operatively plan reconstruction of functional areas (e.g. vision, mastication, and olfaction), and to guide the physical, psychological and social rehabilitation process (Schellhas *et al.*, 1988; Arslan *et al.*, 2014). Early detection of associated THI in the patients with MFF is an important procedure of initial assessment and treatment planning because it can reduce morbidity and mortality and enhance the outcome of treatment in those patients (Kloss *et al.*, 2008; Zandi and Hoseini, 2013).

The epidemiological studies of MFF differ in types, causes, and their severities which based on the population studied. Those differences between inhabitants regarding MFF causes may refer to the cultural lifestyle and associated risk factor's differences between countries but most likely to be affected by the injury severity (Zandi and Hoseini, 2013). The effect of contributing factors to the costs of MFF management and its epidemiology should refer to their specific causes. Furthermore, the successful of medical treatment and allocate of preventive guidelines should be built based on the outcomes and conclusions made by the epidemiological studies and results (Mouzakes *et al.*, 2001; Gassner *et al.*, 2003).

1.2 Statement of problem

Due to the close anatomic proximity of maxillofacial bone and cranium, it is common that a given patients with MFF to be at risk of and suffer from THI as a consequent event (Pappachan and Alexander, 2006; Zandi and Hoseini, 2013).

Globally, THI will exceed many other diseases as the main cause of disability and death by the year 2020 according to World Health Organization (WHO) since it is a significant public health problem, It impairs brain function and it often results in negative long-term or permanent physical, cognitive, behavioral as well as emotional changes (Hyder *et al.*, 2007). To date, the risk effect of maxillofacial injuries on the brain has not been properly documented with somesuggestingit has a protective function in the brain by absorbing the energy of trauma (Lee *et al.*, 1987; Chang *et al.*, 1994; Akheel and Tomar, 2014), while others oppose this idea by theorized thatthe presence of a higher velocity impact with sufficient force to cause MFF in case of RTA may also be transferred to cranium and produce significant damage to brain and cause THI (Davidoff *et al.*, 1988; Haug *et al.*, 1994; Keenan *et al.*, 1999;

Martin II *et al.*, 2002; Hohlrieder *et al.*, 2003; Salentijn *et al.*, 2014; Zhou *et al.*, 2015).

An understanding of the severities, aetiologies and risk factors of THI associated MFF can assist instituting clinical and research priorities for effective treatment and prevention of these injuries. Additionally, the conclusions of such research allow the government authorities and public institutions to develop and evaluate the preventative measures based on scientific data collection and analysis (Gassner *et al.*, 2003).

1.3 Justification of study

The epidemiological studies of accompanied THI in the patients with MFF are very important for initial assessment and treatment planning for those patients as it can prevent or at least reduce the related disability and mortality and enhance the outcome and costs of treatment in those patients. Thorough knowledge of the definite locations involved with THI patients will lead to more rapid evaluation and thus initiation of treatment as any delay of that initiating therapy in the case of severe THI patients can lead to life-long consequence's for those patients (Keenan *et al.*, 1999; Kloss *et al.*, 2008; Zandi and Hoseini, 2013).

There is a large controversy in the literature in different countries about the association of THI with MFF. Some studies reported that the prevalence was range from 5.4 – 45.5 % (Lim *et al.*, 1993; Tung *et al.*, 2000; Alvi *et al.*, 2003; Mulligan *et al.*, 2010; Arslan *et al.*, 2014), while in other studies this percentage can reach upto 86% in more serious MFF (Hayter *et al.*, 1991; Alves *et al.*, 2014). On the other hand, only a small number of studies reported the frequency of each MFF types with different types of THI. There is a paucity of information in published studies which have evaluated the association between THI among patients with MFF according to age, sex, and etiologies of MFF (Zandi and Hoseini, 2013; Rajandram *et al.*, 2014; Yasir, 2014). However, further studies needed for better understanding.

This study provides a deeper understanding of the influence of associated factors of THI among the patients with MFF. As this study conducted among the patients treated by Oral & Maxillofacial Surgery (OMFS) Unit, Hospital Universiti Sains Malaysia (HUSM); Kelantan, Malaysia**,** the findings would provide a local baseline data on the prevalence of THI among the patients with MFF. This study highlighted the other factors associated with THI in patients with MFF which could be an added value and evidence for oral and maxillofacial surgeons and neurosurgeon as well as the emergency department doctors in their early diagnosis, evaluations and management of the patients with history of MFF sustained THI as it is of high mortality and morbidity rate with serious complications.

The findings and results of this study could be utilised by the government authorities and public institutions to develop and evaluate of preventative measures based on scientific data collection and analysis in planning programs and rules to minimising that complication in the futures.

1.4 Objectives of study

1.4.1 General objective

To assess the association between THI and MFF among patients treated by Oral & Maxillofacial Surgery OMFS Unit, Hospital Universiti Sains Malaysia HUSM, Kelantan, Malaysia**.**

1.4.2 Specific objectives

1. To determine the prevalence of THI among patients with MFF.

2. To determine the types of THI in patients with MFF.

3. To describe the frequency of MFF types in patients with THI.

4. To determine the association of GCS score in patients who sustained THI with MFF.

5. To determine the aetiology of injury among patients who sustained THI with MFF.

6. To determine the factors associated with THI in patients with MFF (age, sex, ethnic group, aetiology of injury, and types of MFF).

1.5 Research questions

1. What is the prevalence of THI among the patients with MFF?
2. What is the most common type of THI found in patients with MFF?
3. What is the frequency of MFF types in patients with THI?

4. What is the association of GCS score found in patients who sustained THI with MFF?
5. What is the aetiology of injury in patients who sustained THI with MFF?
6. What are the factors associated with THI in patients with MFF?

1.6 Research hypothesis

There is an association between THI and age, sex, ethnic group, aetiology of injury and types of MFF sustained by those patients.

1.7 Conceptual framework of study

Figure 1.1 describes the conceptual framework of this study. This framework comprised of predisposing factors of THI in patients with MFF THI. In this study, the effect of demographic factors, aetiology of injuries, and the types of MFF studied.

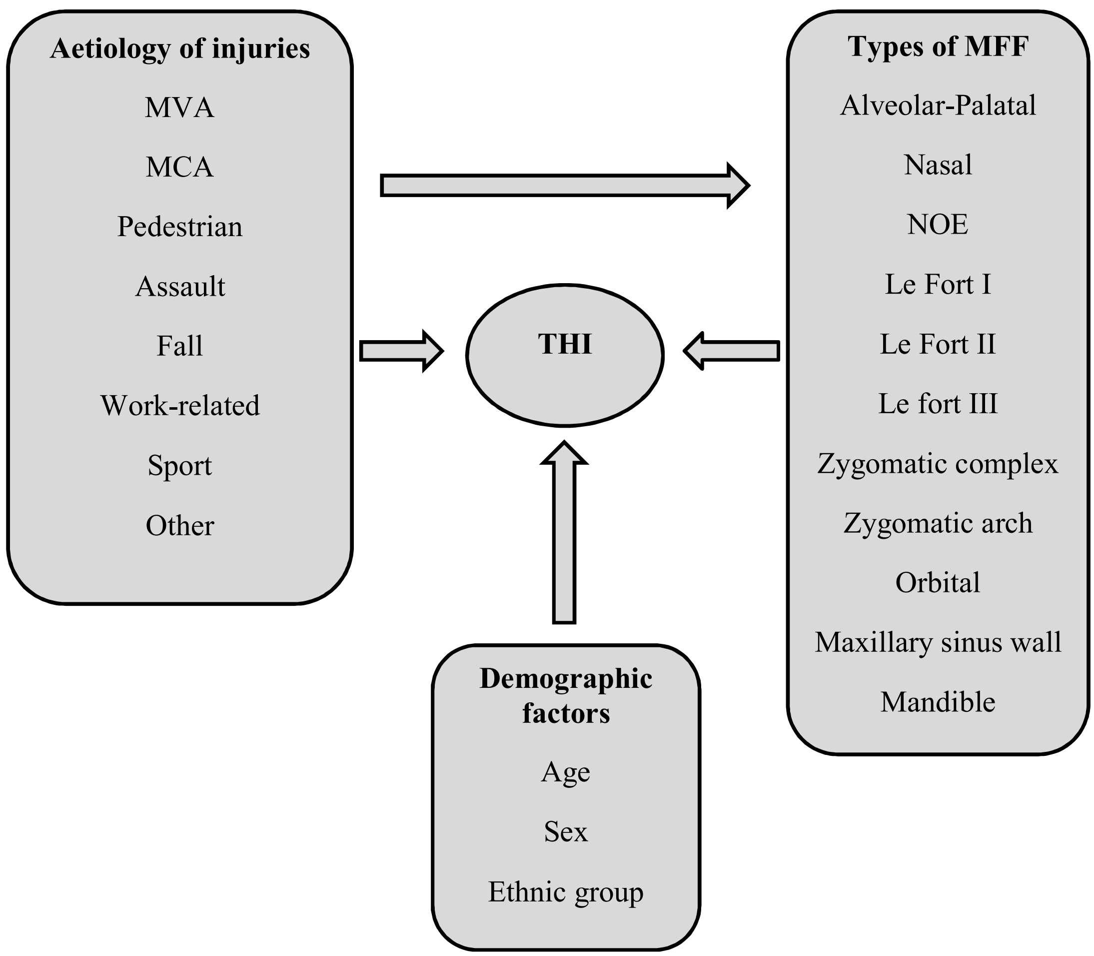

Figure 1.1 Conceptual framework of the study

CHAPTER 2

LITERATURE REVIEW

2.1 Traumatic head injury

Traumatic head injuries (THI) and traumatic brain injuries (TBI) are the medical terms which frequently used interchangeably in the medical field. So, any injury that leads to trauma to the skull or brain can be considered as a THI (Tabatabei *et al.*, 2011). However, the head trauma occurrence may or may not include injury to the brain especially if there are no any neurological manifestations during the clinical examination (Maas *et al.*, 2008).

THI remains the main public health problem around the world. It constitutes the major reason for death and disability in young adults among developed countries, and moreover its incidence constantly increasing by the time in developing countries (Toyama *et al.*, 2005). It is difficult to describe the actual epidemiologic figures of THI due to many of disturbing and confounding factors, such as the inconsistency in the definition and classification system, as well as, the different ways in data collection of these injuries. Furthermore, the differences in hospital admission criteria and proper diagnostic tools which are used to classify these injuries may complicate the epidemiological studies (Dawodu, 2014).

Globally, 10 million people were estimated to be affected annually by THI (Hyder *et al.*, 2007). It represents around 40 % of all death cases from acute injuries in the USA. Approximately up to 200,000 patients diagnosed with THI need admission at the hospital, and 1.74 million cases complaint from the mild type of

THI need frequent follow-up visits as an outpatient case or have a temporary disability per year (Dawodu, 2014).

THI was considered as the most common cause of death and disability in the United Kingdom (UK) among the people with age ranged between 1-40 years according to National Institute for Health and Care Excellence (UK); 2014. Around 1.4 million patient visits the emergency department (ED) complaining of acute head injury in England and Wales (National Institute for Health and Care Excellence NICE, 2014).In Germany, the incidence of severe THI is approximately at 10,000 cases per year. When comparing these incidences to other different causes of brain injury, like stroke, it will be lower, but the socio-economic costs and long-term effects are equal or may be higher due to loss of years of productive life and a need for rehabilitation services for life-long as it mainly affects younger age groups in contrast to the people with stroke (Van Baalen, 2008)

2.1.1 Definitions

The definition of THI is variable and not consistent when used in the daily medical practice as it tends to be modified and differs according to the variant medical specialities, situations and the method of diagnosis used (clinically or radiologically) as there are wide variations in inclusion criteria (Dawodu, 2014). It is defined as evidence of loss of consciousness and/or post-traumatic amnesia in a patient with a non-penetrating head injury (Salentijn *et al.*, 2014).

With improvement of diagnostic tools, THI can be also defined based on medical imaging modalities (CT scan) as heterogeneous disease including a broad range of pathology processes, involving, for example, diffuse axonal injury (DAI), cerebral contusions, epidural haematoma (EDH) and subdural haematoma (SDH) (Moolla, 2007). Another definition is a non-degenerative, non-congenital insult to the brain from an external mechanical force, possibly leading to permanent or temporary impairment of cognitive, physical, and psychosocial functions, with an associated diminished or altered the state of consciousness (Dawodu, 2014). THI, according to Centre for Disease Control and Prevention (CDC), as any disrupts to the normal function of the brain caused by a bump, blow, or jolt to the head or a penetrating head injury (Kreipke and Rafols, 2012).

2.1.2 Classifications

There are a lot of different ways to classify patient with THI. It has been commonly classified by one of the three main categories: physical mechanism of injury (used mostly in the biomechanics and prevention fields); clinical indices of injury severity (used mostly in clinical research to compare patients among centers) and morphology or patho-anatomical of injury (used mostly to describe injuries for acute management and to characterize aspects of THI) (Table 2.1). Each one of these classifications may contribute to the prognosis and management of the clinical condition (Baalen *et al.*, 2003; Moolla, 2007; Saatman *et al.*, 2008).

Generally, to reach the best prognostic patterns; we should include all of the above factors, as well as patient age, any medical comorbidity, and laboratory results. However, management plans are likely best decided by including all of these factors individually rather than as a mass score. More attempts to enhance these classifications are outstanding as they may help to improve treatment plans at future (Saatman *et al.*, 2008).

Table 2.1 Classifications of THI

<table>
<tr><td rowspan="2">Mechanism</td><td>Blunt</td><td colspan="2">High velocity (automobile collision)
Low velocity (fall, assault)</td></tr>
<tr><td>Penetrating</td><td colspan="2">Gunshot wounds
Other penetrating injuries</td></tr>
<tr><td rowspan="3">Severity</td><td>Mild</td><td colspan="2">GCS score 13-15</td></tr>
<tr><td>Moderate</td><td colspan="2">GCS score 9-12</td></tr>
<tr><td>Severe</td><td colspan="2">GCS score 3-8</td></tr>
<tr><td rowspan="4">Morphology</td><td rowspan="2">Skull fractures</td><td>Vault</td><td>Linear vs. stellate
Depressed vs. non-depressed
Open vs. closed</td></tr>
<tr><td>Basilar</td><td>With vs. without CSF leak
With vs. without VII nerve palsy</td></tr>
<tr><td rowspan="2">Intracranial lesions</td><td>Focal</td><td>Epidural haematoma
Subdural haematoma
Contusions and intracerebral haematoma</td></tr>
<tr><td>Diffuse</td><td>Mild concussion
Classic concussion
Diffuse axonal injury</td></tr>
</table>

2.1.2(a) Physical mechanism of injury

THI in this category usually classified into two types which are either closed (blunt) or open (penetrating) head injury that may affect the type of pathologic brain injury. In the case of closed or blunt head injury type, for example, there are two main forces which are acceleration and deceleration forces presenting in RTA and lead to diffuse and more local effect contusion injuries. While in open or penetrating head injuries, the object force results in local destruction and lead to dural membrane penetration, commonly from stab wounds or gunshot, and this will be base on the kinetic power amount transferred to the brain tissue, more widespread destructive injuries can produce. The outcome in penetrating injury is usually severe with bad prognosis, and it is basically defined by mortality rates(Baalen *et al.*, 2003; Moolla, 2007).

THI can be categorised in many different ways based on mechanism and applied forces on the head. Thus, THI classified according to the fact of whether the head is collision by an object (contact or impact loading) and/or the brain moves inside the skull (noncontact or inertial loading). The volume and direction of each affecting force can predict the type and severity of the injury as there is a considerable relation between physical mechanism and patho-anatomic type. For example, the impact loading can lead to most focal lesions like skull fractures, skin laceration, brain contusion and epidural hematoma. In the other hand, diffuse injuries such as concussion and DAI may result commonly from inertial loading (Saatman *et al.*, 2008).

2.1.2(b) Clinical indices of injury severity

THI in the clinical practice has usually classified by applying of injury severity scores and the most commonly used one is the Glasgow Coma Scale (GCS) this system reported by Teasdale and Jennett in 1974. Most of the clinical management plans for THI have categorised patients according to the presence of neurologic criteria on this scale (Saatman *et al.*, 2008). This score specifies the positive and presenting neurologic findings and permits to uniform patients with head injury (Table 2.2) (Moolla, 2007; Saatman *et al.*, 2008).

GCS score originally designed as a dynamic measurement of consciousness in the post-resuscitative phase of a head injury rather than a single measurement on admission, but due to its simplicity and predictive value for overall prognosis, it universally recognised and considered as a standardised tool for proper evaluation for consciousness level and the head injuries classification. However, it is restricted by some disturbing factors such as giving of medical drug sedation, intoxication, interventional endotracheal intubation and complete or partial paralysis of the patient which are usually existing in patients with a low score (Balestreri *et al.*, 2004; Stocchetti *et al.*, 2004; Yokoyama *et al.*, 2006).

Table 2.2 Glasgow Coma Scale GCS adapted from the ATLS® Student Manual 7th Edition 2003

Assessment area	Score
Eye opening (E)	
Spontaneous	4
Response to verbal command or speech	3
Response to pain	2
No eye opening	1
Best verbal response (V)	
Oriented	5
Confused conversation	4
Inappropriate words	3
Incomprehensible sounds	2
No verbal response	1
Best motor response (M)	
Obeys commands	6
Localising response to pain	5
Withdrawal response to pain (Normal flexion)	4
Abnormal flexion to pain (decorticate)	3
Extension to pain (decerebrate)	2
No motor response (flaccid)	1
Total	

(GCS score = (E+V+M), best possible score=15, worst possible score=3)

The head injury severity degree can be categorised depending on the scores of the GCS as mild, moderate or severe. Patients with mild head injury have a score of 13-15, moderate head injury 9-12 and severe head injuries 3-8. Coma considered in the scoring of 8 or less. The significant decrease in consciousness level was considered the single most credible indicator that the patient has a serious and severe head injury (Moolla, 2007).

The mild type of head injury is predominant among all types of head injury admitted to the emergency unit with percentage reach up to 85% of cases, among those patients, around 15% usually, still have symptoms one year after the injury. The mortality rate of moderate type is approximately 2-3% while this percentage could reach to 36% in the severe type of head injury and The likelihood of death or permanent vegetative state in the lowest score of 3 in the severe GCS is 97% (Saboori *et al.*, 2007).

There are other scoring systems as Injury Severity Score (ISS), Revised Trauma Score (RTS), Trauma and Severity Injury Score (TRISS), and Full Outline of Unresponsiveness (FOUR) score have developed in order to try to avoid the disturbing factors during using the GCS score, basically by involving a brainstem examination. However, those scoring systems do not apply the comprehensive record of the GCS score in forecasting the injury prognosis and are very complicated to be applied which may be difficult to understand for non-neurologists practitioners (Eken *et al.*, 2009; Stead *et al.*, 2009).

2.1.2(c) Morphology or patho-anatomical of injury

As mentioned previously, due to the presence of some disturbing factors related to patient's state upon admission, including giving of medical drug sedation, intoxication, interventional endotracheal intubation and complete or partial paralysis of the patient, the clinical assessment of injury severity based on GCS score is interrupted. Also, it does not provide definite information about the pathophysiologic mechanisms responsible for the neurological discrepancies. Thus, for those mentioned causes, the need for more reliable and solid base technical examination by imaging like CT scans and Magnetic resonance imaging is raised (Baalen *et al.*, 2003; Saatman *et al.*, 2008).

Those imaging procedures enable the medical practitioner to evaluate the patient completely and give him a clear picture of the anatomical structure defects and discovering any underlying haemorrhage areas or fractured bones. There are still wide range variations on the using CT scan by emergency doctors for diagnosis of minor head injury from 7-80%. CT scan cannot exclude in minor head injuries with good GCS and absence of neurologic deficits as only 5% of these injuries were found to have an acute intracranial lesion. However, up to 40% of those with severe type have a normal head CT finding initially (Udstuen and Claar, 2001; Saatman *et al.*, 2008).

THI can cause several patho-anatomical injuries such as Skull fracture, SDH, SAH, EDH, Cerebral contusion, Intraparenchymalhaemorrhage, Intraventricular haemorrhage, Focal and diffuse patterns of axonal injury with cerebral edema and most of which can recognise on neuroimaging. There are other classification systems of these lesions by using CT scan procedure including Marshall Scale and Rotterdam scale (Saatman *et al.*, 2008).

- The Marshall scale uses CT scan findings to classify the brain injuries in six different categories (Table 2.3). It is commonly applied in neurotrauma centers and allows prediction of any increasing intracranial pressure. In addition, the outcome of that scale in adults was appropriate but its disadvantage appears in patients with multiple types of brain injury (Maas *et al.*, 2005).
- The Rotterdam scale is a more recent CT-based classification generated to finalise the limitations of the Marshall scale (Table 2.4). It has given early results but requires wider validation (Maas *et al.*, 2005).

Table 2.3 Marshall CT classification of THI

Category	Definition
Diffuse injury I (no visible pathology)	No visible intracranial pathologies are seen on CT scan
Diffuse injury II	Cisterns are present with midline shift of 0-5 mm and/or lesions densities present; no high or mixed density lesion >25 cm^3 may include bone fragments and foreign bodies
Diffuse injury III (swelling)	Cisterns compressed or absent with midline shift 0-5 mm; no high or mixed density lesion >25 cm^3
Diffuse injury IV (shift)	Midline shift >5 mm; no high or mixed density lesion >25 cm^3
Evacuated mass lesion V	Any lesion surgically evacuated
Non-evacuated mass lesion VI	High or mixed density lesion >25 cm^3; not surgically evacuated

Table 2.4 Rotterdam CT classification of THI

Predictor value	Score
Basal cisterns	
Normal	0
Compressed	1
Absent	2
Midline shift	
No shift or shift ≤5 mm	0
Shift >5 mm	1
Epidural mass lesion	
Present	0
Absent	1
Intraventricular blood or subarachnoid haemorrhage	
Absent	0
Present	1
Sum score	Total + 1

The patho-anatomical category of THI classifications mainly determines the anatomical location and features of the head injuries; the THI may widely classify into two main types: (1) skull fractures and (2) intracranial lesions (Table 2.1) (Moolla, 2007).

Most of the patients with a severe pattern of head injuries have more than one type of THI by applying this classification to them. The injuries type includes scalp laceration and contusion, skull fracture, intracranial lesions which include either extra-axial haemorrhage such as EDH, SDH, SAH, intra-axial lesions (intracerebral) like brain laceration and contusion, intraparenchymal haematoma, intraventricular haematoma, focal axonal injury and diffuse axonal injury (Yokoyama *et al.*, 2006; Saatman *et al.*, 2008).

Scalp injury: Focal injury to the head scalp like lacerations and abrasions may play an important role in detection of the site of impact force and also give an idea about the type of object but bruising might be not accurate indicator of impact lesion like in per orbital bruising is commonly seen related to orbital roof fracture following a contra coup to the occipital bone (Whitfield and Thomas, 2009).

Skull fractures: The cranial bones anatomically consists of frontal bone, temporal bone, parietal bone, sphenoid bone and occipital bone (Netter, 2014). The fractures of these bones are not constantly of clinical importance, but it considers as a significant indicator of the nature of forces which are resulting in head injuries and also related to the underlying intracranial lesions. The linear fractures are the most common one, extend from the point of impact force through lines of weak resistance and also depend on the skull's anatomy. The other types are comminuted when the involved area is large, a depressed fracture in a small area and skull-based fractures(Figure 2.1) (Whitfield and Thomas, 2009; Varnamkhasti and Thomas, 2011).

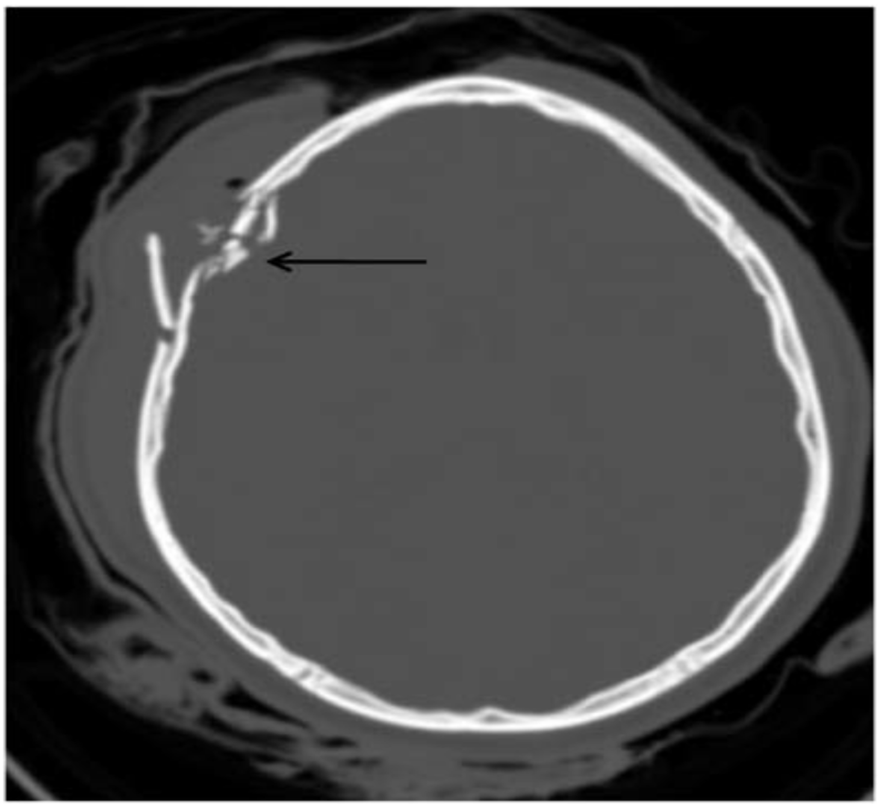

Figure 2.1 Severe depressed and comminuted left sided skull fracture (arrow) (Varnamkhasti and Thomas, 2011)

Epidural haematoma (EDH): It is an accumulation of blood in the space between the inner skull surface and dura due to direct impact (Figure 2.2). It arises from injury to middle and posterior meningeal artery. The most common area is under the temporal bone and classically has a biconvex or lenticular shape. EDH found in around 90% of cases associated with skull fractures and the mortality rate is approximately 5% (Toyama *et al.*, 2005). EDH occurs in up to 4% of all THI, and around 50% of it is related to other intracranial injuries such as SDH, brain swelling and contusion (Varnamkhasti and Thomas, 2011). According to Gavin J. et al., EDH is seen in 2 to 12% of THI, with age peak of 10-30 years and is less common in elderly and children patients (Udstuen and Claar, 2001).

Figure 2.2 Epidural haematoma (arrow) (Varnamkhasti and Thomas, 2011)

Subdural haematoma (SDH): Defined as a collection of blood or bleeding within the space between the dura and arachnoid membranes resulting from tearing of the superficial veins or venous sinus and cerebral contusions. It appears in the CT scan as a crescent shaped homogeneously hyperdense extra-axial collection (Figure 2.3). The mortality rate is 37-57% and seen in up to 29% of persons with THI (Varnamkhasti and Thomas, 2011) while Aiken et al. reported that the mortality rate was 50-85% and SDH observed in 10-20% of patients with THI (Aiken and Gean, 2010).

The age considered as an important predictor factor of death in the patients with THI, with around 74% of patient's ages 65 years or more have a mortal outcome, while in those which ages between 18 - 40 years only 18% died due to SDH. Among all intracranial lesions in a patient with severe THI, SDH had the highest mortality rate with percentage reach to 74%, and the studies have shown significant improvement in the survival rates (Udstuen and Claar, 2001).

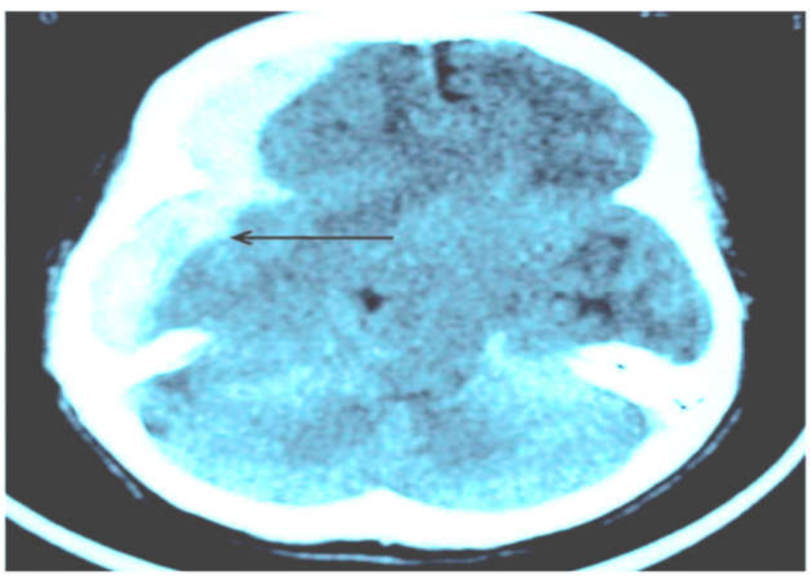

Figure 2.3 Acute subdural haematoma (arrows) (Varnamkhasti and Thomas, 2011)