Introduction

Trauma is injury or damage caused by physical harm from an external source (accidents, falls, hits and weapons). The trauma patient is an injured person who requires timely diagnosis and treatment of acute or potential injuries by a team of healthcare professionals, supported by the appropriate resources, to diminish or eliminate the risk of death or permanent disability ***(Martin and Meredith, 2008).***

Trauma is thought to be a major cause of mortality and the second most common cause of morbidity all over the world, as more than 15,000 deaths worldwide are due to trauma ***(Tebby et al., 2014).*** In developing countries including Egypt, trauma is considered as a silent killer epidemic which is increasing day after day due to lack of statistical data and research in trauma field. Also, lack of available medical resources needed for management and treatment of trauma patients is another cause to be considered in developing countries ***(Mahran et al., 2016).***

Predicting a patient's risk for an upcoming outcome is challenging and complicated due to multiple individual variants and low socioeconomic income in developing countries ***(May, et al., 2016).*** Trauma is an aspect of emergency that extends far beyond the emergency medical care, with many additional medico-legal and ethical concern ***(Hardcastle, 2010).***

A great number of trauma scoring systems have been evolved for managing and expecting the outcome of trauma patients, but unfortunately, these systems need well trained personnel to deal with and calculate them as well as patient's data that may not be available ***(Sharma, 2005).***

There is an increasing need for studying a new scoring system that is simple, rapid, inexpensive and objective to expect the upcoming outcome of trauma patients ***(Majercik, et al., 2014),*** hence decreasing the risk of death as well as helping physicians to avoid any mal-judgment about their patients' condition ***(Sharma, 2005).***

AIM OF THE WORK

This study aims to evaluate the usefulness of Intermountain risk score in predicting the outcome of trauma cases in order to be used in medico-legal and forensic practice.

Chapter 1

TRAUMA

Classification of Traumatic Injuries

Injuries are classified by either severity or location of the damage or a combination of both ***(Sharma et al., 2011).*** They may also be classified medically according to causative agent into blunt force injuries, sharp force injuries, thermal injuries, chemical injuries and blast injuries. For legal purposes, they are classified as simple, dangerous or fatal injuries ***(Barek et al., 2013).*** It is critical to physicians who will be involved in injury assessment to understand the variety of terms that can be applied to different types of injury, which may differ according to the country or medical specialty ***(Irvine, 2002).***

I: Medical Classification:

This classification is used among physicians when describing an injury. This classification is according to causative instrument.

1. **Mechanical injuries**: are injuries caused by application of mechanical force on the body. It can be either blunt force injuries or sharp force injuries.

a. Blunt force injuries

Blunt force injuries are caused by objects having no sharp or cutting edges ***(Irvine, 2002).*** These injuries are abrasions, contusions and lacerations.

- **Abrasions:** are superficial injuries involving the outer layer of the skin, not penetrating the full thickness of the epidermis, caused by friction of a rough blunt object ***(Saukko and Knight, 2013).***
- **Contusions (Bruises):** are injuries resulting from rupture of blood vessels in the skin or internal organs leading to infiltration of the extravasated blood to the subcutaneous tissues ***(Sharma et al., 2011).*** It may be superficial causing a sharp defined and red color injury or deep causing blurred edge and bluish color injury ***(Madea et al., 2014).***
- **Lacerations** are tears of the skin thickness or tears of the internal organs. Lacerations most commonly occur in a body region where a bony base acts as a support ***(Madea et al., 2014).***

b. Sharp-force injuries

Are injuries caused by instruments with sharp edges (e.g choppers, axes, swords or razor blades). Sharp force injuries are either cut wound or stab wound injuries. The depth of the wound line, relative to the length of the cutaneous wound, distinguishes a stab wound from a cut wound ***(Payne-James et al., 2003 and Shkrum& Ramsay, 2007).***

Types of sharp force injuries:

- **Cut wounds:** they are a superficial type of injuries, in which the size of injury on the surface is wider than its depth ***(Sharma et al., 2011).***

- **Stab (punctured) injuries** are deeper than being longer injuries that are caused by penetration of pointed, sharp instruments ***(Sharma et al., 2011).***

Penetrating injury is a stab wound in the body cavity or viscus, joint cavity or scrotal sac, while perforating injury results from piercing through the whole thickness of any part of the body producing two surface injuries ***(Vij, 2011).***

Firearm injuries

They are injuries easily recognized on examination, these injuries vary depending on the weapons projectiles, distance, angle of firing and the part of the body involved. Passage of the bullet produces two types of wounds (inlet and exit) wounds ***(Sharma et al., 2011).*** The differences between both wounds should be distinguished, the inlet is usually small except in contact discharge, the edges are usually inverted, abrasion collar at the wound and burning, singeing, blackening and tattooing may be seen at appropriate distance, but the exit is generally bigger with everted edges and no abrasion or tattooing surounding it ***(Al Madani et al., 2011).***

2. **Chemical injuries:** they are injuries caused by corrosives (acids or alkalies) or an irritative agent (either by weak acids, weak alkalies or animal extract).

3. **Thermal injuries**: they are tissue damage that result from systemic or localized exposure to excessive heat or cold. The heat source may be dry or wet. Dry heat injuries are

called burns, whereas moist heat injuries from water steam or other hot liquids are known as scalds ***(Payne-James et al., 2011)***.

II: legal Classification:

This classification is one that is appropriate, clear and most visible injuries will be included in it. It assists courts in establishing severity of the injury.

A. **Simple**: those wounds that heal in less than 20 days without causing any disability.

B. **Dangerous**: those that heal in more than 20 days &/ or create permanent infirmity.

C. **Fatal**: those that cause death immediately or after a short period ***(Payne-James et al., 2003)***.

In the Egyptian penal code “law No 58 of the year 1937” articles in relation to wounds and injuries are article 238, articles 240 and article 241.

Article 238

Whoever causes by mistake the death of another person, as a result of his neglect, imprudence, carelessness, or unobservance of the law, decrees, statutes, and systems shall be punished with detention for a period of not less than six months and a fine not exceeding two hundreds pound or either penalty.

Article 240

Whoever causing a wound or a beating to another, which results in cutting or separating a member and loss of its utility, blinding him, losing one of his eyes or causing him a permanent irremediable incapacity, shall be punished with imprisonment for a period of three to five years. But if the beating or wound thus caused was preceded with malice, lying in wait, and ambush, the punishment shall be sentencing to hard labor for a period of three to ten years.

Article 241

Whoever causing a wound or beating to another that results in sickness or disability to perform personal works for a period exceeding twenty days, shall be punished with detention for a period not exceeding two years or a fine of not less than twenty Egyptian pounds and not exceeding three hundred pounds.

III: RegionalClassification

Regional injuries include (Head injuries, chest injuries, abdominal injuries and limb injuries).

- **Head Injuries:**

Head injury (HI) can be defined as any alteration in mental or physical functioning related to a blow to the head ***(Olson and Graffagnino, 2005).***

Traumatic head injuries could be classified on anatomical bases into scalp injuries, skull fractures and injuries of the intracranial contents (brain, blood vessels, and meninges) ***(Emery et al., 2016).***

The most common types of scalp injuries are contused wounds and contusions with the great risk of hemorrhage due to the high vascularity and poor elasticity and recoil. The second danger is sepsis whether intra or extra-cranial ***(Emery et al., 2016).***

Skull fractures could be either fracture vault or fracture base. There are different types of vault fractures (fissure, localized depressed, comminuted, chip, or cut fractures) depending on the type of the causative instrument (sharp or blunt), the striking surface (localized or wide) and the used momentum (low or high) ***(Murphy et al., 2015).***

Regarding fracture base, it is more common than vault fractures mostly fissure fracture (ring or hinge) and could result due to direct or in-direct trauma.it could affect the anterior, middle or posterior cranial fossa, with resultant cranial nerve injuries and escape of cerebrospinal fluid and blood ***(Murphy et al., 2015).***

Injuries of the intra-cranial contents involve brain injuries (whether concussion or compression) and injuries of the blood vessels and meninges resulting in different types of intracranial hemorrhage (extra-dural, sub-dural, sub-arachnoid and intra-cerebral). These intra-cranial hemorrhages could be either coup or countercoup and must be differentiated from those due to pathological causes ***(Hrapko et al., 2006).***

- **Chest Injuries:**

The chest can be subjected to all kinds of trauma and specifically subjected to both blunt and penetrating trauma ***(Payne-james et al., 2011).*** Injuries may range from simple bruising or laceration to massive damage or collapse with or without fracture ribs ***(Vij, 2011).***

Traumatic rib fracture of the bony cage are usually produced by blunt trauma, the severity of these injuries ranges from simple fracture of a rib to the involvement of several ribs at multiple points producing “flail chest” or “stove-in chest” ***(Madea et al., 2014).*** Any injury to the chest wall or lung surface that breaches blood vessels and the pleural lining can lead to a hemothorax. Massive hemorrhage comes from large vessels in the lung or mediastinum or from the heart itself, can lead to death due to loss of circulating blood volume ***(Saukko & Knight, 2013).***

- **Abdominal Injuries:**

The anatomy of the abdominal cavity plays a major role in determining the type of injuries that are found ***(Payne-James et al., 2011).*** Sometimes, no surface lesion may be found in spite of severe or fatal internal hemorrhage ***(Vij, 2011).***

Penetrating wounds to the liver and especially the spleen may bleed extensively causing hemoperitoneum. The intestine and mesentery wounds often being multiple because of the overlapping nature of the coils and their mesentery, the stomach is partially protected by the rib margin and the kidneys are rarely stabbed except a thrust in the back. The liver, spleen, intestine, and mesentery are most vulnerable to blunt trauma ***(Saukko & Knight, 2013).***

Bruising of the abdominal wall both (the skin and the underlying muscles), extensive bleeding into the peritoneal cavity, bruising or rupture of the stomach and diaphragm and frequent damage to the intestine and its mesentery are the features that may be present whatever the mechanism of infliction back ***(Madea et al., 2014).***

- **Limbs (extremities) injuries**

Blunt injuries to the limbs are extremely common especially road traffic accidents; any combination of injuries may be encountered ***(Payne-james et al., 2011).***

Injuries to the extremities necessitating amputation or permanently impairing their power constitute grievous hurt. Severe injuries to the extremities may be produced without a weapon, like the violent twisting of a limb that causes dislocation of a joint ***(Shkrum & Ramsay, 2007).***

Pelvic and femur fractures representing hemodynamically significant injury are typically identifiable on plain radiograph ***(Gondek et al., 2017).***

Pathophysiology of trauma

The pathophysiology of trauma is the study of the changes which occur in the body following a traumatic event or injury. Trauma patients often experience different changes within the biochemical and physical aspects of the body after a traumatic event, and sometimes these changes may last the rest of their lives ***(May and Bailey, 2017).*** Following trauma, the patient enters a catabolic phase which, in severely injured patients, may last several weeks. This catabolic phase is characterized by mobilization of fuel stores, i.e. increased gluconeogenesis and lipolysis, and breakdown of proteins. If the patient survives the catabolic phase, the body enters a period of anabolism, with increased protein synthesis and a return of muscle strength and weight gain ***(Winterborn and Cook, 2003).***

All trauma leads to decreased organ perfusion, cellular ischemia, and a cascade of edema and inflammation. Inflammation can lead to multiple organ failure and death even after a patient has been completely resuscitated ***(Nemergutand Thiele, 2017).***

The process of inflammatory reaction to trauma involves mediators (cytokines, chemokines, complement, oxygen radicaland nitric oxide (NO)) and effector cells (neutrophil,monocytes/macrophages and endothelial cells). All these factors are interrelated and interconnected by up-regulatory and down-regulatory mechanisms, which lead to systemic inflammatory response syndrome (SIRS) ***(Tsukamoto et al., 2010).*** This response starts within 30 min of a major injury, and is an inflammatory response to blood loss and tissue damage rather than infection ***(Lord et al., 2014).*** SIRS results from the release of endogenous factorstermed damage-associated molecular patterns (DAMPs) or alarmins after tissue injury. They are secreted byactivated immune cells such as neutrophils or releasedfrom necrotic cells. Non-specific immunity inSIRS is accompanied by suppression of the body's ability to mount a defence against invading pathogens. Theresult is increased susceptibility to infection and sepsis ***(Tsukamoto et al., 2010).***

Cardiovascular changes occurring in the early response to injury result in the redistribution of blood from the skin and viscera to the vital organs and increased contractility of the heart. The system eventually becomes hyperdynamic, with increased cardiac output in order to satisfy the demands of increased metabolism, changes in the thermoregulatory system, and wound healing ***(Winterborn and Cook, 2003).***

Cortisol released in response to injury is profoundly anti-inflammatory. Activation of the hypothalamus-pituitary-adrenal axis usually leads to concomitant release of dehydroepiandrosterone (DHEA) and its sulphated ester

DHEAS. However, following trauma, DHEAS levels fall and cortisol steroidogenesis is predominates. The resulting increased cortisol: DHEA ratio is associated with increased infection rates after trauma ***(Lord et al., 2014).***

The interaction between the brain and nervous system is bidirectional; the traumatized brain exacerbates both SIRS and immunoparesis through parasympathetic and sympathetic pathways, respectively. Mediator of post-traumatic neuroinflammation and secondary neuronal damage, has been ultimately leads to behavioral, emotional, and cognitive problems ***(Tsukamoto et al., 2010).*** Elderly people have a significantly worse prognosis after trauma independent of the nature or severity of the injury, and despite adjustment for comorbidities. The association between age and outcome of injury is potentially confounded, even after risk adjustment ***(Nemergut and Thiele, 2017).*** Elderly people are known to have a low-grade inflammatory state at baseline, termed inflammageing. When injury occurs, the SIRS response can be exaggerated in old people, perhaps because the body has been primed by elevated baseline levels of cytokines, or as a result of their reducedability to produce anti-inflammatory cytokines such as interleukin. Moreover, the capacity to respond to pathogens is more severely suppressed owing to the age-related decline in both the non-specific (innate) and specific (adaptive) immune pathways; a deterioration known as immunosenescence ***(Lord et al., 2014).***

Assessment of trauma patients

"The assessment of trauma patients is based on a treat first what will kill first approach" ***(Parker and Magnusson, 2016).*** It is composed of prehospital care, hospital care, trauma triage and diagnostic procedures.

I <u>Prehospital Care:</u>

The prehospital period is an important phase in the care of all trauma patients. The effectiveness of early triage, intervention, and transport may be the only chance for patients to survive ***(Brown et al., 2017).***

High-quality trauma care begins from the point of first medical contact and continues during transport to local hospitals and ultimately to designated trauma centers ***(Fedor et al., 2017).***

Prehospital trauma care includes, basic life support (BLS) which allows for vital signs assessment, noninvasive airway, ventilation, oxygen administration, basic hemorrhage control and splinting. It also includes advanced trauma life support (ATLS) to enhance breathing, circulation and disability management ***(Gondek et al., 2017).***

To improve patient outcomes after trauma, guidelines have been developed and established in several countries. These guidelines are intended to standardize the assessment and