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TRAUMA LIFE SUPPORT MALAYSIA

Student Provider Manual

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This manual is developed by

The Trauma Life Support Subcommittee,
National Committee on Resuscitation Training
Ministry of Health Malaysia

&

In collaboration with
The Malaysian Society for the Care of Trauma
(MASCOT)

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Trauma Life Support Malaysia

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FOREWORD

Datuk Dr Muhammad Radzi Bin Abu Hassan
Director- General of Health
Ministry of Health Malaysia

Assalamualaikum WBT

Trauma is the leading cause of death among the young generation in Malaysia. It is crucial that a structured and systematic approach is adopted to address this escalating endemic. The Ministry of Health is highly committed to ensuring efforts are put in to reduce morbidity and preventable trauma mortality.

I am proud to announce the Trauma Life Support Malaysia (TLSM) training programme as a strategic initiative aimed at enhancing clinical competency in emergency trauma care and resuscitation. This clinical training module is developed by Malaysia to address the delivery of trauma care within local communities.

Certainly, a structured and sustainable TLSM training programme will fortify the Ministry's effort in accomplishing the agenda of promoting human clinical capital development. Such initiatives are necessary to achieve higher standards of competency care in treating the severely injured patient. These standardised nationwide quality initiatives are a commendable effort to achieve excellence in reducing trauma related deaths.

Finally, I would like to express my most sincere appreciation and gratitude to the Malaysian Society for the Care of Trauma (MASCOT) and the National Committee of Resuscitation Training (NCORT) for their unwavering dedication towards developing the first Malaysian standardised trauma life support training program. I am confident that this applaudable effort will benefit our people and the emergency trauma services as a whole.

FOREWORD

Dr Fatahul Laham Bin Mohamed
Head of National Emergency and Trauma Services
Ministry of Health Malaysia

Assalamualaikum WBT

Trauma management remains an ongoing challenge. Health care workers are faced with the urgency and complexity of caring for injured individuals. The ability to rapidly assess and provide appropriate intervention is the foundation of effective trauma care.

This publication covers the initial care of trauma, including trauma reception, primary and secondary survey assessments for major trauma injuries. It provides a comprehensive understanding of the trauma system, guiding the reader through the steps of assessment, stabilization and treatment. To ensure that this publication remains a relevant guide, the content of Trauma Life Support Malaysia is based on the integration of evidence-based clinical practice and the latest research findings.

Trauma Life Support Malaysia also goes beyond the technical aspects of trauma management, emphasizing the importance of clear communication, teamwork, and a patient-centric approach. Strong emphasis is placed in addressing the psychological and social impact of traumatic injuries for both patient and all health professionals involved in the provision of care. This guide equips the reader holistically to face and address the needs of patients affected by traumatic injuries.

Trauma Life Support Malaysia publications also utilise various adjunct media modalities to ensure easy and interactive access to academic materials. Virtual web-based platforms are utilised to provide pre-course training videos, e-book, quick reference posters and other training materials.

My sincere thanks to the authors, editors, and all those who have contributed to the development and publication of this guide. Their tireless efforts and dedication will undoubtedly change the landscape of emergency trauma care delivery, improving outcomes and providing total quality management for trauma patients in Malaysia.

FOREWORD

Dr Ridzuan bin Dato' Mohd Isa
Chairman
National Committee for Resuscitation Training
Ministry of Health Malaysia

Assalamualaikum WBT

Trauma Life Support Malaysia (TLSM) is a comprehensive clinical resuscitation training module that has been jointly developed by the Malaysian Society for the Care of Trauma (MASCOT) and the National Committee of Resuscitation Training (NCORT) Ministry of Health Malaysia. The TLSM module represents an important component in the development of clinical competency for trauma resuscitation in Malaysia.

This training program denotes an educational module for standardisation of trauma care resuscitation and initial care approach in Malaysia. This vital element is crucial in ensuring the sustenance of predictable quality outcomes for all trauma resuscitation conducted within the national healthcare ecosystem.

The modules developed are based on high quality evidence of the latest research findings as well as clinical expert consensus in trauma resuscitation care. The TLSM module enables participants to acquire and enhance their knowledge as well as clinical skills within the field of trauma resuscitation.

I would like to take this opportunity to provide my utmost gratitude and appreciation to those who have contributed directly and indirectly towards making the TLSM training module a success. May all your efforts be blessed by the Almighty.

FOREWORD

Dr Shah Jahan Mohd Yussof
President
The Malaysian Society for the Care of Trauma (MASCOT)

Assalamualaikum W.B.T

In The Name of Allah, The Most Gracious and The Most Merciful.

Trauma is among the leading causes of death in Malaysia and the World. It is the highest cause of preventable death amongst the younger population in this country. It is imminent time for strategic action be taken to address the needs and challenges of this endemic. The burden of duty is the cumulative responsibility of all stakeholders involved in both, its prevention as well as treatment efforts.

Clinical competency development is amongst the key components required to improve emergency trauma care delivery and achieve higher quality outcomes. The development of The Trauma Life Support Malaysia (TLSM) training program is a strategic collaborative initiative aimed specifically towards achieving these goals. This training program is designed to cater the clinical proficiency needs of our Malaysian trauma care responders, including Doctors, Medical Assistants and Staff Nurses. TLSM training represents a National standardized approach in delivering high-quality evidence based clinical education for the Malaysian trauma care landscape.

The Malaysian Society for the Care of Trauma (MASCOT) is proud to play its collaborative role in responding to the Nations urgent call to reduce preventable trauma morbidity and mortality. MASCOT is committed to advance all possible efforts in promoting the continuous development and improvement of trauma care systems in Malaysia.

Finally, on behalf of The Malaysian Society for the Care of Trauma, I would like to take this opportunity to congratulate all stake holders who have diligently authored and published this comprehensive training manual. MASCOT congratulates all of you for the successful delivery of The Trauma Life Support Malaysia training program. May all your efforts be blessed by The Almighty.

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Glossary

ABG	Arterial blood gas
ASIA	American Spinal Injury Association
ATMIST	A = Age, T = Timing, M = Mechanism, I = Injuries, S = Signs, T = Treatment
BP	Blood pressure
CICO	Can't intubate, can't oxygenate situation
cmH_2O	Centimeters of water
CO	Cardiac output
CO_2	Carbon dioxide
CPP	Cerebral perfusion pressure
CPR	Cardiopulmonary resuscitation
CSF	Cerebrospinal fluid
CT	Computerised tomography
CXR	Chest x-ray
DPL	Diagnostic peritoneal lavage
ECG	Electrocardiogram
EDRT	Emergency Department Resuscitative Thoracotomy
eFAST	Extended focused assessment with sonography in trauma
FAST	Focused assessment with sonography in trauma
FBC	Full blood count
FFP	Fresh frozen plasma
FiO2	Fractional inspired oxygen concentration
GCS	Glasgow coma scale

HR	Heart rate
hrs	Hours
ICP	Intracranial pressure
ICU	Intensive care unit
IO	Intraosseous
IV	Intravenous
LMA	Laryngeal mask airway
MAP	Mean arterial pressure
MAPLE	A = Allergies, M = Medications used currently, P = Past medical history/Pregnancy, L = Last Meal, E = Events/Environment related to injury
MBC	Medical Base Commander
MELO	Medical Liaison Officer
MESARO	Medical Search and Rescue Officer
METHANE	M=Major incident declared?, E= Exact location, T=Types of incident, H=Hazard, A=Access, N= Number of estimated casualties, E=Emergency services available
MILS	Manual in-line stabilisation
mmHg	Millimeters of mercury
mmol/l	Millimoles per litre
MRI	Magnetic resonance imaging
MTP	Massive Transfusion Protocol
NEXUS	National Emergency X-radiography Utilisation Study
OMC	On Scene Medical commander
$PaCO_2$	Arterial partial pressure of carbon dioxide
PaO_2	Arterial partial pressure of oxygen
RBCs	Red blood cells

Rh	Rhesus
SBP	Systolic blood pressure
SGA	Supraglottic airway
SCIWORA	Spinal cord injury without radiological abnormality
SpO_2	Peripheral oxygen saturation
TBI	Traumatic brain injury
% TBSA	Percentage of total body surface area
TTL	Trauma team leader
T-MTP	Targeted Massive Transfusion Protocol
WBC	White Blood Count

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INTRODUCTION

Trauma is a global disease occurring at a pandemic scale; it occurs constantly within all communities and causes significant morbidity and mortality. Worldwide, 16,000 people die every day as a result of trauma (5.8 million deaths/year). Motor vehicle accidents are the leading cause of trauma related death globally. A further 20 to 50 million people suffer from non-fatal injuries with associated disabilities. Approximately 93% of the world's fatalities on the roads occur in low- to middle-income countries. In Malaysia, trauma ranks the top five highest cause of death in 2022 and the leading cause of death for young adult population (19 - 40 years old). It is the highest contributor to premature death in Malaysia.

MAJOR TRAUMA

Definition: A clinical syndrome induced by injury that has the potential to cause prolonged disability or death.

Major trauma criteria:

1. Serious injury to two or more body systems
2. Trauma patients with Injury Severity Score (ISS) ≥12
3. Trauma patients who succumbed to their injuries after admission
4. Trauma patients admitted to ICU or high dependency area for >24 hours
5. Trauma patients requiring mechanical ventilation
6. Trauma patients who require urgent surgery within 24 hours (intracranial, intra-thoracic, intra-abdominal, pelvis or spine)

THE CONCEPT AND OVERVIEW OF THE TRAUMA DEATH

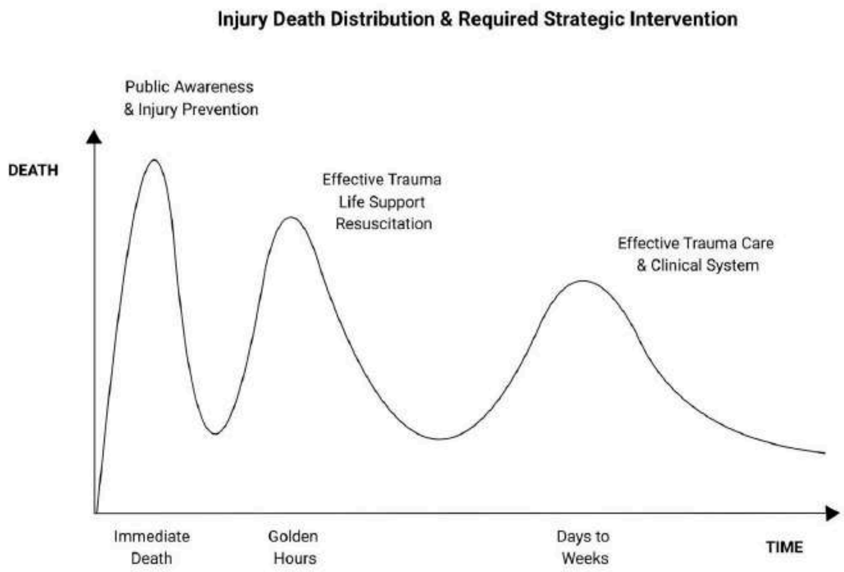

Figure 1.1: Injury Death Distribution & Required Strategic Intervention

PHASE	DESCRIPTION	EXAMPLE
FIRST PHASE	**Immediate** Seconds to minutes Preventive measures can reduce the number of deaths in this phase.	• Brain stem injury • High spinal cord injury • Laceration to heart or great vessel
SECOND PHASE	**Minutes to hours** Timely life saving intervention for favourable outcome/prognosis Principles: 1. On-site Intervention & Transportation to the nearest appropriate hospital 2. Rapid assessment and stabilization 3. Rapid decision making 4. Rapid definitive management	• Hemorrhagic shock • Life threatening injuries
THIRD PHASE	**Days to weeks** Due to complications from injuries. Optimal management is crucial to prevent death in this phase.	• Multiple organ failure • Sepsis • Nosocomial Infection

Table 1.1: Trauma Death Distribution

The trimodal distribution of death describes the 3 peaks of patient death that occur amongst major trauma victims. The first peak is the highest peak and is inevitably due to the injury itself. Most patients succumb to injuries on scene or en-route. Trauma prevention measures may reduce death in this phase.

The second peak of death is potentially preventable with an improved trauma healthcare system. This phase of death is due to clinical deteriorations compounded by secondary injury in patients. Improved clinical efficiency and competency can largely reduce the incidence of death within this phase.

The third peak of death occurs within the subsequent weeks to months. This peak of trimodal death is largely contributed by infection and multiorgan failure. Patients’ comorbidities also play a significant role in this phase and it can be reduced with improved infrastructure, service, intensive care facility, ward and early rehabilitation.

BIOMECHANICS OF INJURY

The biomechanics of injury is the understanding of the mechanism, extent of energy transmission, trajectory of impact and surrounding circumstances that lead to injuries.

Biomechanics of Injury:

1. Anticipate injury patterns apart from the obvious injuries.
2. It assists in determining the nature of the impact (blunt or penetrating).
3. It reflects the extent of tissue damage and organ specific injury.
4. Provides an estimation of energy transfer and the direction of impact. In blunt trauma, the energy is extended deep into the body from the point of impact. In penetrating trauma, damage occurs either by puncturing a vital structure or by releasing energy laterally into tissues causing destruction.

INDICATIONS OF HIGH RISK MECHANISM OF INJURY

1. Injuries that penetrate the chest, abdomen, head, neck, and groin.
2. High risk motor vehicle crash
    - Intrusion, including roof : > 30cm, occupant site : > 45cm, in any site
    - Ejection out of motor vehicle
    - Death in same passenger compartment
    - Vehicle telemetry data consistent with high risk injury
    - Motor vehicle vs. pedestrian/cyclist thrown, run over, or with significant speed (32 km/h)
    - Motorcycle crash > 32 km/hour
    - Rollover mechanism
3. Burns over more than 20%(adult) or 10% (children) of the body or inhalation injury
4. Fall Injuries:
    - Adults: Falls from a height approximately 24 feet or equivalent to two floors' height
    - Children: Falls from a height 2 times the child's own height

THE PHYSIOLOGY AND THE METABOLIC RESPONSE TO TRAUMA

Introduction

Trauma results in significant physiological changes, essentially via the metabolic and endocrine pathway. Intrinsically it involves the inflammatory and autonomic systems. The aim is to optimize tissue repair. The metabolic and endocrine response focuses on mobilizing fuel sources, conserving volume and minimizing blood loss. There is a complex interaction between these pathways with a surge in hypermetabolism and catabolism. These pathways are complex and can result in failure of negative feedback.

The metabolic response will correlate directly with the degree of tissue damage. This response will also be dependent on the age, sex, comorbidities, nutritional state and the timing of treatment and its effectiveness.

It is vital for the trauma care provider to have an understanding of these concepts to minimize the consequences of injury, optimize and support the body's physiological responses.

Initiation

The First Hit from the trauma vector causes tissue damage and hemorrhagic shock. The tissue damage triggers somatic and visceral afferent neurons that ascend to the central nervous system. The complement pathway is activated when the tissue damage occurs which releases the Danger-associated Molecular Pattern (DAMP). The breach of the skin protective layer may introduce pathogens and the release of Pathogen Associated Molecular Pattern (PAMP). The aim is to limit further tissue damage and promote tissue repair.

The Immunological response

The aim of the immune responses is to protect by killing pathogens, clearing tissue damages and initiating tissue repair. The complement pathway is activated when the tissue damage occurs. This results in neutrophil and macrophage activation with subsequent release of inflammatory mediators (interleukin-1, TNF-alpha and platelet activating factor). Consequently there is up regulation of other acute phase proteins (fibrinogen, oxygen free radicals and proteases, thromboxanes and prostaglandins). There is cross-talk between the complement and coagulation cascades. The end result of this earliest phase of the propagation of the coagulation cascade, neutrophil accumulation at the site of injury and a lymphocytes with induction of both cell mediated and humoral pathways.

Hemostasis

Various hemostatic mechanisms are activated in an attempt to prevent ongoing blood loss and conserve volume. These include vasoconstriction, platelet adhesion and platelet aggregation leading to clot formation. These processes are augmented by the inflammatory response such as thromboxane A2. Imbalance between pro and anti-coagulant factors eventually will result in a hypercoagulable state.

Volume conservation and redistribution

Major trauma may result in a shock state with hypoperfusion of vital organs. Several physiological responses occur in an attempt to maintain organ perfusion. The overall aim is to ensure redistribution of blood flow to vital organs, volume conservation and optimal hemostasis.

The hypothalamic pituitary axis plays a central role in coordinating the endocrine and metabolic responses. The hypothalamus receives multiple inputs including from the baroreceptors, volureceptors and pain fibers stimulated during trauma. In response a number of vital pathways are activated via the pituitary glands, adrenal glands and the sympathetic nervous system.

The hypothalamus activates the sympathetic nervous system and the adrenal cortical system to produce the "flight or fight responses." The increased sympathetic outflow leads to positive cardiac inotropy and chronotropy. Sympathetically mediated peripheral venoconstriction mobilizes blood from reservoirs to increase the venous return. Arteriolar vasoconstriction redistributes blood flow from peripheral to central structures.

Cardiovascular

Hypertension and tachycardia occur when the myocardial and vascular adrenergic receptors are triggered by both direct sympathetic innervations and circulating catecholamines. This will increase the cardiac output.

Renal

In order to promote fluid retention, renin is released from the juxtaglomerular cells by direct sympathetic innervations. Anti-Diuretic Hormone(ADH) increases the number of aquaporin channels to promote water resorption.

Mobilisation of energy resources

Corticotrophin releasing hormone (CRH) from the hypothalamus results in release of adrenal corticotrophin hormone (ACTH) from the anterior pituitary into the blood. It acts on the adrenal cortex resulting in a surge of cortisol. Cortisol induces gluconeogenesis and mobilizes energy stores. The rise of cortisol level would result in negative feedback into the hypothalamic pituitary axis and reduce the release of CRH.

The growth - hormone releasing hormone (GHRH) is also released from the hypothalamus which leads to the release of growth hormone (GH) from the anterior pituitary. It will increase catabolism via insulin growth factors. There is a decrease in insulin secretion and increase of glucagon secretion by the pancreas. These pathways all result in an increase in gluconeogenesis via glycogenolysis, lipolysis and proteolysis. There is also a relative insulin resistance. This will increase the circulating blood glucose levels and decrease the glucose uptake by the cells. This will increase the glucose at the cellular level to support the body post trauma.

Clinical and Therapeutic Relevance

All these processes seek to preserve vital organ functions and allow survival following traumatic insults. However, without appropriate management, the compensatory mechanisms can be overwhelmed resulting in death. The healthcare provider must take steps to prevent or reduce the effect of the Second Hit. Wherever possible, efforts should be made to reduce the magnitude and duration of the initial insult. This will reduce the extent of the metabolic changes. Thus aggressive resuscitation, control of pain and temperature, limiting acidosis, adequate tissue debridement, avoidance of unnecessary blood component administration and nutritional support is critical.

THE MALAYSIAN TRAUMA CHAIN OF SURVIVAL

The Malaysian Trauma Chain of Survival is a strategic concept that delineates the vital flow and core processes that a severely injured trauma victim would undergo from the point of injury to recovery. It emphasizes the importance of a seamless care process and equal importance of every trauma related specialty in assuring the best outcome and survival probability. The “chain” symbolizes the close association and relationship required amongst all team members in order to deliver quality and meaningful trauma care outcomes in Malaysia. It is divided into 5 phases:

Phase 1: Early Activation & Pre-Hospital Trauma Care

1. Incorporates community first aid
2. Prevent immediate deterioration
3. Early activation and rapid response of pre-hospital trauma care service
4. Initiation of damage control resuscitation

Phase 2: Trauma Life Support and Resuscitation

1. Rapid primary and secondary survey assessment
2. Advanced trauma resuscitation and stabilization
3. Damage control resuscitation
4. Rapid diagnostic interventions and strategic clinical planning

Phase 3: Acute Surgical and Interventional Care

1. Damage control or primary definitive surgery
2. Interventional radiology and hemorrhage control

Phase 4: Intensive & Definitive Care

1. Definitive surgical and interventional trauma care management
2. Trauma intensive care monitoring
3. Trauma ward care management

Phase 5: Recovery & Rehabilitation

1. Early mobilization and advanced trauma rehabilitation
2. Quality of life restoration and skills development
3. Occupational rehabilitation and psycho-social therapy

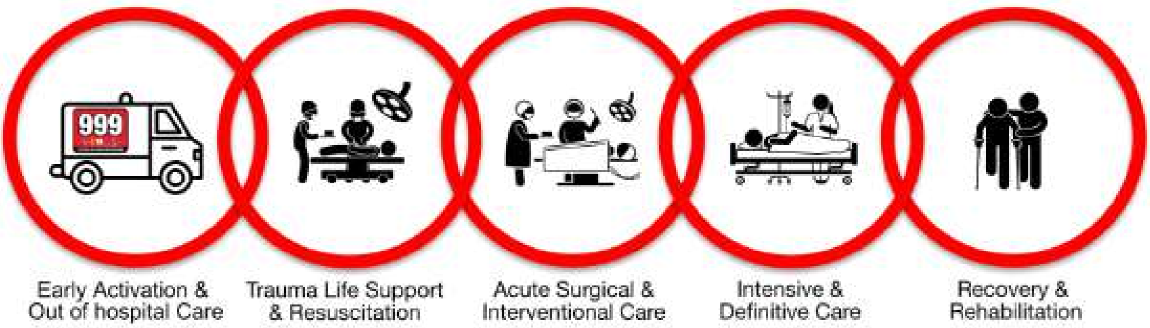

Figure 1.2 : The Malaysian Trauma Chain of Survival

CHAPTER 1

INITIAL TRAUMA ASSESSMENT & MANAGEMENT

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Identify correct sequences and priorities of managing a major trauma victim.
2. Apply principles outlined in primary & secondary surveys.
3. Identify common pitfalls associated with trauma victim clinical assessment.
4. Re-evaluation of patients not responding to initial management.

1.1 PRE HOSPITAL PHASE

In the pre hospital phase, clinical assessment and intervention will focus on the following:

1. Airway management and cervical immobilization.
2. Breathing and ventilation.
3. Circulation resuscitation & external hemorrhage control.
4. Immobilization of the patient.
5. Early administration of tranexamic acid.
6. Avoidance of overzealous fluid resuscitation.
7. Communication with receiving hospital & immediate transport to the closest, appropriate facility.

The Pre-Hospital Care (PHC) team must notify the Emergency Department and relay crucial information. Online medical direction should be requested if there are any queries on the management or a Trauma bypass is needed. The management of Multiple Casualty Incident (MCI) is discussed in Chapter 17.

1.2 IN HOSPITAL PHASE

A structured approach to managing a major trauma patient is important. An overview of the approach is shown in Figure 1.3. In addition, the non-technical skills (i.e close loop communication, time management etc) are of emphasis and should be explicitly done.

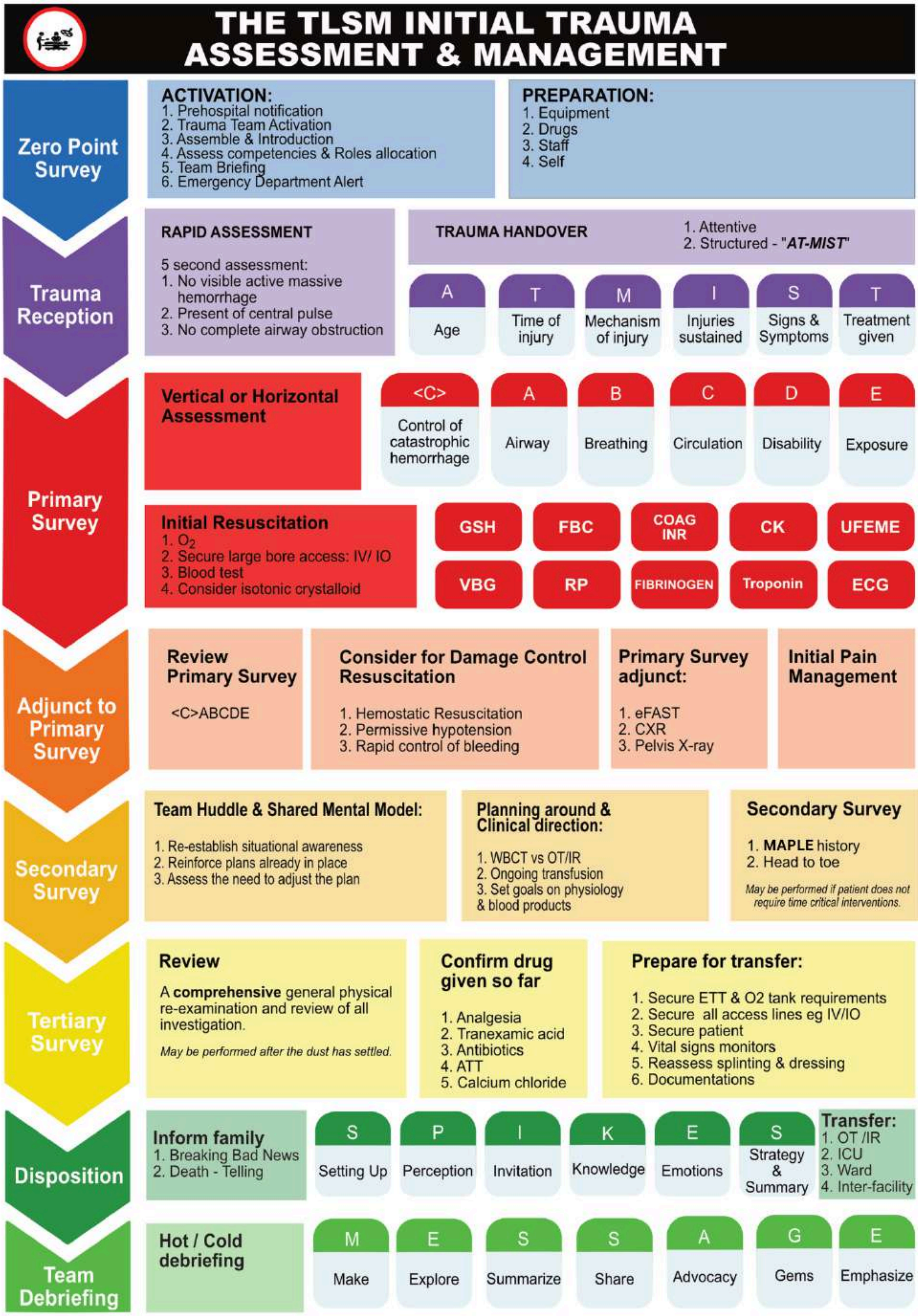

Figure 1.3 : Overview approach of initial assessment & management

1.2.1 Zero Point Survey

1.2.1.1 PRE-HOSPITAL TRAUMA NOTIFICATION

Prior to the patient's arrival, the PHC team should notify the ED. This will allow the receiving hospital to make the necessary preparations prior to patients' arrival (refer to Chapter 16).

1.2.1.2 TRAUMA TEAM ACTIVATION

Trauma team activation shall be initiated in the Emergency Department of the receiving hospital. Various centers may have different Trauma team activation protocols (refer to Chapter 16)

1.2.1.3 TEAM BRIEFING & EMERGENCY DEPARTMENT PREPARATION

During the Zero point survey, the Trauma Team Leader (TTL) is recommended to provide a pre-arrival team briefing. The clinical information acquired from the PHC, as well as the predicted immediate course of action required, must be discussed with the team during the briefing. Based on the information obtained, the team must also prepare the necessary equipment, medications, staff and self.

1.2.1.4 ROLES ALLOCATION

Ideally, the team members and their roles should be identified ahead of time for each shift. The TTL should be the most experienced member of the team. If it is an ad hoc team, the TTL should conduct a quick assessment of the team members' competencies before assigning a role.

1.2.1.5 PREPARATION

Preparation aims for a smooth transition of care from prehospital to in hospital setting during the Trauma Reception.

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No	Category	Description
1.	PPE	Mask Glove Apron Goggles/ Eye shield
2.	Trolley	Consider special trolley for bariatric patients
3.	Airway & cervical spine control equipment	Basic & Advanced airway Suction Ventilator Semi rigid collars, blocks and tape Difficult airway Surgical airway
4.	Breathing	Monitoring Chest drainage
5.	Circulation	Dressing/tourniquet Limb immobilizers Pelvic binder or sheet Large bore vascular access/ Intraosseous Transfusion devices

Table 1.2 : Preparation of equipment for major trauma patient

1.2.1.6 TRAUMA RECEPTION & HAND OVER

The TTL shall perform a rapid assessment upon the patient's arrival at the Resuscitation Bay to confirm for presence of a central pulse, identify any visible exsanguinating hemorrhage that requires immediate intervention, and assess for any complete airway obstruction. If there are any abnormalities, such as no pulse, the traumatic cardiac arrest algorithm will be used, and the handover will be between the TTL and the PHC team. If not, it is crucial that the handover is structured and done attentively. The Trauma Team should pay attention during this process, while the PHC team provides the following information:

AT-MIST

	Information	Description
A	Age	Name, Age, Sex
T	Time	Time of Injury Estimated time of arrival (ETA)
M	Mechanism of injury Medical illness	Highlight any high-risk mechanisms History of medical or surgical illness.
I	Injuries suspected or known	Pain, deformity, injuries, and injury patterns
S	Signs and Symptoms	Vitals: Initial/current/worst GCS: E/V/M Total
T	The treatment administered and its subsequent effects.	Tubes, lines (location and size), fluids. Medications and response Immobilization and dressings.

Table 1.3 Essential pre-hospital information (**AT-MIST**)

1.3 PRIMARY SURVEY

<C>	A	B	C	D	E
Control of catastrophic hemorrhage	Airway	Breathing	Circulation	Disability	Exposure

Definition: A systematic examination performed during the initial phase of trauma reception to ***identify and treat immediate life-threatening injuries.***

> Clinical assessment must be performed repeatedly to identify any changes in the patient's clinical status that would necessitate the need for any additional intervention.

The process constitutes the assessment of the "<C>ABCDE" of trauma care to identify and treat any immediate life-threatening conditions by adhering to the following systematic approach:

<C> - IMMEDIATE CONTROL OF ANY CATASTROPHIC HEMORRHAGE
(Massive Open Hemorrhage That Is Immediately Life Threatening if not controlled)
A - AIRWAY MAINTENANCE AND CERVICAL SPINE PROTECTION
B - BREATHING AND VENTILATION
C - CIRCULATION AND HEMORRHAGE CONTROL
D - DISABILITY ASSESSMENT AND NEUROLOGIC EVALUATION
E - EXPOSURE AND ENVIRONMENTAL CONTROL

Immediate life - threatening injuries
(ATOM - TC)

A - Airway Obstruction
T - Tension Pneumothorax
O - Open Pneumothorax
M - Massive Hemothorax
T - Tracheobronchial Injury
C - Cardiac Tamponade

STOP THE BLEEDING

(When adequate number of team members are present, critical tasks can be performed simultaneously and in horizontal manner)

Figure 1.4 : Catastrophic Hemorrhage from Rt. Subclavian Artery Laceration with immediate intervention to control Exsanguinating bleed during early primary survey <C>

1.3.1 AIRWAY MAINTENANCE AND CERVICAL SPINE PROTECTION

The airway should be assessed to ascertain patency. The level of consciousness must be quickly assessed using the following criteria:

A – Alert
V – Respond to verbal stimuli
P – Respond to pain stimuli
U – Unconscious

The airway is considered patent if the patient is able to speak clearly. Rapid assessment for signs of partial or total airway obstruction is required, which includes suctioning, inspecting for foreign bodies, and determining any severe facial injury that may necessitate a temporary digital reduction.

	ASSESSMENT	ACTION
INSPECTION	Look at nasal and mouth opening for any obvious deformity, bleeding or obstruction - Vomitus - Debris - Blood - Tongue - Maxillofacial injury	Gentle chin lift / jaw thrust. Suction using rigid suction catheter to clear out any obstructions. Assessment of gag reflex and the use of airway adjunct. Application of high oxygen concentration to all trauma patients. Definitive/ Surgical airway if indicated
PALPATION	Palpate for any tenderness or facial bone fracture.	Indication for digital reduction for severe facial injury.

Table 1.4 : Examination of Airway

SIGNS OF AIRWAY OBSTRUCTION

- Snoring or gurgling
- Stridor or abnormal breath sounds
- Agitation (hypoxia)
- Using the accessory muscles of ventilation
- Cyanosis (late)

While assessing and managing a patient's airway, great care should be taken to prevent excessive movement of cervical spine. Any excessive neck movement at all ranges must be prevented. The application of a cervical collar and head immobilizer should be performed as soon as possible.

Figure 1.5 : Jaw Trust

Figure 1.6a

Figure 1.6b

Figure 1.6a & 1.6b : Placing a Cervical collar and head immobilizer for improved cervical protection during transportation

PERFORMING ANTERIOR APPROACH IN-LINE CERVICAL IMMOBILISATION

The following concerns need to be addressed:

- Do not "lock the jaw" of the patient by immobilising the temporo-mandibular joint
  - This will induce difficulty in performing laryngoscopy and endotracheal intubation
- Do not "rest your arms" and body weight onto the patient's chest
  - This will complicate ventilation efforts and reduce the ability to clearly visualise chest movements

Prior to applying cervical collar, examine and look for:

- Expanding hematoma
- Subcutaneous emphysema around the neck region

Indication for applying cervical collar and head immobilizer:

1. Patient with injuries above the clavicle
2. Complain of neck pain on movement
3. Patients with neurological deficits
4. Patients who are unconscious or subconscious
5. Patients with high-risk mechanism of injury
6. Blunt trauma patients with 2 or more system involvement
7. Major trauma patients requiring inter-facility transfer

If immobilization devices need to be removed temporarily, one of the team members should manually stabilize the patient's head and neck using in-line immobilization technique.

Figure 1.7 Manual in-line cervical immobilization (from above / posterior approach)

Figure 1.8: Manual in-line cervical immobilization (from below)

1.3.2 BREATHING AND VENTILATION

Airway patency alone does not ensure adequate ventilation. Ventilation is a very important component and requires adequate function of lungs, chest wall and diaphragm. There are 6 life - threatening injuries that should be identified and require immediate attention for ventilation efforts to be effective.

		ASSESSMENT	OBJECTIVES
I	INSPECTION	Expose adequately neck and chest - Assess for jugular venous distension - Any wound - Chest expansion - Respiratory rate	To identify -Tension Pneumothorax -Open pneumothorax -Massive Hemothorax -Tracheobronchial injury -Cardiac Tamponade
P	PALPATION	Position of trachea Subcutaneous emphysema Ribs and sternal tenderness	As above
P	PERCUSSION	Percuss for dullness or hyper-resonance	Useful for diagnosis of hemothorax and pneumothorax
A	AUSCULTATION	Auscultate any abnormality of air entry and heart sounds	As above

Table 1.5 : Examination for breathing and ventilation

1.3.3 CIRCULATION AND HEMORRHAGE CONTROL

Trauma patients require prompt vascular access for fluid resuscitation and medication administration. Peripheral intravenous (IV) lines are the preferred method commonly with sizes of 18G or larger. Intraosseous (IO) access or central venous cannulation may be necessary if peripheral access is unavailable or fails. Timely vascular access is crucial for resuscitation and better management of trauma patients.

Hemorrhage is the leading cause of preventable injury related deaths. Therefore, it is crucial to identify the source of bleeding, aim for definitive control, correct deficits guided with laboratory investigations, point of care tests or viscoelastic hemostatic assay (VHA) and look for other potential injuries and manage accordingly. Consider anti-thrombotic agent reversal in patients with ongoing bleeding guided by goal directed strategies.

Principles of management:

1. Rapid & accurate assessment within seconds to assess for shock (CCTVR)
    a. Colour
    b. Capillary Refill Time
    c. Temperature
    d. Volume
    e. Rate
2. Identify the source and stop the bleeding

- External - Look for any open wound especially on the scalp or extremities.
  - Apply direct compression, consider topical haemostatic agents, specific suture techniques, deep fascial packing, and applications of appropriate tourniquet with an appropriate definitive control plan.

- Internal - Major areas of internal bleeding are from chest, abdomen, retroperitoneum, pelvis and long bones. Bleeding may involve more than one organ or system. Appropriate resuscitative efforts with judicious fluids, targeted volume resuscitation, correction of deficits or imbalances with goal directed therapy. May require further contrast imaging in stable patients. Consider interventional radiology, surgery or ICU care where appropriate.

HEMORRHAGIC SHOCK IS A LIFE-THREATENING CONDITION AND MUST BE RECOGNISED AND TREATED IMMEDIATELY

Remember the Mantra

"Collar the neck, Collar the hips"

Circumferential Pelvic Binders / Splints should be affixed for all patients with high-risk mechanism of injuries and suspected pelvic fractures. This intervention should be performed early and during the pre-hospital phase

Circumferential pelvic binders / splints should be applied to all the following trauma patients.

1. Patients with suspected pelvic fracture
2. Unconscious trauma patients
3. Trauma patients with multiple system injuries
4. Trauma patients experiencing pain over the abdomen or pelvic region
5. Trauma patients with high impact mechanism of injuries

Figure 1.9: Direct compression pressure

Figure 1.10: Tourniquet – Should be used when direct pressure is ineffective in massive exsanguination from an extremity

Specific Population

- Elderly patients have a limited ability to increase HR in response to blood loss. Medication(s) & premorbid illness may mask symptoms of hypovolemic shock.
- Children may have abundant physiologic reserves, however once the compensatory plateau diminishes they can deteriorate very rapidly.
- Well trained athletes may have baseline bradycardia and may not demonstrate the usual response level of tachycardia.

Pharmacological Adjuncts**:**

- Tranexamic Acid should be administered in all patients who are bleeding or at risk of significant bleeding including suspected or confirmed traumatic intracranial bleed, within the first 3 hours of injury.
- Consider the use of Prothrombin Complex Concentrate (PCC) in bleeding patients on Warfarin.
- Also consider the use of PCC in patients on Direct Oral Anticoagulants (DOAC) without the presence of specific antidotes.

While hemorrhage remains the primary cause of shock in trauma patients, it is essential to consider alternative etiologies. By expanding our diagnostic approach to include obstructive shock (cardiac tamponade or tension pneumothorax), neurogenic shock, and cardiogenic shock, we can improve patient outcomes through timely recognition and appropriate intervention. Vigilance, knowledge, and a comprehensive understanding of these alternative causes are paramount in providing optimal care to trauma patients presenting with shock.

1.3.4 DISABILITY ASSESSMENT AND NEUROLOGIC EVALUATION

A rapid neurological assessment is performed to establish the patient's level of consciousness (using Glasgow Coma Scale), pupillary size, reaction, lateralizing signs, spinal cord injury and neurological deficit. Aside from the direct impact of head injury, other factors may also contribute to a decreased level of consciousness such as hypoxia, shock, hypoglycemia, alcohol or substance abuse. However, all neurological deficits should be investigated appropriately with appropriate CT / MRI imaging, and all other causes of reduced conscious levels should also be explored

The focus should be to prevent secondary brain injury by providing effective cerebral protection

1.3.5 EXPOSURE AND ENVIRONMENTAL CONTROL

- Expose the patient for complete examination.
- Patients' clothing should be removed to enable a complete head to toe examination.
- Garments should be cut along seam lines in order to minimize patient movement / manipulation

- Wet clothing should be removed early to prevent hypothermia and replaced with warm blankets / heated sheets after examination is completed.
- Caution should be emphasized amongst all staff when encountering broken glasses and other sharp debris on patients clothing, skin and even hair.
- Prevent hypothermia and risk of coagulopathy by infusing warm fluids.

Logroll Examination:

- Log roll examination can be performed either in primary survey or secondary survey depending on the clinical presentation and injury pattern of the patient.
- The decision on when to perform the log-roll should be made by the team leader based upon the clinical assessment and presentation of the patient.
- A log-roll examination can be performed once the trauma team leader is convinced that there is an unlikely risk of the patient sustaining an unstable pelvic fracture.
- Performing log-roll in patients with unstable pelvic fracture may cause further harm, injury and aggravation of hemorrhage. Therefore, it is crucial to rule out an unstable pelvic fracture prior to performing a log-roll examination.
- An assessment to rule out unstable pelvic fracture can be made either clinically (i.e. conscious and cooperative patient) or by adjunct use of appropriate imaging such as an x-ray / CT imaging
- Do not perform a "pelvic-spring" examination. This maneuver may further aggravate injury to the already unstable pelvic bone structure.
- Any pelvis examination and assessment for tenderness should be performed based upon a "*single hand palpation" method. i.e. as performed for abdominal examination.*
- In a case of suspected unstable pelvic fracture, the pelvis primary x-ray can be used to rule out unstable fractures prior to performing a log-roll. In the event the primary X-ray may not be adequate for this purpose, the log-roll examination may be delayed till after more detailed imaging can be performed such as a CT-scan. Pelvic binders should be kept in place for all such patients until an unstable pelvic fracture can be definitively ruled out.

In the event that a log-roll cannot be performed due to a suspected unstable pelvic fracture;

- o Immediate life-threatening injuries on the posterior torso of the body can be clinically identified / suspected early by performing a "*back sweep"* prior to a complete log roll examination. The patient's trunk may be gently tilted to an angle no more than 15 degrees on each sight to facilitate assessment by running the palm of the examiner's hand from top to bottom on each side of the posterior torso. The examiner will be able to palpate and identify abnormalities such as bleeding / lacerations or presence of foreign bodies.
- o In the event that the "back sweep" examination reveals ie; Evidence of bleeding / blood stained linen or any other significant findings that may suggest an immediate life threatening condition, the Trauma Team Leader can make a decision on a risk vs benefit assessment of performing a log-roll prior to ruling out a suspected unstable pelvic fracture.
- o In the event that there are no clinical findings to suggest an immediate life-threatening injury over the posterior torso, the log-roll examination can then be delayed until an unstable pelvic fracture can be definitively ruled out by appropriate imaging or clinical assessment.

- During the log roll, a complete inspection and palpation of the torso should be performed.
- Clinical assessment of the entire spine to look for step deformity, swelling, tenderness and crepitus should be performed in a careful manner. This examination can be facilitated by the use of a lubricating gel during palpation of the spine. The application of gel onto the surface of the examining gloved hand, will increase the sensitivity to identify abnormalities during palpation over the spine such as step deformities and minor swellings.

  - Routine neurological digital rectal examinations should not be performed for all trauma patients. Digital rectal examinations to assess anal tone, abnormalities or reflexes should be performed for patients with signs suggesting possible spinal cord injuries. ie; neurological deficits, paraplegia, priapism or patients who are intubated prior to assessment of neurological function.
  - Otherwise, a general neurological assessment may include assessment of the perianal sensation and the ability of the patient to contract the gluteal muscles.

Performing a log roll in a patient with an unstable pelvic fracture will lead to further hemorrhage and shock. Unstable pelvic injuries should be ruled out prior to performing a Log-roll examination.

1.3.6 DAMAGE CONTROL RESUSCITATION

In cases of uncontrolled bleeding, the TTL will continue management in line with the principles of damage control resuscitation (DCR). The strategies include

1. Permissive Hypotension / Balanced Resuscitation
2. Hemostatic Resuscitation
3. Early identification of source and control of hemorrhage
4. Prevent hypothermia, metabolic acidosis, coagulopathy and hypocalcemia
5. Damage Control Surgery

1.3.7 ADJUNCTS TO PRIMARY SURVEY & RESUSCITATION

1. Arterial Blood Gasses
   - Should be used to monitor adequacy of oxygenation and ventilation.
   - This can also give information regarding acid base derangement and presence of shock.

2. Serum lactate
   - Helps to detect hypoperfusion.
   - Prompt corrections should be initiated to reduce mortality
   - Caution in patients under drug / alcohol influences and liver impairment as the levels may be misleading.

3. Hemoglobin level
   - Initial level and its trend, coupled with clinical evaluation will help to decide the type/rate of subsequent blood transfusion.

4. Primary X - ray Examination
   - X-Ray examination should be used judiciously and should not delay patient resuscitation.
   - Chest (AP) and Pelvic (AP) often can provide information that can guide resuscitation of patients.

5. Extended Focused Assessment with Sonography in Trauma (e-FAST) is a useful adjunct to identify causes of hemodynamic instability.

6. Electrocardiographic (ECG) monitoring
   - Any dysrhythmias including ST changes in ECG and ventricular ectopics may indicate blunt cardiac injury.
   - Pulseless electrical activity may indicate cardiac tamponade, tension pneumothorax, and/or hypovolemia.

7. Urinary and Gastric catheter
   - Urine output is a sensitive indicator of the patient's volume status and reflects renal perfusion.
   - Transurethral bladder catheterisation is contraindicated in urethral injury
   - Urethral injury should be suspected when there is:
     - Blood at urethral meatus
     - Anogenital hematoma
     - High riding or non-palpable prostate
   - Gastric catheter is inserted to decompress the stomach to prevent the risk of aspiration and assess for upper gastrointestinal hemorrhage from trauma.

8. End tidal CO_2
   - Helpful in confirming the placement of endotracheal tube and adequacy of ventilation.
   - This also reflects cardiac output.

1.4 SECONDARY SURVEY

Definition: Secondary survey is a systematic head to toe examination in order to identify any potential life-threatening injuries.

Secondary Survey is performed once primary survey is completed, resuscitative efforts are underway & normalisation of vital signs have been demonstrated.

1.4.1 HISTORY

Sometimes, history cannot be obtained from the patient itself. Information can be gathered from prehospital care personnel or family members. The **MAPLE** history is a useful mnemonic for this purpose:

M - Medicines and Medical conditions
A - Allergy history
P - Pregnancy
L - Latest meal and time
E - Encounter / Experience / Event

The mechanism of injury significantly impacts the patient's condition. Prehospital care personnel can obtain valuable information on the mechanism of injury and all information must be reported to doctor;

MECHANISM OF INJURY	ANTICIPATED INJURY PROFILE
Frontal - Rear impact High Risk Factors • "Spider-web" windshield fracture • Deformed steering wheel • Broken dashboard • Seatbelt marks on anterior torso • Airbag deployment	• Cervical spine fracture • Whiplash injury • Anterior flail / "stoved-in" chest • Maxillofacial injury • Myocardial contusion • Aortic dissection • Intrabdominal injury • Posterior hip dislocation
T-bone impact (Lateral impact)	• Diaphragmatic injury • Cervical spine sprain / fractures • Lateral chest injuries • Intrabdominal injury based on side of impact

MECHANISM OF INJURY	ANTICIPATED INJURY PROFILE
Occupant Ejection and Pedestrian Injury	• Combination of multimechanism injuries is considered an injury with high severity prediction such as o Severe Traumatic Brain Injury o Maxillofacial trauma o Cervical Spine injury o Aortic dissection o Intrabdominal injury o Pelvic fractures o Lower extremity injury (includes crush injury, dislocation, compartment syndrome, amputation)
Fall from Standing Height (low impact fall)	• Traumatic brain injury • Cervical spine and Cord injury • Rib fractures • Pelvic/ Neck of Femur fracture In elderly consider medical causes of pre-syncopal / syncopal attack.
Fall from Extreme Height (high impact fall ≥ 24 feet)	• Calcaneal fractures • Tibia-fibula fractures • Hip / Acetabular fractures • Lumbar sacral and cervical spine injuries • Intrabdominal injury • Severe Traumatic Brain Injury • Radius & ulnar fracture (protective reflexes)

Table 1.6: Biomechanism and anticipated Injury profiles

1.5 HEAD TO TOE EXAMINATION

There are a few potentially life threatening injuries that are not recognised during primary survey, which must be diagnosed and treated:

1. Simple pneumothorax
2. Hemothorax
3. Pulmonary contusion
4. Flail chest
5. Blunt cardiac injury
6. Traumatic aortic disruption
7. Traumatic diaphragmatic injury
8. Blunt esophageal rupture

1.5.1 HEAD

- The entire scalp and head should be examined for laceration, contusions and evidence of fractures.
- Re-evaluate the eyes for :
  - Visual acuity
  - Pupillary size
  - Hemorrhage of conjunctiva and/or fundus
  - Penetrating injury
  - Contact lenses
  - Dislocation of the lens
  - Eye movements

1.5.2 MAXILLOFACIAL STRUCTURE

- Palpation of all bony structures, assessment of occlusion, intra-oral examination and assessment of soft tissue.
- Avoid gastric decompression via nasal route. Insert an oral-gastric tube instead if indicated.
- Some maxillofacial injuries, such as nasal fracture, non-displaced zygomatic fractures, and orbital rim fractures, can be difficult to identify. Hence, serial and frequent assessment is mandatory
- Facial oedema can cause difficulties to complete eye examination. So, it is important to perform eye examination earlier before oedema develops.
- Posterior nasal bleeding needs to be stopped.
- Le Fort 3 fractures : immediate reduction to reduce bleeding.

1.5.3 CERVICAL SPINE AND NECK

- Patients with maxillofacial or head trauma should be presumed to have an unstable cervical spine injury and cervical collar need to be applied until the injury has been excluded.
- Although there is no neurological deficit in a patient with maxillofacial or head trauma, CT Cervical Spine must be obtained before cervical clearance. A proper systematic examination of the neck is mandatory in order to rule out any fractures or vascular injury
- Penetrating injury to the neck can potentially injure several organ systems. Any wound beyond the platysma should be explored in Operation Theatre.

1.5.4 CHEST

- Chest examination must be evaluated at both anterior and posterior regions. It requires systematic examination from inspection, palpation, percussion and auscultation.
- Chest trauma is a common cause of trauma death.

1.5.5 ABDOMEN AND PELVIS

- It is more important to establish the presence of abdominal trauma than identifying the specific abdominal injuries.
- A serial examination, monitoring and observation is very important especially in blunt abdominal trauma, preferably the same examiner as the patient's findings can change over time.
- Presence of ecchymosis at the pelvis region and pain on palpation of pelvic ring is highly suspicious of pelvic fracture.
- Repeated eFAST is essential even if the patient is hemodynamically stable.
- CT abdomen and pelvis is warranted in unexplained hypotension.

1.5.6 PERINEUM, RECTUM AND VAGINA

- A rectal and vaginal examination may be performed if indicated

1.5.7 MUSCULOSKELETAL SYSTEM

- Extremities must be inspected and palpated for injuries and deformities.
- Maintain a high level of suspicion for compartment syndrome especially in long bone fractures and crush injuries.

1.5.8 NEUROLOGICAL SYSTEM

- A comprehensive neurological examination includes motor, sensory and re-evaluation of the patient's GCS as well as pupillary size and reaction.
- Serial monitoring of GCS and neurological assessment must be done in a patient with suspected head injury with early neurosurgical consultation.
- Protection of the spinal cord is required at all times until spine injury is excluded.
- Early consultation with a surgeon is necessary if a spine injury is detected.

1.5.9 IMAGING IN THE MAJOR TRAUMA PATIENT

1. Radiograph – additional examination such as spines and extremities when necessary
2. CT Scan – head, cervical, thorax & abdomen & pelvis (CT TAP), thoracolumbar
3. CT Contrast – angiography & urography
4. Ultrasound
5. Transesophageal Echocardiography, bronchoscopy

1.6 PAIN MANAGEMENT

The Principles of Pain Management:

1. Analgesia should be integrated into a comprehensive patient evaluation and management plan.
2. The emotional and cognitive aspects of pain must be recognised and treated.
3. Pain control must be individualized.
4. Anticipate rather than react to pain.
5. Whenever possible, let the patient control his or her own pain.
6. Pain control is often best achieved by multimodal therapy.
7. Pain control requires a multidisciplinary team approach.

1.6.1 ANALGESIC LADDER

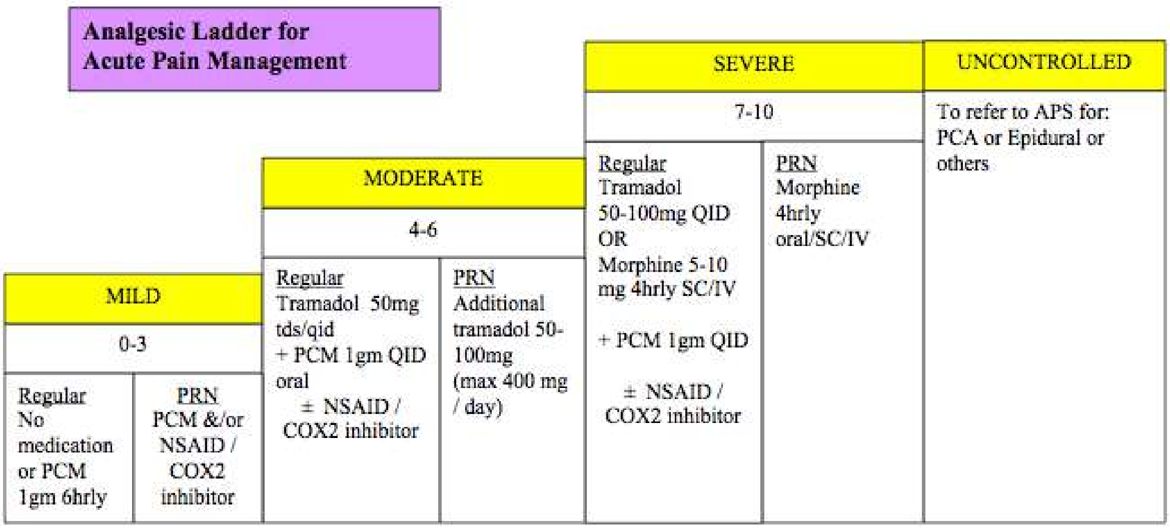

Figure 1.11 : Analgesic Ladder for Acute Pain Management
Pain Management Handbook, 3rd Edition 2022, Ministry of Health Malaysia

CAUTIOUS USE OF NSAIDS IN MAJOR TRAUMA
Due to its effect on platelet function and risk of bleeding

1.6.2 PAIN MANAGEMENT MODALITIES IN THE EMERGENCY DEPARTMENT

1.6.2.1 Psychological method

1. Make appropriate eye contact
2. Make appropriate physical contact (e.g. humanistic contact)
3. Talk to the patient
4. Explain what is happening
5. Ask about worries and needs
6. Warning before any painful procedure
7. Maintain dignity

1.6.2.2 Physical method

1. Fractures immobilization
2. Surface cooling & covering burns
3. Remove spinal boards
4. Keep patient warm

1.6.2.3 Pharmacological method

Common drugs used in the Emergency Department:

Drug	Route given	Dose	Comments
Morphine	IV	0.1 - 0.2 mg/kg	Titrate to effect
Fentanyl	IV	0.5 - 1 mcg/kg	Rapid onset. Titrate to effect
Ketamine	IV	0.25 - 0.4 mg/kg	Slower onset. Titrate to effect. Doses of >1mg/kg may produce anaesthesia. Risk of delirium on recovery.
	IM	2mg/kg	Slow onset Prolonged duration.
Paracetamol	IV/PO	15mg/kg	Every 4-6 hours. May cause worsening of underlying liver impairment.

Table 1.7 : Common drugs used in the Emergency Department for pain management.

1.6.3 REGIONAL BLOCKS

The principal benefit of regional anaesthetic techniques and peripheral nerve blocks are the provision of high-quality analgesia that is site-specific and effective. Regional anaesthesia provides many advantages over systemic opioid parenteral analgesic therapies for trauma patients as it reduces risk of cardiorespiratory suppression and conscious reduction. Specific populations that have shown benefits (including morbidity and mortality advantages) with regional analgesic techniques include those with fractured ribs, femur and hip fractures, and patients undergoing digital replantation.

Benefits of regional analgesia is as below :

- Reduced side effects of systemic analgesia (i.e. hypoxia, hypotension, nausea, vomiting)
- Reduced the need for parenteral sedation
- Reduced opioid requirements
- Reduced stress response to injury
- Reduced staff workload; reduced the need for continuous monitoring compared to procedural sedation or systemic high dose analgesia
- Reduced length of hospital stay
- Improved comfort and safety during patient transport

Common regional block techniques are as follows.

Upper Limb	Lower Limb	**Truncal**
o Interscalene Block o Supraclavicular Block o Axillary Block o Mid Forearm Block o Wrist Block o Digital Block	o Fascia Iliaca Plane Block o Femoral Nerve Block o Saphenous Nerve Block o Subgluteal Sciatic Nerve Block o Popliteal Sciatic Nerve Block o Ankle Block	o Serratus Anterior Plane Block o Erector Spinae Plane Block

Table 1.8 : Common Regional Blocks

1.7 Team Huddle, Shared Mental Model and Planning

A team huddle is a critical component of effective communication and coordination within trauma teams. During the huddle, the TTL re-establish situational awareness by sharing information about the patient's condition, progress, and any new developments. This helps ensure that everyone shares the same mental model and has a clear understanding of the current situation. The planning around during the huddle also serves to reinforce the plans already in place, reminding team members about the agreed-upon strategies and tasks. It provides an opportunity to assess the need to adjust the plan based on new information or changes in the patient's condition. This allows the team to adapt and make decisions accordingly, ensuring that the care provided is tailored to the specific needs of the patient. Additionally, the team huddle facilitates planning around clinical direction, as the team leader can provide guidance and direction based on their interpretation of the collected information. This helps the team anticipate and address potential problems or complications, ultimately improving patient outcomes.

Figure 1.12: Planning Subsequent Trauma Management

1.8 RE-EVALUATION

- Trauma patients need to be continuously re-evaluated to look for clinical deterioration or missed injuries
- In the event of deterioration, primary and secondary survey should be repeated
- Continuous close monitoring is crucial in the acute phase of trauma reception and management

1.9 DEFINITIVE CARE

The decision to transfer a patient should be considered whenever the patient's treatment needs exceed the capability of the current institution in providing the required definitive care. (Refer to Chapter 15: Transfer to Definitive Care)

1.10 TRAUMA TERTIARY SURVEY

The Trauma Tertiary Survey (TTS) is a comprehensive and structured clinical reassessment process for trauma patients who have completed the secondary survey and have been clinically stabilized.

A trauma tertiary survey is a complete and systematic head to toe examination to identify any missed injuries/diagnosis prior to Emergency Department disposition. (ie : prior to discharge, ICU, ward transfer). A tertiary survey is best conducted using a comprehensive checklist method and conducted by an experienced clinician.

The survey is also typically repeated when the patient is awake, responsive, and able to communicate any new complaints. Patients will be re-examined systematically from head to toe, Investigations including laboratory blood results and radio imaging investigations will be re-reviewed, clinical plans reassessed, communication loops and care plans re-examined for safety and completeness. The TTS assessment provides clinicians with a "reminder" in concluding and closing the loop upon critical examination and trauma care processes.

The TTS objectives and functions are as follows;

i. A comprehensive re-examination process of patients in order to avoid / reduce the risk of missed injuries.

ii. To provide improved efficiency amongst clinicians to review patients, imaging modalities and clinically important investigations.

iii. A process that assists clinicians in improving clinical documentation and review of clinical notes for all disciplines

iv. It also serves as a point-of-care survey for all trauma patients in the ETD undergoing transfer to another department.

v. It also serves as a checklist for trauma patients who are discharged from the ETD, reducing the risk of missed injuries and subsequent morbidity/mortality.

1.11 BREAKING BAD NEWS AND DEATH DISCLOSUREu

1.11.1 FAMILY & NEXT OF KIN MANAGEMENT

- An initiative should be taken to explain to patients, family members and next of kin regarding the trauma.
- A complete information regarding the injuries involved, investigation results and treatment that has been provided must be conveyed.
- The team member must be honest and answer these questions within the limitations of his/her knowledge.
- Avoid giving unrealistically high or low expectations
- These conversations must be well documented.
- Expectations from family members must also be managed well and misinformation must be avoided. If possible, frequent updates regarding the treatment outcome and the likelihood of disability would be beneficial.
- Appoint a team member as a clear point of contact between family and Trauma Team.
- If the situation permits or the patient insists; a family member can accompany the victim especially in Pediatric Trauma.
- The Paediatric Team should be involved in all cases with suspected Non Accidental Injuries.
- Involve the Police Officers early to trace the next of kin of unaccompanied adults or children.

1.11.2 SPIKES FRAMEWORK

The SPIKES framework improves communication by providing a structured and comprehensive approach to breaking bad news. It helps healthcare professionals deliver the information in a way that is sensitive, clear, and personalized to the patient's needs. By addressing emotional reactions and involving patients in the decision-making process, the framework aims to enhance patient satisfaction, trust, and overall quality of care.

The SPIKES framework is a six-step protocol that may be used for delivering bad news or death disclosure. The acronym stands for:

1. Setting up the interview: This involves preparing the environment, privacy, and ensuring adequate time and space for the conversation. It helps create a comfortable setting for the recipient and allows them to mentally prepare for the news.

2. Assessing the patient's perception: Before providing the news, the healthcare professional needs to understand the patient's current understanding of their condition. This step allows the provider to gauge the level of information the patient already possesses and tailor their approach accordingly.

3. Obtaining the patient's invitation: It is essential to assess if the patient is ready and willing to receive the information. This step encourages an open dialogue and consent from the patient to hear the news, ensuring their emotional readiness for the information.

4. Giving knowledge and information: The healthcare professional should provide clear and accurate information about the diagnosis, prognosis, and treatment options in a compassionate and understandable manner. This step should involve using plain language, avoiding medical jargon, and repeating or summarizing key points to ensure comprehension.

5. Addressing emotions with empathetic responses: Breaking bad news often triggers emotional reactions from patients. It is crucial to acknowledge and validate their emotions, showing empathy and providing support. This step allows healthcare professionals to connect with patients on an emotional level, promoting trust and understanding.

6. Strategizing and summarizing: Towards the end of the conversation, the healthcare professional should summarize the key points discussed and collaboratively create a plan for moving forward. This step helps ensure that the patient understands the next steps and can ask any further questions they may have.

1.12 DOCUMENTATION & PROPERTY

- A complete and comprehensive clinical documentation should be made available for every patient.
- All properties found together with the patient should be identified, documented and kept safely in a designated area based upon the processes delineated by local hospital protocol.

1.13 DEBRIEFING

Debriefing is an essential process that occurs in various settings such as the emergency department and medical simulation scenarios. It involves a structured conversation or discussion that takes place after a clinical event or a difficult situation, where individuals involved can reflect on their experiences, emotions, and actions. The purpose of debriefing is to facilitate learning, promote emotional support, and enhance performance in future situations. Through debriefing, healthcare professionals can address any issues or concerns, share insights and lessons learned, and identify areas for improvement. Proper debriefing techniques can also contribute to reducing burnout and improving the well-being of emergency medical services professionals. Overall, debriefing serves as a valuable tool in enhancing communication, teamwork, and overall patient care.

A debriefing may be conducted using the following steps:

1.	Make opening remarks and set the Stage :	Acknowledge the challenging nature of the event, appreciate participants' efforts, and emphasize open communication. Create a safe and supportive environment, ensuring participants understand the purpose and structure of the session.
2.	Explore Perspectives and Emotions:	Encourage participants to share their experiences, thoughts, and emotions, fostering non-judgmental discussions.
3.	Summarize Key Points:	Identify common themes, areas of agreement or disagreement, and important learning points from participants' perspectives.
4.	Share Insights and Lessons Learned:	Facilitate a discussion where participants reflect on insights gained, including positive and negative aspects of performance, challenges faced, and improvement strategies.

5.	Use Advocacy with Inquiry:	Encourage questions, seek clarification, and promote constructive feedback, allowing everyone to contribute to the discussion.
6.	Highlight Key Takeaways:	Summarize the main lessons learned and insights gained from the debriefing.
7.	Emphasize Team Involvement:	Stress the importance of teamwork and collaboration, encouraging support and collective responsibility for patient care.

It is important to adapt and customize these steps based on the specific context and goals of the debriefing session.

1.14 SUMMARY

The outcome of major trauma patients is dependent on early and accurate intervention performed during pre-hospital and Emergency Department trauma reception. A systematic and structured approach utilizing principles within the primary and secondary survey assessment would enable the clinician to conduct a comprehensive and effective resuscitation. The efficacy of the care provided can best be obtained by a well-trained trauma team, led by an experienced trauma team leader equipped with both clinical, technical and non-technical skills.

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1.16 SKILL STATION : INITIAL ASSESSMENT AND MANAGEMENT

Learning Outcome

1. Able to demonstrate the systematic initial assessment and treatment of patient.
2. Able to perform primary survey.
3. Able to establish resuscitation in a major trauma patient.
4. Able to identify life threatening injuries base on primary survey and the help of adjuncts.
5. Able to demonstrate secondary survey with appropriate history taking
6. Re-evaluate patient's condition and response to therapy instituted.

1.16.1 PRIMARY SURVEY

FIRSTLY;

< C >	PROVIDE IMMEDIATE CONTROL OF ANY OBVIOUS EXSANGUINATING HAEMORRHAGE

THEN PROVIDE;

A - AIRWAY MAINTENANCE WITH CERVICAL SPINE PROTECTION	
STEP 1	**ASSESSMENT** a. Assess patency b. Rapidly assess for airway obstruction
STEP 2	**ESTABLISH A PATENT AIRWAY** a. Perform a gentle chin lift or jaw thrust b. Clear the airway using rigid suction and assess for gag reflect c. Insert oropharyngeal/nasopharyngeal airway d. Supplementation of Oxygen e. Establish a definitive airway • Intubation • Surgical cricothyroidotomy
STEP 3	Maintain the cervical spine with devices or temporary manual in-line cervical immobilization when establishing an airway
STEP 4	Reinstate immobilization of the c-spine with appropriate devices after establishing an airway
B – BREATHING & VENTILATION	
STEP 1	**ASSESSMENT** a. Expose the and evaluate neck and ensure cervical immobilization b. Determine rate and depth of respiration c. Inspection and palpation for tracheal deviation, unequal movement of the chest and any sign of chest injury d. Percussion e. Auscultation for both lung and heart sound

STEP 2	**Management** a. Administer high concentration of oxygen b. Ventilate with bag valve mask c. Alleviate tension pneumothorax d. Seal open pneumothorax e. Attach pulse oximeter to patient f. CO2 monitoring devices to the endotracheal tube
C - CIRCULATION AND HEMORRHAGE CONTROL	
STEP 1	**ASSESSMENT** a. Identify source of external and internal bleeding b. Assess pulse: quality, rate, regularity and paradox c. Skin colour and capillary refill time d. Measure blood pressure
STEP 2	**MANAGEMENT** a. Apply direct pressure to external bleeding sites b. Anticipate for internal bleeding and possibility for emergency surgical intervention c. Insert 2 large bore IV cannula d. Obtain trauma blood panel and pregnancy test when necessary e. Initiate warm IV fluid f. Initiate blood product when indicated g. Prevent hypothermia h. Put on pelvic binder if pelvic fracture is suspected
D - DISABILITY: BRIEF NEUROLOGIC ASSESSMENT	
STEP 1	Determine the level of consciousness using GCS
STEP 2	Examine pupil for size and reaction
STEP 3	Assess for lateralizing signs and spinal cord injuries
E - EXPOSURE AND ENVIRONMENTAL CONTROL	
STEP 1	Completely expose the patient, but prevent hypothermia
ADJUNCTS TO PRIMARY SURVEY AND RESUSCITATIONS	
STEP 1	FBC and ABG analysis + Full Trauma Blood Panels
STEP 2	CO_2 monitoring with appropriate device
STEP 3	Attach to Cardiac monitoring leads
STEP 4	Urinary and Gastric catheter unless contraindicated, monitor urine output hourly
STEP 5	Get X-ray – AP Chest and AP Pelvis if necessary
STEP 6	Perform e-FAST
REASSESS PATIENT'S ABCDE AND CONSIDER NEED FOR PATIENT TRANSFER	

1.16.2 SECONDARY SURVEY

MAPLE HISTORY AND MECHANISM OF INJURY	
STEP 1	Obtain MAPLE history from patient, family and PHC team
HEAD AND MAXILLOFACIAL	
STEP 3	**ASSESSMENT** a. Inspection and palpation entire head and face b. Re-evaluate level of consciousness and GCS score c. Assess eyes for hemorrhage, penetrating injury, visual acuity, dislocation of lens d. Re-evaluate pupils e. Evaluate cranial nerve function f. Inspection of ear, nose and throat for CSF leakage g. Inspection of mouth, oral cavity and teeth
STEP 4	**MANAGEMENT** a. Maintain airway, ventilation and oxygenation b. Control hemorrhage c. Prevent secondary brain injury d. Remove contact lens if any
CERVICAL SPINE AND NECK	
STEP 5	**ASSESSMENT** a. Inspect for signs of blunt and penetrating injury, tracheal deviation and use of accessory muscle for respiration b. Palpate for tenderness, deformity, subcutaneous emphysema, tracheal deviation c. Auscultate for carotid bruits d. Obtain a CT cervical or lateral cervical spine X Ray
STEP 6	**MANAGEMENT** a. Maintain adequate cervical in line immobilization
THORAX	
STEP 7	**ASSESSMENT** a. Expose and inspect the chest to look for abnormalities b. Palpate for any rib tenderness, subcutaneous emphysema, crepitus c. Percuss for hyper-resonance and dullness d. Auscultate all area for breath sound and heart sound
STEP 8	**MANAGEMENT** a. Perform needle decompression of pleural space or tube thoracostomy b. Perform on how to use chest tube drainage c. Correctly dress on open chest wound d. Perform pericardiocentesis, under ultrasound guided e. Get cardiothoracic consultation or transfer to operating room

ABDOMEN	
STEP 9	**ASSESSMENT** a. Expose adequately and examine to look for any signs of blunt or penetrating injury and internal bleeding b. Palpate for tenderness, involuntary guarding, rebound tenderness and /or a gravid uterus c. Percussion d. Auscultate for bowel sound e. Obtain a pelvic x-ray f. Do e-FAST g. Obtain CT of abdomen if patient is hemodynamically stable
STEP 10	**MANAGEMENT** a. If patient hemodynamically unstable in spite of resuscitation, for surgical intervention b. For pelvic compression binder or wrap using a sheet around the pelvis if suspected pelvic fracture
PERINEUM/RECTUM/VAGINA	
STEP 11	**PERINEAL ASSESSMENT** a. Contusion and hematoma b. Lacerations c. Urethral bleeding
STEP 12	**RECTAL ASSESSMENT** a. Rectal bleeding b. Anal sphincter tone c. Rectal wall integrity d. Bony fragments e. Prostate position
STEP 13	**VAGINAL ASSESSMENT** a. Presence of blood in vaginal vault b. Vaginal laceration
MUSCULOSKELETAL	
STEP 14	**ASSESSMENT** a. Inspect the upper and lower extremities – for evidence of blunt, penetrating injury and sign of fractures or dislocations b. Palpate for tenderness, crepitation, abnormal movement and sensation on both upper and lower limbs. Feel for the pulses c. Assess for any evidence of pelvic fracture d. Inspect and palpate for thoracic and lumbar spines – any wounds, contusions, lacerations, tenderness, deformity and sensation e. Evaluate for pelvic fracture on pelvic x-ray film f. Evaluate for abnormality of thoracic and lumbar spine if indicated g. Obtain x-ray films of suspected fracture sites as indicated clinically

STEP 15	**MANAGEMENT** a. Apply splinting devices correctly for extremities fractures b. Maintain immobilization of thoracic and lumbar spines c. Wrap a sheet around the pelvis or pelvic compression binder to reduce pelvic volume and control hemorrhage in suspected pelvic fractures d. Administer tetanus immunization (ATT) e. Consider possibility of compartment syndrome f. Perform a complete neurovascular examination of the extremities
NEUROLOGICAL EXAMINATION	
STEP 16	**ASSESSMENT** a. Re-evaluate the pupil – size and reaction b. Determine the GCS score c. Evaluate upper and lower extremities for motor and sensory function d. Observe for lateralizing signs
STEP 17	**MANAGEMENT** a. Continue ventilation and oxygenation b. Maintain adequate immobilization of entire patient
ADJUNCTS TO SECONDARY SURVEY	
STEP 18	Consider the need for and obtain these diagnostic tests if patients condition permits: 2. Spinal x-rays 3. CT of the head, chest, abdomen, and/or spine 4. Contrast urography 5. Angiography 6. Extremities x-rays 7. Transesophageal ultrasound 8. Broncho/esophagoscopy

Scan QR code or click here to watch the Trauma Moulage video

CHAPTER 2

AIRWAY & VENTILATION

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Able to recognize the causes, signs, symptoms and manage airway obstruction.
2. Able to assess ventilation adequacy and its causes.
3. Able to describe the indication, preparation and technique in performing rapid sequence intubation.
4. Able to manage difficult airway in a can't intubate can't oxygenate (CICO) situation.

2.0 INTRODUCTION

The trauma patient often rapidly deteriorates due to inadequate oxygenation and ventilation. It is preventable in the event that early recognition, adequate clinical assessment and appropriate interventions are performed. In trauma, airway can be further made difficult by the presence of associated maxillofacial injuries, neck and laryngeal trauma. The management of such injuries require specific airway manoeuvres and interventions. It is essential to consider the airway in all trauma patients as potentially difficult and therefore always be equipped with a difficult airway contingency plan.

2.1 ANATOMY

The airway can be divided into the upper and lower segment. The upper airway consists of the nasopharynx, oropharynx and laryngopharynx. The lower airway is made up of the trachea, the left and right main bronchus, bronchioles and the alveoli.

2.2 CAUSES OF AIRWAY OBSTRUCTION IN TRAUMA PATIENTS

2.2.1 SOFT TISSUE & SWELLING

- The most common cause of airway obstruction is the floppy tongue that falls backwards, causing obstruction to the upper airway.
- Maxillo-facial injuries may lead to loss of structural integrity, distortion of anatomy and diffuse oedema of the surrounding soft tissues resulting in airway obstruction.
- Repeated failed or poor attempts at endotracheal intubation may induce laryngeal or vocal cord injury with subsequent inadvertent oedema / airway obstruction.

2.2.2 FOREIGN BODY & SECRETIONS

Dislodged / broken teeth, dentures, vomitus and blood may obstruct the airway passage.

2.2.3 LARYNGOSPASM

Laryngospasm may result as a complication of traumatic attempts at failed intubations, medications, reaction towards stress as well as existing underlying comorbidities.

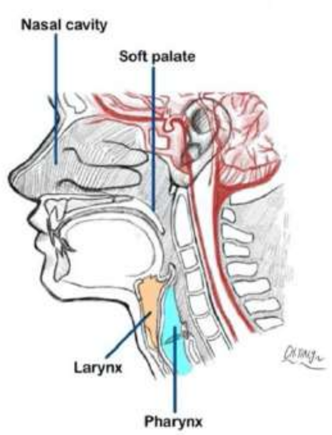


Figure 2.1 Upper Airway

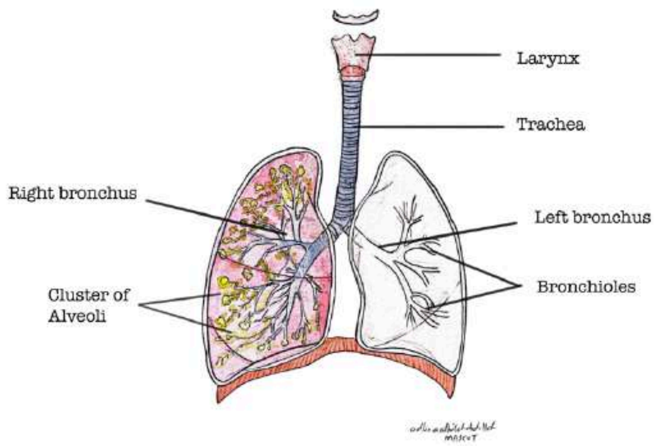


Figure 2.2: Lower airway

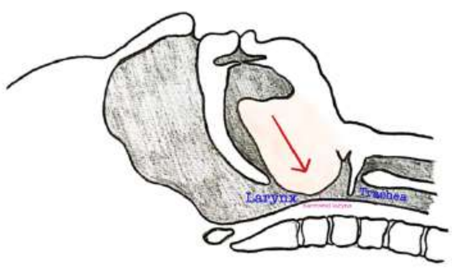


Figure 2.3: Retrograde Floppy tongue

2.3 ASSESSMENT OF AIRWAY PATENCY

ACTION	ASSESSMENT	INTERVENTION
Look	- Agitated, abusive : may suggest underlying hypoxia - Obtunded : may suggest underlying hypercarbia - Look for obvious maxillofacial injuries - Look for the presence of blood/vomitus in the oral cavity - Look for foreign body in the oral cavity (ie. Teeth / dentures)	- Provide oxygen support - Suction secretions - Remove visible foreign body using appropriate instruments ie. Magill forceps
Listen	Listen for abnormal sounds - Snoring - Stridor - Gurgling sounds - Hoarseness of voice	- Open the airway ie. Jaw thrust - Use airway adjunct ie. Oropharyngeal airway (OPA)
Feel	Examine and palpate for the following abnormalities - Crepitus in the tissues of the neck - Neck swelling / expanding haematoma - Tracheal deviation - Fractures / disruptions of the maxillofacial structure	- Early identification / investigation and treatment

Table 2.1: Assessment of Airway Patency

2.4 DIFFICULT AIRWAY ASSESSMENT

Difficult Bag-Mask Ventilation **ROMAN**	Difficult Laryngoscopy and Intubation **LEMON**
RODS Difficult Extraglottic Factors	**SMART** Difficult Surgical Airway

4 Dimensions Difficulty Assessment

2.4.1 DIFFICULT BAG-MASK VENTILATION (ROMAN)

- **R**adiation/Restriction : Radiotherapy to the neck, poor lung compliance
- **O**besity/Obstructive **:** Large body mass, resistance to diaphragmatic excursion,resistance to airflow, angioedema, epiglottitis
- **Mask seal/Mallampati/Male sex**: Bushy beards, blood or debris on the face
- **A**ge > 55 : Loss of muscle mass and tone
- **N**o teeth : The surrounding perioral soft tissue and cheeks tend to cave in

2.4.2 DIFFICULT LARYNGOSCOPY & INTUBATION (LEMON)

- **L**ook externally:
  - Any obvious maxillofacial injuries
  - Blunt or penetrating neck injuries
  - Signs of inhalational injury – presence of soot in the oral cavity / singeing of facial hair
- **E**valuate the **3-3-2 rule**
  - Mouth opening > 3 fingers
  - The distance from chin-to-hyoid bone distance should be about three fingers.
  - Distance between the floor of the mandible to the thyroid notch: 2 fingers
- **M**allampati score:
  - Reflects the relationship between mouth opening, the size of the tongue, and the size of the oropharynx.
  - It is an objective assessment utilised to predict difficulty for intubation in awake and cooperative patients

- **O**bstruction :
  - Any condition that may cause obstruction and interfere with laryngoscopy manoeuvre ie. Large tongue, pedunculated tooth, dentures etc
- **N**eck mobility
  - Patients with restricted neck movement (on cervical collar, cervical injury, degenerative disease of the cervical vertebrae etc.)

Figure 2.4: **3-3-2 Rule** for airway evaluation

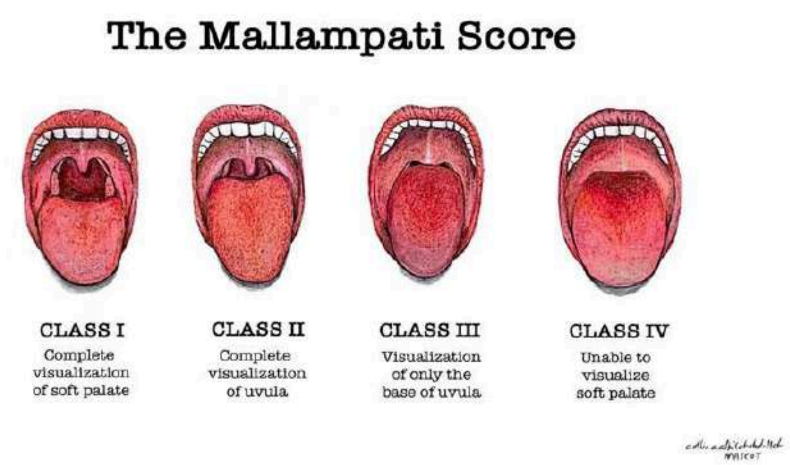


Figure 2.5: Mallampati Assessment & Score

2.4.3 <u>DIFFICULT EXTRAGLOTTIC FACTORS (RODS)</u>

- **R**estricted mouth opening
- **O**bstruction
- **D**isrupted or distorted airway
- **S**hort thyromental distance

2.4.4 DIFFICULT SURGICAL AIRWAY – CRICOTHYRODOITOMY (SMART)

- **S**urgery to neck: Previous surgery, scarring
- **M**ass : Anterior neck mass such as hematoma, abscess
- **A**ccess/Anatomy: Cervical collar, short neck, extraneous device
- **R**adiation distortion: Previous radiation therapy
- **T**umour: Difficult access and easily bleed

The Cormack-Lehane grading classifies views obtained by direct laryngoscopy based on the surrounding anatomical structures seen.

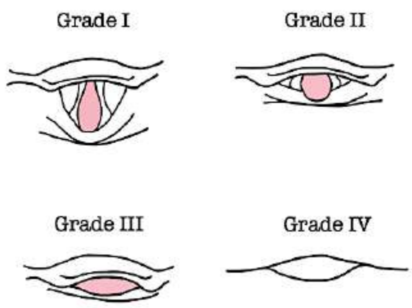


Figure 2.6. Cormack-Lehane Classification

GRADE	CORMACK-LEHANE DESCRIPTION
1	Almost the entire glottis can be visualised
2	Only the posterior portion of the glottis is visualised
3	Only the tip of the epiglottis is seen
4	Neither the epiglottis or the glottis can be visualised

Table 2.2 Cormack – Lehane Description

For video assisted laryngoscopy, we recommend the use of Percentage of Glottic Opening (POGO) score to describe the visualised glottis

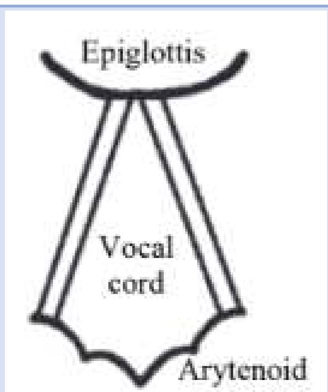
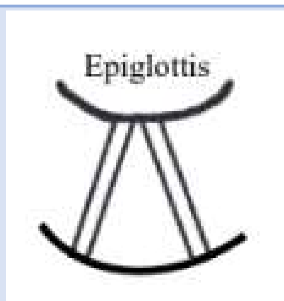
Video laryngoscopic view			
Percentage	**100%**	**50%**	**0%**

Table 2.3 Percentage of Glottic Opening (POGO) Score

Figure 2.7 : Visualised glottis on video laryngoscope

2.5 TECHNIQUES OF AIRWAY MAINTENANCE

2.5.1 MANUAL MANOEUVRES

1. **Chin Lift**

   The fingers of one hand are placed under the mandible and gently lift the chin upward. The thumb of the same hand lightly depresses the lower lip to open the mouth. While performing the manoeuvre, avoid hyperextension of the neck.

Figure 2.8: Chin Lift

2. **Jaw thrust**

   The angles of the lower jaw are grasped by the hand, one on each side and the mandible is lifted upwards (anteriorly in a supine patient) without flexing or extending the neck. This manoeuvre is often very effective in opening a difficult airway and is recommended for suspected cervical spine injuries.

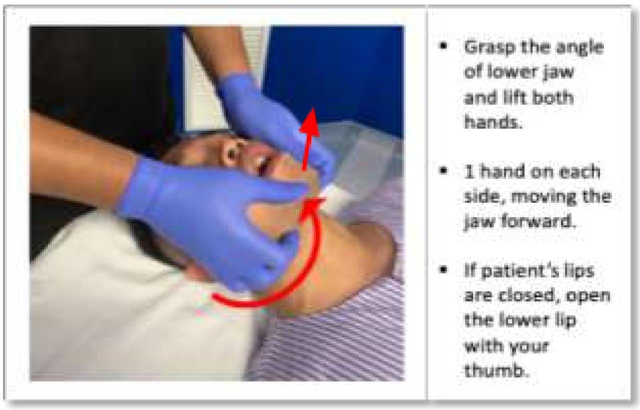


Figure 2.9: Jaw thrust

2.5.2 AIRWAY

1. Oropharyngeal airway (OPA)

- Oropharyngeal Airway is a rigid device that conforms to the surface of the tongue displacing it away from the posterior pharynx, restoring airway patency.

- This device is inserted in patients who do not have a gag reflex. Inserting this device will otherwise cause retching and vomiting, increasing the risk of aspiration.

- An appropriate size OPA should be selected in order to avoid causing further airway obstruction.

- Clear the oropharynx of any obstructing foreign bodies, secretions and vomitus prior to insertion of OPA.

- Identify the appropriate size of the OPA device by measuring the airway adjunct by either of the below methods:

    i) Measure the airway adjunct from the mid upper incisor to the angle of the mandible.

    ii) Measure the airway adjunct from the corner of the mouth to the tragus or external auditory meatus.

- Once an appropriate size is identified, insert the OPA into the mouth with the tip pointed to the roof of the mouth (ie, concave facing upwards).

- Rotate the OPA 180 degrees as you advance it into the posterior oropharynx. This technique prevents the OPA from pushing the tongue backwards during insertion causing further obstruction of the airway.

- Once the airway adjunct had been completely inserted, the flange of the OPA should rest over the patient's lips.

- Alternatively, it is also possible to use a tongue blade / depressor to press down the tongue as you insert the OPA with the tip pointed to the floor of the mouth (ie, concave facing down). This method also prevents the OPA from pushing the tongue backwards during insertion.

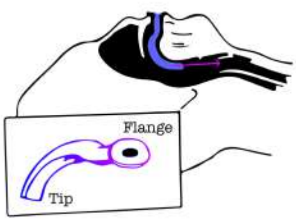


Figure 2.10: Oropharyngeal airway

2. Nasopharyngeal airway (NPA)

- Nasopharyngeal airway adjuncts are flexible tubes with one end flared shape and the other end bevelled.
- The NPA is inserted into the nasopharynx using the bevelled end.
- Nasopharyngeal airways are better tolerated and preferred rather than oropharyngeal airways for obtunded patients with intact gag reflexes.
- This device requires lubrication and is inserted in one nostril and passed gently into the posterior oropharynx.
- It is **relatively contraindicated** in patients with suspected cribriform plate fracture (base of skull) due to risk of cranial vault penetration through the fractured segment. This is however a rare condition.
- An oropharyngeal airway may be concurrently used together with a nasopharyngeal airway device.
- Clear the oropharynx of any obstructing foreign bodies, secretions and vomitus prior to insertion of NPA.
- Determine an appropriate size of the NPA. An appropriately sized NPA will extend from the tip of the nose to the tragus of the ear. A poorly selected size will potentially cause further obstruction or ineffective ventilation.
- Open the nares of the nose to reveal the nasal passage. Inspect both nares to identify the wider side.
- Lubricate the NPA with either water-soluble lubricant or anaesthetic jelly.
- Insert the NPA posteriorly (do not insert cephalad) and parallel to the floor of the nasal cavity. Insert with the bevel of the tip facing toward the nasal septum (ie, with the pointed tip lateral and open side facing the septum). Insert with gentle and firm pressure .
- If resistance is encountered, gently rotate the NPA and re-advance. If resistance is persistent, insert the NPA into the other nostril.
- Advance the NPA straight until the flange is resting over the nasal opening.
- The insertion of NPA should be carefully performed in order to avoid injury / bleeding over the Kiesselbach's plexus.

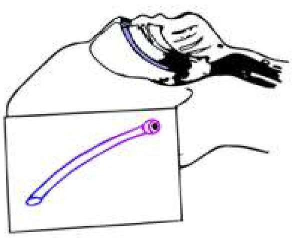


Figure 2.11: Nasopharyngeal airway

3. Supraglottic Airway Device

- Supraglottic airway devices are used to attain a patent airway to enable positive pressure ventilation for unconscious patients without gag reflex.

- SGA devices can be inserted without direct visualization of the glottis, thus it is a useful airway device to be used in the prehospital setting, failed intubation and difficult airway algorithm.

- The laryngeal mask airway (LMA) is a commonly used supraglottic airway device. The LMA is an orally introduced airway tube with an end cuffed mask that forms a low-pressure seal over the larynx.

- Comparatively to bag valve mask (BVM) ventilation technique, the LMA reduces the difficulties of attaining an adequate face-mask seal and bypasses the soft tissue obstruction of the upper airways. When used appropriately, it causes less gastric insufflation as compared to BVM ventilation.

- Apply low pressure ventilation when using an LMA device in order to prevent air from escaping the low-pressure seal, causing gastric insufflation and aspiration. SGA devices do not protect from risk of gastric aspiration.

- Prior to insertion of the LMA, select the appropriate size and note the maximum cuff inflation volume. The size and maximum inflation volume are commonly printed over the side of the tube.

- As a guide,

    - size #2 is suitable for patients weighing 10 to 20 kg
    - size #2.5 is suitable for patients weighing 20 to 30 kg
    - size #3 is suitable for patients weighing 30 to 50 kg
    - size #4 is suitable for patients weighing 50 to 70 kg
    - size #5 is suitable for patients weighing 70 to 100 kg

- Prior to insertion, inflate and deflate the cuff, check its volume and identify any leaks.

- Deflate the cuff completely, apply sterile water-soluble lubricant to the posterior surface of the distal mask and cuff.

- Insert the LMA into the mouth with the mask opening facing anteriorly.

- Manually guide the mask along the hard palate into the throat by pushing the tube with the index and middle finger (or thumb - pencil holding technique) placed over the junction where the tube attaches to the mask.

- Push the LMA, directing it cephalad. Lubricate the posterior surface of the mask and insertion should follow the curve of the hard and soft palates. To avoid tube from deflecting and obstruction by the epiglottis, the LMA should enter the hypopharynx along the posterior wall.

- Once the tube reaches the appropriate position, (as identified by markings over the tube), the mask will overlie the laryngeal opening.

- Aside from tube markings, the appropriate position can be ascertained when the insertion of the LMA meets resistance as the end of the mask tip meets the oesophageal opening.

- Assess lung ventilation by auscultation, chest rise and end tidal CO_2 if available. Adjust the LMA tube in place by further positioning the tube as appropriate.

- Remove the LMA without deflating the cuff.

Figure 2.12: Laryngeal mask airway

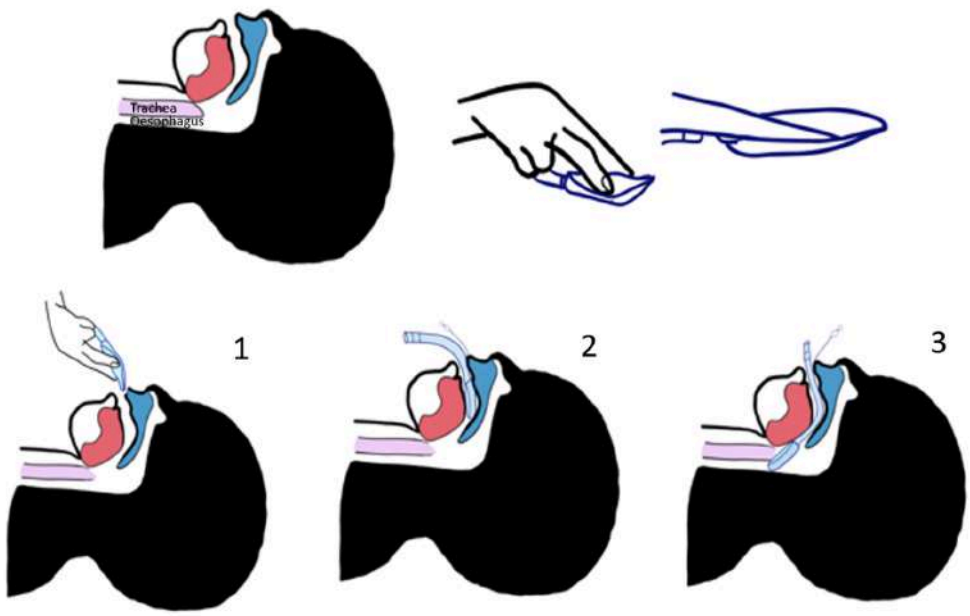


Figure 2.13: Method of inserting LMA

2.5.3 DEFINITIVE AIRWAY

A definitive airway is an airway tube that is inserted into the trachea with a cuff inflated below the level of the vocal cords and connected to an oxygen enriched source. The inflated cuff enables the effective delivery of a positive pressure mode ventilation and protects the airway from risk of aspiration.

A definitive airway is indicated when there is a need to protect the airway and provide optimal ventilation. It is frequently performed in the resuscitation and treatment of patients in severe shock, ventilatory and metabolic compromise, as well as for patients undergoing cerebral protection. A definitive airway is also required for patients undergoing major surgery under general anaesthesia.

1. Common methods in introducing an endotracheal tube for definitive airway;

    - Direct laryngoscopy
    - Video assisted laryngoscopy
    - Fibre-optic laryngoscopy

2. Rapid Sequence Intubation (RSI)

    Rapid sequence intubation involves the administration of a **potent induction agent** followed immediately by a **rapidly acting neuromuscular blocking agent (NMBA)**, after preoxygenation and patient optimization, to achieve the state of unconsciousness and motor paralysis for tracheal intubation. RSI provides emphasis upon a step by step process required for placement of a cuffed endotracheal tube in a **non-fasted patient.** It is the method of choice in establishing an emergency definitive airway.

Steps for performing Rapid Sequence Intubation :

1. Preparation
2. Pre-oxygenation
3. Pre-treatment
4. Paralysis with induction
5. Positioning
6. Placement and proof
7. Post-intubation care

I. Preparation

The preparation phase consists of preparing the patient, intubation equipment, medications and the team members. While preparing the patient, it is necessary to assess the likelihood of difficult intubation based upon the "LEMON" mnemonic mentioned earlier. The patient should also be continuously monitored for Blood Pressure (BP), Pulse Rate (PR), Capillary Oxygen Saturation (SPO_2), End tidal Carbon dioxide ($ETCO_2$) and cardiac rhythm throughout the procedure. The RSI equipment required can be summarized using the following mnemonic

MALES:

M	Mask with bag-valve device, Magill's forceps, Monitoring equipment
A	Airways : OPA , NPA, LMA
L	Laryngoscope, lubricant
E	Endotracheal tubes
S	Suction apparatus, Stylet, Stethoscope, Syringe for cuff inflation, Securing tape

Table 2.4 : Preparation for Rapid Sequence Intubation

Team member roles & assignment;

- Airway manager
- Cervical spine immobilisation
- Circulation manager
- Drugs preparation
- Scriber person

II. Pre-Oxygenation

Pre-oxygenation is the administration of oxygen to a patient prior to performing intubation. It is performed in order to "wash out" nitrogen in the lungs and replace it with oxygen, also known as denitrogenation. This process prolongs the safe apnea time.

Patients should be provided with 100% (15 L/min) oxygen.
In patients with poor respiratory effort, the pre-oxygenation process can be assisted with the adjunct use of a BVM.

III. Pre-Treatment

Pre-Treatment is the administration of medications to reduce or blunt the potential physiological response induced by intubation such as bradycardia, hypertension, increased intracranial pressure and so forth. The choice of medications may differ from case to case.

IV. Paralysis with induction

Paralysis and induction is the process of administering drugs to induce deep anaesthesia and neuromuscular paralysis in order to facilitate the introduction of an endotracheal cuffed tube into the airway.

The choice of induction agents will depend on the patient's clinical presentation and the injuries sustained. Following the intravenous administration of an induction agent, a neuromuscular blocking drug (NMB) is administered.

V. Positioning

Optimal position in trauma patient prior to intubation can be achieved by:

i) sufficient height of the bed.
ii) ensuring the head is positioned at the end of the bed.
iii) external laryngeal manipulation can be applied to improve the glottis view.

Always ensure cervical spine immobilisation in trauma patients.

VI. Placement and Proof

With a laryngoscope, insert an ETT into the airway by direct visualization. Insert to the depth as marked on the tube. After insertion, inflate the ETT cuff using a syringe. Intra-tracheal placement of an endotracheal tube can be confirmed by the following methods:

- Direct visualization of the ETT crossing the vocal cords
- $ETCO_2$ reading on monitor

Subsequently, administer positive pressure ventilation, verify the correct depth of ETT placement by auscultating for equal air entry.

Note:

The following methods are utilised, however are not confirmatory in providing proof of correct intra- tracheal ETT placement.

→ Presence of "fog" in the ETT tube
→ 5 points auscultation : both anterior, lateral chest wall and epigastrium

VII. Post Intubation Care

- Airway
  - Inflate the cuff with recommended volume of air
  - Secure the ETT using a readily available commercial device or by tying it using an appropriate material. (When using a tying method, avoid causing the obstruction of venous return).

- Breathing
  - Confirm air entry by auscultating for bilateral equal and adequate breath sounds
  - Ventilator settings
  - Arterial Blood Gas
  - End tidal CO_2

- Circulation
  - Repeat vital signs
  - Vasopressors or inotrope support if needed

- Imaging
  - Post intubation CXR : Confirm correct depth of the ETT. Tip of ETT should be at the “T4 '' vertebral region / just above the carina bifurcation.
  - Aside from identifying any underlying lung pathology, the CXR is also used to look for any evidence of lung collapse, pneumothorax or aspiration.

- Others
  - Aspiration precaution : prop up the patient or position in Reverse Trendelenburg.
  - Sedation and analgesia.
  - Orogastric / nasogastric tube.
  - Continuous bladder drainage.

POTENTIAL EARLY COMPLICATIONS OF ENDOTRACHEAL INTUBATION

COMPLICATIONS	EFFECTS
Failed intubation	Hypoxia, hypoxic brain injury, hypercarbia
Physiologic responses	Tachycardia Hypertension/hypotension Arrhythmia Increased pressure – intracranial, intra-ocular and intra-gastric Laryngospasm, bronchospasm
Airway trauma	Broken/dislodged teeth Trauma to the lips, soft tissue, gums, tongue, trachea Dislocation of the mandible Barotrauma, pneumothorax
Aspiration	Blood, gastric contents
ETT malposition	Esophageal intubation, endo-bronchial intubation
Cervical spine injury	Neurological sequelae

Table 2.5: Early Complications of Endotracheal Intubation

2.5.4 FRONT OF NECK AIRWAY ACCESS (FONA)

FONA encompasses all forms of airway access which utilizes the anterior neck approach. Following are examples of FONA;

i) Needle cricothyroidotomy
ii) Surgical cricothyroidotomy
iii) Percutaneous tracheostomy
iv) Surgical tracheostomy

Types of FONA:

I. Needle Cricothyroidotomy

Needle cricothyroidotomy can be achieved using a makeshift needle/cannula and syringe method or by using a readily available commercial product.

Needle cricothyroidotomy is an emergency lifesaving procedure that involves passing an over-the-needle catheter through the cricothyroid membrane to serve as a temporary relief method to oxygenate and ventilate patients in severe respiratory distress. This method is advocated for patients who can't be intubated and ventilated, despite the use of other airway adjuncts and manoeuvres.

Needle cricothyroidotomy can be performed on patients of all ages. As compared to surgical cricothyroidotomy, needle cricothyroidotomy is a preferred choice in infants and children up to 10 to 12 years due to less potential damage to the larynx and surrounding structure.

Performing Needle Cricothyroidotomy

- Prepare a 12 or 14-gauge cannula and attach it to a syringe that is partly filled with sterile water.
- Alternatively, use a commercially available device designed for this procedure.
- Clean the anterior neck area with antiseptic solution
- Identify the cricothyroid membrane (situated between the thyroid and cricoid cartilages). Use the non-dominant hand to stabilize the thyroid cartilage.
- Insert the cannula into the cricothyroid membrane at a 30-45 degree angle to the skin, and direct caudally.
- Apply negative pressure to the syringe as the cannula is advanced. Look for bubbles of air in the syringe, which signifies that the cannula has entered the trachea.
- Remove the needle and syringe, while advancing the cannula caudally.
- Secure the cannula to the patient's neck and attach the end of the cannula to a 3ml syringe with the plunger removed. Connect the 3ml syringe (barrel flange) to a size 7.0mm endotracheal tube's universal connector. Attach to oxygen source. Ventilate the patient, look for chest rise and auscultate for breath sounds bilaterally.

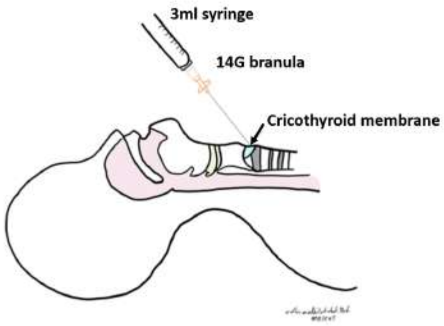


Figure 2.14: Needle cricothyroidotomy

Figure 2.15: Example of readily available needle cricothyroidotomy set

Figure 2.16: Example of needle cricothyroidotomy insertion method

II. Surgical Cricothyroidotomy

Surgical cricothyroidotomy is an emergent lifesaving airway procedure in which a surgical incision into the cricothyroid membrane is made prior to advancing a tracheostomy or endotracheal tube into the trachea. The tube is then attached to a bag-mask ventilator or any other appropriate oxygen source to provide positive pressure ventilation.

Surgical cricothyroidotomy is indicated in similar circumstances as a needle cricothyroidotomy. These are circumstances posing imminent life threatening respiratory compromise coupled with a “can’t intubate can’t oxygenate” situation (CICO). It is a temporary bridge towards attaining a definitive airway. However, due to the larger diameter tube, it provides more effective ventilation than a needle cricothyroidotomy and is typically chosen instead of needle cricothyroidotomy in adults and children over 10 to 12 years of age.

Performing Surgical Cricothyroidotomy

- Assemble the equipment – use an available surgical cricothyroidotomy set. If not available, use a basic procedure set. Prepare antiseptic/sterilizing solution, scalpel blade, a small sized cuffed endotracheal tube (ETT size 5-6) or Tracheostomy tube (Size 4.5-5).
- Clean the anterior neck area with antiseptic. Ensure aseptic technique.
- Identify the thyroid and cricoid cartilages and the cricothyroid membrane in between. Use the non-dominant hand to stabilize the thyroid cartilage.
- Make a vertical skin incision from the thyroid cartilage to the cricoid cartilage.
- Bluntly dissect down to the cricothyroid membrane.
- Make a horizontal incision into the cricothyroid membrane. Keep the incision open using a hook or forceps or your index finger.
- Insert a small sized cuffed ETT / tracheostomy tube into the incision, directing the tube distally. Inflate the tube, connect it to an oxygen source and ventilate the patient.
- Secure the tube, watch for chest rise and auscultate for breath sounds bilaterally.

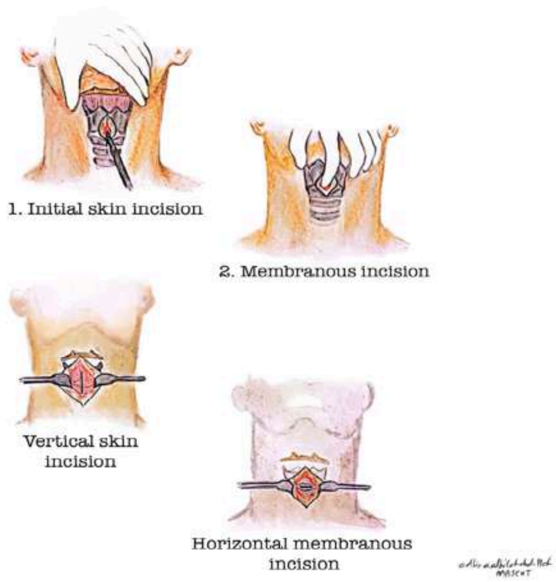


Figure 2.17: Method of performing surgical cricothyroidotomy

III. Tracheostomy

Tracheostomy is a definitive airway procedure. It involves the placement of a cuffed tracheostomy tube through an anterior tracheal incision or Seldinger puncture method. It is commonly performed surgically in an operation theatre or percutaneously by the bedside in an Intensive care / Emergency setting.

2.6 VENTILATION

2.6.1 CAUSES OF VENTILATORY COMPROMISE

CAUSES	EXAMPLE
Hypoventilation	Rib Fractures and Severe Torso Pain
Impaired gas exchange	Lung contusion Pulmonary oedema Aspiration Hemothorax Pneumothorax
Impaired ventilatory mechanics	Open pneumothorax Flail chest
Nervous system dysfunction	Spinal cord injury Phrenic nerve injury

Table 2.6 : Causes of Ventilatory Compromise

2.6.2 ASSESSMENT OF VENTILATION

ACTION	ASSESSMENT
INSPECTION	1. Expose the chest: - Important signs of injuries may be missed if the chest wall and torso is not adequately exposed 2. Determine the rate, depth and regularity of respirations - Rapid respiratory rate may indicate hypoxia and impending respiratory failure. 3. Inspect for clinical signs of underlying chest injuries: a. <u>Chest movement</u>: ▪ Look for symmetrical rise and fall of the chest. ▪ Unequal movement or poor bilateral chest expansion may suggest underlying lung pathology such as hemothorax or pneumothorax. ▪ Paradoxical movement may suggest the presence of a flail chest. b. <u>Chest Deformities</u>: ▪ Underlying rib fractures may cause surface deformities c. <u>Open wounds</u>: ▪ Penetrating injuries can cause open pneumothorax which require prompt management. d. <u>Bruises:</u> ▪ Underlying lung contusion may be present with overlying bruises over the chest wall 4. Look for distended neck veins suggestive of increased intrathoracic pressure such as in tension pneumothorax.
PALPATION	1. Gentle chest palpation (do not perform “chest spring”, this may cause further harm and injury to the patient. Use single hand palpation method) 2. Trachea position. A deviated trachea may suggest underlying tension pneumothorax 3. Crepitus 4. Subcutaneous emphysema may suggest underlying pneumothorax
PERCUSSION	1. Lung hyper-resonance may suggest pneumothorax. 2. Stony dullness may suggest underlying presence of haemothorax

ACTION	ASSESSMENT
AUSCULTATION	1. Listen for any unequal air entry which may suggest hemo/pneumothorax 2. Abnormal breath sounds

Table 2.7: Assessment of Ventilation

2.6.3 VENTILATION WITH BAG VALVE MASK (BVM)

Positive pressure ventilation using a bag valve mask technique may be required during resuscitation of a cardiorespiratory arrest patient or prior to performing an intubation. Effective ventilation can be achieved by utilizing a 1 or 2-person method.

When to Provide BVM?

- High flow O_2 with positive pressure ventilation required
- Positive end-expiratory pressure (PEEP) is needed
- Emergency provision of controlled ventilation is necessary
- Augmentation of spontaneous ventilation is required

How to Provide Bag Valve Mask (BVM) Ventilation?

- Select an appropriately sized mask according to the patient's face.
- An appropriately sized mask should be able to rest over the bridge of the nose, cover both the malar eminences and lower lip without having an air leak.
- Connect the bag-mask device to the oxygen supply via the correct tubing and ensure oxygen flow is 15L/min.
- Ensure that the reservoir bag of the bag-mask device is properly inflated.
- Open the patient's airway using either an OPA/NPA.
- Apply the mask to the patient's face and ensure a good mask seal (C-E clamp).
- One hand holds the mask in place with adequate seal, while the other hand squeezes the bag to ventilate the patient.
- Observe the patient's chest rise to ensure adequate ventilation is provided.
- Ventilate the patient once every 6-8 seconds.

Figure 2.18: C-E clamp with 1 man method

Figure 2.19: C-E clamp with 2 man method

2.6.4 Ventilation strategy in intubated trauma patients

- Protective lung ventilation should be used for mechanically ventilated patients with traumatic lung injury such as tracheobronchial injury, pneumothorax, and flail chest. Such injuries will decrease compliance of the affected lung and are risk factors for developing ARDS.
- In lung protective strategy, the tidal volume of 6mL/kg (6-8mL/kg) is placed based on the predicted body weight (PBW) of the patient.
- The plateau pressure is targeted to be < 30 cm$H_2$0.
- PEEP ≥ 5 cmH_2O and as optimal as possible, without compromising the hemodynamic stability.
- FiO_2 is kept as low as possible to achieve SpO_2 ≥ 90 % or PaO_2≥ 60mmHg
- Higher respiratory rate 15-20 breaths per minutes can be tolerated as long as pH ≥ 7.2
- The ventilation strategy should be modified in patients with other concurrent conditions such as traumatic brain injury, obstructive airway disease or asthma to prevent complications.

Suggested Protective Lung Ventilation Strategy

- **Tidal Volume 6mls/kg of PBW**
- **Plateau Pressure (Pplat) <30cmH_2O**
- **PEEP ≥ 5 cmH_2O**
- **FiO_2 titrate to achieve SpO2 ≥ 90 % or PaO2≥ 60 mmHg**
- **Respiratory rate 15-20 breath per minute**

2.7 PEARLS

Look out for common pitfalls during BVM and ventilation process:

a. Poor mask seal and BVM malfunction
b. Incorrect mask size
c. Poor suction
d. Laryngoscope malfunction
e. Dislodged / disconnection of tube and breathing circuit
f. Ventilatory equipment and oxygen source failure
g. Inadequate sedation and paralysis
h. Failure to recognize blood gas abnormalities

2.8 SUMMARY

1. Management of the airway and ventilation is critically important in all major trauma patients. The patency and adequacy of the airway necessitate prompt and precise assessment.
2. Establishing and maintaining patent airway includes manoeuvres such as chin lift, jaw thrust and the use of adjuncts such as, OPA, NPA and LMA.
3. All trauma doctors, emergency and acute care staff should be well versed with the knowledge and skills in providing emergency airway and ventilatory support for trauma patients
4. All trauma intubations should be presumed as difficult airway with appropriate preparations made in place including the provision of emergency surgical airway interventions.
5. Surgical airway is indicated when an immediate life threatening airway compromise is coupled with a "Can't Intubate and Can't Oxygenate" (CICO) scenario.

2.9 REFERENCES

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2.10 AIRWAY SKILL STATION

2.10.1 INSERTION OF OROPHARYNGEAL AIRWAY (OPA)

1. Choose the correct sized OPA : Measure from the angle of the mouth to the tragus.
2. Insert a tongue depressor and depress the tongue.
3. Insert the OPA following the roof of the mouth until it sits behind the tongue.
4. Remove the tongue depressor.
5. Alternatively, insert the OPA upside down and once it has reached the back of the throat, rotate 180 degrees into place.

2.10.2 INSERTION OF NASOPHARYNGEAL AIRWAY (NPA)

1. Choose the correct sized NPA. Measure the size according to the size of the patient's nostril.
2. Apply lubricant gel to the NPA.
3. Insert the NPA into the nostril and direct it carefully backwards. A gentle rotating motion helps to insert the NPA until the flange rests against the nostril.

2.10.3 BAG VALVE MASK VENTILATION

1. Select an appropriately sized mask according to the patient's face.
2. An appropriately sized mask should be able to rest over the bridge of the nose, cover both the malar eminences and lower lip without having an air leak.
3. Connect the bag valve mask device to the oxygen supply via the correct tubing and ensure oxygen flow is 15L/min.
4. Ensure that the reservoir bag of the bag valve mask device is properly inflated.
5. Open the patient's airway using either an OPA/NPA.
6. Apply the mask to the patient's face and ensure a good mask seal (C-E clamp).
7. One hand holds the mask in place with adequate seal, while the other hand squeezes the bag to ventilate the patient.
8. Observe the patient's chest rise to ensure adequate ventilation is provided.
9. Ventilate the patient once every 6-8 seconds.

2.10.4 ADULT ENDOTRACHEAL INTUBATION

1. Prepare the necessary equipment.
2. Check that the endotracheal tube (ETT) size is adequate for the patient.
3. Check that the cuff of the ETT tube is functioning and does not leak. Then, deflate the cuff.
4. Ensure functioning suctioning equipment is available and ready.
5. Check that the correct size laryngoscope blade is attached to the laryngoscope handle, and functioning light source.
6. Assess the patient's airway for possible difficult intubation using the LEMON rule.
7. Ask an assistant to perform manual in-line cervical immobilization.
8. Hold the laryngoscope in the left hand.

9. Insert the laryngoscope into the patient's mouth from the right side, displacing the tongue to the other side.
10. Carefully advance the laryngoscope blade and visualize the epiglottis and the vocal cords.
11. Hold the endotracheal tube (ETT) in the right hand.
12. Insert the endotracheal tube into the trachea, ensuring that the cuff is situated below the vocal cords.
13. Remove the laryngoscope and inflate the cuff of the endotracheal tube.
14. Connect the endotracheal tube to the bag-valve and squeeze the bag to ventilate the patient.
15. Observe the patient's chest movements for equal chest expansion.
16. Check the endotracheal tube placement and secure it with a tape or ribbon gauze.

Scan QR code or click here to watch the **Airway Skill Station** video

2.10.5 NEEDLE CRICOTHYROIDOTOMY

1. Prepare a 12 or 14-gauge cannula and attach it to a syringe that is partly filled with sterile water.
2. Alternatively, use a commercially available device designed for this procedure.
3. Clean the anterior neck area with antiseptic solution
4. Identify the cricothyroid membrane (situated between the thyroid and cricoid cartilages). Use the non-dominant hand to stabilize the thyroid cartilage.
5. Insert the cannula into the cricothyroid membrane at a 30-45 degree angle to the skin, and direct caudally.
6. Apply negative pressure to the syringe as the cannula is advanced. Look for bubbles of air in the syringe, which signifies that the cannula has entered the trachea.
7. Remove the needle and syringe, while advancing the cannula caudally.
8. Secure the cannula to the patient's neck and attach the end of the cannula to a 3ml syringe with the plunger removed. Connect the 3ml syringe (barrel flange) to a size 7.0mm endotracheal tube's universal connector. Attach to oxygen source. Ventilate the patient, look for chest rise and auscultate for breath sounds bilaterally.

2.10.6 SURGICAL CRICOTHYROIDOTOMY

1. Assemble the equipment - surgical cricothyroid set (if available – otherwise, a basic procedure set), antiseptic/sterilizing solution, scalpel blade, a small sized cuffed endotracheal tube (ETT), tape.
2. Clean the anterior neck area with antiseptic. Ensure aseptic technique.
3. Identify the thyroid and cricoid cartilages and the cricothyroid membrane in between. Use the non-dominant hand to stabilize the thyroid cartilage.
4. Make a vertical skin incision from the thyroid cartilage to the cricoid cartilage.
5. Bluntly dissect down to the cricothyroid membrane.
6. Make a horizontal incision into the cricothyroid membrane. Keep the incision open using a hook or forceps or your index finger.
7. Insert a small sized (5.0 or 6.0), cuffed ETT into the incision, directing the tube distally. Inflate the tube, connect it to an oxygen source and ventilate the patient.
8. Secure the tube, watch for chest rise and auscultate for breath sounds bilaterally.

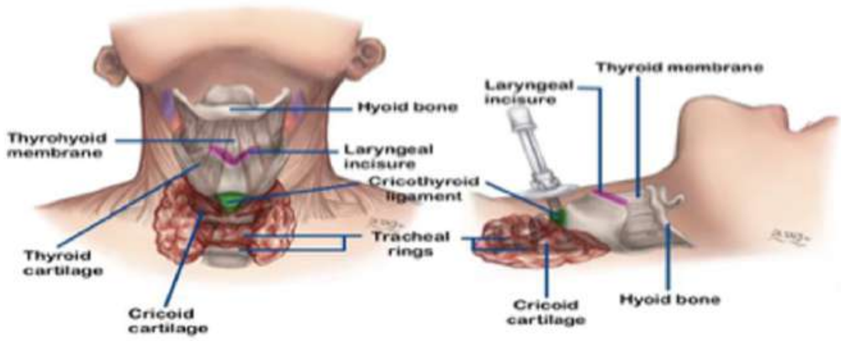

Figure 2.20 : Boundaries of cricothyroid membrane

Scan QR code or click here to watch the **Surgical Airway Skill Station** video

2.10.7 Massive airway decontamination technique

1. A larger bore suction catheter can improve suctioning and simultaneous intubation. Another alternative is using double suction setup.
2. The Suction Assisted Laryngoscopy and Airway Decontamination (SALAD) technique was created to address the issues of a massively contaminated airway.
3. It improves the ability and confidence of clinicians managing contaminated airways and has the potential to minimize adverse events associated with multiple intubation attempts.

2.10.7.1 Indications/ Contraindications

Indication

1. Massive airway contamination. As soon as the suction catheter is removed and the endotracheal tube (ETT) is picked up, the liquid re-accumulates, preventing visualization of the airway structures.

Contraindication

1. Small mouth opening

2.10.7.2 Technique

1. Connect the neonatal meconium aspirator to the end of the ETT.
2. Then connect the ETT to the suction tubing.
3. To suction occlude the suction activation hole with a fingertip.

Figure 2.21 : Large bore suction catheter : Endotracheal tube attached to a meconium aspirator and suction.

2.10.7.3 Suction Assisted Laryngoscope Airway Decontamination (SALAD)

1. Position the patient appropriately
2. The Rigid Suction Catheter (RSC) is gripped overhand with the right hand.
3. The RSC is inserted into the mouth and swept from side to side.
4. Continuous airway suction as it is advanced just ahead of the laryngoscope blade around the base of the tongue under direct visualisation.
5. Displace the tongue and lower jaw to maximize the space.

6. The laryngoscope blade is positioned optimally and controls the upper airway structure.
7. Use the suction catheter to clear the surrounding area of the glottis and proximal trachea under direct visualization.
8. The RSC is withdrawn and repositioned to the left of the laryngoscope blade and seated in the upper esophagus (SALAD Park Manoeuvre) to provide continuous suction of the hypopharynx.
9. The endotracheal tube is delivered through the vocal cords.
10. The endotracheal tube lumen is suctioned with a soft catheter prior to ventilation

2.10.7.4 Post procedure

1. Insert pharyngeal packing if there is a continuous pooling of blood in the oropharyngeal area
2. Consider inserting appropriate nasal packing if massive epistaxis is the source of bleeding.

CHAPTER 3

SHOCK IN TRAUMA

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Able to describe concept of shock in trauma
2. Able to describe the proper initial management of hemorrhagic shock
3. Able to explain the importance of Damage Control Resuscitation
4. Able to explain the role of Trauma Transfusion Protocol
5. Able to understand the concept of Acute Traumatic Coagulopathy (ATC)

3.0 INTRODUCTION

Shock is an immediate life-threatening condition characterized by circulatory failure. It is a state of hypoperfusion with resultant cellular dysfunction and death. The effects of shock may initially be reversible, if left untreated it will rapidly worsen and progress to an irreversible state resulting in multi-organ failure and death.

In the setting of trauma, loss of circulating blood volume from **severe hemorrhage is the most common cause of shock (hypovolemic shock).** It is amongst the main causes of preventable death in trauma.

It is essential for clinicians to be able to immediately recognize the presence of shock, identify the cause and immediately initiate appropriate treatment to reverse or mitigate the subsequent complications of shock in trauma.

3.1 DEFINITION

A state of circulatory inadequacy causing tissue hypoperfusion resulting in cellular dysfunction and death.

3.2 CLASSIFICATION OF SHOCK

a) **Hypovolemic / Haemorrhagic**

Reduced intravascular volume from blood loss can result in hypovolemic shock.

b) **Cardiogenic**

A state of shock arising from cardiac pump failure. In rare instances, cardiogenic shock can be caused by blunt cardiac injury (myocardial contusion).

c) **Distributive**

A state of shock characterized by severe vasodilatation mediated by either loss of sympathetic tone or humoral/cellular mediators, common examples are as follow:

a. Neurogenic shock
Spinal cord injuries may precipitate vasodilatation and bradycardia from denervation of sympathetic tone.

b. Septic shock
A state of shock induced by the body's systemic inflammatory response towards pathogens. Uncommon in the acute trauma phase but may present as a subsequent sequelae.

c. Anaphylactic shock
A state of shock when it involves the release of inflammatory mediators in an escalating cascade from certain types of white blood cells triggered by either immunologic or non-immunologic mechanisms

d) **Obstructive**

A state of circulatory shock precipitated by cardiac in flow or/and outflow obstruction.

a. Tension pneumothorax
A pneumothorax large enough to significantly increase intrathoracic pressure, impaired venous return and impede cardiac output.

b. Cardiac tamponade
A state of shock caused by increased intrapericardial pressure (tamponade effect) causing impairment in diastolic cardiac filling and reduction of cardiac output.

c. Massive Pulmonary Embolism
Obstruction of pulmonary artery tree, a possible delayed complication in trauma patients

3.3 HYPOVOLEMIA & HEMORRHAGIC SHOCK

3.3.1 Pathophysiology of Hemorrhagic Shock

- Hemorrhage is the most common cause of shock in trauma patients.
- Early physiological compensatory response to blood loss attempts to maintain adequate tissue perfusion.
- The typical response to acute volume loss is an increased sympathetic tone resulting in:
    - Increase heart rate and contractility to preserve cardiac output
    - Peripheral vasoconstriction to preserve blood flow to the kidneys, heart and brain.
    - The release of endogenous catecholamine increases peripheral vascular resistance which in turn increases the mean arterial pressure

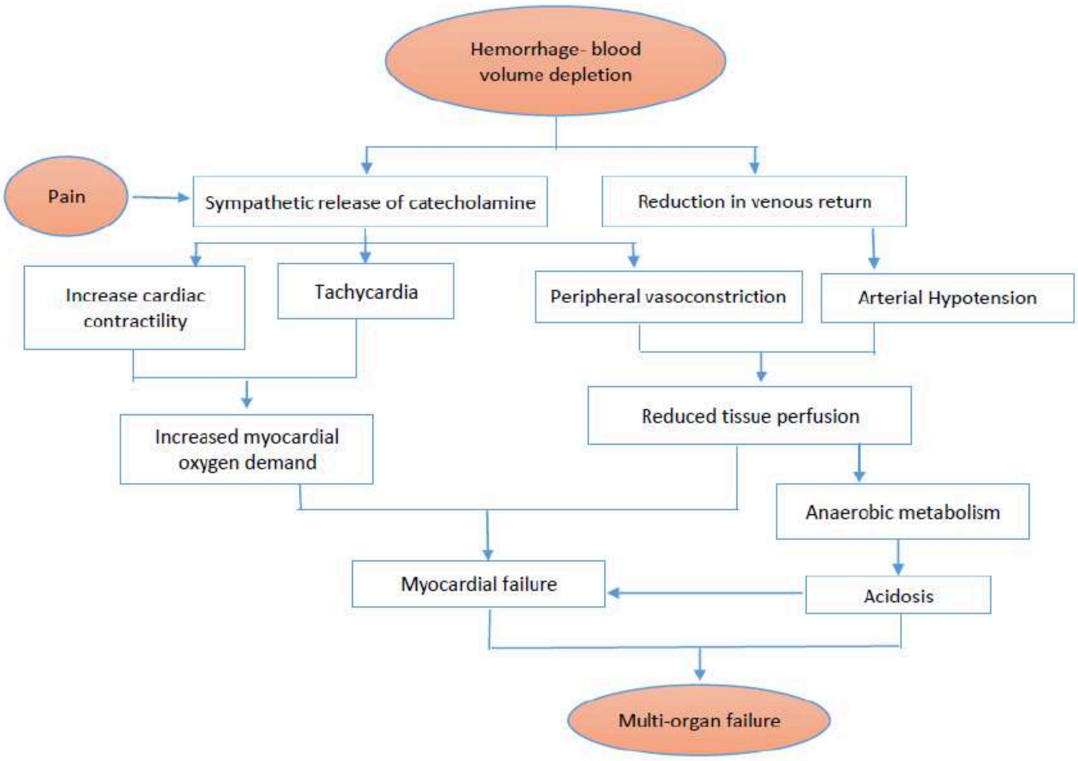

Figure 3.1: Sequalae of hemorrhagic shock

- In shock, cellular hypoperfusion is compensated by **anaerobic metabolism** which results in increased **lactate production** causing worsening **metabolic acidosis**, eventually multi-organ failure and cardiovascular collapse. The pathology worsens in a vicious cycle promoting accelerated cellular death.

- Treatment priority should focus upon immediate **restoration of adequate cardiac output** and end organ perfusion. This can be achieved by **restoring venous return**, **stopping** the hemorrhage and advocating appropriate volume **repletion**.
- In life-threatening hypovolemic shock which is resistant or poorly responding to volume resuscitation, vasopressors can be considered. In such cases, vasopressors are pharmacological adjuncts used in conjunction with blood / volume transfusion to achieve specific blood pressure targets, abiding to a damage control permissive hypotension strategy.

3.3.2 Circulatory Blood Volume

- Circulating blood volume is about **70 ml/kg** in adults, and **80-90 ml/kg** in paediatrics.
- An average Asian adult would have a total blood volume of approximately 5.0L - 5.5L
- Balanced pressure resuscitation with immediate hemorrhage control intervention must be initiated / advocated when early signs and symptoms of severe blood loss are apparent.

TYPE OF SHOCK	HYPOVOLEMIC SHOCK	OBSTRUCTIVE SHOCK	CARDIOGENIC SHOCK	DISTRIBUTIVE SHOCK
Blood Pressure	↓	↓	↓	↓
Pulse Pressure	↓	↓	↓	↑ or =
Heart Rate	↑	↑	↑	Variable (Dependant on Etiology)
Respiratory Rate	↑	↑	↑	↑
Jugular Venous Pressure	↓	↑	↑	↓ or =
Skin Temperature	↓	↓	↓	↓ or =
Mechanism	Circulatory volume loss	Mechanical obstruction	Pump failure	Vasodilation and vasoplegia
Response to Fluid	Improve	Minimal improvement	Minimal or non sustained improvement	Minimal or non sustained improvement
Example	Severe hemorrhage	Tension Pneumothorax	Cardiac Contusion	Neurogenic shock

Table 3.1: Types of Shock.

- Shock index (SI) may be used to assess the degree of hypovolemic shock. A value of more than 1.0 may indicate significant hemorrhage.

Shock index (SI) = HR / SBP
Normal = <0.7

3.3.3 Potential Source of Hemorrhage

- The priority in managing hemorrhagic shock is to identify the source and immediately arrest the bleeding.
- Sources of potential blood loss can be referred to by the following mnemonic: SCALPER
  - **S**calp/Skin/Street
  - **C**hest
  - **A**bdomen
  - **L**ong bones & Muscles
  - **P**elvis
  - **E**ar Nose Throat
  - **R**etroperitoneum

3.4 INITIAL MANAGEMENT OF HEMORRHAGIC SHOCK

3.4.1 The two immediate priorities in managing hemorrhagic shock are:

i. **STOP** the bleeding
ii. **REPLENISH** loss of volume

PRIMARY SURVEY PRINCIPLES

<C> A B C D E

<C> Catastrophic or Exsanguinating Hemorrhage Control; followed by the subsequent assessment and intervention

A - Airway and Cervical Spine Control
B - Breathing Assessment and Ventilation
C - Circulation Assessment and Haemorrhage Control
D - Disability Assessment and Neurological Evaluation
E - Extremity / Exposure / Environment Control

3.4.2 Circulation Assessment & Early Intervention

- Assess the patient and inspect for signs of circulation compromise.
- Look for any evidence of concealed or obvious bleeding. Inspect the skin for color and look for the presence of **pallor**. Touch the patient and inspect for any evidence of **cold or clammy peripheries**. Examine the capillary refill time and look for any evidence of delayed filling (i.e., > 2 seconds). Assess the **volume** and character of the central and peripheral arterial pulses to look for evidence of reduced circulating blood volume and hypovolemic shock.

CCTVR

Color
Capillary refill time
Temperature
Volume
Rate – Pulse rate

- Presence of the following palpable pulses may suggest the following approximate systolic blood pressures:

Palpable Pulse	Approximate SBP
Internal Carotid Artery	: > 60 mmHg
Femoral Artery	: > 70 mmHg
Radial Artery	: > 80 mmHg
Dorsalis Pedis Artery	: > 90 mmHg

- Insert a minimum of 2 large-bore (18 gauge or larger) peripheral vascular access.
- Short and large caliber peripheral cannulas are preferred for volume resuscitation. *Poiseuille's law*: Flow rate depends on cannula radius (to the fourth power) and length (inversely related).
- During insertion of vascular access points, blood should be drawn for type & crossmatch and baseline hematologic studies (Trauma Blood Panel).

- The Trauma Blood Panel may include:
  - Full Blood Count
  - Coagulation Profile (PT/aPTT/INR) + Fibrinogen
  - Blood Urea and Serum Electrolyte + Creatinine
  - Liver Function Test (Liver Enzymes)
  - Blood Gas, Acid & Base Balance (Arterial/ Venous)
  - Lactate level
  - Creatinine Kinase
  - Cardiac Troponins
- Warm isotonic crystalloid may be administered in the initial phase of hemodynamic resuscitation. When available, a balanced solution is a preferred crystalloid as compared to isotonic saline.
- In the event of ongoing hemorrhage with hemodynamic compromise, early blood product transfusion is advocated. This may be initiated using a Massive Transfusion Protocol (MTP) which is locally available.
- A fixed ratio transfusion strategy with RBC (Packed Cell), FFP, Platelet and Cryoprecipitate may be advocated in the initial phase of blood transfusion i.e. 1:1:1:1 ratio
- If MTP is not available, Emergency Group O or conventional transfusion strategies should be advocated immediately.
- In centers with available resources, a targeted massive transfusion strategy (T-MTP) may be preferred. The Targeted Massive Transfusion Protocol provides an avenue to rapidly initiate large volume transfusion using a hematological point of care guided method. This method enables the clinician to transfuse desired blood volume and components to achieve effective volume replacement and hemostasis whilst avoiding blood wastage or unnecessary access transfusion.
- Intravenous fluid warmers should be used when transfusing blood products in the severely ill major trauma patient. All measures to avoid or treat hypothermia should be advocated.
- The Emergency Group O blood is commonly stored in the Blood Fridge. Rapid transfusion of large amounts of Emergency Group O blood without using an IV Fluid warmer may predispose the patient to severe hypothermia.
- Early identification of bleeding source and presence of coagulopathy is advocated.

- The following are methods utilized to Locate source of Bleeding
    - Whole body physical examination (Primary & Secondary Survey)
    - Point of Care & Diagnostic imaging
    - Chest X-ray
    - Pelvic X-ray
    - FAST scan
    - Whole body Contrasted CT scan (WBCT) for detection of active hemorrhage and injury identification (Refer to Local Pan-CT Protocol in Major Trauma)
- In hypotensive trauma patients without a source of bleeding, consider a non-hemorrhagic cause for shock (ie. Distributive, cardiogenic or obstructive shock)

3.4.3 Hemorrhage control

- The following are various methods utilized to attain emergency control of life-threatening hemorrhage in the out of hospital and in hospital setting.
- Local compression; manual compression or application of compression bandage to limit life threatening bleeding
- Deep Wound packing and Hemostatic suture / Compression bandage with Adjunct use of hemostatic agents (Hemostatic Gauze / Powder / Sponge / Granules)
- Application of Hemostatic sutures or Skin staplers
- Arterial Tourniquets to stop persistent / non-compressible open extremity bleeding
- Immobilization of long bone fractures
- Application of External Pelvic Binders for unstable pelvic fractures
- In patients with obvious or suspected bleeding, early administration of Tranexamic Acid reduces mortality when provided within the first three hours of injury. Tranexamic acid can be administered via the intravenous route, at a dose of 1 gram given as a slow bolus (slow push) followed by 1 gram over 8 hours.

3.4.4 Initial Fluid Resuscitation Strategies

- The focus is to restore organ perfusion and tissue oxygenation while limiting further hemorrhage.
- In the event of hemodynamic instability with ongoing or suspected bleeding, a restrictive fluid resuscitation strategy should be advocated to achieve

permissive blood pressure targets. Permissive pressure resuscitation enables the patient to attain a balance between acceptable tissue perfusion whilst limiting excessive blood losses. This is an interim strategy, bridging time for definitive hemorrhage control measures to be performed.

- Restricted volume replacement strategy:
    - An initial bolus of less than 1 liter (for adults) or less than 10 ml/kg (for pediatrics) of a preferably warm isotonic crystalloid solution (37-40^{0}C) may be initiated.
    - The initial fluid bolus can be given in titration doses, while monitoring the response to achieve targeted Permissive Systolic Blood Pressures [SBP 80-90 mmHg in adults, 55 + (Age x 2) in Pediatrics]
    - Balanced isotonic electrolyte solution is recommended over normal saline as the initial fluid of choice
    - Blood product transfusion can be initiated immediately once available
    - Vasopressors may be initiated as adjunct therapy in non-responders or imminent life threatening hemodynamic compromise to facilitate resuscitation measures in order to achieve targeted permissive blood pressure targets.
    - Avoid the use of colloids in patients with ongoing or suspected bleeding due to its adverse effects on hemostasis.

3.4.5 Monitoring Response to Fluid Resuscitation

- Observe and identify improvement of organ perfusion
    a. Skin : warm, improvement in capillary refill time
    b. Renal : increased urinary output, 0.5-1ml/kg/hr
    c. Vital signs : Reduction in shock index (SI)
    d. CNS : improved level of consciousness
- Subsequent volume replacement strategies are determined by the patient's response to initial therapy and the ability to control / stop ongoing hemorrhage.
- Appropriate interventions should be performed immediately to attain definitive hemorrhage control.
- Perform serial hematological assessment (POCT if available) such as blood gasses, full blood count, coagulation profile and lactate levels to facilitate assessment of response to resuscitation and presence of coagulopathy.

3.5 SHOCK AND COAGULOPATHY

3.5.1 Complications associated with Shock

Hypothermia

- The rapid infusion of cold intravenous solution / blood products may induce / worsen hypothermia. Other causes may include exposure, hypovolemic shock and extreme heat loss from severe skin burns
- Hypothermia induced coagulopathy, decreasing platelet function and promoting fibrinolysis
- Always keep the patient warm using either a passive or active method. Such methods may depend upon available resources and expertise (ie. warm blankets, Conduction forced-air warmers, infusion of warm IV fluids, etc)
- Target normothermia of core temperature between 36-37^{0}C

Early coagulopathy

- Coagulopathy is a well-known sequelae for major trauma patients experiencing hemorrhagic shock. The 3 following known mechanism of coagulopathy in trauma are as follows;
  - **Dilutional coagulopathy:** Massive fluid resuscitation, with the resultant dilutional effects towards the coagulation factors contribute to coagulopathy in major trauma patients
  - **Consumption coagulopathy**: Poor fracture site immobilization causing recurrent clot breakdown & build up leads to consumption / depletion of coagulation factors and its components
  - **Acute Traumatic Coagulopathy:** Tissue injury with resultant hypo-perfusion leading to a systemic inflammatory, humeral and cellular response resulting in auto-anticoagulation and fibrinolysis

Acidosis

- **Inadequate tissue perfusion** with resultant accumulation of anaerobic by product (lactic acid) contributes to the development of metabolic acidosis in acute trauma
- Acidosis impairs function of clotting factors, platelets as well as fibrinogen activity

Hypocalcemia

- Calcium plays a key role as catalyst in homeostasis, platelet aggregations and cardiac contractility.

- Calcium levels can be significantly decreased with rapid blood product transfusion. This is contributed by the citrate preservative that is added in stored blood.

- Citrate binds to the free calcium ions (chelating agent) causing reduction in serum calcium levels and its resultant adverse effect on hemostasis.

- Hypocalcemia is also contributed by its component reduction with ongoing blood loss

- Severe shock reduces the liver's ability to metabolize citrate, resulting in more calcium being bound and less made available in circulating blood

3.5.2 Acute Traumatic Coagulopathy (ATC)

- ATC is an early endogenous process driven by the combination of tissue injury and shock.
- ATC is associated with high morbidity and mortality
- Endothelial activation of Protein-C is the central mechanism of ATC, producing rapid auto anti-coagulation and fibrinolysis in the severely ill trauma patient.
- The two-phases contributing to coagulopathy in trauma is described by having Trauma Induced and Resuscitation-Associated Coagulopathy.
- Interruption of platelet activity, fibrinogen utilization, endothelial dysfunction and neuro-hormonal pathways contributes to the development of ATC.

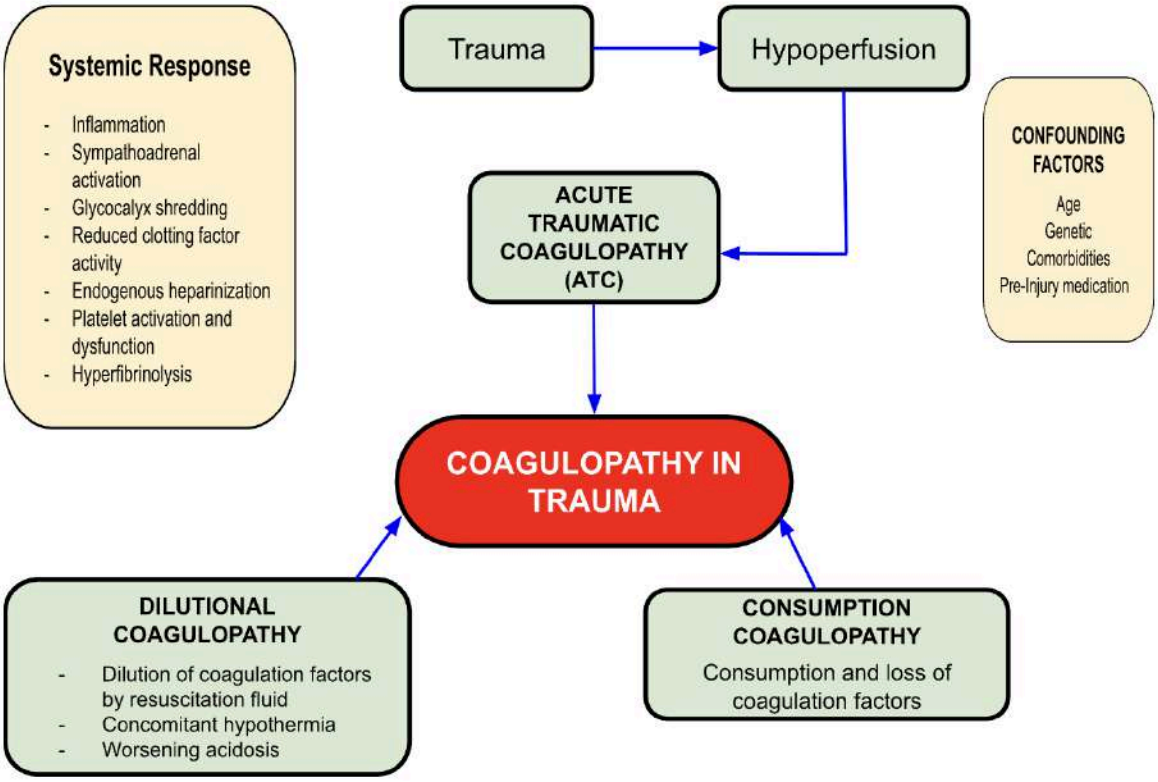

Figure 3.2: Traumatic Coagulopathy

3.5.3 Hematological Parameters, Transfusion and End-Points

- Hemoglobin level (Hb) : low initial (arrival) Hb levels of <10 g/dL is associated with significant bleeding injuries and risk of traumatic coagulopathy. Initial Hb levels may not represent the actual state of hemoglobin loss and repeated serial Hb measurements are required.
- During blood transfusion (Packed Cell), a target of Hb 7-9 g/dL is desired. In patients with ischemic heart disease, a higher target of 10g/dL should be advocated.
- In major trauma patients who have no active bleeding, a targeted platelet level of >50,000 should be advocated. In patients who are having ongoing bleeding, a target of >100,000 should be achieved.
- A fibrinogen level of > 150 - 200 mg/dL should be targeted in major trauma patients with risk of bleeding. Fibrinogen levels can be increased by transfusing Fresh Frozen Plasma or Cryoprecipitate

- For major trauma patients who have ongoing bleeding or are at risk of bleeding, keep targeted INR of ≤ 1.4

- Target to achieve serum lactate < 2 mmol/L and base deficit of < -6 mEq/L within the first 24 hours

- In major trauma patients with hypocalcemia, target normal serum calcium values. Serum calcium levels can be increased by administering intravenous Calcium Gluconate / Calcium Chloride.

3.6 DAMAGE CONTROL RESUSCITATION

- Damage control resuscitation is an early strategic clinical approach in resuscitation of major trauma patients to reduce the 2nd peak of trauma death and improve overall survival outcomes
- It is a strategy that provides a structured resuscitation approach from the first point of clinical contact to the point of clinical normalization
- The major principles of DCR include:
    - Advocating Permissive Hypotension (Balance Resuscitation)
    - Administering Hemostatic Resuscitation
    - Achieving Immediate Control of active Hemorrhage (via damage control interventions / surgery)

3.6.1 Permissive Hypotension (Balance Resuscitation)

- In patients **without** severe traumatic brain injury, a SBP of 80-90mmHg or MAP 50-60 mmHg may be targeted to reduce the severity of bleeding prior to attaining definitive hemorrhage control

- This is an "interim" clinical strategy utilized to bridge time for advocating definitive interventions aimed to attain complete cessation of active hemorrhage (ie. Bleeding Control of Open Wounds, Angio Embolization via Interventional Radiology, Damage Control Surgery / Damage Control Laparotomy, etc.)

- Maintaining the SBP /MAP at a low "permissive state" reduces bleeding & risk of bleeding from clot displacement / promotes clot formation by minimizing intravascular hydrostatic pressure whilst providing a transient acceptable tissue perfusion state.

3.6.2 Hemostatic Resuscitation

- It is a key component of damage control resuscitation aimed at restoring physiological hemostasis in the bleeding trauma patient.
- This strategy involves the use of blood components and pharmacological adjuncts to combat coagulopathy & attain hemostasis
- This method of resuscitation is a **“critical volume strategy”** providing functional intravascular volume replacement in order to improve tissue perfusion, reduce traumatic coagulopathy and combat the lethal causes of death
- Infusion of non-blood products tend to temporarily compensate intravascular volume deficit, but not the integral function of blood itself
- Hemostatic resuscitation involves administering different blood product components in various ratios during emergency transfusion of the bleeding trauma patient.
- Massive Transfusion Protocols (MTP) commonly engage the principles of hemostatic resuscitation by advocating the combination of various blood components in a fixed aspect ratio to reconstitute “whole blood” or capability to improve hemostasis in the bleeding patient.
- MTP strategies are commonly based upon a fixed minimum aspect ratio of 1:1:2 (FFP-1 : Platelet-1 : Packed Cell-2). However, a ratio of 1:1:1 may reduce the risk of exsanguination hemorrhage within the first 24 hours.
- An initial fixed ratio transfusion of 1:1:1:1 may also be instituted depending upon local hospital protocols (FFP: platelet: cryoprecipitate: packed cell). This strategy advocates early replenishment of fibrinogen loss.
- After the initial phase of transfusion and upon restoration of hemodynamic stability, a more guided and goal directed transfusion strategy may be advocated. If blood transfusion is further required, it should be guided by basic laboratory markers such as FBC, PT, APTT, INR and fibrinogen levels.

3.6.3 Hemorrhage Control Interventions & Damage Control Surgery (DCS)

- Advocating Immediate Hemorrhage Control Interventions and/or Damage Control Surgery is in accordance with the principles of Damage Control Resuscitation
- Hemorrhage Control Interventions and / or Damage Control Surgery (DCS) are critical interventions primarily aimed at achieving immediate control of active hemorrhage, as opposed to performing a definitive repair procedure.
- The goals are to achieve immediate hemostasis and to reinstate physiological perfusion. The definitive surgical repair / intervention is performed subsequently after stabilization, intensive care, and optimization of physiological parameters.
- Immediate hemorrhage control interventions may include wound packing procedures of junctional hemorrhages, angio embolization by interventional radiology, or damage control surgery /thoracotomy & laparotomy by respective surgical specialties.

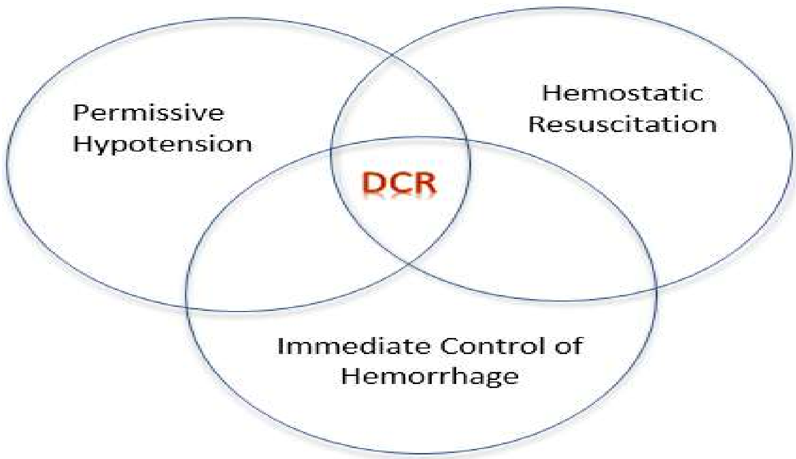

Figure 3.3: Damage Control Resuscitation

3.6.4 Targeted Massive Transfusion Protocol

- Targeted Massive Transfusion Protocol (T-MTP) is a strategic rapid blood transfusion protocol that enables the attending clinician to individually formulate the ratio and type of blood products that is best required for the individual patient.
- This requirement can be customized to specifically suit the need of each individual patient based upon the patient's premorbid state, injury pattern, site and extent of bleeding
- This strategy is best adjunct by the measure of point of care parameters (POCT) such as bedside PT/APTT/INR, FBC, and Blood Gases (also with future use of Viscoelastic Assays).
- The attending clinician may then choose the desired ratio and volume of each blood component product which is required for immediate rapid transfusion, instead of having a fixed volume and predetermined ratio under a standard MTP protocol.
- Targeted transfusion strategies are available in certain Trauma Centers and may reduce incidence of unnecessary blood transfusions, complications, and blood wastage.

3.7 SUMMARY

1. Shock is an abnormality of the circulatory system resulting in inadequate cellular perfusion and oxygenation.
2. Hemorrhage is the leading cause of hypovolemic shock in trauma patients; management focuses on immediate bleeding control and circulatory volume replacement.
3. Damage control resuscitation comprises permissive hypotension strategy (Balance Resuscitation), Hemostatic Resuscitation and attaining Immediate Control of active Hemorrhage (via damage control interventions / surgery).
4. Damage control resuscitation is a clinical approach in resuscitation of major trauma patients advocated to reduce the 2nd peak of trauma death from first point of clinical contact throughout to the point of clinical normalization.

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3.9 SKILL STATION

3.9.1 Establishing Vascular Access in Trauma Patients

3.9.1.1 <u>Peripheral Intravenous Catheters</u>

- Insert two large bore cannulas, size 14 - 18G into any available upper extremity veins.
- Based on Hagen-Poiseuille law : the flow through a tube is directly proportional to the fourth power of the radius and inversely related to its length —> large diameter, faster flow, reduced turbulence flow.
- Consider using Ultrasonography guidance in multiple failed attempts.

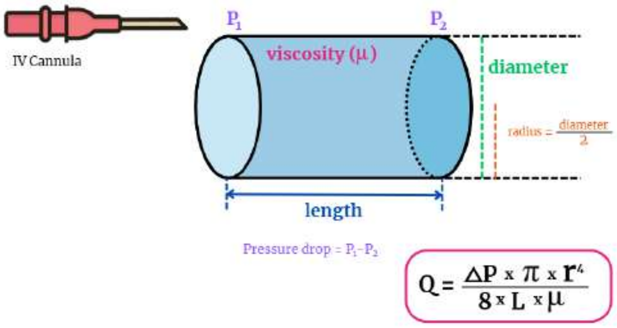


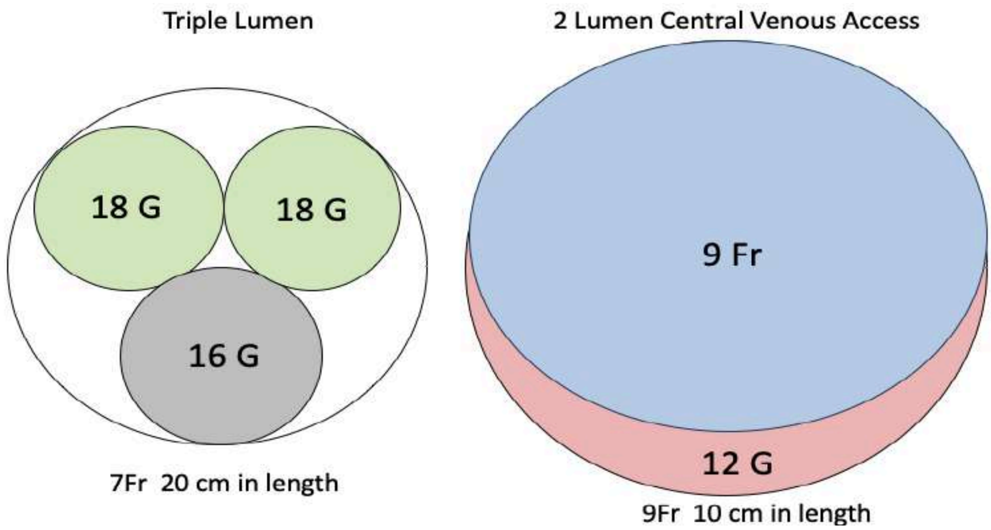
Figure 3.4 : Hagen - Poiseuille Law

3.9.1.2 Central Venous Catheterization

- May be considered in failed attempts for large bore peripheral cannulation.
- Usage of Ultrasound Guided Vascular Cannulation is encouraged.
- Advantages :
  - Alternative to unsuitable peripheral cannulation
  - Larger volume may be delivered
- Disadvantages :
  - Hematoma
  - Infection
  - Line misplacement
  - Air embolism
  - Arterial puncture
  - Thrombosis of catheter
- Contraindication :
  - Coagulopathy (if severe)
  - Local infection at injection site

- Site of cannulation :
    - Femoral Vein
    - Internal Jugular Vein
    - Subclavian Vein
    - Axillary Vein

Figure 3.5: Large bore multi-lumen access catheter



Proximal	18 G = 20ml/min	= 1200 ml/H	
Middle	18 G = 20ml/min	= 1200 ml/H	
Distal	16 G = 54ml/min	= 3240 ml/H	
	TOTAL	= **5640ml/H**	

Proximal 12 G	= 13, 000ml/H
Distal 9 Fr	= 33,000 ml/H
TOTAL	= **46,000 ml/H**

Figure 3.6 : Triple Lumen versus Multi-lumen access catheter

3.9.2 Intraosseous access (IO)

- The IO needle is placed in the epiphysis of long bones due to thinner compact bones and abundance of cancellous bones, where lies a vast system of blood vessels and sinusoids, Haversian's canals and Volkmann's canals.
- It has non-collapsible canals. Through IO infusion, the blood, fluids and medications can rapidly flow until it reaches the systemic system.
- The intraosseous cannula needs to be removed within 24 -48 hours once alternative for vascular access is secured.
- Indications
  - Difficulty to establish venous access after multiple attempts
- Contraindications
  - Fracture in target bone because the fluid will exit through the fractured bone
  - Attempted IO access in past 48 hours at the same bone
  - An extremity with vascular interruptions, whether from trauma or venous cutdown because the fluid in the bone will leak through the open blood vessels.
  - Excessive tissue ie: severe obesity, various anomaly of normal body anatomy
  - Infection at the insertion site
  - Significant orthopaedic procedure at the site, prosthetic limb, or joint
  - Patient with right to left intracardiac shunts (ie. Tetralogy of Fallot, Pulmonary atresia) who has higher risk for bone marrow emboli or cerebral fat emboli.

- Site of insertion
  - Proximal Humerus
  - Distal Femur
  - Proximal / Distal Tibia
  - Manubrium (specific IO needle and size)

- Complications
  - Extravasation leads to soft-tissue necrosis, compartment syndrome
  - Bone fracture, through and through IO needle
  - Injury to growth plate (paediatrics)
  - Osteomyelitis
  - Fat emboli
  - Skin infection - cellulitis, subcutaneous abscess

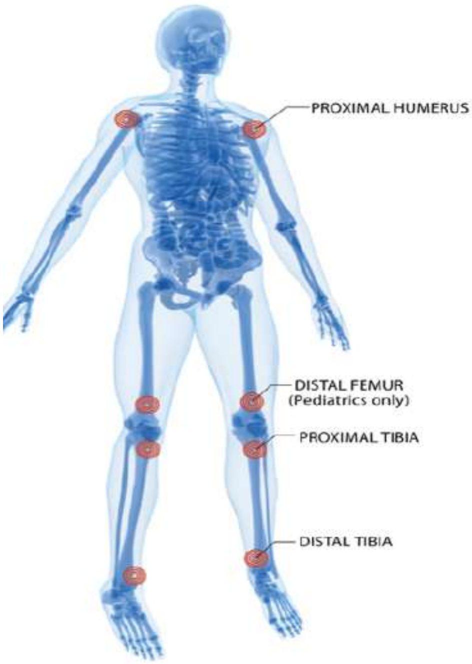


Figure 3.7 : Landmarks for IO Insertion

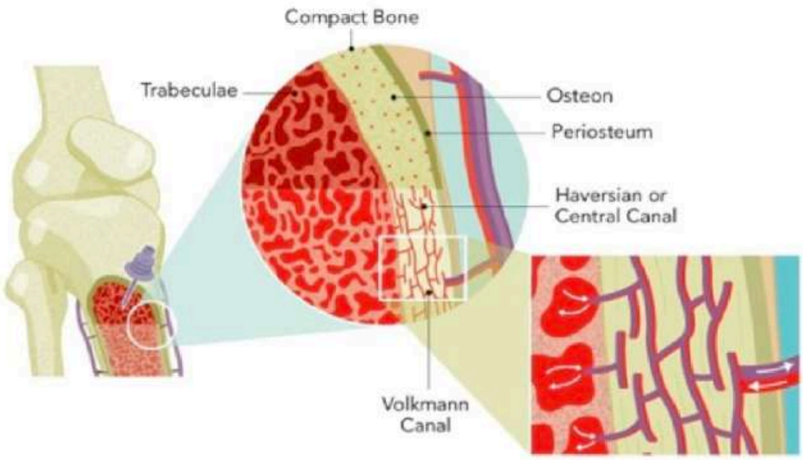


Figure 3.8 : Trabeculated spaces of medullary bone structure for IO blood flow and perfusion.

3.9.2.1 Proximal Humerus IO insertion

- The greater tubercle of the proximal humerus is appropriate for IO placement in skeletally mature adolescents and adults.
- To identify greater tubercle of humerus, adduct and internally rotate the upper arm by placing the patient's ipsilateral hand on the abdomen. This reduces the risk of injuring the contents of the bicipital groove during IO insertion.
- The greater tubercle of the proximal humerus can be palpated about 2 cm below the acromion process. Alternatively, it can be directly palpated from below.

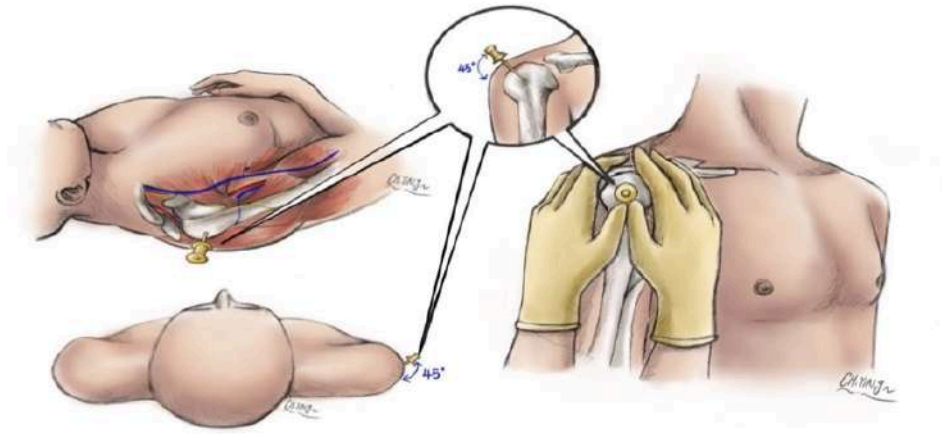


Figure 3.9 : Landmark for insertion of Humeral IO

Steps for Intraosseous Insertion

- Identify the site of insertion using landmark technique.
- Choose a suitable IO needle length.
- Consider giving local anaesthesia at the site of insertion.
- Sterilise the area with antiseptic solution.
- Insert IO needle at the site until there is a give or loss of resistance. This indicates that the needle has reached the medullary space.
- Ensure that the needle in situ by presence of blood on aspiration and ease of giving fluid boluses.
- Ensure that there is no expansion of tissue, posterior to the bone or hematoma formation.

- Advantage
  - Average flow rate of 6.3L – 12L/ hour under pressure for proximal humerus, while 1L/hour for proximal tibia
  - In 3 seconds, the drugs and fluid are able to reach the central circulation.

- Preparation

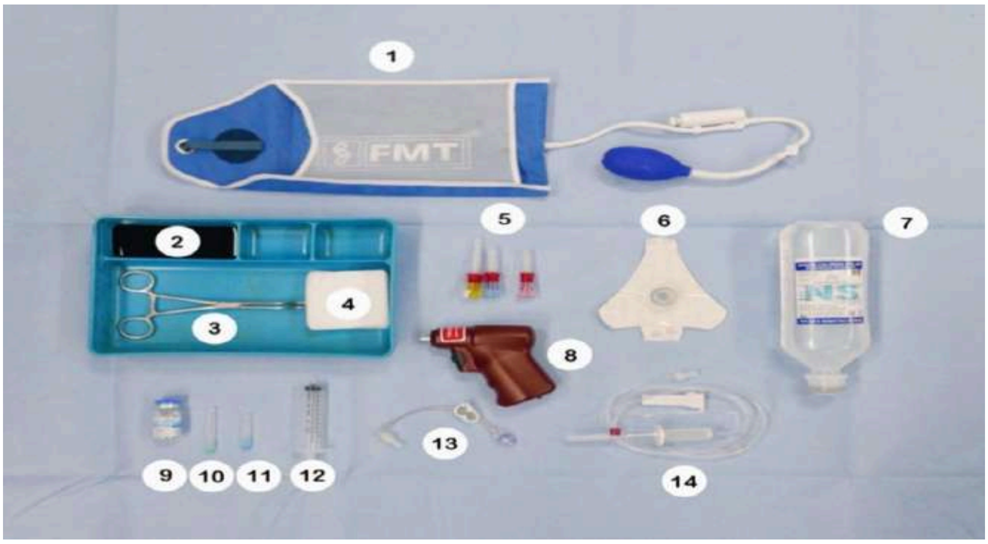
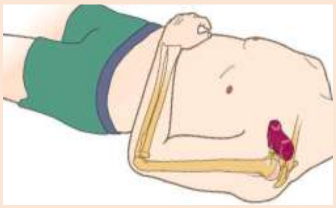
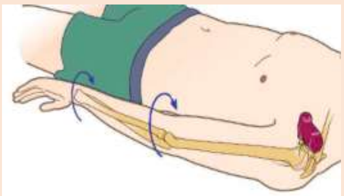


Figure 3.10 : Equipment preparation for insertion of IO

1. Pressure Bag
2. Skin Preparation solution – Chlorhexidine, Povidone solution
3. Sponge Forcep
4. Sterile Gauze
5. Intraosseous Needle and Trocar
6. EZ IO stabilizer
7. Normal Saline 0.9%
8. EZ IO set (Drill)
9. Local Anaesthetic agent – Lignocaine 2%
10. Hypodermic Needle – 18G
11. Hypodermic Needle – 22G
12. 10cc Syringe
13. EZ IO connection extension tubing
14. IV infusion line

- Identification And Insertion Technique

Steps	Illustration	Details
1	  	● Adduct elbow and rotate humerus internally. ● Place the patient's hand over the abdomen with arm tight to the body ● Or alternatively, rotate the arm internally so that the palm is facing outward, with the thumb pointing downward.
2		● Place your palm on the patient's shoulder anteriorly ● The area that feels like a ball under your palm is the target area ● You should be able to feel this ball even on an obese patient, by pushing deeply
3		● Place the ulnar aspect of your hand vertically over the axilla
4		● Place the other hand along the midarm of upper arm laterally
5		● Place your thumbs together over the upper arm ● This defines the vertical line of insertion on the proximal humerus

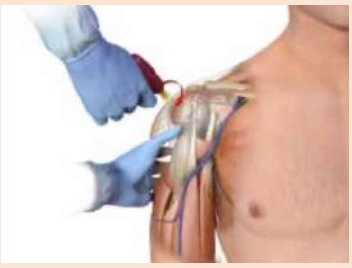
Steps	Illustration	Details
6		● Palpate deeply up to the humerus to the surgical neck ● It will feel like 'a golf ball on a tee' ● That spot is where the surgical neck is located
7		● The insertion site is 1-2 cm above the surgical neck, on the prominent aspect of the greater tubercle
8		● Using an aseptic technique with local anaesthesia given at the site of insertion, point the drill at 45-degree angle to the anterior plane and posteromedial ● Stabilize the bone and gently press the needle into the skin until it reaches the bone ● The 5mm mark should be visible on the skin before drilling. ● Squeeze the trigger and apply the gentle pressure onto the needle until it stops drilling, indicating that it already has reached medullary space. ● Stabilize the hub, remove the stylet and the driver, then apply the dressing over the hub. ● Attach an IO catheter to the hub with clamp open ● Using a Normal Saline pre-filled 10cc syringe, flush the IO catheter to confirm the placement, either by aspiration of blood or ease of fluid bolus. ● Ensure there is no expansion of surrounding tissue, indicating leaking or inappropriate placement. ● Use a pressure bag to optimize the infusion flow rate.

Table 3.2 : Guide for Intraosseous Insertion of Proximal Humerus

3.9.2.2 Removal of IO needle

- Using a sterile luer-lock syringe as a handle, attach to the hub of the IO catheter, maintain alignment, then rotate clockwise while pulling straight up.
- Avoid rocking the catheter on removal.

Scan QR code or
click here to watch the **Proximal Humerus Intraosseous Access Skill Station** video

3.9.3 Compression of Bleeding Site

- Any active bleeding wound should be controlled adequately to prevent massive blood loss that can lead to hypovolemic shock.
- Early control of external traumatic hemorrhage, especially an exsanguination or large wound determines the outcome of the wounded patients.
- Although in normal haemostasis reaction of the body, the blood would coagulate and stop eventually. However, this is not the case in a patient who has a large wound and continuously loses blood.
- There are many techniques to be used and the technique depends on the type of wound, the size and the location of a wound.
- Preparation of material:
    - Tape
    - Gauze / Gamgee / Clean Cloth
    - Elastic Bandage
    - Hemostatic agent
- In a non-penetrating wound, the application of compression is direct onto the wound, meanwhile in penetrating injury, care must be taken should there be any impaled foreign object in the wound. This is because the foreign body might cause additional injuries to the patient by inflicting a new wound or dissecting the injured wound track or causing extension of injury to the surrounding structure such as vessels, nerves or organs.

Figure 3.11: Tape or Adhesive tape Figure

Figure 3.12: Elastic bandage (Non-adhesive or adhesive)

Figure 3.13 : Direct Compression at actively bleeding wound

Technique of Compression Bandage

- **Apply gauze dressing** directly over the bleeding wound.
- Immediately **apply direct and continuous pressure** on the dressing using the **heel of your palm**.
- Maintain continuous compression for a minimum of **three minutes**.
- **Secure the dressing** with a rolled gauze or crepe bandage.
- If bleeding continues, **apply an additional layer of gauze** on top of the first dressing.
- **Do not remove the first layer.**
- Continue to maintain compression.
- **Monitor distal perfusion** by checking capillary refill time, skin color, or distal pulses to ensure adequate blood flow.

3.9.4 Tourniquet Application.

- Life-threatening hemorrhage significantly contributes to mortality. It is crucial to identify and manage such bleeding effectively.

- Identify the life-threatening bleeding
    - Spurting or profuse bleeding from a wound
    - Clothing or bandages saturated with blood
    - Partial or complete limb amputation
    - Symptoms of dizziness or unconsciousness in the injured individual

- Severe uncontrolled bleeding could occur in these areas
    - Arms and Legs
    - Junctional Bleeding : Armpit, Neck, Groin
    - Internal bleeding : Intraabdominal, Retroperitoneal and Intra-thoracic

- Indication
    - Failure to control persistent, exsanguinating hemorrhage in the extremities using compression methods.

- Technique of application

    - Apply a tourniquet tightly 2-3 inches above the wound.
    - Avoid placing it directly over a joint; if necessary, apply it as close to the wound above the joint.
    - Pull the velcro and tighten the band firmly over the limb.
    - Turn the windlass and twist it tightly until the bleeding stops or no distal pulse is palpable.
    - Once the windlass cannot be twisted anymore place the windlass in the holder.
    - Take the remaining strap and place it across the windlass.
    - Write the date and time of tourniquet placement
    - Do not loosen or remove the tourniquet until further help arrives.
    - Provide analgesic when possible to minimize the pain.

- Additional cautions for Tourniquet Usage
  - Ensure the time of tourniquet application is written.
  - Ensure the tourniquet remains visible or known to the next medical personnel in charge.
  - Should hemorrhage persist after the initial application, further rotation of the windlass is required to increase tourniquet tension.
  - If the initial attempt fails, a second tourniquet should be applied either slightly above the first tourniquet.
  - Remove all the keys, wallets or foreign objects that can hinder the tourniquet application.

Figure 3.14 : Application of Arterial Tourniquet to the injured right upper limb

Scan QR code or click here to watch the **Hemorrhage Control Skill Station** video

CHAPTER 4

CHEST TRAUMA

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Able to identify and initiate acute clinical management for immediate life-threatening thoracic injuries.
2. Able to identify and initiate the early clinical management for potentially life-threatening thoracic injuries.
3. Able to understand the basic pathophysiology of thoracic trauma
4. Able to understand the potential complications that may arise within the acute phase of thoracic injury management

4.0 INTRODUCTION

Chest trauma contributes significantly to morbidity and mortality. However, the majority of acute thoracic injuries are effectively managed by appropriate airway and ventilation control, performing thoracic decompression and introducing an intrapleural drain. Major surgical interventions are only required in 10% of blunt chest injuries and 15%-30% of penetrating injuries. Hypoxia, hypercarbia and acidosis are serious consequences of thoracic trauma.

4.1 ANATOMY

The thoracic cavity is bounded by ribs, the vertebra column and the sternum. Vital structures within the thorax are as follows:

- **Cardiovascular system** including the heart, aorta, superior and inferior vena cava, azygous veins and pulmonary vessels.
- **Respiratory systems** including the trachea, bronchi, lung parenchyma and diaphragm.
- **Gastrointestinal system** including the esophagus.
- **Nervous system** including the thoracic spinal cord, vagus nerve, phrenic nerve and paired sympathetic chain.
- **Lymphatic system** including the thoracic duct.
- **Musculoskeletal system** including the thoracic spine, sternum and ribs.

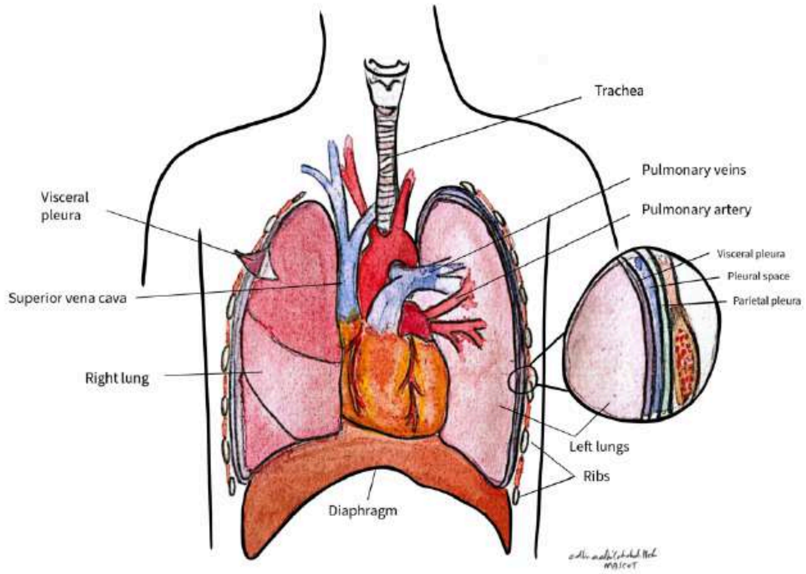


Figure 4.1: Thoracic cavity and contents

4.2 PATHOPHYSIOLOGY

Morbidity and mortality in the chest trauma is commonly attributed to the failure in ventilation mechanics, compromised airway patency, hypovolemia and circulatory dysfunction.

Direct tissue injury

The energy transmission from a physical force to the human body may result in direct tissue injury. The extent of injury is often proportionate to the amount of force or impact transmitted. The degree of injury is also determined by the mechanism of assault, such as concomitant use of weapons etc. Depending upon the mechanism of trauma, the injury may present as blunt, penetrating or a combination of both.

4.2.1 AIRWAY PATENCY

The patency of the airway is vital to enable ventilation and gas exchange to ensue. An obstructed airway may occur due to accumulation of secretions, loss of anatomical conformity due to direct impact of trauma, obstruction by dislodged foreign body, acute spasm, etc.

4.2.2 VENTILATION MECHANICS

Injury may cause alteration in the normal breathing mechanics involving the thoracic cavity and lung parenchyma. The movement of air into the upper-lower airways and subsequently the alveolus is much dependent upon a passive process. The air flows into the airways due to a reduced intrathoracic pressure, generated by the inhalation biomechanics that increases the thoracic volume.

This process occurs by a dynamic combination of movement involving the diaphragm, intercostal muscles and the skeletal ribs. The diaphragm muscle contracts causing it to flatten and increase the intrathoracic volume. With the help of the intercostal muscles, the thoracic cage moves “upward” and “outward” during inspiration. These movements increase the volume during inspiration and are commonly described as the “bucket handle” (lower ribs) and “pump handle” (upper ribs) motion.

In response to a significant thoracic injury, vital thoracic structures may sustain injuries leading to intra thoracic hemorrhage, pulmonary air leak and consequent difficulty in breathing with associated failure of ventilation. This is commonly seen in cases of traumatic hemothorax, massive hemothorax, pneumothorax, tension pneumothorax and flail chest.

Tension pneumothorax occurs due to a rapid buildup of pulmonary intrapleural air pressure causing an immediate threat to life by impairing ventilation mechanics and cardio circulatory function (obstructive shock). This condition may be caused by lung parenchymal and tracheobronchial injuries. Air within the intrapleural space may also accumulate from a penetrating thoracic injury. In such injuries, the external environment directly communicates to the intrapleural space. This condition is called an open pneumothorax. Respiratory compromise may be minimal in small chest wall defects. However, if the open wound / chest wall defect is more than 2/3rd of the trachea diameter, air will preferentially enter through the chest wall defect during inspiration. The flow and movement of air will take the path of least resistance. This may cause the ipsilateral lung to collapse, subsequently resulting in impaired gas exchange and failure in ventilation. Penetrating thoracic injuries may also result in a combination of both air and blood accumulation within the pleural space, known as open hemo-pneumothorax.

Injuries to the lung parenchyma or rarely esophagus may lead air to seep within the subcutaneous tissue planes and cause the buildup of subcutaneous emphysema. Extensive subcutaneous emphysema in a spontaneously breathing patient may lead to respiratory failure.

Hemothorax is the accumulation of blood within the pulmonary intrapleural space. Hemothorax can occur in both blunt and penetrating chest injuries. Massive hemothorax may result from extensive bleeding into the intrapleural space. Massive hemothorax is defined as immediate blood drainage of >1,500 mL after insertion of an intrapleural chest drain or a continuous haemothorax bleeding rate > 200 mL/hr for at least 2-4 hours. The extensive collection of blood within the intrapleural space results in poor lung expansion, failure in ventilation and subsequent impaired gas exchange. The resultant injury often contributes to severe hypovolemia and ventilatory failure.

4.2.3 CIRCULATORY FAILURE

- **Severe Haemorrhage**

  Bleeding can arise from damage to intra-thoracic vessels and/or lung parenchyma. Massive hemothorax can be caused by injury to the intercostal or pulmonary arteries / pulmonary vein, deep lung lacerations and etc. Severe intrathoracic hemorrhage (massive hemothorax) can lead to ventilation failure, hypovolemia, and circulatory shock.

- **Pump Failure**

  Severe blunt thoracic injuries may cause damage to the underlying heart. This injury results in myocardial contusion that can potentially cause myocardial conductions abnormalities and heart failure

- **Obstructive Shock**

  Obstructive shock is the inability to produce an adequate cardiac output despite having a normal intravascular volume and myocardial function. The state of shock occurs due the inability to obtain adequate ventricular diastolic filling caused by an increased intrathoracic pressure in tension pneumothorax and an increased intra-pericardial pressure in cardiac tamponade.

4.3 ASSESSMENT AND MANAGEMENT OF THORACIC INJURIES

4.3.1 PRIMARY SURVEY: THORACIC INJURIES

Life-threatening thoracic injuries that should be recognized and intervened immediately include tension pneumothorax, open pneumothorax, massive hemothorax, tracheobronchial tree injuries and cardiac tamponade.

The approach to primary survey for thoracic injuries is similar to other systems. In the event that there is no active exsanguinating external hemorrhage, assessment and intervention should be performed in the order of establishing airway patency / cervical immobilization, followed by breathing/ ventilation mechanics and circulation / hemorrhage control. Any required interventions should be immediately performed as they are recognized. When permitted by adequate human resources, the sequence of assessment and intervention can be performed simultaneously.

See *Chapter 1: Initial Trauma Assessment and Management*

Immediate life-threatening thoracic injuries that must be recognized and addressed during the primary survey are as follows:

Immediate life - threatening injuries
(ATOM - TC)

A - Airway Obstruction
T - Tension Pneumothorax
O - Open Pneumothorax
M - Massive Hemothorax
T - Tracheobronchial Injury
C - Cardiac Tamponade

The following is the approach to primary survey. The principle of approach is to rapidly identify and treat immediate life-threatening conditions.

A – Airway & Cervical Spine Immobilization

- Assessment of airway patency and recognition of injuries that cause airway obstruction Look (Inspection), Listen (Hearing) & Feel (Palpation) method.
- Establish a secure and patent airway, if indicated
- Provide cervical spine immobilization using a rigid cervical collar. A head immobilizer can be applied for further stabilization.
- The details in injuries affecting the airway and further management are addressed in *Chapter 2: Airway and Ventilation*

B – Breathing & Ventilation

Assessment & recognition of injuries should be performed with the patient adequately exposed.

ACTION	ASSESSMENT
Inspection (I)	1. Assess the respiratory rate. 2. Observe asymmetrical chest movement. 3. Observe for paradoxical chest movement which may suggest clinical flail chest (indrawing flail segment during inspiration and moving outwards during expiration) 4. Observe the presence of any external signs of injury over the chest (abrasion, laceration, open wound, bruises, penetrating objects, seat belt sign, tire marks, etc.) 5. Observe the usage of accessory muscles.

ACTION	ASSESSMENT
Palpation (P)	1. Palpate the trachea to identify for any deviation. Tracheal deviation may suggest tension pneumothorax or massive hemothorax over the contralateral side of the lung. 2. Palpate for the presence of chest wall tenderness indicating rib fractures. 3. Palpate for subcutaneous emphysema which suggests possibility of pneumothorax.
Percussion (P)	Percuss the chest bilaterally to observe for the presence of dullness (may suggest hemothorax) or hyperresonance (may suggest pneumothorax). *** Consider traumatic diaphragmatic rupture as well if the percussion note is abnormal.
Auscultation (A)	Determine equality of breath sounds over the chest bilaterally. Reduced breath sound on the affected side may suggest presence of thoracic injury such as pneumothorax or hemothorax.

Table 4.1: Clinical Assessment of Breathing & Ventilation

Thoracic Examination Method

Avoid the "Chest Spring" maneuver (bilateral chest compression) for thoracic examination. It's **not recommended** due to risks like increased pain, worsened bleeding, and aggravated injuries.

Instead, use a **single-hand palpation method**. This safer approach minimizes harm while still providing vital diagnostic information.

Patient safety is key during examinations.

Early Management

Following are among interventions that may be taken;

1. Administer oxygen and attach pulse oximetry.
2. Provide bag-valve-mask ventilation, if indicated.
3. Secure and establish a patent airway.
4. Decompress tension pneumothorax immediately by performing a finger thoracostomy. Alternatively, when there is no available expertise / equipment to perform a finger thoracostomy, the procedure can be replaced by a needle thoracentesis.
5. Seal open pneumothorax wounds with a three-sided occlusive dressing.

6. After finger thoracostomies are performed, provide intrapleural drainage using a tube thoracostomy and an underwater seal when feasible.

Needle Thoracentesis:

The needle thoracentesis performed for intrapleural decompression is a blind procedure. This procedure may result in increasing risk of iatrogenic injury. In the event that expertise and facilities are readily available, a finger thoracostomy is a preferred alternative

Finger Thoracostomy:

The finger thoracostomy is a safer and more effective alternative procedure to the needle thoracentesis in emergent decompression of a suspected tension pneumothorax. Numerous studies have suggested needle thoracocentesis to be inconsistent in decompressing the pleural space and may cause more harm in patients. The finger thoracostomy is a pleural decompression procedure performed using an open method approach. The pleura is breached (pleurotomy) after a skin incision is bluntly dissected through utilizing the operator's finger and a blunt forceps as an adjunct. The method of decompressing the intra-pleural space is similar to initial steps of placing a tube thoracostomy. This method enables blunt tactile feedback to confirm the pleural space has been accessed.

C - Circulation with Haemorrhage Control

Life-threatening thoracic injuries that may commonly lead to circulatory compromises are massive hemothorax, tension pneumothorax, and cardiac tamponade.

- **Assessment**
  - Identify source of any external haemorrhage.
  - Identify potential source(s) of internal haemorrhage such as massive haemothorax or cardiac tamponade.
  - Assess the pulse for volume and rate. Peripheral pulses may be absent in severely hypovolemic patients.
  - Assess for capillary refill time.
  - Observe skin for colour and feel for temperature.
  - Observe for jugular venous distension which may suggest underlying tension pneumothorax and cardiac tamponade. However, distended neck veins may be absent in patients with concomitant hypovolemia.
  - Measure blood pressure and pulse pressure.

- **Management**
  - Stop external source(s) of bleeding by applying direct pressure.
  - Insert two large-bore IV access and simultaneously obtain blood for trauma blood panel, group and crossmatch. Initiate IV fluid therapy with

warmed crystalloid solution and consider blood product replacement, if indicated.

- Consider the presence of internal / concealed haemorrhage (such as massive haemothorax) and potential need for subsequent operative intervention.
- Consider the presence of obstructive shock from cardiac tamponade that may require immediate intervention i.e pericardiocentesis or an emergency surgical thoracotomy.
- Immediately decompress tension pneumothorax, subsequently insert a tube thoracostomy with an underwater seal.
- If massive haemothorax is present, decompress the thorax and allow pleural drainage by inserting a tube thoracostomy with an underwater seal. Early surgical intervention may be required.

Adjuncts to Primary Survey

Diagnostic and monitoring adjuncts used to identify and manage thoracic injuries during primary survey include:

- Electrocardiographic (ECG) monitoring:
  - Dysrhythmias including unexplained tachycardia, atrial fibrillation, premature ventricular contractions and ST segment changes can indicate blunt cardiac injury.
  - Pulseless electrical activity (PEA) can indicate cardiac arrest from cardiac tamponade, tension pneumothorax, and/or profound hypovolemic shock.
  - Bradycardia, aberrant conduction, and premature beats may suggest hypoxia, hypoperfusion or extreme hypothermia.
- Arterial blood gas (ABG) analyses:
  - To measure adequacy of ventilation
  - Should be measured on all intubated and ventilated trauma patients, and any patient with significant thoracic trauma or evidence of hemodynamic instability
- Pulse oximetry monitoring
- Colorimetric carbon dioxide detector or end-tidal CO_2 ($ETCO_2$) monitoring:
  - The definitive method of confirming correct (intra-tracheal) placement of an endotracheal tube.
  - Allows an estimate for arterial $PaCO_2$ level and acts as a continuous monitoring device.

- X-ray examination.

  Chest x-ray (AP view or an upright view if the patient's condition permits) to look for;

  - Loss of lung markings
  - Presence of intra-pleural fluid
  - Widening of mediastinum
  - Rib fractures - Multiple rib fractures and fractures of the first or second rib(s) indicate significant force during injury
  - Loss of anatomic details.
  - Abnormality in extra thoracic soft tissue markings (i.e. subcutaneous emphysema)
  - Chest X-Rays are also performed after insertion of tube thoracostomy / endotracheal intubation to confirm correct placement and to look out for immediate complications.

- Extended Focus Assessment Sonography in Trauma (e-FAST) is performed to detect presence of pericardial fluid which may indicate cardiac tamponade, pleural effusion which may indicate haemothorax or "lung point" / loss of the "sliding sign" which may indicate presence of pneumothorax.

> Signs of significant thoracic injury may be subtle or even absent during the initial assessment. While the initial primary survey may identify some of these injuries, an initial "normal" examination does not exclude any of them. Serial examinations and repetitive reassessments with use of adjuncts is important to avoid missing these significant injuries.

4.3.2 SECONDARY SURVEY: THORACIC INJURIES

The secondary survey is a complete head to toe examination performed after completion of the primary survey assessment and intervention. It is an examination conducted to identify any "potential life-threatening injuries".

A high index of suspicion and appropriate use of adjunctive studies are required to identify these diagnoses. These injuries may not be obvious and are often undetected during the initial assessment.

Details on secondary survey *see* Chapter 1: Initial Assessment and Management.

A thorough and complete assessment of the chest region needs to be performed during the secondary survey in order to avoid missing potentially life-threatening thoracic injuries. Potential life-threatening injuries comprise of simple pneumothorax, hemothorax, esophageal injuries, traumatic diaphragmatic injuries, blunt cardiac injuries, pulmonary contusion, traumatic aortic disruption, ribs and sternal fractures.

Management

- Insert a tube thoracostomy with an underwater seal for clinically significant pneumothorax or haemothorax as indicated.
- Apply appropriate dressing for an open chest wound.
- Perform pericardiocentesis or emergency surgical thoracotomy as indicated (pericardial tamponade)
- Provide adequate analgesia for patients with rib fractures to avoid respiratory failure / lung collapse (regional blocks is an effective adjunct to parenteral analgesics and can be provided early in the care process when expertise and facilities are available)
- Safe and rapid transfer of the patient to the operating theatre when indicated.

Adjuncts to Secondary Survey

Consider performing relevant adjunct diagnostic tests when the patient's condition permits;

- CT Scan of the thorax (or part of whole-body CT protocol in major trauma patients)
- Angiography
- Transoesophageal ultrasound
- Bronchoscopy
- Esophagoscopy

4.4 LIFE THREATENING THORACIC INJURIES

Life-threatening thoracic injuries that must be recognized and addressed during the primary survey are as follows:

Immediate life - threatening injuries (ATOM - TC)

A - Airway Obstruction
T - Tension Pneumothorax
O - Open Pneumothorax
M - Massive Hemothorax
T - Tracheobronchial Injury
C - Cardiac Tamponade

4.4.1 AIRWAY OBSTRUCTION

During primary survey, it is important to recognize and perform appropriate intervention for injuries that affect the airway.

Potential Mechanism of Airway Obstruction

1. Direct laryngeal injury - direct blow to the neck, misplaced seat belt across the neck
2. Posterior dislocation of the clavicular head
3. Penetrating trauma to the neck – results in injury and bleeding
4. Airway may also be obstructed due to oedema, blood, vomitus and a floppy tongue

Intervention

1. Airway obstruction - *Refer to Chapter 2 : Airway and Ventilation*
2. Posterior dislocation of the head of the clavicle can be reduced by extending the patient's shoulder and grasping / reducing the clavicle with a penetrating towel clamp. However, this procedure should be performed by experienced personnel.

4.4.2 TENSION PNEUMOTHORAX

This is an immediate life-threatening condition arising from a 'one-way valve air leak' occurring from either the lung parenchyma or the chest wall. Air is trapped within the pleural space under positive pressure compressing the lung may result in displacement of the mediastinum. This will lead to raised intrapleural / intrathoracic pressure, kinking of great vessels, reduction of venous return and decreased cardiac output (obstructive shock). The diagnosis of tension pneumothorax in shock should be made clinically and not radiologically.

Examples of causes for tension pneumothorax

1. Blunt or penetrating trauma to the chest
2. Mechanical positive pressure ventilation in patients with lung parenchymal injury
3. Iatrogenic complications i.e. insertion of central venous catheters
4. Total occlusive dressing for open pneumothorax – when secured at all four sides
5. Kinked / Obstructed / Clamped / wrongly assembled intrapleural chest drain

Clinical assessment

Patients who are breathing spontaneously commonly exhibit features of respiratory compromise while mechanically ventilated patients commonly manifest hemodynamic collapse.

Look	- Distended neck veins (might be absent in hypovolemic patient) - Respiratory distress - Asymmetrical chest wall movement - Cyanosis is a late sign of hypoxia. Absence of cyanosis doesn't rule out adequacy of ventilation or tissue perfusion.
Listen	- Unilateral absent / reduced breath sounds
Feel	- Trachea is shifted to the contralateral side - Tenderness, crepitus, deformity over the chest - Hyperresonance percussion on the ipsilateral site
Tachycardia & Hypotension are SIGNS OF SHOCK	

Table 4.2 : Clinical assessment of Tension Pneumothorax

Adjuncts

Point of Care Ultrasound

Features that may be present on Extended FAST (e-FAST) ;

- Absence of sliding sign
- Presence of A lines/ absence of B lines
- Presence of stratosphere sign or barcode sign
- Presence of "lung point" (absent in complete retraction of lung)
- Absence of lung pulse

Intervention

Requires immediate thoracic decompression converting tension pneumothorax into a simple pneumothorax

1. **Needle thoracocentesis**

   Needle thoracocentesis of the chest is a temporary measure. However, there is significant risk of failure and iatrogenic injuries associated with needle thoracocentesis when indication is inappropriate and placement is inaccurate.

Successful decompression occurs only if the needle is inserted in the anatomically correct location. Inaccurate placement of needle thoracocentesis into subcutaneous emphysema, intrapulmonary bullae or bronchial tree may lead to release of gas, resulting in false assumption that the pleural space has been decompressed

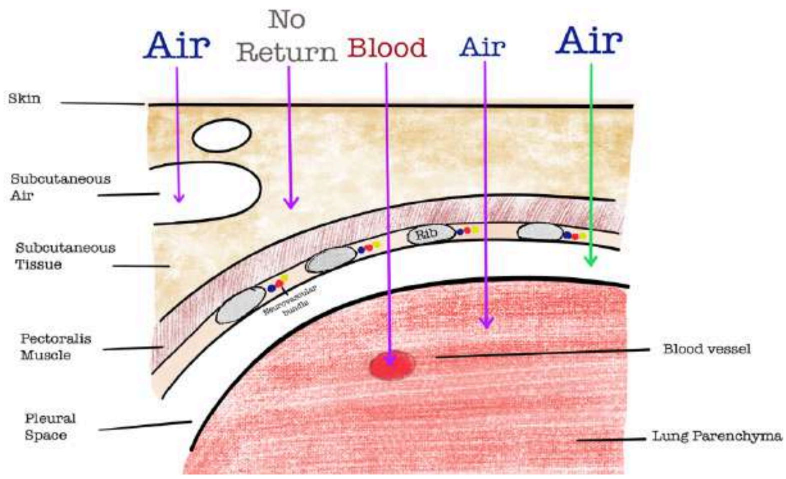


Figure 4.2: Possible positions of needle thoracocentesis

Aside from ensuring accurate anatomical position, the success of needle thoracocentesis is largely influenced by the thickness of the chest wall and needle length. Inaccuracy of needle placement may occur commonly, leading to adverse morbidity.

In the hospital setting, finger thoracostomy is a preferred alternative method of pleural decompression as compared to needle thoracocentesis.

2. Finger thoracostomy

Finger thoracostomy is a safer and much more effective alternative to performing needle thoracentesis. It requires additional expertise, equipment and facilities to perform finger thoracostomies. Bilateral finger thoracostomies are performed in the resuscitation of the traumatic cardiac arrest patient presenting with evidence of severe thoracic injury.

3. Tube thoracostomy with underwater seal

A tube thoracostomy is inserted after decompression of the intrapleural space. However, the insertion of the tube thoracostomy need not be rushed immediately after thoracic decompression. This process is less urgent and can be performed as a second stage procedure once the acute phase of resuscitation is complete and the patient has been stabilized. The finger thoracostomy incision site during the resuscitation period can be temporarily covered/ protected with a sterile appendage.

In clinical tension pneumothorax, the immediate concern is to decompress the intrapleural space. The insertion of the tube thoracostomy can be subsequently performed in a less chaotic environment, so that the drain is introduced accurately, carefully and secured in a safe manner. This strategic approach will also allow the acute resuscitation phase to be performed without any unnecessary obstruction by the team inserting the tube thoracostomy.

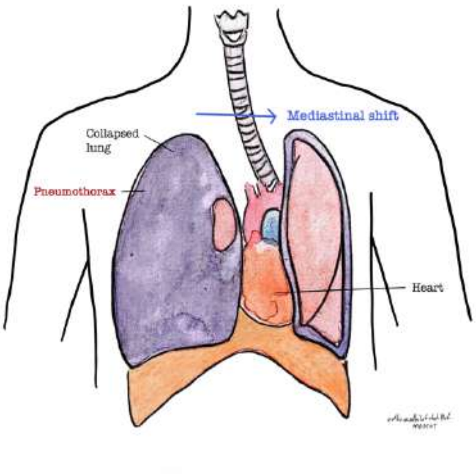


Figure 4.3 Pathophysiology of Tension Pneumothorax

Figure 4.4 : Finger Thoracostomy

4.4.3 OPEN PNEUMOTHORAX

Open pneumothorax may occur when there is an open chest wall defect creating a direct communication between the pleural space and the surrounding atmosphere, enabling air to enter the intrapleural space and resulting in collapse of the ipsilateral lung. Intrathoracic pressure and atmospheric pressure equilibrate immediately. In the event that the opening into the chest wall is larger than $2/3^{rd}$ of the cross-section size of the trachea, air may preferentially follow the path of least resistance, flowing directly through the chest wall defect as opposed to the upper airways (in passive ventilation) resulting in inadequate lung expansion, lung collapse, reduced oxygenation, gas exchange and failure in ventilation.

Causes of open pneumothorax

Penetrating trauma to the chest (motor vehicle accidents, stab wounds, gunshot etc)

Clinical assessment

Look	- Look for any open wounds over the chest wall - Look for any gas bubbles escaping through the wounds - Respiratory distress and use of accessory respiratory muscles
Listen	- Noisy movement of air through the chest wound - Decreased breath sounds over the ipsilateral side
Feel	- Tenderness, crepitus and defects over the chest wall - Hyper resonance on percussion of the ipsilateral side

Table 4.3 : Clinical assessment of open Pneumothorax

Immediate Intervention

1. Close the chest wall defect with a large sterile occlusive dressing covering the edges of the wound as a temporary measure. Three sides of the dressing are secured creating a flutter valve effect. Air escapes from the pleural space through the open end of the dressing during exhalation. The 3-way secure occlusive dressing will disable air to re-enter the pleural spaces during inspiration, creating a one-way valve effect. This is followed by placement of a tube thoracostomy with an underwater seal.
2. Tube thoracostomy should not be placed into or through the penetrating chest wound. It should be placed via a new skin incision, away and safe from the original penetrating wound. This will reduce the risk of infection and improve the efficacy of the drain.
3. Soon after the insertion of the tube thoracostomy, the underwater seal system is examined for its efficacy. The chest wound can then be surgically repaired and closed accordingly.

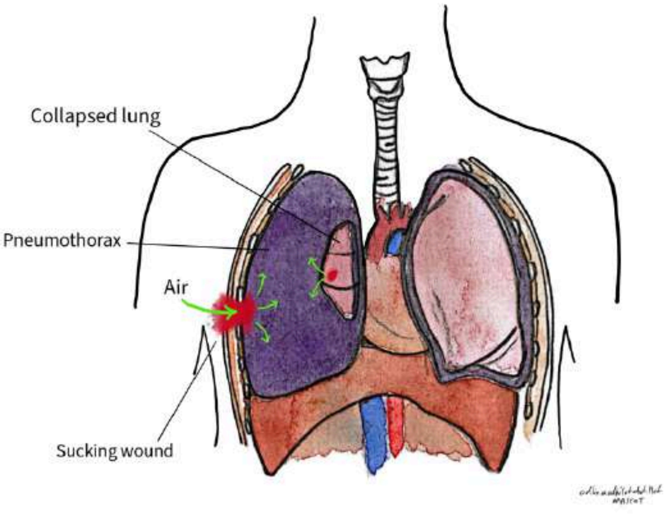


Figure 4.5 : Pathophysiology of Open Pneumothorax

Figure 4.6 : Occlusive dressing for open pneumothorax

4.4.4 MASSIVE HEMOTHORAX

Massive hemothorax is defined as rapid accumulation of more than 1.5 L of blood or one third of total body blood volume in the thoracic intra pleural space. Massive hemothorax is also defined as a continuous loss of > 200ml/hour for 2-4 hours.

Causes of massive haemothorax

Blunt and penetrating trauma to the chest

Clinical assessment

Look	-Patient may have distended or collapse neck veins; ● Distended neck veins may be present with concurrent tension pneumothorax or displacement of the mediastinum to the opposite site in massive hemothorax ● Collapsed or flat neck veins may be present in cases of severe hypovolemia - Reduced chest wall expansion on the affected side - Respiratory distress and use of accessory muscles - Decreased oxygen saturation
Listen	- Unilateral absent / reduced breath sounds
Feel	- trachea is midline or in severe cases it may be mildly shifted to the contralateral side - Dullness on percussion
Tachycardia & Hypotension are SIGNS OF SHOCK	

Table 4.4: Clinical assessment of Massive Haemothorax

Adjuncts

Point of Care Ultrasound

Features that may be present on Extended FAST (e-FAST);

- Hypoechoic collection above the diaphragm
- Presence of “spine sign”
- Absence of “curtain sign”

Intervention

1. **Haemostatic resuscitation**
   - Refer to *Chapter 3: Shock*

2. **Thoracic decompression and pleural drainage**
   - Insertion of tube thoracostomy at the "thoracic safety triangle".

3. **Indication for urgent thoracotomy**
   - Immediate return of more than 1.5L of blood in the chest drain.
   - Continuous bleeding of > 200ml/hour for 2-4 hours.
   - Penetrating injury into the region of the mediastinal box should alarm the clinician the possibility of cardiac, major vessel and hilar structures injuries.

Mediastinal Box

The "Mediastinal Box" is a concerning region for any penetrating injury to occur. Injuries to this region may inflict fatal and potentially fatal harm due to presence of vital structures. The anatomical region is defined superiorly at the level of the manubrium, laterally the outer thirds of the clavicles and inferiorly the level of the xiphoid process.

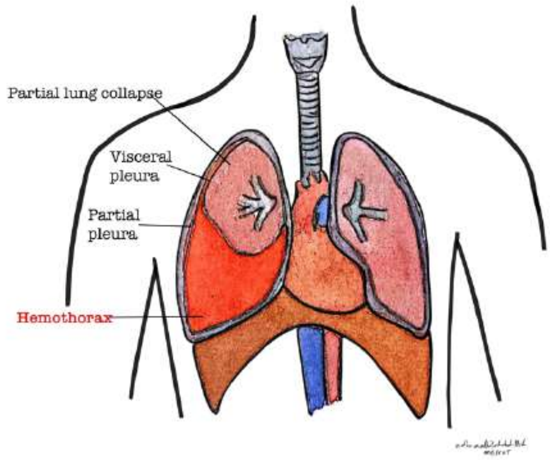


Figure 4.7 : Haemothorax

Clinical Examination	Tension Pneumothorax	Massive Pneumothorax	Open Pneumothorax	Flail Chest
Inspection	Unequal chest rise	Unequal chest rise	Open chest wound ≥ 2 / 3 tracheal diameter	Paradoxical chest movement
Palpation	Tenderness, Crepitus	Tenderness	Sucking chest wound, Crepitus	Tenderness, Crepitus
Percussion	Hyperresonance	Dullness	Hyperesonance	Hyperresonance / Dullness
Ausculation	Reduced breath sounds	Reduced breath sounds	Reduced breath sounds	Normal breath sounds ± reduced
Tracheal Deviation	Present	Not usually present	Absence	Absence
Jugular Venous Pressure	Distended (in absence of hypovolemia)	Flat	Normal to Flat	Flat

Table 4.5: Differentiating types of chest trauma

4.4.5 TRACHEOBRONCHIAL INJURY

Tracheobronchial injuries are less common, nevertheless potentially fatal. Such injuries may result from both blunt and penetrating mechanisms. Death may occur from immediate asphyxiation or subsequently due to ventilation compromise. Early detection and intervention are key in assuring best outcomes.

Mechanism of injury that may result in tracheobronchial trauma:

1. Blunt trauma
    - Rupture of the trachea-bronchus airway due to compression against the rigid vertebral body
    - Rupture due to increased airway pressure from thoracic injury i.e. compression with a closed glottis
2. Blast injuries may produce severe tracheobronchial damage due to massive energy force transmission and rapid gas expansion within air filled cavities. The inhalation of fumes may also cause fatal injuries to the tracheobronchial tree with subsequent bronchial spasm and asphyxiation.
3. Penetrating trauma or deep lacerations

Clinical assessment

Patients may present with tension pneumothorax, subcutaneous emphysema, hemoptysis and/or cyanosis. It should be highly suspected when there is a persistent large air leak (continuous bubbling in the chest drain) and the lung does not fully expand after placement of tube thoracostomy.

Intervention

1. **Consider immediate placement of a definitive airway**
   - o May potentially be difficult due to anatomical distortion i.e., paratracheal hematoma and oropharyngeal injuries. Fiberoptic assisted intubation may be required to place the ETT past the tear site or selective intubation of the unaffected bronchus
2. **Tube thoracostomy**
   - o In larger air leaks, more than one intrapleural chest drain may be required to allow adequate lung expansion.
3. **Early diagnosis and definitive care plan are crucial.**

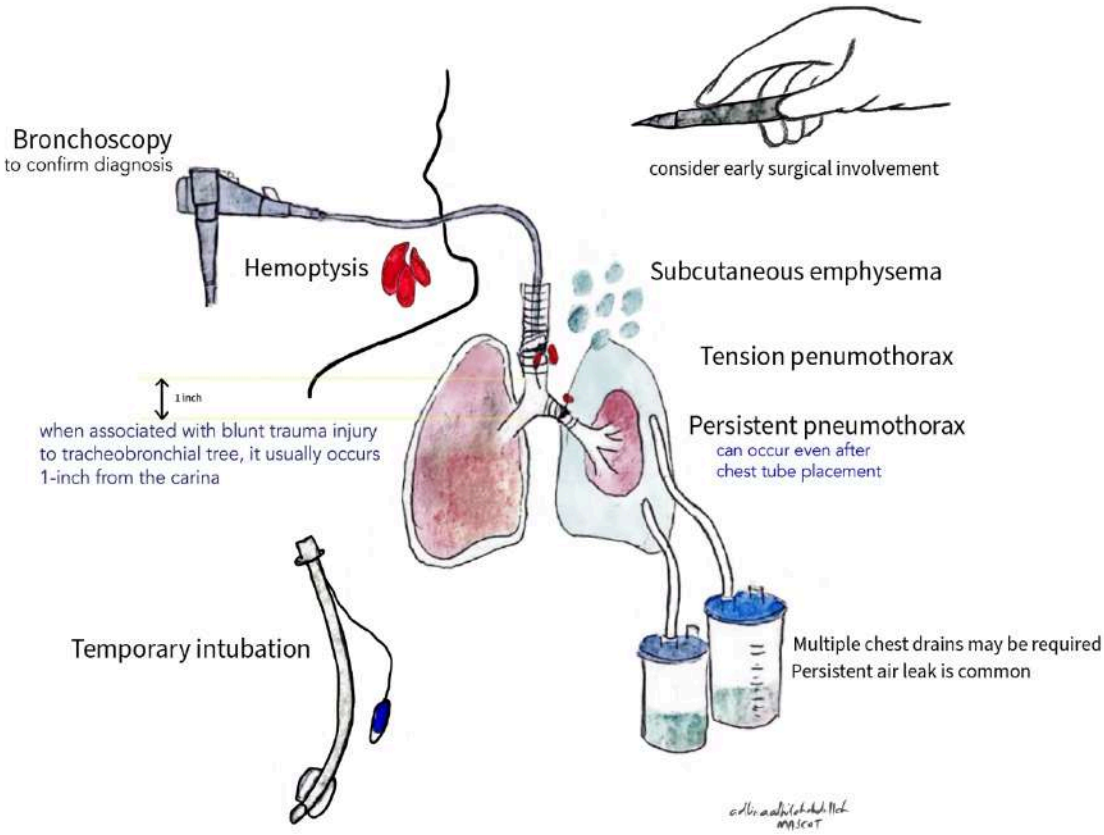


Figure 4.8 : Tracheobronchial tree injuries

4.4.6 CARDIAC TAMPONADE

Cardiac tamponade results from accumulation of fluid (blood) within the pericardial sac, increasing the intrapericardial pressure, resulting in reduced venous return from direct compromise of right ventricular diastolic function and subsequent reduction in cardiac output. Due to the rigid fibrous structure of the pericardium, small amounts of blood within the pericardial space can rapidly lead to cardiac pump failure and obstructive shock. Blood may accumulate from the heart, great vessel, and epicardial vessel.

Causes of cardiac tamponade

Blunt and penetrating trauma to the chest

<u>Clinical assessment</u>

1. The classic clinical triad of muffled heart sounds, hypotension and distended neck veins may not be typically present in all patients with cardiac tamponade. Muffled heart sounds – are difficult to be appreciated in the noisy environment of a busy ED and distended neck veins may be obliterated by coexisting severe hypovolemia.

2. Pulseless Electrical Activity (PEA) and cardiac arrest may be suggestive of cardiac tamponade.

> Left sided tension pneumothorax can mimic the presence of cardiac tamponade. Absence of unilateral breath sounds and hyperresonance on percussion differentiates tension pneumothorax from cardiac tamponade. Both these pathologies contribute to obstructive shock.

Adjuncts

Point of Care Ultrasound (POCUS), features that may be present:

- Anechoic collection around the pericardium
- Collapse of right ventricle during diastolic phase
- Plethoric inferior vena cava

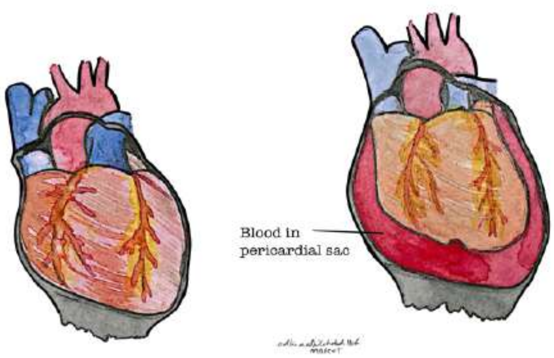


Figure 4.9 : Cardiac Tamponade

Intervention

1. Pericardiocentesis may be performed as an immediate measure to release (decompress) pericardial tamponade. However, it may not constitute definitive care. In order to reduce complications and to improve success rates, the ultrasound guided pericardiocentesis is a preferred method as opposed to performing the procedure using anatomical landmark guided techniques . Surgical thoracotomy may be indicated in cases of persistent pericardial fluid re-accumulation and tamponade.

2. In witnessed cardiac arrest arising from traumatic pericardial tamponade, resuscitative thoracotomy and release of tamponade is indicated in order to attain return of spontaneous circulation (ROSC) and haemorrhage control. However, this procedure requires a clinician who is trained in performing the procedure, presence of a readily available trained team to assist resuscitation, appropriate infrastructure, equipment and facilities.

A Pulseless Electrical Activity (PEA) seen on electrocardiogram or cardiac monitoring may represent an underlying reversible cause of traumatic arrest arising from massive hemothorax, cardiac tamponade, hypovolemia, hypoxia, tension pneumothorax and other possible causes alike.

4.4.7 TRAUMATIC CARDIAC ARREST (TCA)

Traumatic cardiac arrest carries a high mortality. The response to TCA is time critical and its success depends on a well-established chain of survival. Resuscitative efforts focus on simultaneous treatment of reversible causes and CPR with <C>ABC management.

Patients with TCA may present with loss of consciousness, agonal or absence of spontaneous breathing and non-palpable central pulse. Initial cardiac rhythm in TCA is commonly seen as pulseless electrical activity (PEA) and ventricular fibrillation (VF). A peri-arrest state is characterised by cardiovascular instability, hypotension, loss of peripheral pulses and a deteriorating conscious level, without obvious underlying central nervous system problems. Peri- arrest state may progress to traumatic cardiac arrest if left untreated. Bedside point of care (POC) ultrasound may be a helpful adjunct to aid identification of potential causes of TCA and monitoring the progress of the resuscitative efforts.

Causes of TCA

1. Uncontrolled Haemorrhage
2. Tension Pneumothorax
3. Asphyxia
4. Pericardial Tamponade

Consider withholding resuscitative efforts in TCA in any of the following conditions

1. No signs of life within the preceding 15 minutes
2. Lethal trauma incompatible with survival (e.g. decapitation)

Consider termination of resuscitative efforts in the following event:

1. No ROSC/ signs of life after performing high quality cardiac compression and resuscitation (considering all potential reversible causes have been addressed).
2. Clear evidence of futile outcomes as decided by the resuscitation team leader i.e bilateral fixed and fully dilated pupils despite aggressive prolonged high quality resuscitation.

Initial management of TCA

1. Management of TCA requires a team effort with all the measures carried out simultaneously rather than sequentially.
2. The focus lies on treating reversible causes of TCA and performing simultaneous CPR with <C> ABC management.
3. However chest compression should not delay the treatment of reversible TCA causes.
4. Management of hypovolemic traumatic arrest should focus on haemorrhage control and haemostatic resuscitation. Compressible bleeding is controlled with techniques such as direct compression, wound packing with haemostatic gauze and application of tourniquet. Incompressible bleeding may be managed by splinting of long bones, application of pelvic binder for pelvic fractures and administration of intravenous tranexamic acid. Once ROSC is attained, patients may be managed with damage control surgery and /or interventional radiology intervention. In addition, immediate restoration of intravascular volume with warm fluids and blood products are warranted.
5. Hypoxemia in TCA can be caused by airway obstruction and traumatic asphyxia. Rapid ventilation management is required in order to reverse hypoxic arrest.
6. Bilateral finger thoracostomies are performed to decompress potential underlying tension pneumothorax in patients presenting with evidence or suspicion of thoracic trauma.
7. In centres with available facilities and clinical expertise, consider resuscitative thoracotomy for the following;
    - Release of pericardial tamponade in TCA
    - Attaining haemorrhage control in massive haemothorax
    - When access to internal cardiac massage is required

8. Resuscitation is performed abiding to local life support resuscitation guidelines.

Traumatic Cardiac Arrest / Peri-Arrest Algorithm

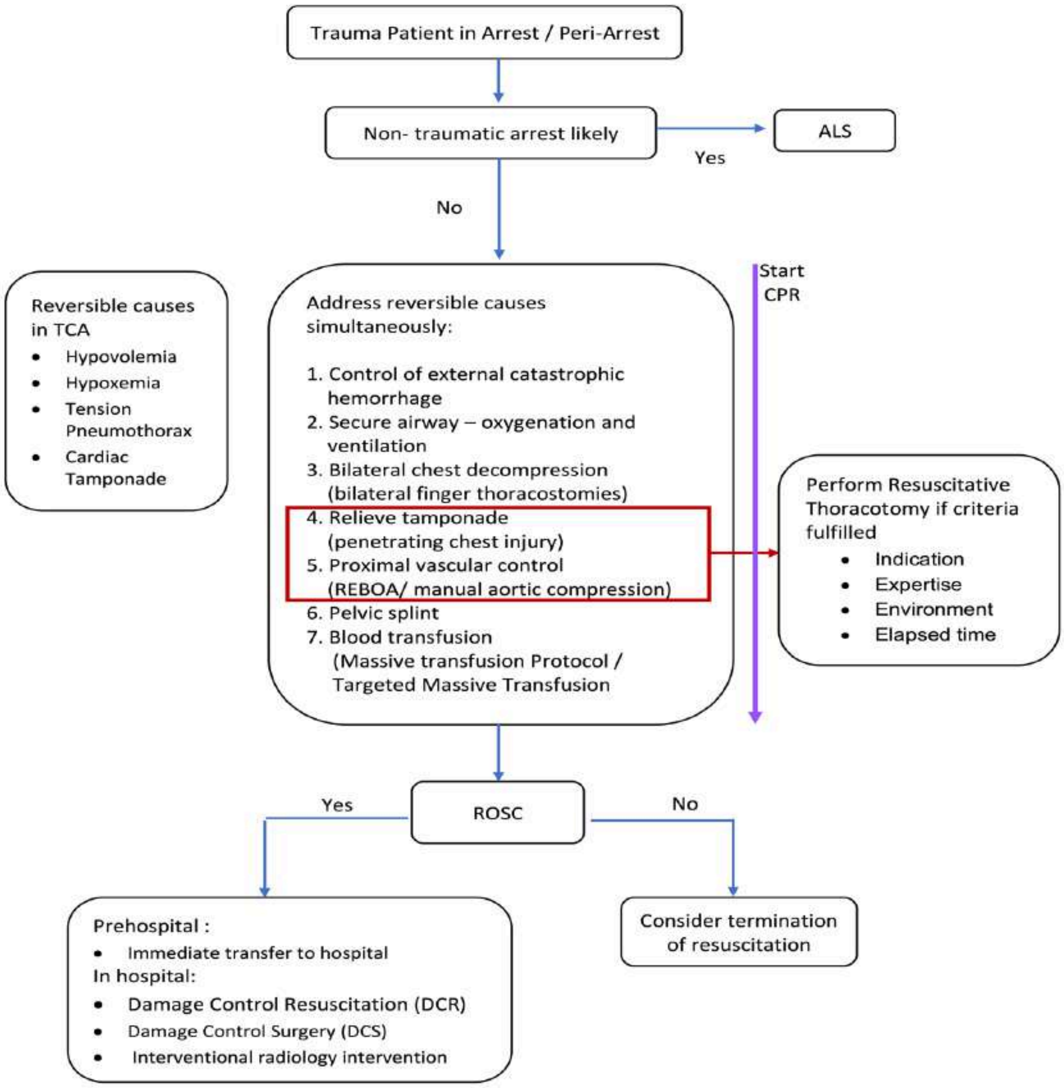


Figure 4.10 : Traumatic Cardiac Arrest Algorithm

4.5 POTENTIAL LIFE THREATENIING THORACIC INJURIES

Potential life-threatening injuries may not be obvious on initial physical examination. Recognition requires a high index of suspicion and other adjunct studies as failure to manage these injuries may result in morbidity and mortality. The eight-potential life-threatening thoracic injuries that must be recognized and addressed during the secondary survey are as follows:

- Simple pneumothorax
- Hemothorax
- Pulmonary contusion
- Flail chest
- Blunt cardiac injury
- Traumatic aortic disruption
- Traumatic diaphragmatic injury
- Blunt oesophageal rupture

4.5.1 SIMPLE PNEUMOTHORAX

Simple pneumothorax results from air entering the space between the parietal and visceral pleura leading to lung collapse and potentially resulting in ventilation-perfusion defect.

Causes of simple pneumothorax

1. Blunt trauma- Lung laceration with air leakage is the commonest cause of simple pneumothorax
2. Penetrating injuries

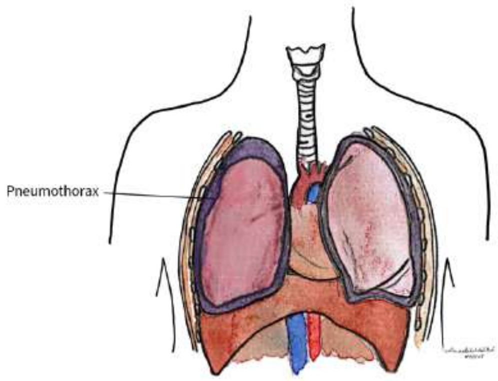


Figure 4.11: Simple Pneumothorax

Clinical Assessment

Look	- Bruising, laceration, contusion of the chest wall - Asymmetrical chest rise
Listen	- Decreased breath sounds over the ipsilateral side
Feel	- Tenderness, crepitus and defects over the chest wall - Hyper resonance on percussion of the ipsilateral side

Table 4.6: Clinical assessment of Simple Pneumothorax

Adjunct

- Chest Xray
- E-FAST – refer to tension pneumothorax topic

Intervention

1. Insertion of a tube thoracostomy with underwater seal via a thoracostomy incision over the "thoracic safety triangle".
2. Small, asymptomatic or subclinical pneumothorax may be managed conservatively. The decision to place a tube thoracostomy should be made by an experienced clinician.

Note:

Patients who are undergoing general anesthesia, receiving positive pressure ventilation and potentially being transferred by an air ambulance should likely require a tube thoracostomy. However, these clinical decisions should be made by an experienced physician.

4.5.2 SIMPLE HEMOTHORAX

Hemothorax is a collection of blood within the intrapleural space. In simple hemothorax, bleeding is commonly self-limiting and does not require major surgical interventions.

Causes of haemothorax

1. Injury to lung parenchyma, great vessels, intercostal vessels or internal mammary artery due to either blunt or penetrating trauma.
2. Injury to lung parenchyma or vessels by thoracic spine / rib fractures.

Clinical Assessment

Look	- Bruising, laceration, contusion of the chest wall - Asymmetrical chest rise - Examine the posterior chest as well
Listen	- Decreased breath sounds over the ipsilateral side
Feel	- Dullness on percussion over the ipsilateral side

Table 4.7 : Clinical assessment of Simple Hemothorax

Adjuncts

- Chest X-ray – homogenous opacity over the affected side
- E-FAST – refer massive haemothorax topic

Intervention

Insertion of a tube thoracostomy drain with underwater seal via a thoracostomy incision over the “thoracic safety triangle” (select appropriate tube thoracostomy size to reduce risk of tube obstruction i.e. size 32 for adults)

- Allows evacuation of blood reducing the risk of hemothorax collection which may result in infection, empyema and fibrothorax
- Monitoring of the amount of blood loss
- Enables the underlying collapsed lung parenchyma to re-expand and improve alveolar ventilation / perfusion & gas exchange
- Pleural fluid assessment for potential diaphragmatic injury

Note: Operative exploration may be required if;

- o Hemodynamic instability occurs
- o Patient requiring continuous blood transfusion
- o Continuous drainage of >200ml for 2-4 hours

4.5.3 FLAIL CHEST AND PULMONARY CONTUSION

A flail chest occurs when a separated segment of adjacent ribs loses bony continuity with the rest of the thoracic cage. Flail chest is defined as 3 or more adjacent rib fractures occurring in 2 or more places. The "free" segment may move independently and reciprocally with the other parts of the thoracic cage during inspiration and expiration. Flail chest results in instability of the chest wall leading to visible paradoxical movement. During inspiration, the flail segment moves inwards and during expiration, it moves outward, in a paradoxical movement to the entire thoracic cage. This pathology causes the underlying lung to poorly expand, resulting in hypoxia and ventilatory failure. The reciprocal movement of the flail segment also induces a "rebreathing phenomenon" which results in hypercarbia and type 2 respiratory failure. This injury may be associated with severe underlying pulmonary contusions, associated complications such as pneumonia and inadvertent respiratory failure.

Pulmonary contusion is defined as bruising of the lung tissue resulting in accumulation of blood and other fluids that may lead to inadequate oxygenation, ventilation and impaired ventilation perfusion ratios. In children, pulmonary contusion may occur without overlying rib fractures due to pliability of the bones. However, pulmonary contusion in adults is commonly associated with rib fractures.

Clinical Assessment

- Pulmonary contusion injuries may present subtly and may not be obviously apparent during the initial clinical assessment
- Inadequate respiratory effort may be present - due to pain, atelectasis and underlying pulmonary contusion
- Paradoxical respiratory motion may be seen in flail chest injuries
- Tenderness and crepitus may be noted on examination by single hand palpation.

> Underlying lung parenchymal injury may cause severe pain and intercostal muscle spasm during inspiration, resulting in reduced air entry over the affected hemithorax

Adjunct

Chest x-ray – identify rib fractures, pulmonary contusion and atelectasis

Intervention

- Ensure adequate oxygenation and ventilation.
- Patients can be treated with a face mask or non-invasive ventilation. Intubation may be required in patients with significant respiratory failure.
- Judicious fluids administration.
- Adequate analgesia – i.e. intravenous opioids or regional blocks

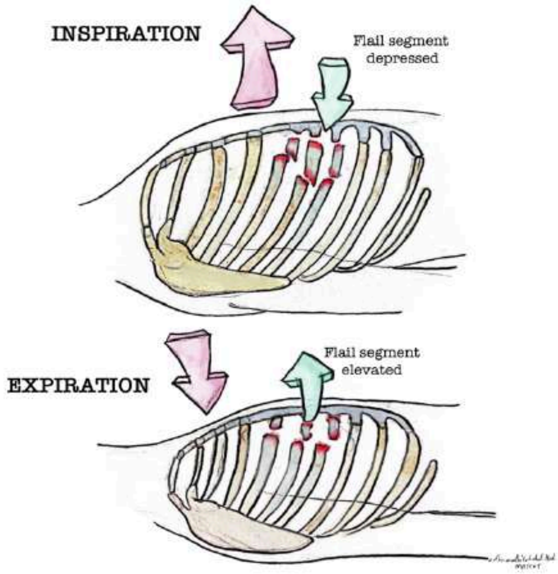


Figure 4.12 : Paradoxical Chest Movement in Flail Chest

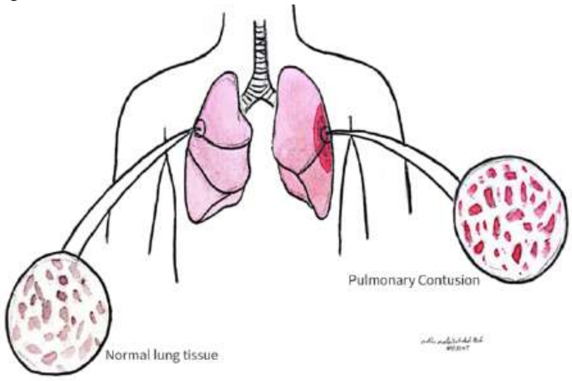


Figure 4.13 : Pulmonary Contusion

4.5.4 Blunt Cardiac Injury (BCI)

Incidence of blunt cardiac injury varies from 10-50%. BCI comprises myocardial muscle contusion, cardiac wall rupture, valvular disruption, septal wall disruption, coronary artery dissection and thrombosis. Cardiac tamponade may develop immediately or in a delayed fashion. It is also important to recognize that medical conditions such as acute myocardial infarctions may have precipitated the traumatic event.

Causes of blunt cardiac injury

1. Direct impact to myocardium
2. Shearing force to great vessels, valves and septal walls.

Clinical presentation

- Chest pain – may be due to BCI, chest wall contusion, sternal and rib fractures
- Hypotension
- Dysrhythmias

Adjuncts

1. E-FAST or Echocardiogram
   - Look for evidence of cardiac tamponade
   - Regional wall motion abnormality

2. ECG (changes may be variable)
   - Sinus tachycardia
   - Multiple premature ventricular contractions
   - S-T segment changes
   - Atrial fibrillation
   - Bundle branch block

3. Serum Troponin
   - Levels may be raised in acute myocardial infarction & blunt cardiac injury

Intervention

1. Patients with dysrhythmia should be closely monitored. Dysrhythmia should be managed as per advanced cardiac life support protocol.
2. Cardiac Tamponade: refer to *Cardiac Tamponade.*
3. Valvular or septal disruptions may likely require surgical interventions

4.5.5 TRAUMATIC BLUNT AORTIC INJURY

Traumatic blunt aortic injuries (TBAI) are common causes of immediate traumatic death after sustaining a fall or motor vehicle accident. A high index of suspicion is necessary in patients presenting with rapid deceleration injuries. Patients with aortic injuries who survived commonly have a low-grade aortic dissection (incomplete aortic dissection near the ligamentum arteriosum of the aorta). Contained mediastinal hematoma and intact adventitial layer prevents further exsanguination and death. Specific signs and symptoms are frequently absent.

Clinical Assessment

- Chest pain – i.e. sharp, ripping and tearing pain
- Pain radiating to the back
- Cardiac complication – i.e. Aortic regurgitation, myocardial infarction or ischemia, heart failure, cardiogenic shock
- Neurological complication – i.e. Dissection involves vertebral arteries and carotid arteries

Adjunct

1. Chest x-ray: Potential findings in chest radiograph for patients presenting with traumatic aortic blunt injury;

- Apical or Pleural Cap
- Widened mediastinum
- Depression of the left main stem bronchus
- Elevation of the right main stem bronchus
- Obliteration of the aortic knob
- Obliteration of aortic pulmonary window
- Left hemothorax
- Deviation of the esophagus
- Trachea deviated to the right
- Widened paratracheal stripe
- Widened paraspinal stripe
- 1^{st} or 2^{nd} rib fractures

Note:

- o False positive / negative signs may commonly be noted over chest radiographic studies. Chest X-ray findings can be unreliable and therefore high clinical acuity is required in diagnosing such injuries.
- o 1-13% of cases found no mediastinal abnormalities with normal findings on initial chest X-ray.
- o In suspicious cases, proceed for a CT Thorax / Angiogram for a definitive diagnosis.

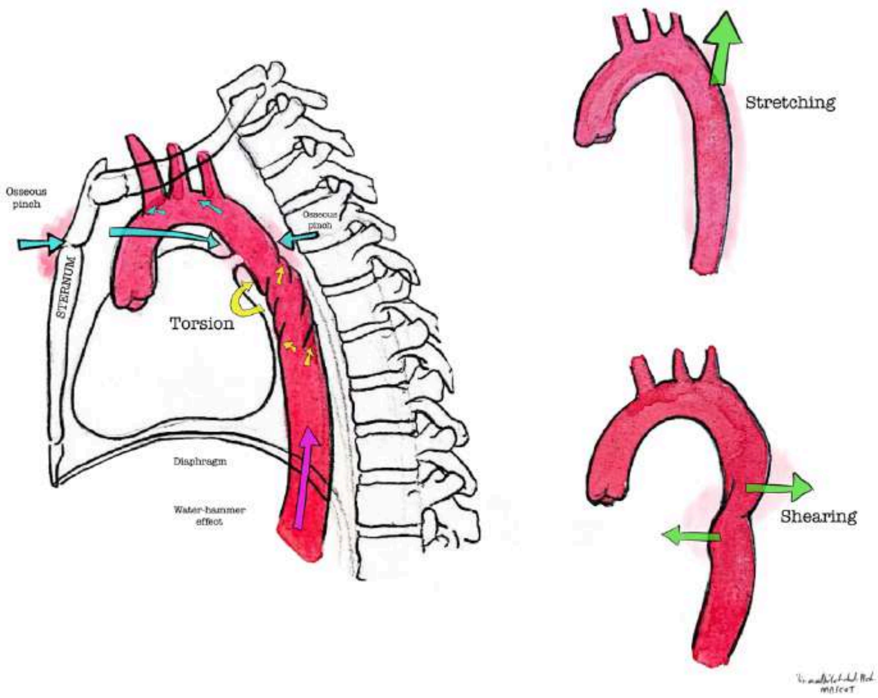


Figure 4.14 : Aortic Dissection

Intervention

1. Early consultation and referral to facilities capable of rapid diagnostic imaging and treatment.
2. Adequate analgesia.
3. Heart rate control <60 per minute.
4. Blood pressure control: SBP 100-120mmHg or MAP 60-70mmHg.

Note:

- o Beta blocker can be used in controlling blood pressure and heart rate.
- o If beta blocker is contraindicated, calcium channel blockers e.g. nicardipine can be used

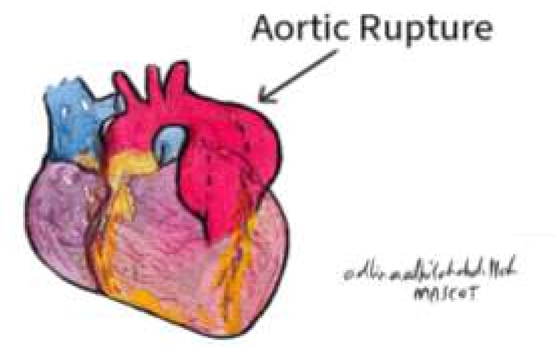


Figure 4.15: Aortic rupture

4.5.6 ESOPHAGEAL INJURY

Causes of esophageal injury

1. Penetrating – most common
2. Blunt - Rare
   - Blow to the lower sternum or upper abdomen may result in forceful expulsion of gastric content into the esophagus leading to tear or rupture.
   - Failure to identify the injury may result in mediastinitis and empyema.

Clinical Assessment

- Pain and shock that is out of proportion.
- Presents with left pneumothorax or haemothorax without evidence of rib fracture, pleural drainage may contain gastric content.
- Pneumomediastinum.
- Subcutaneous emphysema.

Intervention

1. Drainage of the affected pleural space.
2. Operative repair of the injury

4.5.7 TRAUMATIC DIAPHRAGMATIC RUPTURE (TDR)

Traumatic diaphragmatic rupture is a potentially fatal and frequently missed injury. A high index of suspicion is required at all times in order to attain diagnosis. TDR commonly occurs over the left hemidiaphragm. The right hemidiaphragm is protected by the liver, however it may still be predisposed to injuries. Injuries to the right hemidiaphragm therefore are often missed. Herniation of intraperitoneal content through the diaphragm rupture may result in ventilation compromise, entrapment and strangulation.

Causes of traumatic diaphragmatic rupture

1. Blunt - may produce large tears.
2. Penetrating - may result in small to large tears
   - small perforations that may be initially asymptomatic

Adjuncts

1. Chest x-ray: Potential findings in chest radiograph for patients presenting with traumatic diaphragmatic ruptures;
   - Subpulmonic effusion
   - Loculated hemopneumothorax
   - Elevated diaphragm
   - Acute gastric dilatation
   - Orogastric tube or nasogastric tube coiled in the thoracic cavity
   - Presence of intraperitoneal contents in the thoracic cavity
2. CT Scan
3. Upper gastrointestinal study

Note:

In TDR, peritoneal fluid or intestinal content may be seen in the intrapleural chest drainage.

Intervention

Surgical repair of the injury.

Complications

1. Respiratory and ventilation compromise.
2. Strangulation or entrapment of peritoneal contents.

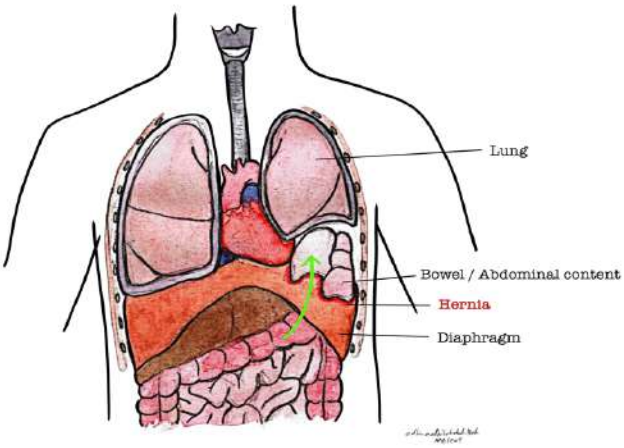


Figure 4.16 : Traumatic Diaphragmatic Rupture

4.6 OTHER THORACIC INJURIES

4.6.1 SUBCUTANEOUS EMPHYSEMA (SE)

Subcutaneous emphysema is a clinical condition that occurs when air travels into the soft tissues under the skin. In thoracic trauma, this clinical finding is commonly found around the chest wall and neck region. In more severe cases, the SE may be found over the abdominal region as well. This pathology may result from various mechanisms including blunt and penetrating trauma, pneumothorax, barotrauma or as a complication of resuscitation related procedures. It may also result from tracheobronchial tree injury, lung parenchymal and esophageal injuries. The treatment is commonly targeted to the underlying cause. In severe cases, respiratory compromise may ensue, requiring endotracheal intubation, positive pressure ventilation and insertion of a tube thoracostomy.

4.6.2 RIBS, STERNUM AND CLAVICLE FRACTURES

Rib Fractures

- **1st to 3rd ribs**
  - These ribs are short and anatomically protected by the clavicle, scapula and muscles of the upper chest wall. Fractures of these ribs suggest a high impact injury mechanism and therefore pose a higher risk of significant associated injuries.
- **4th to 9th ribs**
  - Most commonly fractured ribs. These ribs are more exposed, have reduced mobility due to its anterior attachment to the sternum and posterior attachment to the thoracic spine.
  - Direct injury to these ribs may cause the fractured ends of the bones to spear into the underlying lung parenchyma resulting in haemothorax / pneumothorax.
  - Antero-posterior compression of the chest wall may result in the bowing of

the ribs outwards producing a lateral rib fracture pattern.
- lateral compression of the chest wall instead may produce a posterior-lateral rib fracture pattern.
- Isolated posterior rib fracture patterns are commonly due to a direct posterior impact to the posterior thoracic wall.

- **10th to 12th ribs**
  - These rib fractures are commonly associated with an increased risk of intra-abdominal injuries, (i.e. liver and splenic injuries)
  - In children, the ribs are more pliable, therefore less likely to sustain rib fractures. Rib fractures in children implies a significant impact / energy transfer and should trigger the clinician to suspect increased risk of significant underlying injuries.
  - Osteopenia may be seen in elderly patients. The elderly patients are prone to rib fractures despite sustaining trivial injuries. A high index of clinical suspicion for rib fractures should be placed for elderly patients presenting with significant pain despite apparent normal looking chest radiographs.

<u>Sternal & clavicular fractures</u>

- These fractures are commonly a result of a direct blow. Clavicular fractures are also commonly caused by transmitted forces during falls impacting the shoulder and upper limbs.
- Trauma causing posterior dislocation of the clavicular head requires immediate attention and emergency reduction as it may be associated with significant underlying vascular injuries and superior vena cava obstruction.

Intervention

1. Adequate analgesia is crucial in managing these injuries. Ineffective analgesia gives rise to poor respiratory effort, inadequate oxygenation, poor cough and secretion clearance, atelectasis and pneumonia.
2. Currently, taping, rib belts and external splints are less commonly performed in the management of rib fractures.
3. Perform appropriate radiological diagnostic imaging such as CT scan / CT angiogram – in patients with high risk mechanism of injury / clinical suspicion to rule out significant intrathoracic injuries.

4.7 EMERGENCY DEPARTMENT RESUSCITATIVE THORACOTOMY (EDRT)

Indications for EDRT

1. Blunt or penetrating thoracic injury patients presenting with witnessed arrest
2. Blunt or penetrating thoracic injury patients presenting with non-witnessed arrest and presence of cardiac electrical activity
3. Blunt or penetrating thoracic injury patients presenting in peri-arrest state with a refractory SBP < 70 mmHg despite adequate resuscitation

Notes

- EDRT should be conducted by the first attending specialist who is trained & privileged in performing the procedure.
- The resuscitation during EDRT should include endotracheal intubation (single lung intubation may be required), ventilation, open cardiac massage, arrhythmia management, advanced cardiac life support, restoration of blood volume and haemorrhage control.
- The aim for EDRT is to resume Return of Spontaneous Circulation (ROSC). Once ROSC is achieved, post damage control resuscitation care, damage control surgery and intensive care should be immediately advocated
- The mortality rate for trauma victims requiring EDRT is very high. Performing EDRT requires a team approach, appropriate infrastructure, equipment, clinical expertise, trained allied team members and an existing trauma protocol within the institution.

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4.9 THORACIC SKILLS STATION

4.9.1 NEEDLE THORACOCENTESIS

Indication:

1. This procedure is performed to decompress / release immediate life threatening tension pneumothorax

   Note : In the event of this technique being performed without actual pneumothorax, the risk of iatrogenic pneumothorax and damage to the lung parenchyma is 10 -20%. Therefore the "open method" finger thoracostomy is a preferred option.

Method:

1. Apply high-flow oxygen to the patient.
2. Identify the landmark: 2nd intercostal space in the mid clavicular line or thoracic safety triangle on the affected side.
3. Apply alcohol swab and provide local anaesthesia at the insertion area if the patient is conscious or time permits.
4. Attach a large bore over-the-needle catheter (branula) (5 cm length in smaller adults, 8 cm in large adults) to a syringe.
5. Introduce the needle at the landmark identified above, and direct it just above the rib into the intercostal space. Aspirate the syringe while advancing the needle. Puncture the parietal pleura. Once the needle penetrates the parietal pleura, withdraw the needle leaving the catheter behind.
6. Aspirate as much air as possible.
7. Prepare and proceed with insertion of a tube thoracostomy attached to an underwater seal.

Complication:

- Local cellulitis / sepsis
- Local hematoma
- Subcutaneous emphysema
- Pleural infection / empyema
- Pneumothorax / Re-accumulation of tension pneumothorax
- Injuries to vessels or lung parenchyma

4.9.2 FINGER AND TUBE THORACOSTOMY

Indication :

1. Pneumothorax (simple, open & tension)
2. Haemothorax (simple or massive)
3. Penetrating chest trauma
4. Tracheobronchial Injury

Preparation :

- Consent
- Local analgesia
- Tube thoracostomy set
- Sterile equipment
- Sterile-preparation: chlorhexidine & povidone
- Sterile PPE: gown, cap, mask, gloves
- Drapes
- Needles, syringes, blade
- Sutures, translucent water-proof dressing
- Gauze
- Underwater seal bottle & tubing
- Chest tube sizes (Largest size available)
  - -32F in adults
  - -12-28F for children
  - -12-18F for infants

Method :

1. Position the patient- ipsilateral arm extended overhead and flexed at the elbow (unless precluded by other injuries). Also prepare and drape the surgical site.
2. Identify the anatomical landmark, "thoracic safety triangle" and insertion site should be between anterior and mid axillary line.
3. Alternatively, the thoracostomy incision site may also be accurately identified using a biometric method.
4. Inject the incision site with local anaesthesia; including the skin and subcutaneous tissue
5. Pre-measure the depth of the tube thoracostomy by placing the tip near the clavicle with a gentle curve of tube thoracostomy toward the incision. Normally the tube thoracostomy markings will be at 10–14cm at the skin, however it depends on the physic of the patient
6. Make an incision of 3-5 cm on the skin over the predetermined site and bluntly dissect the subcutaneous tissue to and through the intercostal muscles just above the rib.
7. While using the finger as a guide, gently puncture the parietal pleura using the blunt tip of the forceps as an adjunct. Prevent sudden deep insertion of the instrument which may cause injury to the underlying structures. Gently advance the clamp over

the rib and widen the pleural opening.

8. Air or fluid will gush out / be evacuated. Perform a finger sweep to clear any adhesions and clots that may be present surrounding the parietal pleural incision. Using the tactile approach, confirm that the incision has breach into the intrapleural space. Ensure that there are no intra-abdominal organs palpated within the cavity. If so, there may be an associated traumatic diaphragmatic rupture over the ipsilateral site.
9. Place a clamp on the distal end of the tube thoracostomy. Using either another clamp at the proximal end of the tube thoracostomy or a finger as a guide, advance the tube into the intrapleural space to the desired depth.
10. Connect the chest drain to an underwater seal apparatus with a collection chamber.
11. Secure the tube to the skin using appropriate suture material. Ensure the tube is secured in a safe and proper manner. (i.e. using a double mattress suturing technique) and tie on both opposite sides of the chest tube. The rest of the incisional wound may be closed with either mattress, simple interrupted suture / staplers. Secure the chest drain appropriately using a “mesenteric dressing method”.

Scan QR code or
click here to watch the **Double Mattress Suturing for Tube Thoracostomy Insertion** video

Scan QR code or
click here to watch the **Mesenteric Dressing for Tube Thoracostomy Insertion** video

12. Ensure the tube thoracostomy is appropriately connected to the underwater seal apparatus as described by the device manufacturer. Inappropriate device connection to the under- water seal inlet will result in failure of drainage and ventilation compromise.

13. Evidence of correct tube thoracostomy placement is suggested by the presence of bubbling, fluctuation during respiration and drainage of pleural fluid.
14. Obtain a chest x-ray after the procedure. Continuously reassess the patient, look for potential complications and clinical progress.

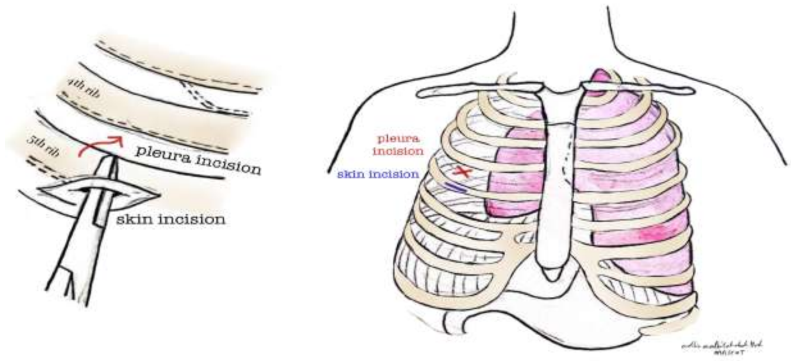

Figure 4.17: Blunt intra-pleural thoracostomy dissection

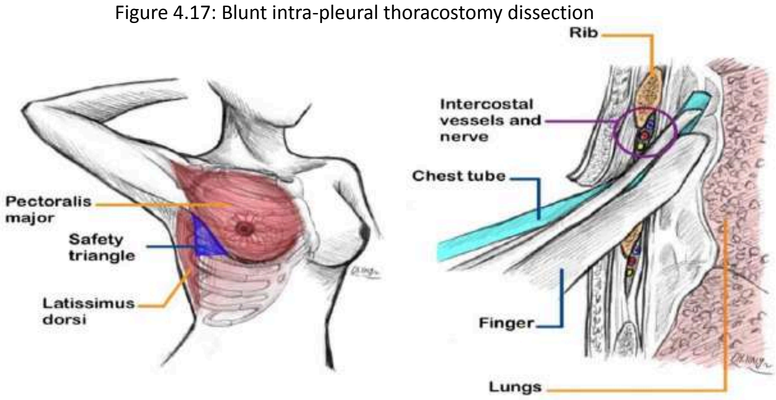

Figure 4.18: Chest tube insertion site - “The thoracic safety triangle“

Step 1 The ipsilateral arm is adducted with the elbow flexed to 90 degrees and the forearm in the mid-pronation	
Step 2 Mid-point of arm is identified by measuring the mid-point between the tip of acromion and the tip of olecranon	

Step 3 Perpendicular to the mid-point, the corresponding interspace is identified The interspace at the level of the midpoint of the arm is identified and marked with a pen while the arm remains in adduction.	
Step 4 The arm is then abducted to 90 degrees and clinical examination/palpation is used to determine which interspace corresponds/correlates to the marked point.	

Table 4.8 : Identification of thoracostomy incision site using a biometric method

Complications of tube thoracostomy insertion:

Insertion	▪ Pain ▪ Damage to local structures ▪ Pulmonary injury ▪ Bronchopleural fistula ▪ Bleeding ▪ Insertion into vascular structure – pulmonary artery or left ventricles ▪ Infection
Usage	▪ Tube blockage ▪ Tube displacement ▪ Tube dislodgement ▪ Infection ▪ Misuse of drainage system leading to introduction of air or fluid into pleural cavity
Removal	▪ Recurrence of the underlying condition ▪ Wound dehiscence ▪ Scarring

Table 4.9 : Complications of tube thoracostomy insertion

4.9.3 PERICARDIOCENTESIS

On completion of this station, participants should be able to:

- Describe the indications and contraindications for emergency pericardiocentesis
- Describe the anatomical landmark for safe pericardiocentesis
- Demonstrate the critical steps in performing an emergency pericardiocentesis using ultrasound guided.

4.9.3.1 Overview

Pericardiocentesis is an invasive but potentially lifesaving procedure which involves the aspiration of fluid from the pericardial space. Traditionally pericardiocentesis has been performed blindly. This approach is associated with a low success rate and a high complication rate. Bedside ultrasound allows the emergency physician to rapidly diagnose pericardial effusion, increase the success rate and lower the complication rate of the procedure.

The pericardium is a double-walled sac which envelops the heart and fuses superiorly with the adventitia of the great vessels. The normal pericardial space contains <50 mL of thin serous lubricating pericardial fluid.

Within the pericardium, the anterior sternocostal surface of the heart is formed by low pressure right sided chambers while the left ventricle forms left cardiac border and apex. The right coronary and left anterior descending coronary arteries course over the anterior surface of the heart where they are vulnerable to inadvertent puncture during pericardiocentesis.

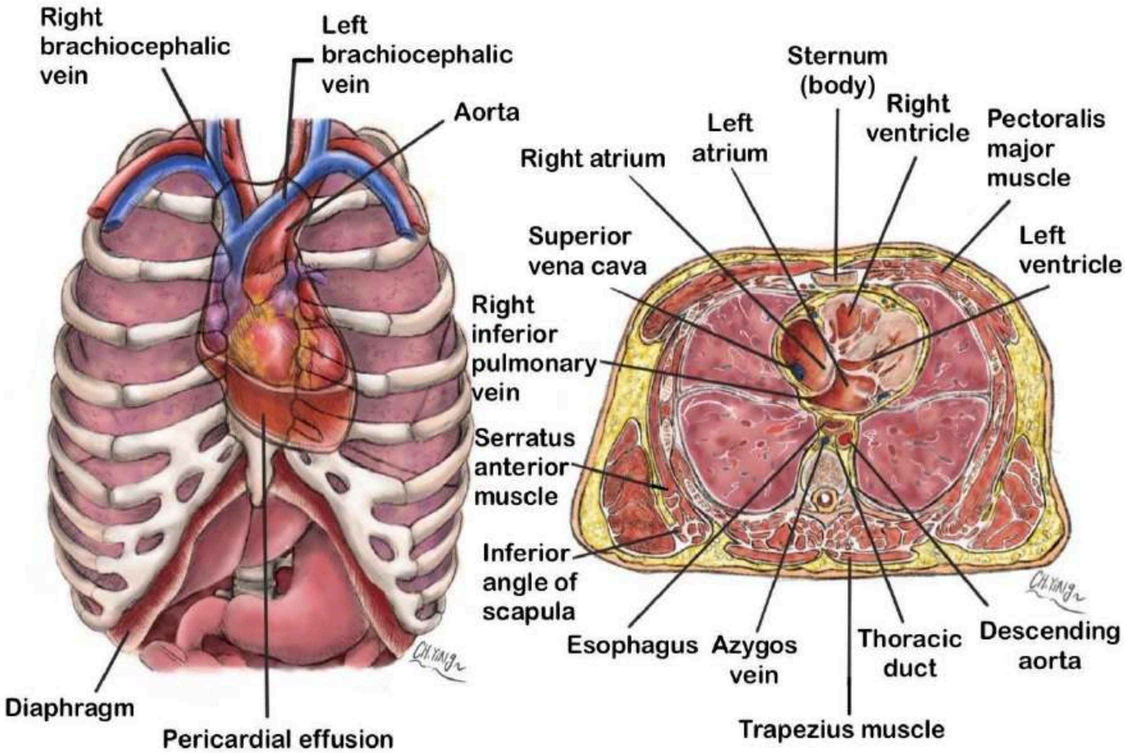

Figure 4.19: Anatomy of the thorax

4.9.3.2 Indication

Diagnostic

To determine the cause of pericardial effusion.

Therapeutic

Evidence of Pericardial tamponade clinical or on ultrasound with hemodynamic instability or in arrest.This procedure is performed in order to remove pericardial fluid in patients with pericardial tamponade.

4.9.3.3 Contraindication

Absolute

None if the patient is in extremis.

Relative

a. Coagulopathy
b. Prosthetic heart valve
c. Pacemakers and cardiac devices

4.9.3.4 Equipment

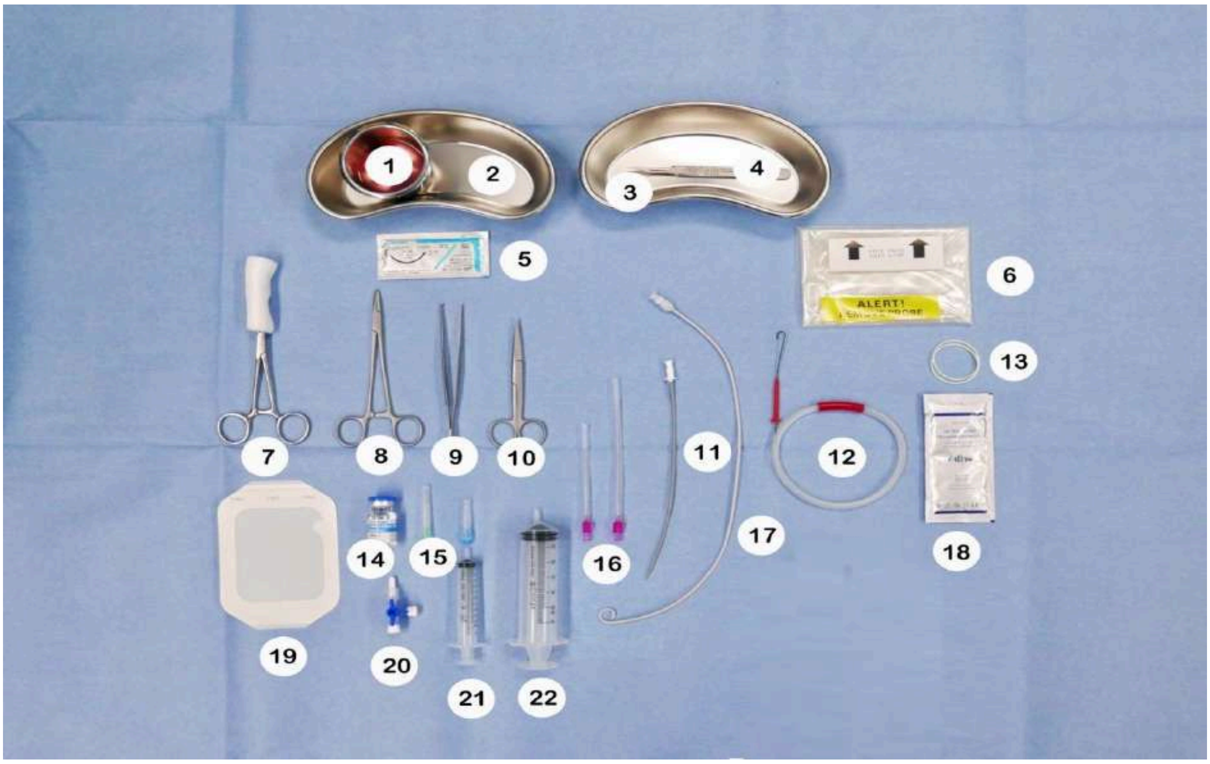

Figure 4.20 : Equipment Preparation

1. Skin preparation solutions (e.g., chlorhexidine 2% in 70% alcohol or povidone iodine)
2. Kidney dish and gallipot
3. Straight scalpel blade No. 11
4. Scalpel handle
5. Silk or nylon suture 1-0
6. Sterile ultrasound sheath
7. Sponge forceps
8. Needle driver
9. Toothed dissecting forceps
10. Dressing scissor straight sharp
11. Dilator
12. J-tipped guidewire
13. Sterile rubber bands for ultrasound sheath
14. Local anaesthetic (lignocaine 2% with or without adrenaline 10mL)
15. Hypodermic needle 18G and 20G
16. Introducer needle
17. Centesis catheter
18. Sterile ultrasound gel
19. Tegaderm film dressing
20. 3-way stopcocks
21. 10ml syringe
22. 50ml syringe
23. Ultrasound machine with cardiac, linear, and curvilinear transducers

Figure 4.21: High frequency linear probe

4.9.3.5 Pericardicentesis : Subxiphoid Approach

Steps:

1. Identify needle insertion site: 1 to 2 cm (1 finger breadth) inferior to the left xiphochondral junction.
2. Monitor the patient's vital signs and ECG tracing.
3. Prepare, swab and anaesthetize the insertion area.
4. Attach a 10cc syringe to a size 16G or 18G cannula which is at least 15 cm long.
5. Introduce the cannula at a 45-degree angle and point it towards the left shoulder.
6. While introducing the cannula, monitor the ECG, if the needle touches the myocardium, ST changes or a widened QRS complex will be visible in the cardiac monitoring. If this occurs, withdraw the needle slightly and continue to aspirate.
7. This procedure may be performed with better outcomes using an ultrasound guided approach. However, this approach would require a trained operator and readily available equipment.
8. Once aspiration has been performed, the cannula can be left in the pericardial space and securely anchored.

4.9.3.6 Ultrasound guided pericardiocentesis -Parasternal approach

For parasternal approach, needle insertion should be done over the superior rib margin to avoid intercostal neurovascular bundles at the inferior rib margin. The internal thoracic (mammary) artery and vein run parallel 1-2 cm to the sternum border before dividing into the superior epigastric and musculophrenic vessels at the sixth intercostal space.

There are many advantages using the in-plane parasternal medial-lateral approach using a high-frequency probe. Due to its feasibility and safety, it abolishes the risk of liver injury, enables real-time visualization of the needle trajectory and avoids internal thoracic vessels, lung and heart perforation.

Echocardiographic finding suggestive of cardiac tamponade includes:

1. Plethoric IVC.
2. Right ventricular collapse during diastole.
3. Right atrial collapse during systole.
4. Swinging of the heart.

Pre procedure

1. Ensure patient is on continuous cardiac monitoring
2. Position the ultrasound machine on the patient's left side in line with the operator on the patient's right side allowing direct view of the ultrasound screen.
3. Clean and drape the patient if time permits.
4. Place a sterile probe cover over the probe.
5. Anesthetize the site if time permits.

Identify landmarks

1. Left thoracic ultrasound examination, use the high-frequency linear probe to identify the sternum bone, internal thoracic vessel, lung sliding, pericardial effusion, and myocardial border of the right ventricle.
2. Look for the deepest pocket to identify the best needle insertion area (measuring the maximal parietal to visceral pericardial distance).

Needle insertion

1. Adjust the depth of the sector on the screen and focus position to visualize only the pericardial effusion and the right ventricle.
2. In-plane medial-to- lateral approach with a 45° angle on the patient's left chest to visualize the needle trajectory and its entrance into the pericardial space. Avoid the ***left internal mammary artery***.
3. Attach a saline-filled syringe to the needle.
4. Gently aspirate while slowly advancing the needle.
5. Once the pericardial space is entered, confirm the placement by injecting agitated saline and aspirating it, monitored by ultrasonography to detect a ‘rocket flare’ appearance.

Wire and catheter position

1. Use the Seldinger technique to place the guide wire under real time visualization.
2. Remove the needle.
3. Dilate the subcutaneous space with the dilator.
4. Place the single lumen catheter into the pericardial space.

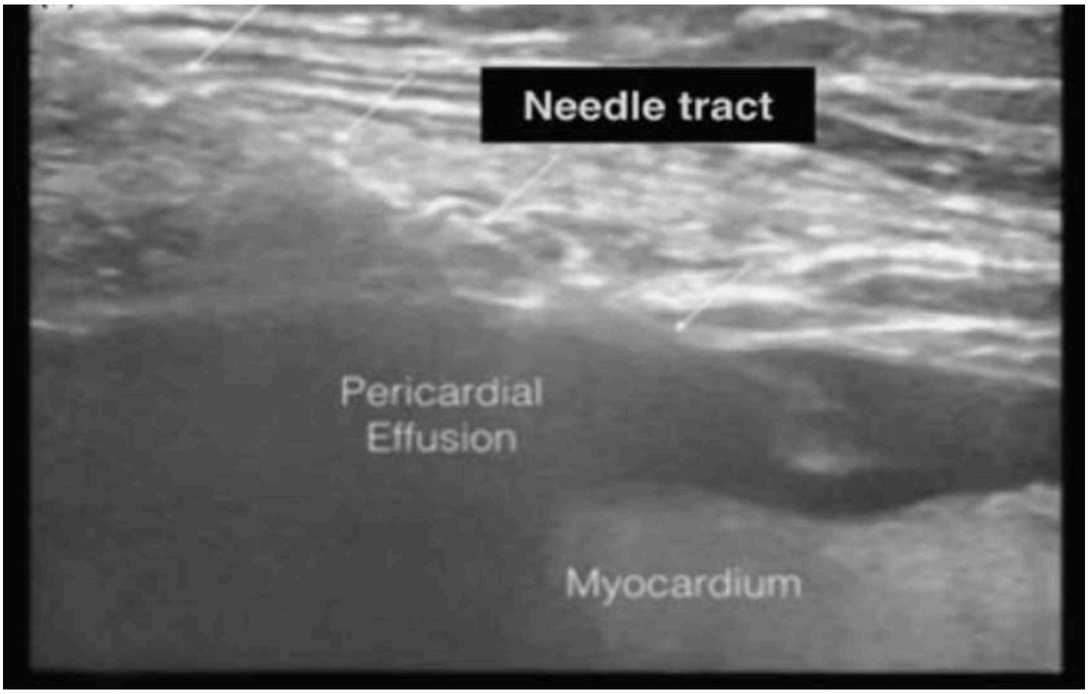

Figure 4.22 : Needle tip penetrates the skin, intercostal muscle and pericardial tissue under real-time ultrasound guidance

Pericardial drainage

1. Connect the catheter with a three-way stopcock and a syringe.
2. Drain the pericardial effusion to reverse the tamponade by observing for hemodynamic stabilization.

3. Keep the catheter in place, while repeated ultrasound examinations are executed to ensure absence of effusion and other post-procedural complications.
4. Record the amount of fluid drained.
5. Leave the catheter in place and secure the catheter with a suture and dressing.
6. If any hemodynamic instability occurs, the drainage procedure can be repeated.
7. Arrange for emergency thoracotomy if aspiration is successful as it is a temporizing measure

4.9.3.7 Complications

1. **Cardiac complications:**
    a. Free wall laceration and myocardial perforation (<1%)
    b. Coronary puncture
    c. Bacterial pericarditis
    d. Arrhythmias and cardiac arrest
    e. Vagal reaction and bradycardia
    f. Pneumopericardium
    g. Decompression syndrome and congestive heart failure

2. **Non cardiac complications:**
    a. Pneumothorax
    b. Haemothorax - internal mammary artery laceration
    c. Hepatic or intra-abdominal bleeding
    d. Diaphragmatic laceration and phrenic nerve injury

4.9.3.8 Pearls and Pitfall

1. Blood aspiration does not always confirm pericardial puncture because pleural collection may be traversed during the pericardiocentesis and may represent accidental cardiac puncture.
2. Hemodynamic improvement after blood aspiration is more consistent with successful pericardiocentesis.
3. It may be difficult to localise the tip of the needle on ultrasound scan. Fortunately, agitated saline bubble injection through the advancing needle is helpful to identify the needle position. This can be done by mixing 9 ml of saline with 1 ml of air between two syringes which are connected to the advancing needle via a three-way stopcock before injection. The bubble contrast which travels around the heart confirms the correct position.
4. Cardiac tamponade may recur despite successful initial aspiration due to blood re-accumulation in the pericardial cavity.
5. Continuous drainage is associated with a higher rate of catheter occlusion compared to intermittent drainage.

4.9.3.8 Reference

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CHAPTER

5

ABDOMINAL TRAUMA

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Able to identify the key anatomical regions of the abdomen
2. Able to recognize and evaluate patients at risk of having intra-abdominal injury.
3. Able to understand the application of appropriate diagnostic tools and procedures to identify abdominal injuries.
4. Able to describe the clinical pathway and acute management of abdominal injuries.
5. Able to identify patients that require surgical consultation for indications of emergency exploratory laparotomy and relevant general surgical procedures.

5.1 INTRODUCTION

Abdominal and pelvic trauma constitutes 9.2% of all severe bodily injuries. Intra abdominal injuries may result from both blunt (80%) and penetrating (20%) mechanisms. Significant blood loss within the abdominal cavity may lead to severe hemorrhagic shock and death if undetected early. Recognizing intra-abdominal injuries is challenging especially amongst polytrauma, combative, altered mental status and associated spinal injury patients. Early accurate assessment and treatment is key in assuring the best possible outcomes.

5.2 ANATOMY OF THE ABDOMEN

It is crucial to attain competent knowledge regarding the anatomy of the abdomen in order to perform precise physical examination and documentation. Identification of abdominal pathology can be challenging on the initial assessment, hence understanding the surface anatomy and its relation to underlying organs plays a major role in determining accurate diagnosis. The anatomy of the abdomen is illustrated in the diagram below :

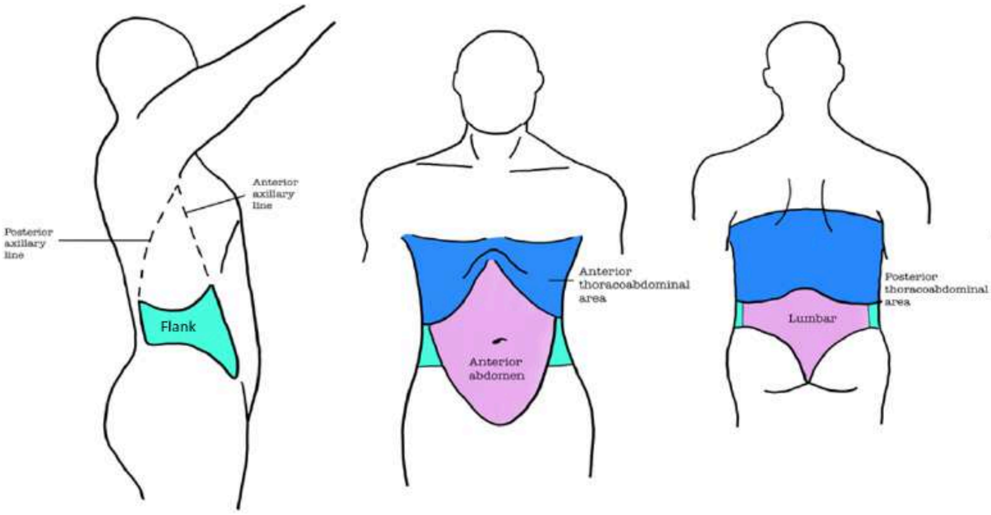

Figure 5.1 Anatomy of the abdomen.

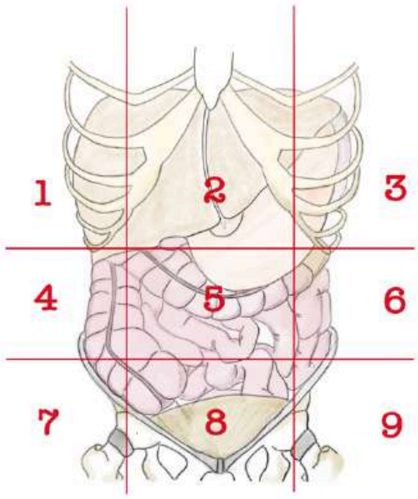

Figure 5.2 Major Organs according to Abdominal Quadrants

The abdomen can be divided into the following regions:

a) Anterior abdomen

- Further divided into nine regions using two parasagittal planes through mid-clavicular lines and two transverse lines through subcostal plane and inter-tubercular plane (of iliac bone).
- Bounded by anterior axillary lines laterally, costal margin superiorly and inguinal ligament as well as symphysis pubis inferiorly.
- Thoraco-abdominal area is bounded by the area superiorly limited by the fourth intercostal space (anterior), sixth intercostal space (lateral), and eighth intercostal space (posterior), and inferiorly limited by the costal margin.
- Injuries in the thoraco-abdominal region increase the likelihood of chest, mediastinal, and diaphragmatic injuries.

b) Flank

- Between the anterior axillary line and the posterior axillary line from the 6th intercostal space to the iliac crest

c) Back

- Located posterior to the posterior axillary line, and from the tip of the scapula to the iliac crest. It encompasses the lower part of the posterior thoracoabdomen.

e) Pelvic Cavity

- Surrounded by pelvic bones.
- It contains rectum, bladder, iliac vessels and internal reproductive organs.

5.3 MECHANISM OF INJURY

Two main types of injury mechanisms that occur in abdominal trauma are blunt and penetrating Injury. Injuries can also present with the combination of both mechanisms.

5.3.1 Blunt Injury

5.3.1.1 Deceleration

- Rapid deceleration causes differential movement between adjacent structures.
- As a result, shearing forces are created causing hollow, solid, visceral organs and vascular pedicles to tear, especially over the fixed and relatively mobile points of attachment.
- For example, the distal aorta is attached to the thoracic spine. This portion of the aorta is relatively more "fixed" as compared to the proximal and arch segments. In rapid deceleration injuries, the fixed segments decelerate much more quickly than the relatively mobile segments, resulting in shearing forces causing possible aortic disruption.
- Similarly, these shearing forces can occur over the renal pedicles, cervicothoracic junction of the spinal cord and bowel mesenteric regions.

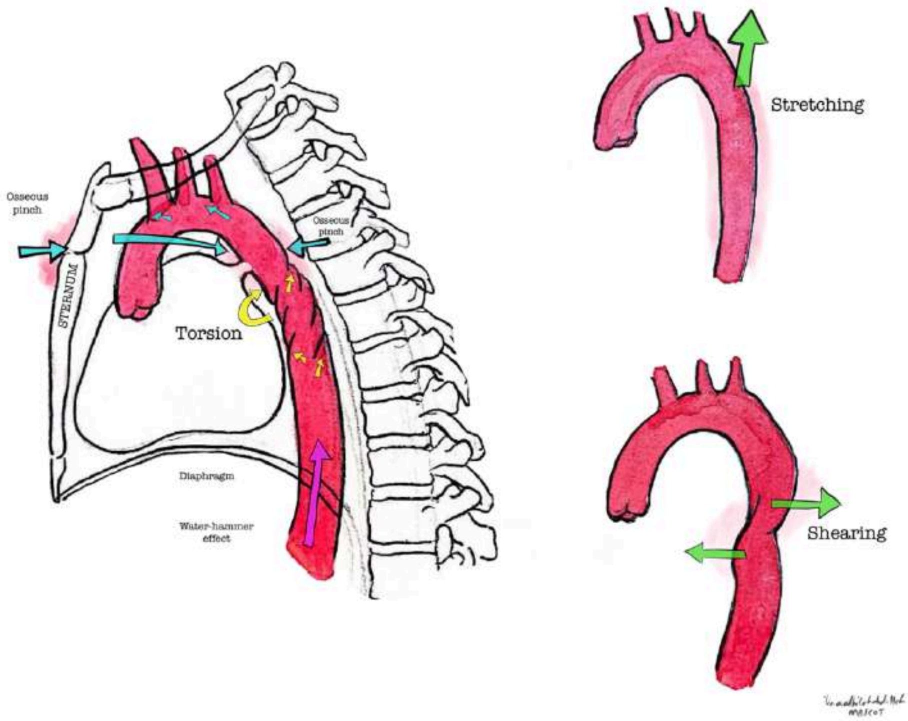

Figure 5.3 : Shearing effect and external compression effect leading to aortic injury.

5.3.1.2 Crush injury

- In severe blunt trauma, intra-abdominal contents may undergo crush injury. This may occur when the abdominal contents are "crushed" between the anterior abdominal wall and the vertebral column / posterior thoracic cage.
- This produces a crushing effect, to which solid viscera (eg, spleen, liver, kidneys) are especially vulnerable.

5.3.1.3 External Compression Injury

o This mechanism of injury may arise from a direct impact of the abdomen against a static structure (i.e. seen in lap seat belt injuries) causing compression forces to transmit through the abdomen. External compressive forces result in sudden rise of intra-abdominal pressure causing potential rupture of hollow viscus organs (i.e., in principles of Boyle law). This injury mechanism may also cause direct injuries to solid organ structures.

o Seat belt injuries are also commonly associated with "Chance Fractures" of the thoraco-lumbar spine. These fractures are due to sudden forceful flexion followed by rapid extension of the spine (flexion distraction injuries). These fractures are profound with lap belt injuries.

Figure 5.4 Seat Belt Injury

5.3.2 Penetrating Trauma

5.3.2.1 Stab Wound

Stab wound causes tissue injury by combination of lacerating and cutting mechanism. The severity of injury may not be well determined by external examination. The extent of injury is very dependent upon depth, trajectory and internal organ injuries during stabbing.

Figure 5.5 Penetrating Injury

5.3.2.2 Gunshot Wounds (GSW)

- Abdominal gunshot wounds are more likely to penetrate the peritoneum (80%), and those that do are more likely to cause serious intraperitoneal injury.
- Bullets and similar missiles penetrate the body at high velocity and may ricochet resulting in unpredictable wound tracts and shrapnel trajectory.
- GSW to the abdomen requires early expert consultation in order to achieve best outcomes

5.3.3 Other mechanisms and injuries

5.3.3.1 Blast injuries

Blast injuries produce a complex combination of injury biomechanics. It can be classified into four categories with each category producing a unique pattern of injury.

Primary Blast Effect:

This injury results from the impact of an over-pressurization wave against the body surface by rapidly expanding gas formed due to extreme heat production from the blast. Air filled structures / organs are most affected and prone to injury / rupture. Common injuries include barotrauma, tympanic membrane injuries, eye globe rupture and intestinal injuries.

Secondary Blast Effect:

This injury results from flying shrapnel and blast debris. Injuries can be penetrating and blunt in nature. Any part of the body may be susceptible to these injuries.

Tertiary Blast Effect:

This injury results from the impact of the victim being thrown by the blast wind / effect. Injuries are due to direct impact of the body against physical objects and surfaces. The extent and severity of injury is dependent upon the victim's biomechanics, motion & trajectory.

Quaternary Blast Effect:

This injury category is due to all the other effects of the explosion not included within the primary, secondary and tertiary blast effects. Blast effects from this category include smoke inhalation injuries, burns, exacerbation of pre-existing illness, infections and radiation related injuries.

5.3.3.2 Intra-abdominal Impaled objects

Caution needs to be executed in removal of impaled objects. Removal needs to be performed under a controlled environment with the presence of expertise and adequate equipment. Improper preparation during removal of impaled objects may result in further injury and uncontrolled exsanguinating hemorrhage. During initial resuscitation, the impaled object should be stabilized to minimize movements in order to avoid further injury and prevent hemostatic clots from being dislodged. The removal of the object is best performed in a planned manner and in an operation theater.

5.3.3.3 Evisceration of intra-abdominal content

Bowel evisceration may occur as a result of penetrating injuries to the abdomen.
During initial resuscitation, special care should be provided to ensure no further injury is inflicted upon the eviscerated bowel segments. Do not attempt to force the bowel back into the abdomen, this may cause further injury. Care should be advocated in keeping the eviscerated bowel safe by providing a warm, sterile and moist cover over the entire segment. The subsequent repair of the injury should be performed in an operation theater.

Figure 5.6: Bowel evisceration

5.4 ASSESSMENT

5.4.1 History

- In patients involved in motor vehicle accidents the history of speed, type of collision, vehicle intrusion into the passenger compartment, types of restraint, deployment of airbag, patient's position in the vehicle and status of other passengers need to be attained.
- For patients injured by a fall, the height, surrounding environment and circumstances leading to the fall is important to be determined.
- For patients sustained penetrating trauma, the type of weapon, time of injury, distance from the assailant, associated blunt trauma, other environmental circumstances and the amount of bleeding noted at the scene should be attained.
- Aside from attaining detailed history pertaining to the circumstances of the injury itself, the "MAPLE" history needs to be taken as well.

5.4.2 Physical Examination

a) Inspection
   - Patients should be fully undressed for complete examination.
   - Look for abrasions, contusions, lacerations, penetrating wounds or impaled foreign bodies.
   - Be sure to examine the “folds” which may reveal “hidden” injuries and these areas may be less obvious to the eyes such as the axilla fold, groin regions, etc.
   - The external genitalia should be inspected for swelling, bruising, laceration, blood at urethral meatus, vagina and rectum which may suggest an associated pelvic fracture.

b) Palpation
   - Patients should be inspected and examined in a safe manner to look for any obvious signs of injury. Special care has to be given to ensure that no further harm is inflicted during the process of performing a physical examination.
   - Careful palpation is required to elicit clinical signs of tenderness, guarding and peritonism.
   - Routine vaginal and digital rectal examination is not required. These examinations are only performed when an injury is suspected / examination indicated.
   - Always inspect the scrotum and perineum for any hematoma, swelling, lacerations or presence of blood at the urinary meatus. These regions are less visible and the signs are more subtle, therefore careful examination needs to be performed in order to prevent missed injuries.

c) Auscultation
   - Auscultation of the abdomen should be performed to look for any evidence of diminished or reduced bowel sounds. Such findings may indicate the presence of intra-abdominal injuries.
   - Auscultation for bowel sounds should be performed in a less noisy or non-chaotic environment.

d) Assessment for pelvic tenderness

   - Physical examination findings suggestive of a pelvic fracture may be evidenced by signs of a ruptured urethra, limb length discrepancy and rotational deformity of the leg without other obvious fractures

- In order to elicit tenderness, a single hand palpation method is advocated as opposed to performing a "Spring" method examination. Performing a "Spring" method examination may cause more harm, further displaced fractures, induce severe pain and cause further hemorrhage.
- Serial examinations may be necessary to look for dynamic changes and development of new clinical signs.

e) Digital Rectal Examination

- A Digital Rectal Examination should not be performed as a routine. In trauma, it is performed in indicated cases such as;

    - Patients presenting with a suspected neurological deficit or neurogenic shock. Digital Rectal Examination is performed to complete the neurological assessment and look for coexisting signs of spinal shock
    - When a patient's injury is directly involving the rectal /pelvis region. Digital Rectal Examination is performed to look for possible complications and other associated injuries.
    - As part of the neurological assessment when it is required on an intubated patient / unconscious patient

- In awake patients, assessment of the motor and sensory function of the sacral plexus can be performed by asking the patient to squeeze the "bum cheeks" to look for anal contraction (the external anal sphincter is a voluntary muscle and is innervated by S2-S4 nerve root) and sensory assessment by assess sensation around the perianal region (perianal sensation is supplied by the pudendal nerve from the S2-S4 nerve root).

- For trauma patients presenting in an unconscious state, the rectal examination (anal tone and bulbocavernosus reflex) may be able to provide clues to the presence of an underlying spinal cord injury. In intubated patients given neuromuscular blockade drugs, the assessment of the anal tone may be of limited value.

5.4.3 Adjuncts to Physical Examination

a) Oral or nasogastric tube

- The oral or nasogastric tube requires careful insertion. Caution should be advocated for nasogastric tube insertions in patients with suspected base of skull fractures. Although rare, previous cases of cribriform plate penetration with intracranial placement have been reported. In such cases, an orogastric tube is a preferred choice.
- The gastric tube provides an avenue to examine the gastric contents, deflate the stomach, reduce risk of aspiration and provide access to deliver medication when indicated.

b) Urinary catheter

- The urinary catheter is an important clinical examination adjunct. It should be inserted in a careful and aseptic manner.
- The catheter serves various purposes including, assessing the presence of gross hematuria, decompressing the urinary bladder, aid in diagnostic imaging and monitoring the urine output.
- Presence of gross hematuria may suggest significant genitourinary trauma
- In cases presenting with blood at the meatus, scrotal hematoma or perineal ecchymosis, a retrograde urethrogram may be required before inserting a urinary catheter. Inserting a urinary catheter may cause further shearing of the already injured urethra. Consider placing a suprapubic catheter as an alternative until a urethral injury can be safely ruled out or repaired.

c) Other studies

- Hematological examination

o Ie. full blood count, renal profile, creatinine kinase, serum lactate, arterial blood gasses etc.

- X Rays
    - An upright chest x-ray may be useful to identify free intraperitoneal air in stable isolated penetrating injuries patients.
    - Primary survey chest x-rays are done in supine position in AP view
    - Abdominal x-rays can be helpful to demonstrate presence of foreign bodies and dislodged shrapnel from penetrating missile injuries

- A pelvic x-ray is indicated in all major trauma patients as part of the primary survey adjunct. Pelvic X-rays are helpful in identifying unstable pelvic fractures during the initial assessment.

- Focus Assessment Sonography in Trauma (FAST)
  - FAST (Focus Assessment Sonography for Trauma) is a rapid, non-invasive, repeatable, point of care examination that can be performed to reliably detect free intraperitoneal fluid and pericardial tamponade during initial patient assessment.
  - Extended FAST (e-FAST) is a broader scope of examination that includes the assessment of the patient's thorax. This examination provides early detection of hemothorax and pneumothorax.
  - Positive FAST identifying free intraperitoneal fluids should be attributed to hemoperitoneum from cause of trauma until proven otherwise. e.g. a positive FAST in an alcoholic liver cirrhosis trauma patient should be treated as suspected intra-abdominal injury until proven otherwise. Further imaging such as a CT scan may be necessary.
  - FAST and e-FAST scans should be performed by an experienced operator, done in a serial manner and best performed by the same operator.

> **Floating bowel** seen during FAST scan indicates a large volume of intraperitoneal free fluid. In trauma patients presenting with concomitant low blood pressure, this finding may suggest a hemodynamically unstable intraperitoneal injury. These patients may likely require an immediate emergency exploratory laparotomy to control intraperitoneal haemorrhage.

- Computed Tomography Scan (CT Scan)
  - CT Scan is an imaging procedure that has high sensitivity & specificity in diagnosing intra abdominal injuries.
  - The CT Scan is commonly performed with the aid of parenteral contrast, depending upon the indication and suspected injuries.
  - Double (oral & intravenous) and triple contrast (oral, intravenous & rectal) can increase the sensitivity and specificity in detecting injuries.
  - The presence of free fluid in the abdominal cavity without obvious liver or spleen injuries may suggest gastrointestinal tract and/or mesentery sources.

- The CT Scan is commonly performed for patients who are hemodynamically stable.
- For trauma patients presenting with low blood pressure, the use of CT scan in such cases will be dependent upon the physician's / surgeon's discretion. This decision will be based upon various factors including distance of CT scan room, operation theater, available resources, patient monitoring capability, available clinical trauma expertise, patient's clinical condition, the cause of the presenting low blood pressure, local policies, the benefit of CT Scan in decision making / subsequent management of the particular patient, instillation of damage control resuscitation and permissive hypotension strategies.

- Diagnostic Peritoneal Lavage (DPL)
    - A previously common modality used to diagnose intra abdominal injuries by infusing fluid and lavage the cavity.
    - A less favored method currently as it is replaced by point of care non-invasive imaging modalities, such as EFAST. Its use and importance have since decreased considerably.
    - DPL may still be considered in special circumstances with resource constrained settings.

5.5 EVALUATION OF ABDOMINAL TRAUMA

Abdominal trauma can present with blunt or penetrating mechanisms. It can be further divided into hemodynamically stable and unstable categories. Hemodynamically unstable are patients who are unable to maintain an adequate perfusion and acceptable blood pressure. When the cause of the hemodynamic instability is an intraperitoneal haemorrhage, the subsequent priority of resuscitation will be to stop and control the intraperitoneal bleed by means of an emergency exploratory laparotomy.

Hemodynamically stable patients with suspected intra abdominal injuries should undergo diagnostic imaging procedures such as contrast enhanced CT scan. Subsequent management of the patient will depend upon the diagnostic imaging findings and clinical progress of the patient.

5.5.1 Evaluation of Blunt Abdominal Trauma

Blunt abdominal trauma is a frequent occurrence and is a leading cause of morbidity and mortality. Identification and diagnosis can be challenging.

Clinical signs of blunt abdominal trauma may include: abdominal pain, hypovolemia and evidence of signs of peritoneal irritation. Physical examination findings may reveal seat belt marks, steering wheel pattern contusions, ecchymosis, abdominal tenderness, guarding and rigidity and reduced bowel sounds during auscultation.

Determining the hemodynamic stability of the patient is necessary to determine the required immediate interventions and determine subsequent diagnostic and disposition options. In order to avoid missed injuries, a comprehensive assessment and high index of suspicion is always necessary.

5.5.2 Evaluation of Penetrating Abdominal Trauma

Penetrating abdominal trauma commonly results from stabbings, gunshots and industrial injuries. Penetrating trauma may present with hypovolemic shock and peritonitis. Bowel sounds may be diminished due to intraperitoneal bleeding, infection and irritation. The abdomen may be increasingly distended and tender during the course of management indicating the need for surgery.

Abdominal exploration (i.e. exploratory laparotomy, laparoscopy) remains the standard management of all penetrating intraperitoneal trauma. However, improved understanding of injury mechanics and imaging techniques has resulted in conservative strategies in selected cases.

5.5.3 Assessment for peritoneal penetration

- The mechanism of injury and anatomical location will influence the evaluation of penetrating abdominal trauma.
- In the emergency setting, do not blindly introduce fingers/ needle/ probe to assess the depth of the penetrating wound.
- Hemodynamically unstable patients would require emergency abdominal exploration to attain surgical hemostasis.
- Hemodynamically stable patients may benefit from diagnostic radio-imaging investigation to guide further management.

Indications for abdominal exploration in patients with penetrating abdominal injuries:
● Hemodynamic instability ● Signs of peritoneal irritation ● Peritoneal penetration / impalement ● Evisceration of intra-abdominal content ● Hematemesis / gross blood in gastric aspirate / per rectal bleeding ● Pneumoperitoneum may require abdominal exploration. Stable patients with a benign examination and small or questionable free air may undergo additional imaging and close observation

5.5.4 Evaluation of abdominal wound in Hemodynamic Stable Patients

5.5.4.1 Anterior Abdominal wounds

- In stable patients, peritoneal penetration needs to be ascertained early. Evaluation can be performed by serial physical examinations, local wound exploration, FAST, CXR ,CT scan or abdominal exploration.

- Local wound exploration
    - It is performed in order to evaluate penetration of fascia.
    - Local wound exploration should not be performed in a blind manner. It should be performed by trained personnel in a controlled environment.
    - A positive local wound exploration in an examinable patient does not indicate a mandatory laparotomy.
    - Almost 30-50% of patients may eventually result in non-therapeutic laparotomy although local wound exploration is positive, and the incidence is higher in a benign abdomen. A further diagnostic imaging or admission for serial physical examination may be warranted.
    - An alternative approach is required as local wound exploration reliability may be compromised in following clinical situation:
        i. Obese patient with deep subcutaneous tissue
        ii. Multiple stab wound
        iii. Small puncture wound
        iv. Tangential stab wound tracts

- Serial Physical Examination
  - Incidence of non-therapeutic laparotomy may be decreased with accurate clinical interpretation of serial physical examination, vital sign monitoring and laboratory assessment.
  - Serial physical examination of the abdomen is performed in patients where local wound exploration is indeterminate and in stab wounds where immediate abdominal exploration is not the primary method of management.
  - Factors that can interfere with serial physical examination of the abdomen are as follows :
    i. Concomitant Traumatic Brain Injury
    ii. Concomitant Spinal Cord Injury
    iii. In intubated patients
    iv. Intoxicated patients
    v. In acute psychosis
    vi. Patients with GCS <13
    vii. Patient with dementia

- E-FAST : Positive EFAST indicates intra-abdominal injury, however a negative EFAST does not exclude an intra-abdominal injury.

- CT imaging : CT scan findings that may require abdominal exploration are as follows:
  i. visualization of bowel injury
  ii. secondary signs (i.e. unexplained free fluid, free air, bowel wall thickening, mesenteric injury)
  iii. diaphragm injury
  iv. abdominal vascular injury
  v. contrast extravasation indicating ongoing bleeding (IR intervention can be considered)

  CT scan should not be used as a sole criteria for discharging patients. Clinical correlation should be advocated.

5.5.4.2 Thoracoabdominal wounds

- Besides abdominal injuries, patients should be evaluated for possible injuries to the diaphragm and thoracic injuries.
- Clinical evaluation may include CXR, E-FAST, diagnostic CT imaging, abdominal and thoracic exploration.

5.5.4.3 Flank wounds

- The flank muscles assist in protecting the underlying viscera from injuries. Clinical findings and symptoms may therefore be subtle or even absent. Obvious clinical signs of injuries may manifest in a delayed manner.
- However, these patients should be comprehensively evaluated for underlying visceral injuries with the adjunct use of diagnostic CT imaging scan. If a CT Scan cannot be done, serial physical examinations, serial laboratory investigation and serial E-FAST should be performed.

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5.7 SKILL STATION

5.7.1 EXTENDED FOCUS ASSESSMENT SONOGRAPHY FOR TRAUMA (eFAST)

- Indication :
    i. Traumatic injuries to detect free fluid in peritoneal, pericardial or pleural space
    ii. Traumatic injuries to detect pneumothorax
- Advantage : Rapid, portable, non-invasive and accurate examination
- Disadvantage : Depends on user technique
- Limitation and pitfalls:
    i. Injuries to solid organ, hollow viscus and retroperitoneal injuries can't be ruled out by ultrasound
    ii. False negative examinations can result if the amount of fluid is very minimal to detect
    iii. Ultrasound examination view may be limited in obese patients and in the presence of subcutaneous emphysema.
    iv. False positive examinations can occur in the setting of free fluid which has been present before trauma such as ascites, after an ovarian cyst has ruptured, or pleural effusion.

- Probe : CURVELINEAR 3.5 MHz (low frequency)

5.7.1.1 STEP 1 : SUBXIPHOID VIEW

i. There is an option to use either the curvilinear or cardiac probe.
ii. Place the probe at the subxiphoid area with the pointer toward the right of the patient.
iii. Visualize a 4 cardiac chamber with liver acoustic window.
iv. Free fluid will be visualized in the pericardial sac in between liver and myocardium.
v. Signs of right atrium collapse during systole or right ventricle collapse in diastole is concerning for tamponade.

Figure 5.7: Probe placement for subxiphoid view

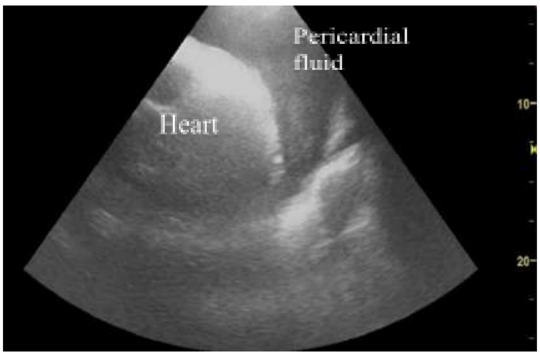

Figure 5.8 : Pericardial fluid in EFAST

5.7.1.2 STEP 2 : RIGHT UPPER QUADRANT

i. Place the probe in sagittal view in midaxillary line 9th or 11th rib space with pointer towards cephalic
ii. Visualize the hepatorenal space (Morisson's Pouch), diaphragm, upper pole of the right kidney.
iii. Free fluid will appear in the hepato-renal space
iv. To rule out hemothorax, slide the probe superiorly from the standard right upper quadrant. In hemothorax, free fluid can be visualized in the right pulmonary base.

Figure 5.9 Probe placement for right upper quadrant view

Figure 5.10 : Normal finding in hepatorenal space (left) and Free Fluid seen in hepato-renal space (right)

Figure 5.11 : Fluid in the pleural space suggestive of hemothorax in trauma patient

5.7.1.3 STEP 3 : LEFT UPPER QUADRANT

i. Place the probe in sagittal view in posterior axillary line at 7th to 9th rib space with pointer towards cephalic
ii. Visualize the splenorenal space, diaphragm and upper pole of the left kidney.
iii. Consider putting the probe more posteriorly in view of the presence of air artifacts of stomach and colon.
iv. Free fluid will appear in splenorenal space.
v. To rule out hemothorax, slide the probe superiorly from the standard left upper quadrants. In hemothorax, free fluid can be visualized in the left pulmonary base.

Figure 5.12: Probe placement for left upper quadrant view

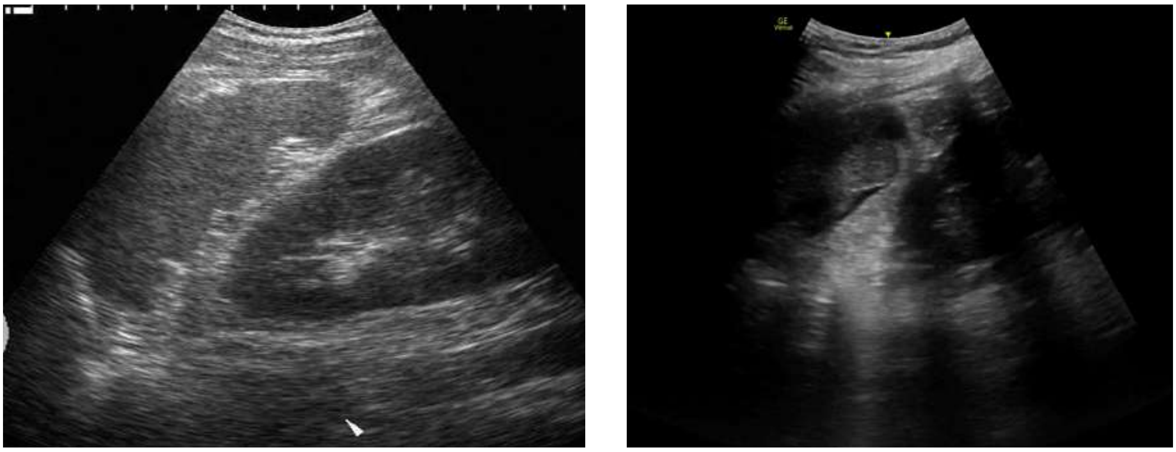

Figure 5.13 : Normal finding in splenorenal space (left) and presence of Free Fluid in splenorenal space (right)

5.7.1.4 STEP 4 : SUPRAPUBIC VIEW

i. Place the probe at the suprapubic area in either transverse or sagittal view.
ii. Visualize the urinary bladder and rectovesical space (men) or pouch of Douglas (women). Image can be differentiated better with a full bladder.
iii. Free fluid can be visualized in Pouch of Douglas (women) or Rectovesical space (men).

Figure 5.14 : Probe placement (transverse and longitudinal) for suprapubic view

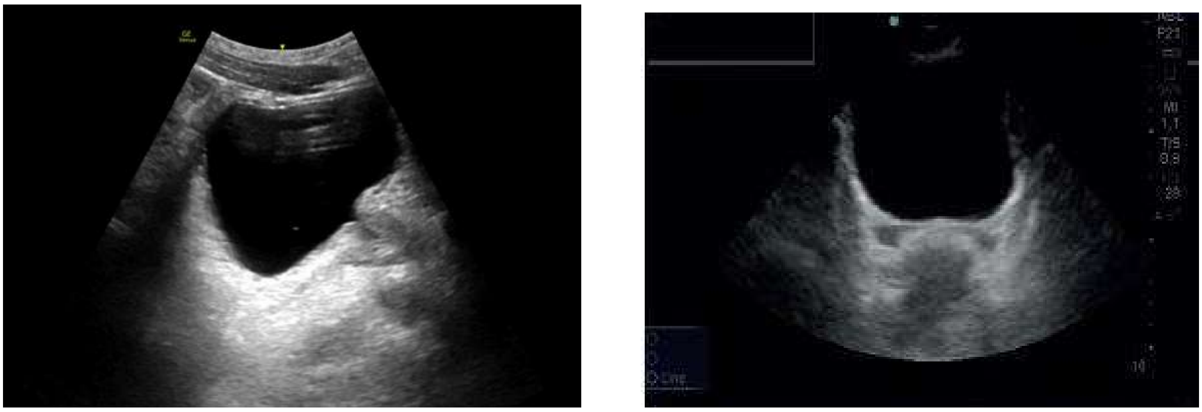

Figure 5.15 : Normal finding in Suprapubic view - Longitudinal View (left) and Transverse View (right)

Figure 5.16 Retrovesical free fluid with organized clot

5.7.1.5 STEP 5 : THORACIC VIEW

i. To rule out pneumothorax, place the curvilinear or linear probe at the anterior chest just below midclavicular line (approximately 3rd – 4th intercostal space) and the pointer towards cephalic.

Figure 5.17 : Probe placement at anterior chest wall for pneumothorax

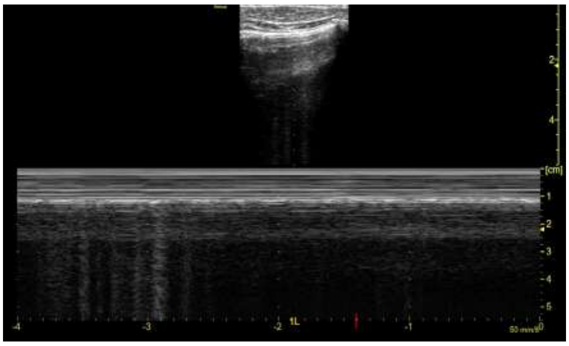

Figure 5.18 Normal (Seashore Sign)

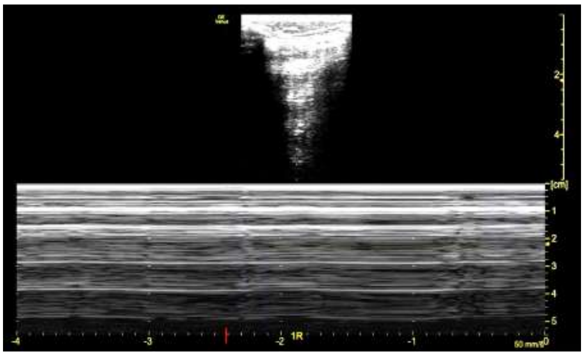

Figure 5.19 : Pneumothorax (Barcode or Stratosphere Sign)

Features suggestive of the presence of pneumothorax

1. Absence of sliding sign (other causes of absence sliding sign are atelectasis, ARDS, pleurodesis and adhesion, endobronchial intubation)
2. Presence of A lines
3. absence of B lines
4. Presence of stratosphere sign or barcode sign
5. Presence of "lung point" (absent in complete retraction of lung)
6. Absence of lung pulse

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CHAPTER

6

PELVIC TRAUMA

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Able to identify patients at risk of pelvic trauma based upon the mechanism of injury.
2. Able to identify appropriate diagnostic procedures that are needed to diagnose pelvic fractures
3. Able to understand key principles and provide early management of stable and unstable pelvic fractures.

6.0 INTRODUCTION

Pelvic injuries are a major contributor to trauma morbidity and mortality. Unstable fractures of the pelvis often lead to severe blood loss. Pelvic fractures can result in loss of 3-4 liters of blood, leading to fatal injury if not identified early and resuscitated effectively. The diagnosis of unstable pelvic fractures should be done early using clinical and radiological assessment such as the primary pelvic X-Ray and/or CT-Scan.

Hemorrhage from unstable pelvic fractures arise most commonly from the major vessels of the pelvic sacro-iliac junction. Bleeding may lead to large amounts of hematoma accumulating within the retroperitoneal space (4 liters or more). Such losses would lead to immediate death if not treated rapidly.

It is important to have a high index of suspicion to enable early diagnosis of unstable pelvic fractures. The primary survey and clinical examination should be performed thoroughly. Out of hospital pelvic immobilization should be placed for all patients in whom an unstable pelvic fracture cannot be ruled out. If not done, an immediate pelvic binder should be applied.

Severe pelvic injuries are also likely to be associated with other intra-abdominal, retro-peritoneal or thoracic injuries. Morbidity and mortality rates from pelvic injuries are high. Mortality ranges from 10-30% and increases to about 50% in open pelvic fractures or patients presenting in shock. In order to reduce morbidity and mortality, a detailed and systematic approach in managing the severely injured trauma patient is mandatory.

6.1 ANATOMY

The pelvis is a strong ring-like structure adjoining the spine and the femurs. The bony ring is made up of the sacrum, the ilium, the ischium, and the pubis (see figure below).

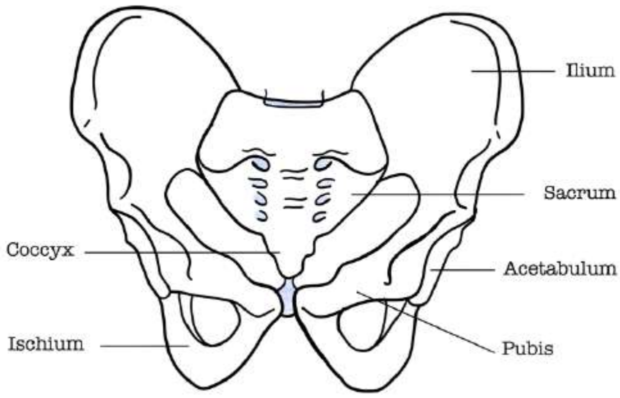

Figure 6.1: Anatomy of pelvic

Each bony component of the pelvic ring is held together by strong bands of fibromuscular ligaments. The pelvis protects the rectum, part of sigmoid colon, urinary bladder, prostate and reproductive organs from injury. Many important blood vessels including the internal and external iliac vessels run through the pelvis. These vessels can be the source of major hemorrhage in an unstable pelvic fracture.

- **Stable pelvic fractures**- refers to bony fracture with intact ligaments.
- **Unstable pelvic fracture**- refers to biomechanical instability, not necessarily associated with hemodynamic instability
- **Unstable pelvic fracture with hemodynamic instability**- refers to unstable pelvic fracture associated with vital sign / hemodynamic instability due to haemorrhage

6.2 MECHANISM OF INJURY

The bony pelvis is a strong and stable structure. Fractures to the pelvis suggest a high impact mechanism involving the transmission of large force to the body. Common mechanisms that cause pelvic disruption are road traffic collisions and fall from heights. There are 4 common mechanisms that cause pelvic fractures:

i) Lateral compression – 60-70% of all pelvic trauma
ii) Anterior Posterior (AP) compression – 15-20%
iii) Vertical shear – 5-15%
iv) Complex or combination pattern

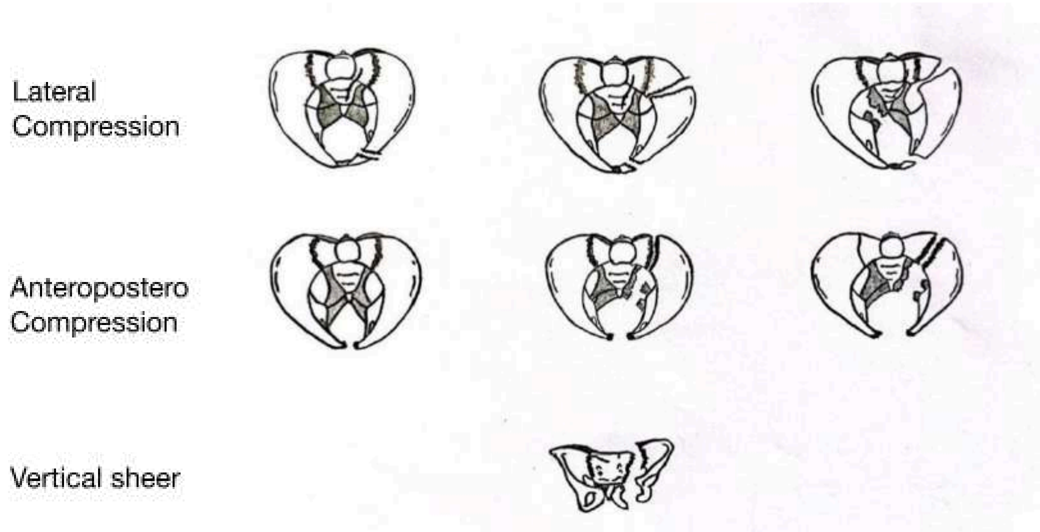

Figure 6.2: Type of Pelvic Injuries Image source:

6.3 ASSESSMENT OF PELVIC FRACTURE

A high index of suspicion is required to achieve early diagnosis of pelvic fractures. It is vital to identify pelvic injury as early as possible during the pre-hospital phase to provide appropriate early management and care.

Upon suspecting a pelvic injury, the pelvis should be immobilized. Pelvic fractures should be suspected in all high impact trauma including motor-vehicle crashes, pedestrian vs motor-vehicle accidents, fall from height and other similar injuries. The presence of an unstable pelvic fracture should be assumed in all such patients. Unless clinically ruled out during initial assessment, a pelvic binder should be placed for all patients. The patient should be transported to the nearest most appropriate hospital for subsequent assessment and management. The binder should only be removed once the pelvis is cleared of an unstable fracture. This can be done through a clinical and radiological assessment (ie. primary survey pelvic x-ray).

“Collar the neck, collar the hips” reminds first responders to immobilize the pelvis early in the care of the severely injured trauma victim. All patients affixed with cervical collar should be considered for placement of circumferential pelvic binders as well. Such is an exemption only in cases where the patient is clearly alert, able to walk, moving both lower limbs, absence of distracting injuries and able to communicate absence of pelvic pain. Always suspect pelvic injuries in patients who are unconscious.

"Collar the Neck, Collar the Hips"

- Unconscious trauma patients
- Polytrauma patients
- High Impact Injuries
- Pain over pelvic region
- Suspicious or unable to rule out presence of an unstable pelvic fracture
- Signs of shock following trauma

ACTION	ASSESSMENT
Inspection	Look for: - Deformity, bruising or swelling over the bony prominences, pubis, perineum or scrotum. - Blood at the urethral meatus or haematuria - Bleeding per rectal or per vagina. - Leg-length discrepancy or rotational deformities of the lower limbs
Palpation	- Gentle one hand pelvic palpation method (Manipulation of a fractured pelvis can potentially increase bleeding) - Per rectal examination – suspicious of rectal injury

Table 6.1: Examination of the pelvis

6.4 INVESTIGATION OF PELVIC TRAUMA

TYPE	INVESTIGATIONS
Laboratory	Trauma Panel 1. Full blood count (FBC) 2. Renal profile (RP) 3. Electrolytes (calcium, magnesium, phosphate) 4. Liver Function Test (LFT) 5. Coagulation Profile (PT/INR/APTT) 6. Fibrinogen 7. Creatine Kinase (CK) 8. Troponin 9. UFEME
Point of Care Imaging	1. E- FAST 2. Primary X-Ray Imaging (Mobile) -Pelvis X-Ray -Chest X-Ray
Radiological & Diagnostics	1. CT scan ie. WBCT for Trauma -CT Pelvis -CT Cystography -CT Angiography

Table 6.2: Investigations for Pelvic Trauma

6.5 MANAGEMENT OF PELVIC FRACTURE

Management of pelvic trauma adheres to the principles of <C> ABCDE concept of primary survey & resuscitation. In the event of no exsanguinating external hemorrhage, the airway and breathing components are assessed and managed first. Subsequently the circulation assessment and hemorrhage control are performed. Any suspicion of pelvic injury should prompt the provider to suspect ongoing / potential life-threatening bleeding and shock. A pelvic binder should be applied in order to mitigate potential hemorrhage and attain tamponade / hemostasis. The pelvic binder should be placed early, preferably in the pre-hospital setting itself.

6.5.1 Out of Hospital management

- The pelvic binder should be placed for all patients whom an unstable pelvic fracture cannot be ruled out. Such patients include, polytrauma cases, unconscious patients, high impact mechanism of injuries, complaints of pelvic pain or whenever the provider is in doubt.
- Do not "log roll" a patient with whom an unstable pelvic fracture hasn't been ruled out. Log rolling a patient with an underlying unstable pelvic fracture will cause further haemorrhage and severe aggravation of the injury. It is preferable to utilize a scoop stretcher when transferring/ transporting these patients.
- Effective immobilization is crucial in order to reduce movements of fractured surfaces, reduce haemorrhage, facilitate tamponade, haemostasis and reduce pain.

Figure 6.3: Pelvic immobilization devices

6.5.2 In-hospital management

- The pelvic binder should be maintained or applied if not applied prior in the prehospital setting. The pelvic binder can then be removed when an unstable pelvic fracture has been ruled out.

- Identify source of bleeding:
  It is not uncommon to have coexisting severe injuries occurring concurrently in a patient with pelvic fractures. Therefore, haemorrhage may also occur simultaneously from other injury sites such as the abdomen or the thorax. It is important to identify these injuries early and initiate appropriate management immediately.

- Associated Injuries commonly related to unstable pelvic fractures

  Visceral Injuries – i.e. bowel, genitourinary system, reproductive organs injuries
  Skeletal Injuries – i.e. acetabular fractures, femur fractures, spine fractures, joint dislocation
  Soft Tissue Injury – i.e. neurovascular injuries, hematoma, Morel-Lavallee lesion, muscle injuries

- Management of unstable pelvic fracture (Figure 6.4)

  Management of an unstable pelvic fracture includes pelvic evaluation, application of pelvic binder, primary pelvis x-ray, FAST and hemodynamic assessment of the patient.

  In a hemodynamically stable patient, further assessment by abdominal and pelvis CT scan is recommended.

  In a hemodynamically unstable patient, damage control resuscitation should be continued. FAST scan should be performed to identify associated intraperitoneal bleeding. A hemodynamically unstable patient with gross intraperitoneal hemorrhage should undergo immediate surgical bleeding control that may include exploratory laparotomy/ damage control surgery.

  Patients may also undergo pelvic fixation, surgical hemostasis (i.e. preperitoneal pelvic packing, internal iliac artery ligation) or angio-embolization of bleeding pelvic vessels

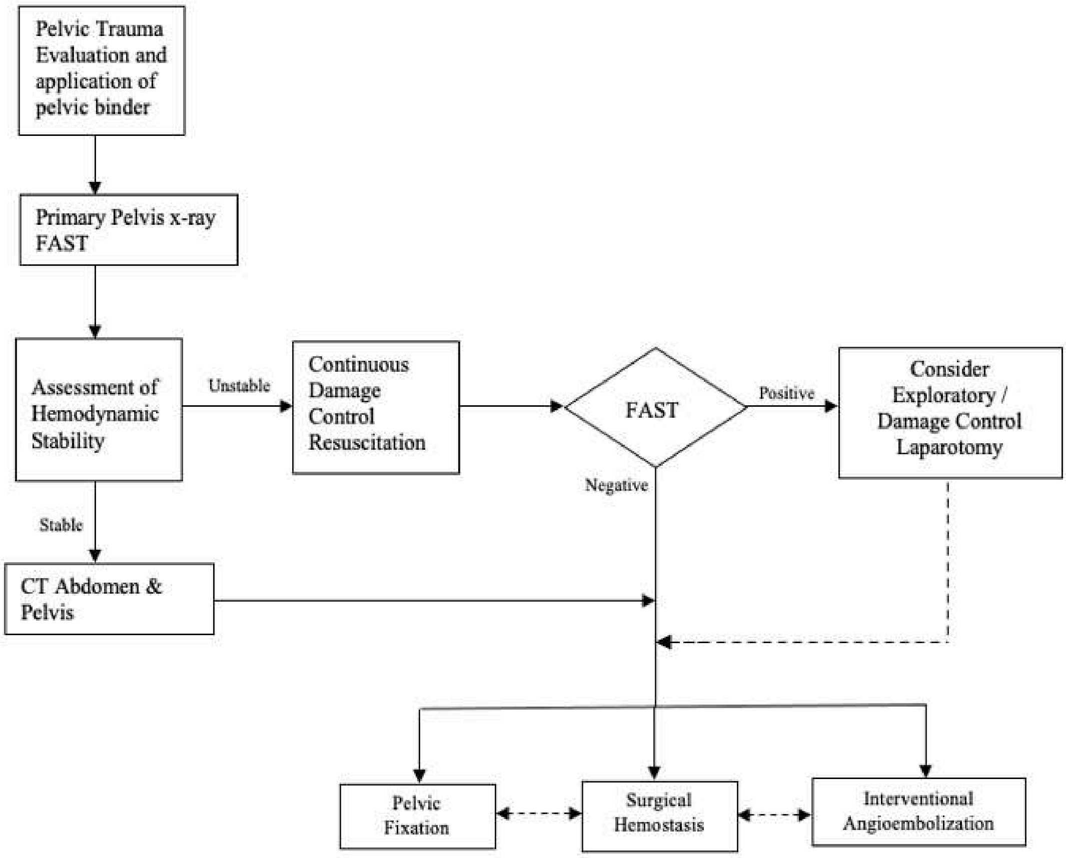

Figure 6.4 : Unstable pelvic fracture management algorithm

6.6 ESSENTIAL POINTS

1. Failure to suspect or detect an unstable pelvic injury will result in significant morbidity and mortality.

2. Do not perform 'pelvic spring' during examination of the pelvis. This will worsen an underlying unstable pelvic fracture.

3. A poorly immobilised unstable pelvic fracture will lead to continued haemorrhage and shock.

4. Do not perform 'log roll' prior to ruling out an unstable pelvic fracture. Log rolling an unstable pelvic fracture will worsen the injury and result in catastrophic haemorrhage.

5. Unstable pelvic fractures are caused by high impact injuries, therefore it is vital to assess for other possible associated injuries i.e. intra-abdominal, retroperitoneal or thoracic injuries.

6. Patients should be reassessed and re-evaluated frequently to identify any changes in the patient's condition.

6.7 SUMMARY

1. Pelvic trauma remains a significant cause of morbidity and mortality. It occurs due to the high impact mechanism of injuries. A thorough systematic primary and secondary survey is required for early identification of pelvic injuries.

2. A suspected unstable pelvis should be immediately stabilized using a pelvic binder or when unavailable, a bedsheet may be used. Early identification, effective pelvic immobilisation and appropriate resuscitation is required to stabilize and successfully manage these patients.

3. Hemodynamically unstable patients may require emergency interventions such as external pelvic fixation, pre-peritoneal packing, emergency angio-embolization, or internal iliac artery ligation. Hemodynamically stable patients should be investigated and further assessed using pelvic CT imaging. However, the patient's hemodynamic may change and it is important to frequently re-assess the patients.

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6.9 SKILL STATION

PELVIC BINDER APPLICATION

Pelvic binder is a noninvasive, life-saving, rapid and an effective pelvic stabilization device. It can be easily applied in out-of-hospital and in-hospital environments.

Objective

1. To understand the principles of pelvic binder application
2. To be able to apply a pelvic binder correctly
3. To be able to recognize various applications of pelvic binders

Principle of Pelvic Binder Application

1. Function
    a. To provide circumferential stabilisation of the disrupted pelvic ring
    b. Reducing potential volume, assist with tamponade and haemostasis formation
    c. Decrease mobility
    d. Reduce pain

2. Indications
    a. Unconscious trauma patients.
    b. Polytrauma patients.
    c. High impact injuries.
    d. Pain over the pelvic region.
    e. Suspicious or unable to rule out presence of an unstable pelvic fracture.
    f. Signs of shock following trauma.

3. Principles of pelvic binder application
    a. At the level of the femoral greater trochanter and symphysis pubis region
    b. Circumferential application with compression
    c. **Never rock / spring** the pelvis.
    d. Do not log roll the fractured unstable pelvis

4. Complication
    a. Skin abrasion
    b. Pressure sores

Method 1

Steps	**Picture**
Step 1 : ● Ensure patient is lying supine ● The pelvis must be stabilised manually by a provider before the binder application ● Fold the pelvic binder belt into two halves. ● Place the folded end of the belt at the level of the greater trochanter of the femur	
Step 2 : ● Prepare the pelvic binder so that the width of the belt would cover the patient's greater trochanter and symphysis pubis region adequately. **Step 3:** ● Place the folded pelvic binder belt at one side of the patient at the level of femoral greater trochanter	
Step 4: ● Perform a controlled "tilt" just enough to pass the pelvic binder belt underneath the patient to reach the midline. Then repeat the "tilt" over the other side just enough to retrieve the folded belt.	

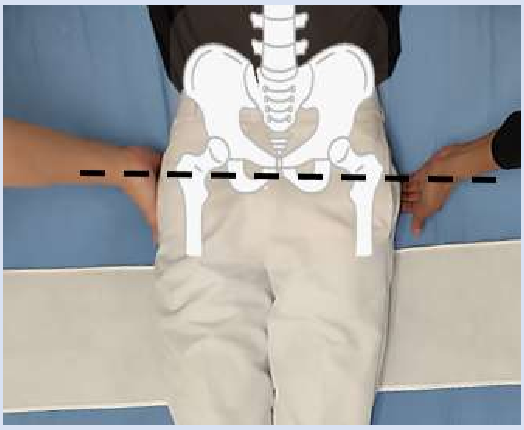
Step 5:

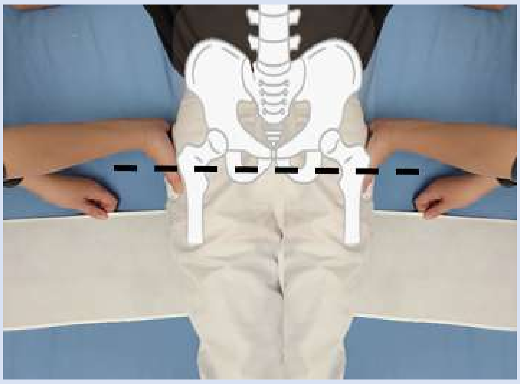
- For commercial pelvic binder, tighten the binder as per manufacturer's instruction.
- A space/ gap of approximately 6 inches should be maintained over the centre of pubic symphysis.
- In male patient, cover the external genitalia with gauze / gamgee before securing the Velcro tension straps of the pelvic binder
- Slowly draw tension creating simultaneous, circumferential compression.
- If bed sheet is used, tighten the sheet by providing circumferential stabilisation of the pelvis and secure the ends of the bedsheet using forceps/clips
- Secure the ankles to minimize external rotation of the thighs.

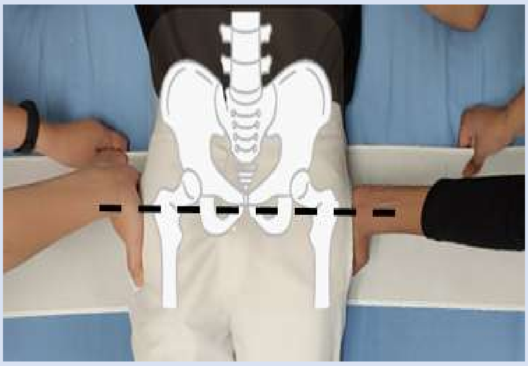
Method 2

Step 1:

- Ensure the patient is lying supine
- The pelvis must be stabilised manually by a provider before the binder application
- Pass the belt under the patient's knees
- Ensure the belt are placed equally on both the sides
- Slide the belt upward cautiously by lifting up gently the pelvis at the level of greater trochanter and place the belt at the correct position.







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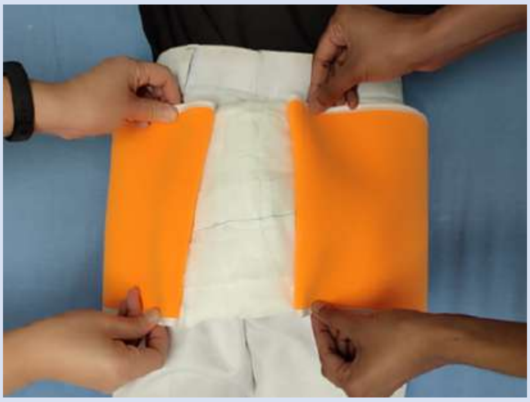

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CHAPTER 7

NEUROTRAUMA

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Able to describe the basic cranial anatomy and physiology.
2. Able to perform comprehensive assessment for patients with head injury including a focused neurological examination.
3. Able to understand the importance of secondary brain injury prevention.

7.1 INTRODUCTION

Head injury is the leading cause of morbidity and mortality among young adults aged below 40 years old. Motor vehicle accidents are the leading cause of trauma and the biggest contributor to premature deaths in Malaysia. 24 out of every 100,000 population die every year due to road related injuries. The majority of motor vehicle accidents inflict blunt injuries. A 2007 Trauma Database report estimated that 90% of these injuries involve the head and neck region.

A systematic approach in managing head injury is crucial to reduce morbidity and mortality. Reliable emergency trauma care is critical in reducing secondary brain injuries and providing best possible outcomes for the patient.

7.2 DEFINITION

Head injury is defined as blunt or penetrating injury to the head from an external force resulting in temporary or permanent impairment in cerebral function. To define head injury, three criteria must be present:

i. **Mechanism** – external force
ii. **Anatomical** – scalp, face, skull with or without brain injury
iii. **Physiological** – alteration in physiology of the brain (i.e. loss of / reduced consciousness, altered mental status, amnesia, seizures etc.)

7.3 CRANIAL ANATOMY

Anatomy of scalp

S - Skin
C - Connective tissue (highly vascular, can bleed profusely)
A - Aponeurosis (tough, tendinous layer)
L -Loose areolar tissue (space for blood to accumulate)
P - Periosteum

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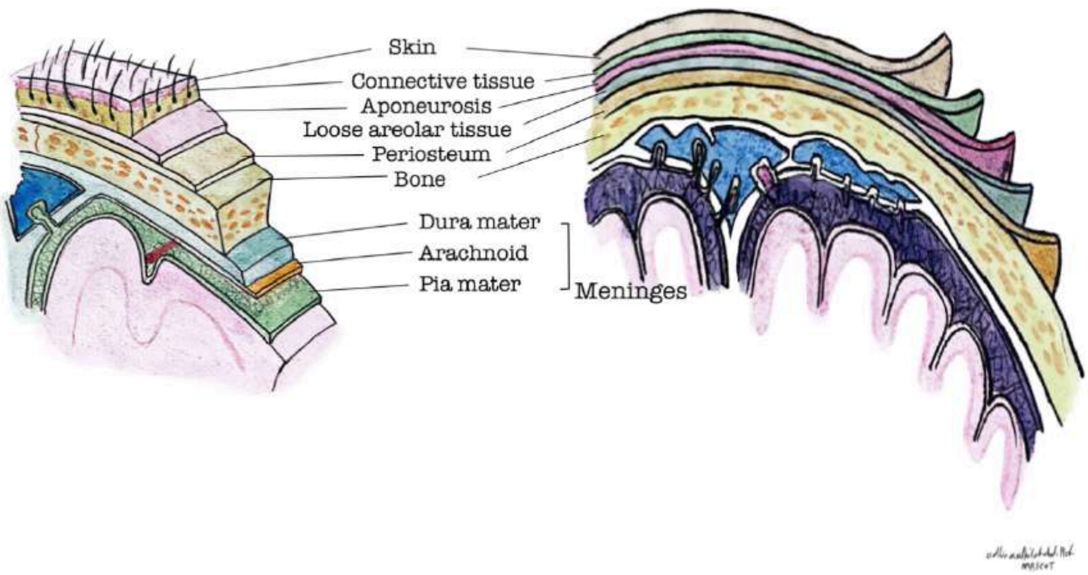


Figure 7.1: Anatomy of Scalp

7.3.1 SCALP INJURY

Injuries and lacerations to the scalp can result in severe hemorrhage due to the enormous blood supply within the scalp. The loose areolar tissue which allows other layers of the scalp to slide off over the pericranium provide a potential space for blood accumulation (subgaleal hematoma). This can cause catastrophic complications in infants with relatively larger head to body surface ratio as the amount of blood accumulated can result in shock.

7.3.2 ANATOMY OF THE SKULL

- The skull is a “rigid box” which is divided into 2 parts: the cranial vault and the base of skull
- The cranial vault is relatively thinner at the temporal region and can be fractured easily. The medial meningeal arteries travel at the inner surface of temporal bone. Thus, a fracture at this site can lead to temporal extradural hematoma.
- The base of the skull is hard, irregular, and rough. It comprises 3 fossae: the anterior, middle, and posterior fossa. Petrous part of the temporal bone in the middle cranial fossa is the hardest part of the skull .
- Acceleration-deceleration force during trauma causes movement of the brain within the skull. The inferior part of the brain is vulnerable to being damaged by the hard, irregular rough surface of the base of the skull during movement.
- Being harder and less exposed, it requires a tremendous force to fracture the base of the skull, thus a fracture indicates a high impact of mechanism.

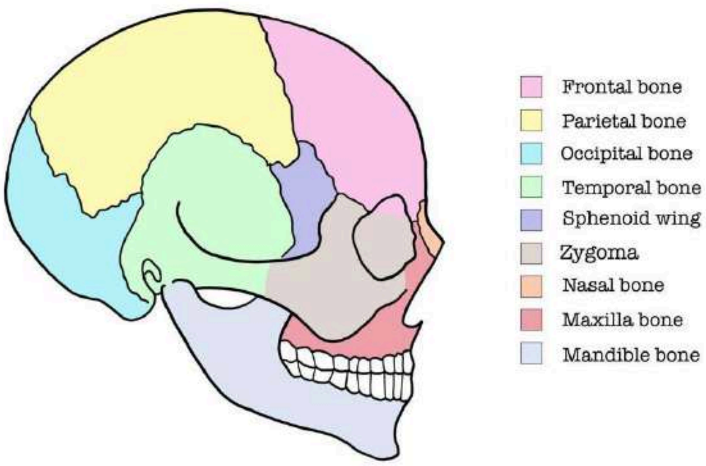


Figure 7.2 : Anatomy of Skull

7.3.3 ANATOMY OF THE MENINGES

- The meninges comprises 3 layers, namely dura, arachnoid and pia mater. It protects the brain and separates it from the bony surface of the skull.
- Dura mater
  - Outermost meningeal layer
  - Tough fibrous membrane closely adhered to the inner surface of the skull
  - Covers the entire brain folding it to form the tentorium

- Beneath the suture lines of the skull lies venous sinuses. If venous sinuses are disrupted during any trauma, blood can collect beneath the dura to form subdural hematoma
- Meningeal arteries lie between the dura and the skull bones. When meningeal arteries are ruptured, bleeding occurs above the dura mater forming epidural or extradural hematoma.

- Arachnoid mater
  - A delicate transparent membrane, found between the dura and the pia mater
- Pia mater
  - A thin but highly vascular membrane
  - Firmly adhered to the surface of the brain

7.3.4 CEREBROSPINAL FLUID

- The cerebrospinal fluid (CSF) is produced by the epithelial cells of the choroid plexus via a process involving the movement of Na^+, Cl^- and HCO^{3-} from blood to the ventricles in the brain at a rate of.
- The daily rate of CSF production is 0.4 ml/min/g tissue per day or 500–600 mls in 24 hours.
- The total CSF volume in the central nervous system is around 150 mls, thus the CSF is replaced three to four times a day.
- The CSF flows between subdural and subarachnoid spaces and is re-absorbed into the arachnoid granulations.
- CSF baths both the brain and spinal cord and is able to absorb “shock” during trauma.
- It is a source of nutrients for the central nervous system.

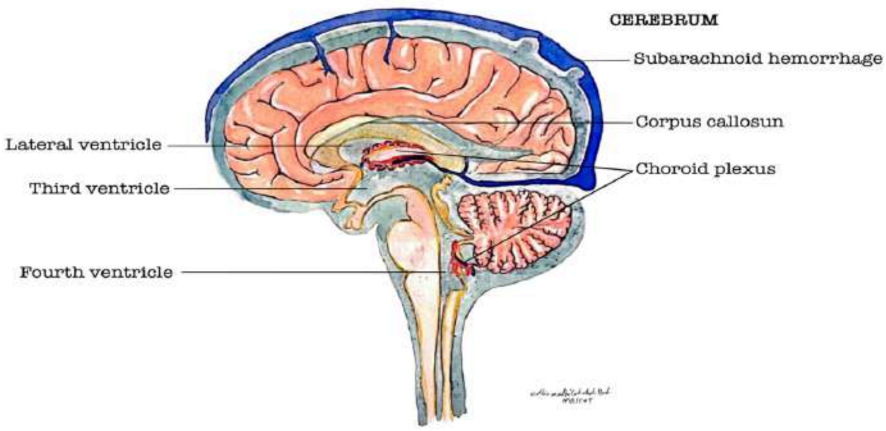


Figure 7.3: Cerebrospinal fluid flow

7.4 BASIC PHYSIOLOGY

7.4.1 Brain

- The brain is divided into 3 major components: cerebrum, cerebellum and brainstem
- Cerebrum
  - o Responsible for higher functions
  - o Consists of 2 hemispheres, each of which is divided into:
    - ▪ Frontal lobe
    - ▪ Occipital lobe
    - ▪ Temporal lobe
    - ▪ Parietal lobe
  - o The left hemisphere controls the right side of the body and vice versa.
- Cerebellum
  - o Controls the coordination and balancing
  - o More primitive
- Brainstem
  - o Consists of the midbrain, pons & medulla
  - o Contain critical structures for maintenance of vital functions
  - o Injury to this portion can be fatal

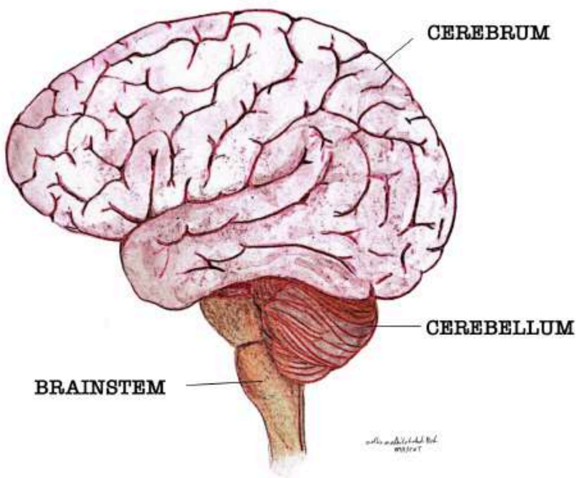


Figure 7.4: Anatomy of brain

Brain cells are incapable of regeneration. Thus, preventing secondary injuries and further damage to the brain after the primary insult is crucial.

7.4.2 Monroe-Kellie Doctrine

- Skull is a rigid box with a fixed volume. Thus, the cranial compartment is incompressible with a fixed intracranial volume.
- 3 main contents that constitute the volume in the cranial fossa is the brain matter, CSF & blood.
- The volume of brain matter, CSF and blood in the cranium at any time must be relatively constant in order to maintain a normal intracranial pressure (ICP) to ensure adequate cerebral blood flow.
- If there is an increase in the volume of any of the 3 main contents of the cranium, the volume of other contents has to be reduced in order to maintain a normal ICP.
- In the event of a rising ICP, CSF will be shunted into the spinal arachnoid space followed by compression of the blood vessels resulting in blood volume and cerebral blood flow reduction. When the critical threshold for the compensatory mechanism has been reached, there will be an exponential rise in ICP.
- As the intracranial pressure volume curve shifts towards the right, small increments in intracranial volume results in exponential rise in ICP.
- This exponential rise in ICP will cause severe reduction in brain perfusion resulting in worsening of secondary brain damage, cerebral herniation and death.
- Pressure increases more rapidly in children and less rapidly in the elderly because of the higher and lower ratios of brain volume to intracranial volume respectively.

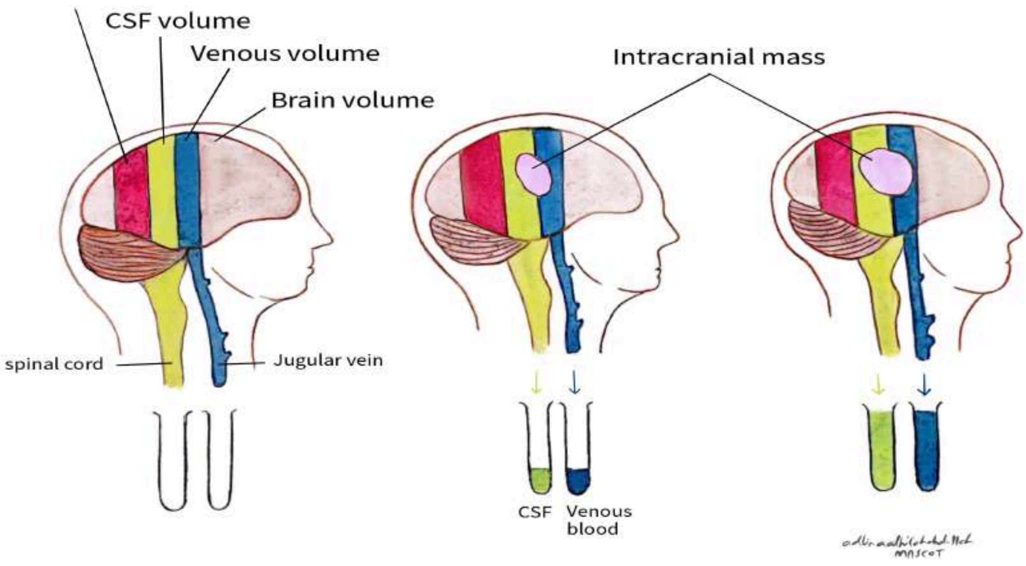


Figure 7.5: Monroe-Kellie Doctrine

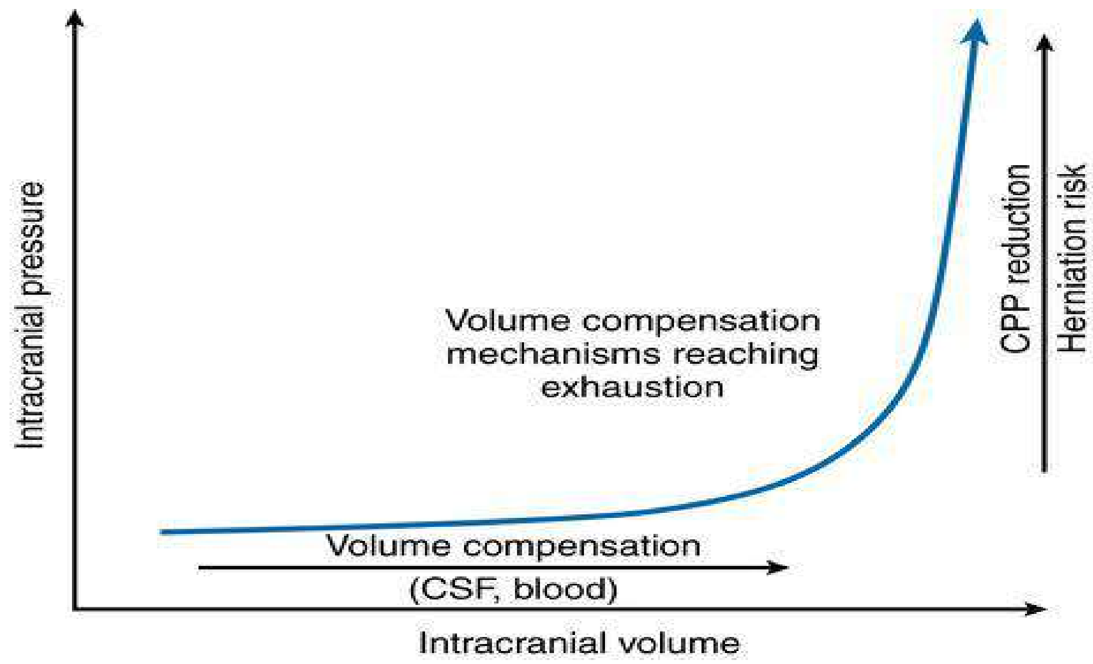


Figure 7.6 Intracranial Pressure vs Volume Curve

7.4.3 Cerebral Perfusion Pressure (CPP)

- Cerebral Perfusion Pressure (CPP)

  = Mean Arterial Pressure (MAP) – Intracranial Pressure (ICP)

CPP = MAP - ICP
Normal = 60 – 70 mmHg

- Normal ICP = 7-15mmHg

  Abnormal ICP = >22 mmHg

- To perfuse the brain, the arterial blood pressure (represented by mean arterial pressure, MAP) must be greater than the intracranial pressure. Otherwise, blood cannot flow into the cranial vault to perfuse the brain.
- When ICP increases, the CPP reduces, resulting in a decrease in cerebral blood flow (CBF) to the brain and thus cerebral ischemia.
- When the MAP is less than the ICP, a reflex called "CNS ischemic response" will be initiated by the hypothalamus. The hypothalamus activates the sympathetic nervous system causing peripheral vasoconstriction to increase cardiac output. These two effects will increase the MAP.

- When MAP exceeds the ICP, blood flow to the brain will be restored. The increased arterial blood pressure caused by the CNS ischemic response stimulates the baroreceptors in the carotid bodies, thus slowing the heart rate drastically causing bradycardia.
- Our body's compensatory mechanism is triggered by increased ICP in order to restore the CPP giving rise to ***Cushing's Reflex:*** hypertension, bradycardia and irregular respiration.
- *Cushing's reflex* helps to salvage the brain tissues during periods of poor perfusion. Unfortunately, it's a late sign of raised ICP and brainstem herniation is imminent.
- Continuous emphasis in ensuring optimal CPP is crucial. During early resuscitation, this can be achieved by adhering to measures of cerebral protection.

7.5 HEAD INJURY CLASSIFICATION

I. By Mechanism
   - Blunt
   - Penetrating
   - Combination

II. By Severity
   - Mild : GCS 13-15
   - Moderate : GCS 9-12
   - Severe : GCS 3-8

III. By Etiology
   - Primary brain injury
     - Induced by mechanical force and occurs directly because of the impact. Two main mechanisms involved are direct impact or acceleration - deceleration injury.
   - Secondary brain injury
     - Delayed brain injury that occurs after the initial insult. It is due to multiple factors including the effect of co-existing injuries, comorbidity, resuscitation as well as the environment.

7.6 INTRA & EXTRA-CRANIAL INJURIES

7.6.1 EXTRACRANIAL INJURIES

7.6.1.1 Scalp Injury – Subgaleal Haematoma

- Hematoma that occurs within the potential space between the periosteum and the galea aponeurosis
- In neonates and toddlers, subgaleal hematoma can be potentially fatal. Without appropriate resuscitation, the continuous accumulation of the hematoma may lead to shock.
- Subgaleal hematoma is diagnosed clinically by a fluctuant, boggy mass developing insidiously over the scalp.
- It occurs due to rupture of the emissary veins and commonly associated with intracranial hemorrhage and skull fractures.
- The hematoma can cross suture lines in contrast to cephalohematomas.
- Management includes identification, vigilant observation, search for associated injuries and management of hypovolemia. Blood transfusion may be necessary.

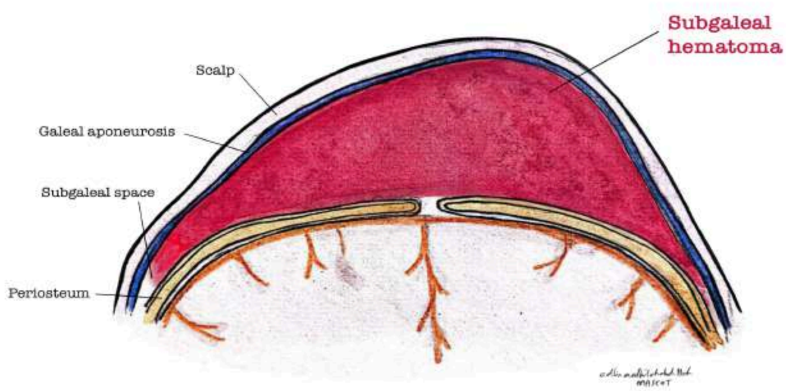


Figure 7.7: Extracranial Subgaleal Hematoma

Figure 7.8: Scan of the Brain Demonstrating Extensive frontal-temporal Extracranial Subgaleal Hematoma in an 85 Year Old Adult Female
Case courtesy of Dr Bruno Di Muzio, Radiopaedia.org, rID: 32115

7.6.1.2 Scalp Injury – Cephalohematoma

- Cephalohematomas or subperiosteal haematoma resulting from accumulation of hematoma between the potential space of the skull and the periosteum.
- It is caused by the rupture of blood vessels crossing the periosteum.
- Cephalohematoma is bounded by the periosteum, thus it does not cross the suture lines in contrast to subgaleal hematoma.
- Clinically, it presents as a well demarcated soft tissue swelling and is commonly managed conservatively.
- Avoid aspirating the accumulated blood due to risk of infection and abscess formation.

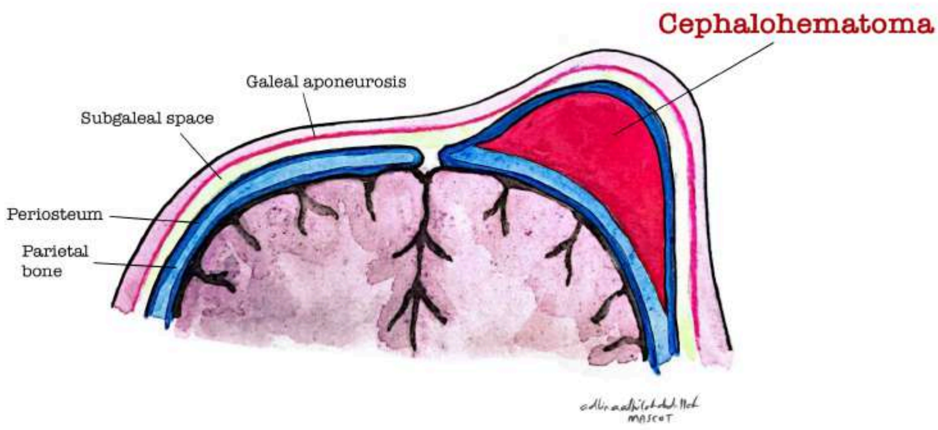


Figure 7.9: Cephalohematoma

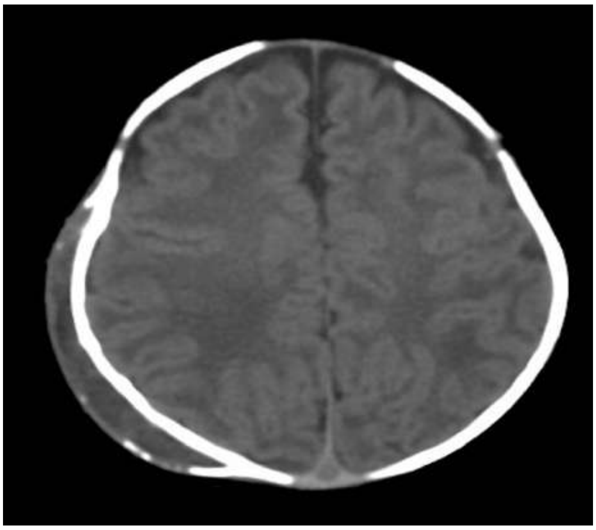


Figure 7.10: CT-Scan of Brain Demonstrating Large Extracranial Right Parieto-Occipital Cephalohematoma in a 1 Week Old Infant
Case courtesy of Dr Fakhry Mahmoud Ebouda, Radiopaedia.org, rID: 84771

7.6.2 INTRACRANIAL INJURIES

7.6.2.1 Extradural Hemorrhage

- Accumulation of blood between the inner surface of the skull and the dura mater.
- Commonly caused by a tear of the middle meningeal artery.
- It is characterized by the presence of a lucid interval after injury.
- Biconvex, lens-like hyperdense lesion which does not cross suture lines on CT brain.
- Requires immediate clot evacuation if causing mass effect.
- Excellent prognosis if treated surgically promptly.

7.6.2.2 Subdural Hemorrhage

- Accumulation of blood between the dura mater and the brain.
- Commonly caused by tears of the bridging veins which cross the subdural space and bleeding from the cortical surface.
- Clinical presentation: altered mental status, progressively worsening of headache or confusion.
- Concave, crescent shape hyperdense lesion which can cross the suture lines on CT brain.
- Early evacuation may improve outcomes.
- High risk of mortality (up to 70%)

7.6.2.3 Intracerebral Hemorrhage (ICH)

- Accumulation of blood within the brain parenchyma.
- Hyperdense lesions seen at either frontal, temporal or occipital region on CT brain.
- Usually presenting with altered mental status and neurological deficits.

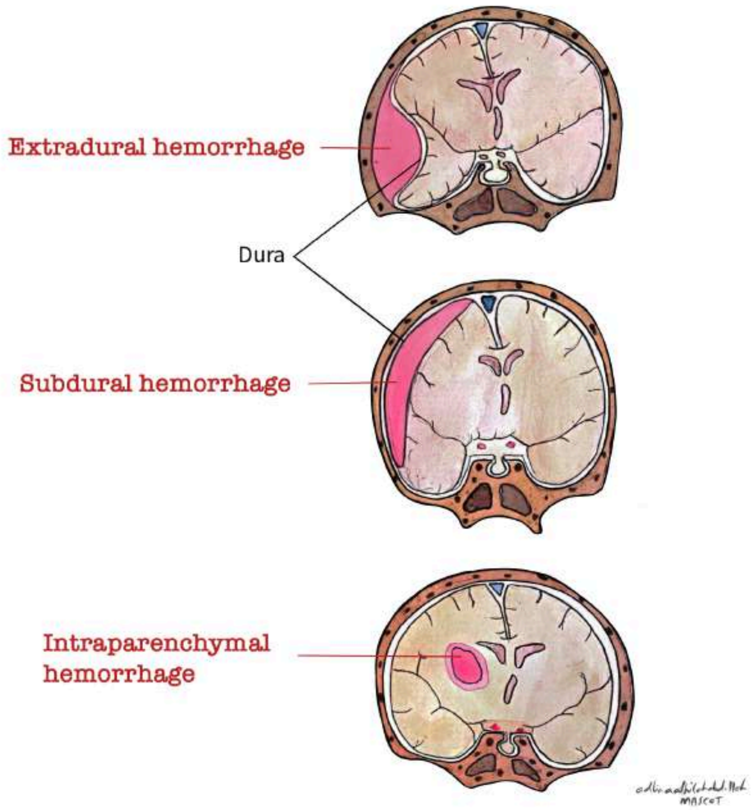


Figure 7.11: Extradural hematoma, Subdural hematoma, Intraparenchymal hematoma.

(a) (b) (c)

Figure 7.12: CT-Scan of Brain demonstrating

(a) Extradural hemorrhage (b) Subdural hemorrhage (c) Intraparenchymal hemorrhage

7.6.2.4 Brain contusion

- Results from shearing force on the cortex.
- Usually occurs at the inferior surface of the frontal or temporal lobes.
- Can be associated with subarachnoid hematoma (SAH) or intracerebral hematoma.

7.6.2.5 Diffuse Axonal Injury (DAI)

- Due to traumatic shearing forces during acceleration- deceleration and rotational motion.
- Resulting in disruption of axons in the white matter of the brain.
- Commonly affects areas like the brainstem, corpus callosum and cerebral hemispheres.
- CT scan may show no gross abnormality or small petechial hematoma characteristically at the grey-white matter interface (predominantly in frontal and temporal lobes), corpus callosum (especially in the splenium) and the brainstem (dorsolateral midbrain)
- DAI carries a high morbidity and mortality rate.

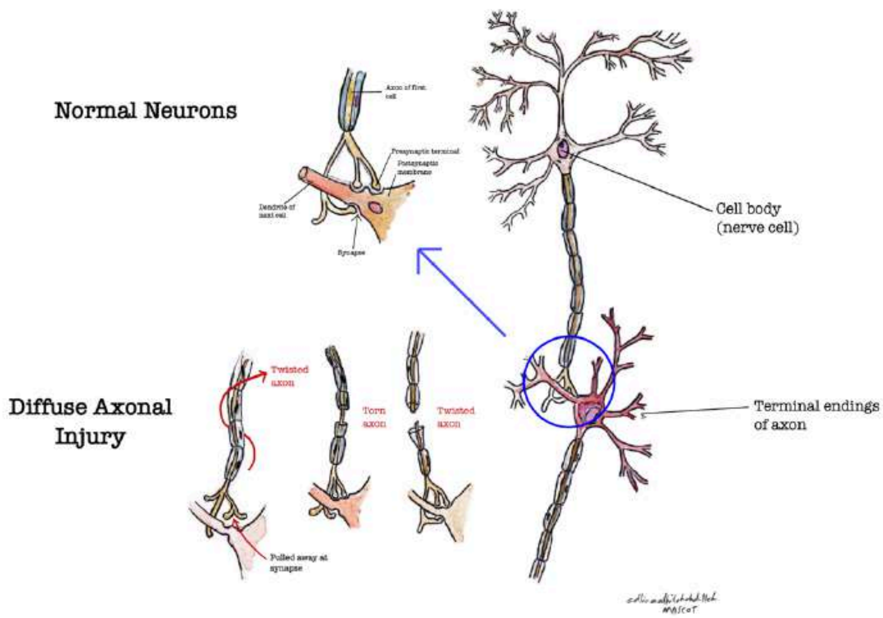


Figure 7.13: Diffuse Axonal Injury

7.7 CLINICAL EXAMINATION

7.7.1 PRIMARY SURVEY

- Examine <C> ABC as per primary survey.
- Ensure the airway is patent and cervical spine is protected at all times
- Assess regularity and pattern of breathing. Support ventilation if necessary.
- Assess and stabilize circulation. Perform hemorrhage control if required.
- Assess the patient's neurological status. Examine for conscious level (GCS or AVPU), pupillary reflexes and neurological deficits

7.7.2 SECONDARY SURVEY

- MAPLE history.
- Examine the head and face thoroughly.
- Look for evidence of basal skull fracture
    - Raccoon’s eyes – bilateral periorbital ecchymosis
    - Battle’s sign – mastoid ecchymosis
    - CSF rhinorrhoea/otorrhea (Halo Sign)
    - Hemotympanum
- Examine for facial fractures
    - Le Forte fractures – palpate for tenderness, crepitus and instability over the facial bones.
    - Orbital rim fracture – palpable step-off, periorbital edema, proptosis.
- Perform a complete neurological examination
    - Assess for tone, motor, power and reflexes
    - Sensory examination
    - Cranial nerve examination
    - Cerebellar examinations

7.7.3 INVESTIGATIONS

7.7.3.1 Blood Investigations

- Trauma blood panel

7.7.3.2 Imaging

- Plain CT scan of the brain should be the modality of choice in identifying traumatic intracranial hemorrhage.
- Consider CT scan of the cervical spine in indicated cases.
- Skull X-Ray:
  - There is no role for skull x-ray to identify traumatic intracranial brain hemorrhage or injury.
  - Skull x-rays can be used to identify isolated scalp foreign bodies, simple linear or depressed skull fractures in centers without CT modality.

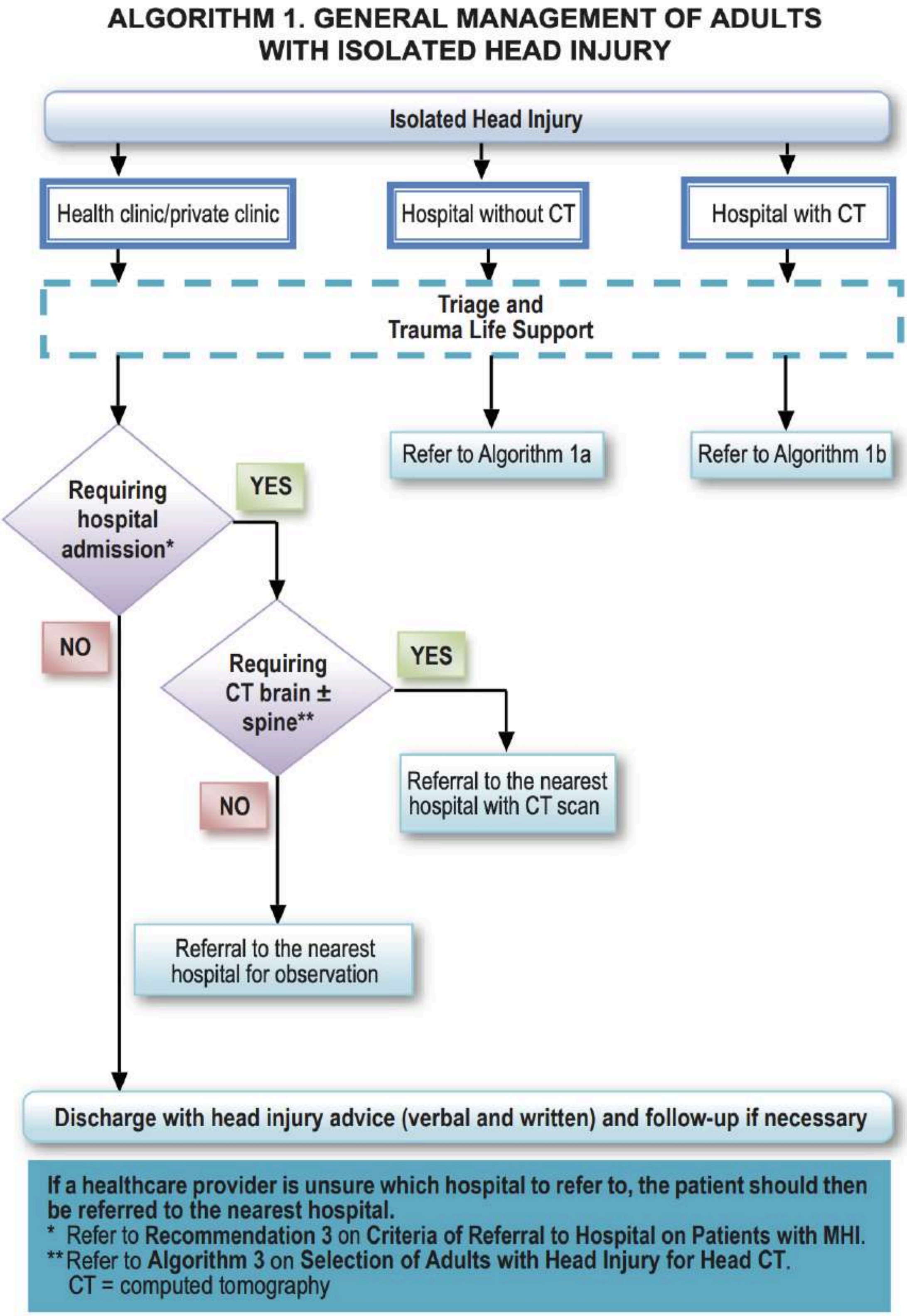


Figure 7.14 : General Management of Adults with Isolated Head Injury

Adopted from : Early Management of Head Injury in Adults, Ministry of Health Malaysia Clinical Practice Guidelines, MOH/P/PAK/304.15(GU), 2015

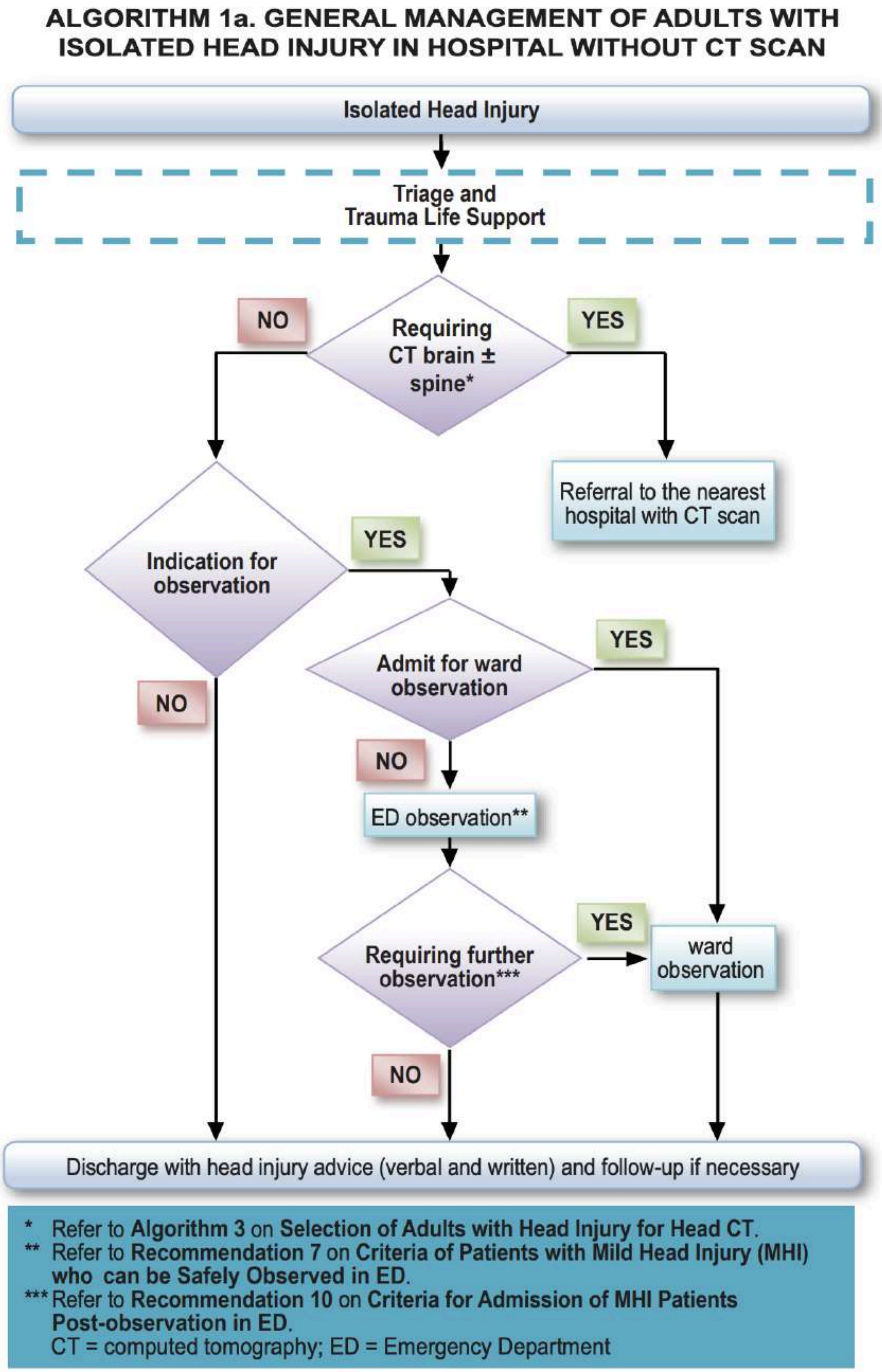


Figure 7.15: General Management of Adults with Isolated Head Injury in Hospitals without CT Scan

Adopted from : Early Management of Head Injury in Adults, Ministry of Health Malaysia Clinical Practice Guidelines, MOH/P/PAK/304.15(GU), 2015

ALGORITHM 1b. GENERAL MANAGEMENT OF ADULTS WITH ISOLATED HEAD INJURY IN HOSPITAL WITH CT SCAN

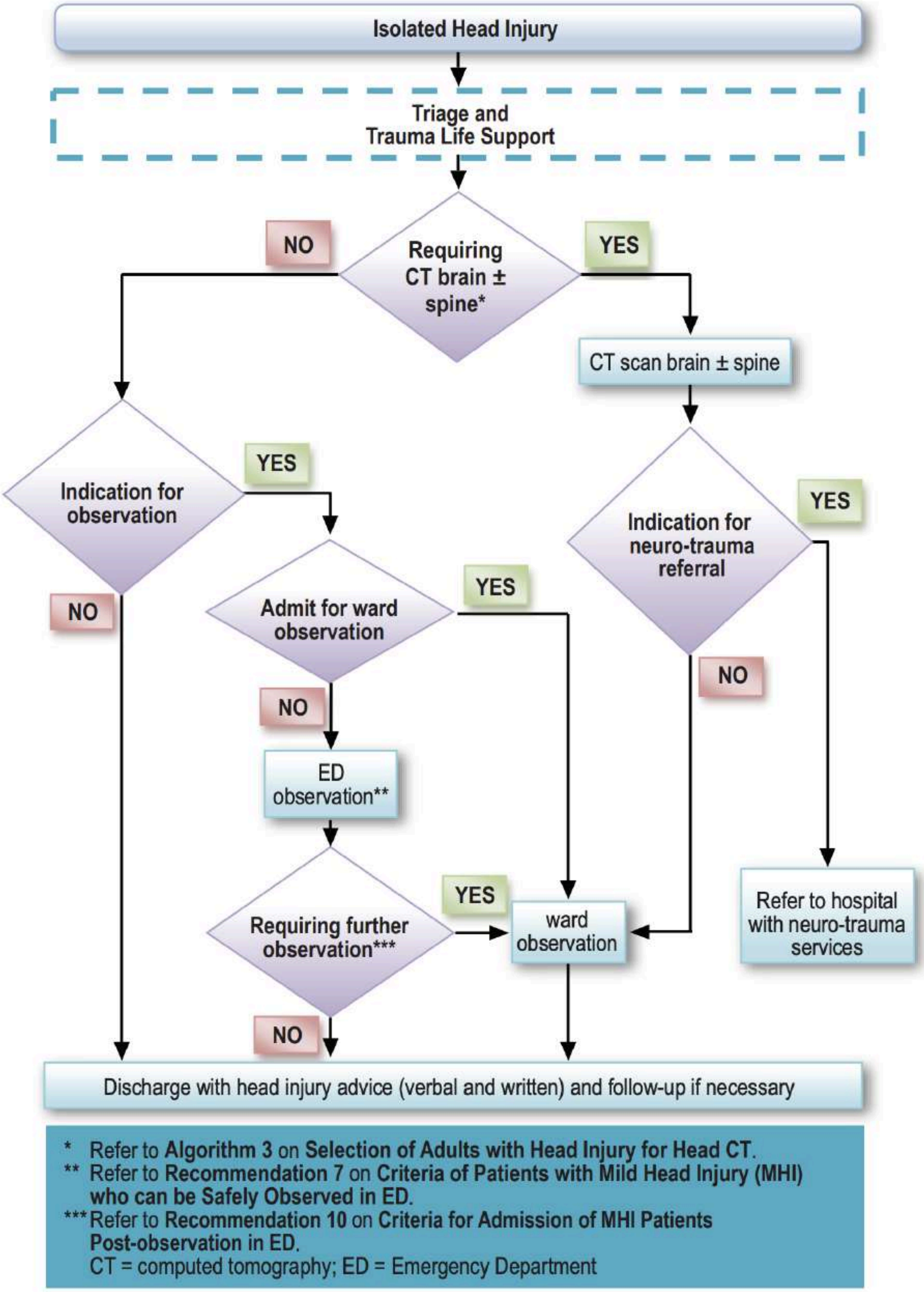
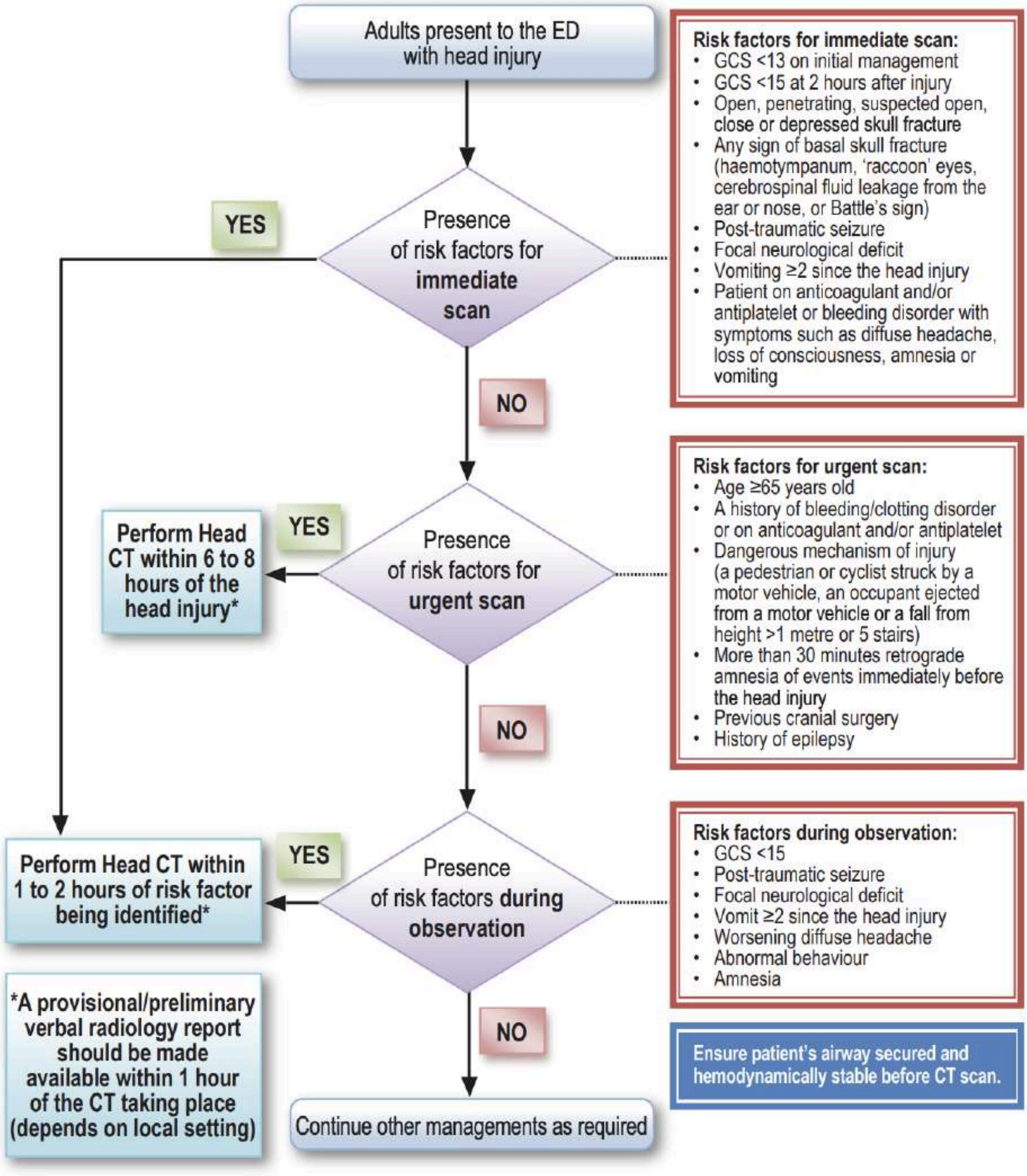


Figure 7.16 : General Management of Adults with Isolated Head Injury in Hospitals with CT Scan

Adopted from : Early Management of Head Injury in Adults, Ministry of Health Malaysia Clinical Practice Guidelines, MOH/P/PAK/304.15(GU), 2015

ALGORITHM 3. SELECTION OF ADULTS WITH HEAD INJURY FOR HEAD CT



Adapted: National Institute for Health and Care Excellence. Triage, assessment, investigation and early management of head injury in children, young people and adults. London: NICE; 2014.

Figure 7.17 : Selection of adults with head injury for CT Scan

Adopted from : Early Management of Head Injury in Adults, Ministry of Health Malaysia Clinical Practice Guidelines, MOH/P/PAK/304.15(GU), 2015

ALGORITHM 4. SELECTION OF ADULTS WITH HEAD INJURY FOR IMAGING OF THE CERVICAL SPINE

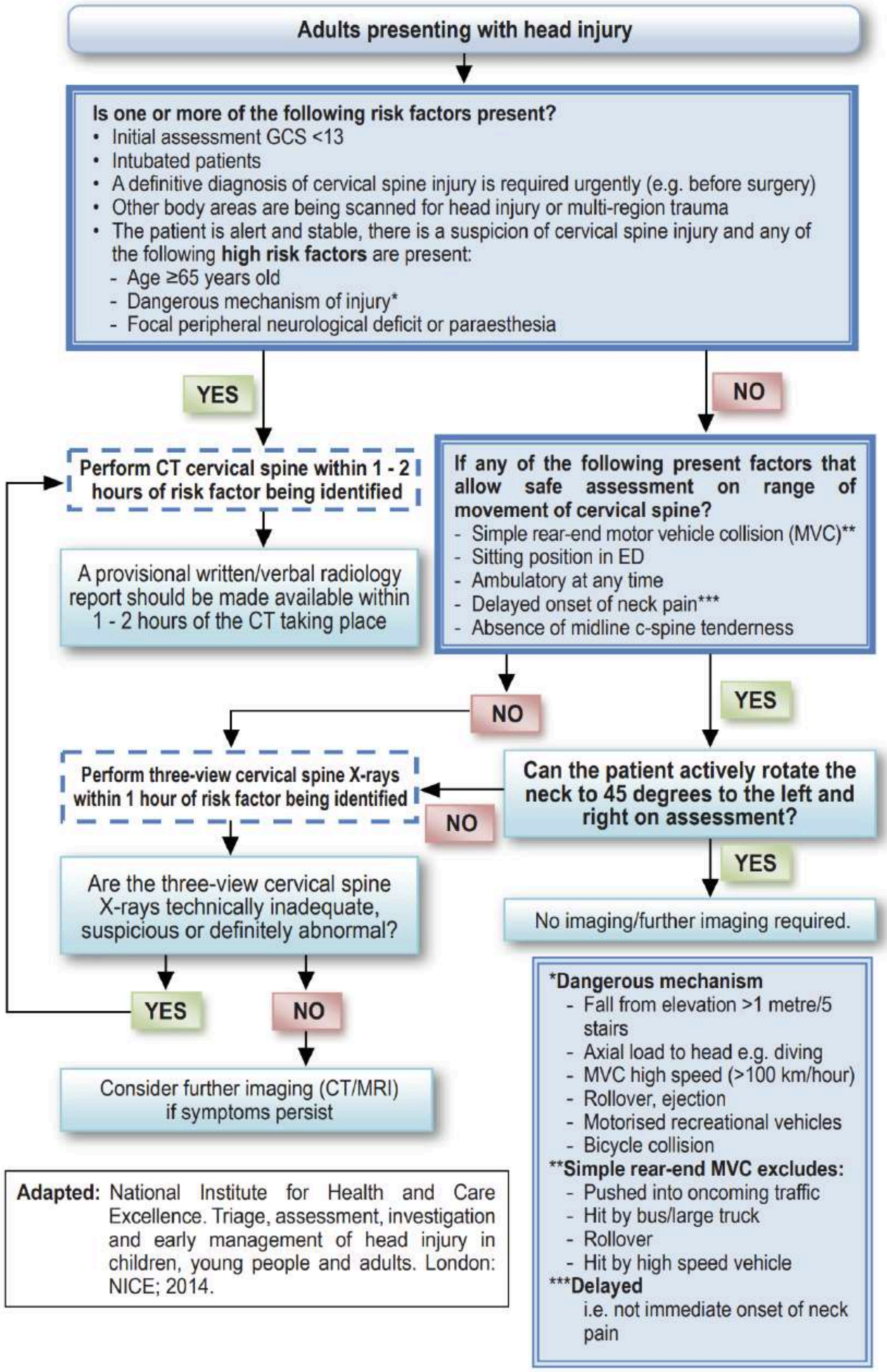


Figure 7.18 : Selection of adults with head injury for imaging of cervical spine

Adopted from : Early Management of Head Injury in Adults, Ministry of Health Malaysia Clinical Practice Guidelines, MOH/P/PAK/304.15(GU), 2015

Referral Recommendation for Head Injury Management

Referral of patients with mild head injury to the nearest hospital should be considered especially if they have any of the following factors:

- Glasgow Coma Scale (GCS) of 15 but symptomatic such as amnesia, headache, vomiting or restlessness
- Age >65years old
- Treated with anti-platelets or anticoagulants
- Alcohol intoxication and substance abuse
- Focal temporal blow
- Social issues
- Indicated for head CT (refer to Algorithm 3 on Selection of Adults with Head Injury for Head CT)

Patient Criteria for ED Observation (Without CT Brain Indication)

Patients with mild head injury in whom computed tomography scan is not indicated and with all the following criteria can be safely observed in emergency department for a minimum of six hours:

- Glasgow Coma Scale score 15 on arrival or two hours later
- No neurological abnormality
- Age < 65 years old
- Not on any anticoagulant or anti-platelet therapy
- No history of coagulopathy
- No multiple injuries

Ward Admission Criteria For Mild TBI Patients

Patients with mild head injury who have been observed for six hours in emergency department should be admitted to ward if they have :

- Clinically significant abnormalities on head computed tomography (CT) imaging
- Glasgow Coma Scale Score < 15*
- Worrying signs (e.g vomit >2 times, seizure, diffuse headache, amnesia, abnormal behaviour or neurological deficit)*
- Other body system injuries requiring admission
- Social problem** including no supervision by a responsible adult

* Patients should have a head CT before admission.
**Transport issue, no communication, stay in remote area, suspected abuse case or other factors affecting the monitoring and safety of patients

7.8 MANAGEMENT

7.8.1 Immediate resuscitation and stabilization of patients.

A - Airway + Cervical Spine Immobilisation

- Ensure airway patency. Clear all secretions or blood.
- Perform jaw thrust in trauma patients for airway opening.
- If the patient unable to protect his airway (i.e. GCS ≤8, absent gag reflex), use airway adjuncts such as an oropharyngeal airway.
- Insertion of nasopharyngeal airway (NPA) and gastric tube via nasal route is relatively contraindicated in patients with suspected basal skull fracture. Orogastric route is preferred. However, intracranial insertion via the perforated cribriform plate is very rare.
- In a compromised airway, the risk versus benefit of inserting NPA must be taken into consideration.

- Consider endotracheal intubation for airway protection in the following patients:
  - Severe head injury patients with GCS ≤8.
  - Inability to maintain airway (i.e. bleeding from oral cavity).
  - Potential airway obstruction from an expanding swelling or hematoma.
  - Inhalational Injury.
- Apply cervical collar for suspected cervical spine injury in traumatic head injury patients.
- Manual in-line immobilization must be performed in suspected cervical spine injury and rapid sequence intubation is the preferred choice of intubation technique.

B – Breathing & Ventilation

- Maintain $SpO_2 > 90\%$ and PaO2 > 60mmHg.
- Provide supplemental oxygen if indicated.
- In severe head injury patients, aim to keep $PaCO_2$ within 35 - 40mmHg.

C - Circulation and Hemorrhage Control

- In suspected severe head injury patients, target MAP ≥ 80 - 90 mmHg.
- Balanced isotonic crystalloid is preferred over normal saline as the choice of crystalloid fluid used for resuscitation.
- Do not use hypotonic crystalloids such as dextrose base solution in head injury patients to prevent further cerebral edema and increasing ICP.

D – Disability & Neurology Deficit

- Assess patient's Glasgow Coma Scale (GCS) (Table 7.1).
- Assess the patient's pupils size and reactivity. Unequal pupils may indicate an uncal herniation and raised ICP.

E – Exposure & Environment control

- Expose the patient fully and examine for any other injuries.
- After examination, ensure and maintain normothermia.

GLASGOW COMA SCALE			
Eye Opening (E)	**Original Scale**	**Eye Opening (E)**	**Revised Scale**
Spontaneous opening	4	Spontaneous opening	4
To speech	3	To sound	3
To pain	2	To pressure	2
None	1	None	1
		Non-testable	NT
Verbal Response (V)		**Verbal Response (V)**	
Orientated	5	Orientated	5
Confused conversation	4	Confused	4
Inappropriate words	3	Words	3
Incomprehensible speech	2	Sounds	2
None	1	None	1
		Non-testable	NT
Best Motor Response (M)		**Best Motor Response (M)**	
Obeys commands	6	Obeys commands	6
Localizes pain	5	Localizing	5
Flexion withdrawal to pain	4	Normal flexion	4
Abnormal flexion (decorticate)	3	Abnormal flexion	3
Abnormal extension (decerebrate)	2	Extension	2
None (flaccid)	1	None (flaccid)	1
		Non-testable	NT

Table 7.1 : Glasgow Coma Scale

7.8.2 Early recognition and treatment of intracranial injury.

- Urgent plain CT brain to detect intracranial hemorrhages and cranial vault fractures.
- Early neurosurgical intervention in surgically indicated patients.

7.8.3 Cerebral resuscitation to prevent secondary brain injury

- Institute cerebral protection measures early
  - Prop up the head of the bed to 30°
  - Avoid excessive flexion of the head or pressure around the neck that may impair cerebral venous return
  - Early removal of rigid cervical collar

- Pharmacological intervention
    - Adequate oxygenation
    - Maintain MAP≥ 80-90mmHg to ensure adequate CPP. Balanced isotonic crystalloid is the preferred choice of fluid in head trauma.
    - Ensure normocapnia, aim for $PaCO_2$ of 35-40mmHg
    - Ensure adequate sedation and analgesia. Appropriate sedation depth will reduce cerebral metabolic rate and cerebral oxygen consumption
    - In mild to moderate head injury:
        - analgesic should be offered when it is indicated
        - short-acting sedative agent may be offered in titrated dose to control agitation/restlessness
    - Phenytoin is recommended as prophylaxis against early post-traumatic seizure in head injury with risk factors (severe head injury, depressed skull fracture, penetrating head injury, and intracranial bleed). Control seizure activity with anti-epileptics.
    - Maintain strict glycemic control between 4-10 mmol/l.
    - Consider usage of hypertonic solution (Mannitol) if evidence of raised ICP.

- Surgical intervention
    - Intracranial pressure monitoring
    - Decompressive craniotomy / craniectomy

7.8.4 Indications for ICP monitoring

- Severe head injury (GCS ≤ 8) + abnormal CT brain
- Severe head injury (GCS ≤ 8) + normal CT brain if 2 of the following are present:
    - Age >40 years old
    - BP ≤ 90mmHg
    - Abnormal motor posturing
- Moderate head injury who cannot be serially neurologically assessed (anesthetized and sedated).

7.8.5 Surgical indication for extradural hematoma (EDH)

- EDH > $30cm^3$ regardless of GCS score
  - EDH < $30cm^3$, less than 15mm thickness, GCS score > 8 and without focal deficit can be managed non-operatively with serial CT scan and close neurological observation in neurosurgical centers.

7.8.6 Surgical indication for acute subdural hematoma (SDH)

- SDH > 10mm or midline shift > 5 mm regardless of GCS score
- SDH in coma GCS ≤ 8 should undergo ICP monitoring
- Coma patient GCS ≤ 8 with SDH <10mm thick, midline shift <5mm should undergo surgical evacuation :
  - If GCS score decrease ≥ 2 point
  - Asymmetrical or fixed and dilated pupils
  - Persistent ICP > 20mmHg

7.8.7 Surgical indication for traumatic intra-parenchymal bleed

- Patient with progressive neurological deterioration, medically refractory intracranial hypertension or sign of mass effect on CT scan
- Frontal or temporal contusions > $20cm^3$ with midline shift >5mm or cisternal compression on CT scan
- Any lesion >$50cm^3$

7.9 GCS & PTA ASSESSMENT

- Post-Traumatic Amnesia is defined as the period in which an individual has either, no recollection of memory prior to the events leading to the head injury (retrograde amnesia) or the inability of the brain to continuously create and recall new formed memory (anterograde amnesia).
- PTA can occur as a sequel of mild-TBI. The duration of PTA has been defined as the interval period between the point of injury and resumption of continuous normal memory.
- The behavioral changes may be minimal, but most commonly, patients exhibit defective memory and confusion, which often is obvious to the patient's social circle.
- PTA studies also illustrate that impairment commonly occurs in the episodic memory while sparing procedural memory.
- A common symptom of cognitive impairment is memory loss or amnesia.
- Identifying persistent PTA in the context of recent head injury (PTA) would signify presence of underlying brain damage despite the presence of a normal CT-brain and a full GCS
- Patients with PTA should undergo further neurological assessments and potentially benefit from subsequent neuro-rehabilitation follow up. Morbidity in undiagnosed cases is high.
- The assessment of PTA should be incorporated into the routine observation and GCS assessment which is performed for "Cerebral Concussion" patients in the Emergency Department Observation wards.

Indication for PTA Assessment (Post Traumatic Amnesia)

All mild TBI patients with GCS 15/15 presenting with the following;

- History of loss of consciousness or amnesia
- Symptoms of giddiness, headache, vomiting, confusion or other signs affecting normal neurophysiology

- The A-WPTAS (Abbreviated Westmead Post Traumatic Amnesia Scale) is a validated screening tool to assess PTA for the first 24 hours post injury. The AWPTAS has been shown to be more accurate than the Glasgow Coma Scale (GCS) in identifying cognitive deficits in Mild TBI patients.
- Patients subjected for A-WPTAS assessment are those whom have
    - sustained closed mild-TBI
    - impact to the head resulting in confusion, disorientation, loss of memory, loss of consciousness
    - those observed in the ED for head charting.
    - This group of patients may or may have not had a CT brain Imaging done.
- A-WPTAS assessment requires the patient to be able to provide a response to verbal communication and demonstrate optimal scores on the motor and eye opening components of the GCS.
- The tool incorporates the GCS component of “Motor”, “Eye”, an elaborated verbal assessment and a 3-picture card memory test. The “Motor” and “Eye” component assessment is similar to the GCS assessment scale. The “Verbal” assessment is elaborated with a specific 5 Question assessment. The 3-picture card test would assess the ability of the brain to retain new-formed memory.
- The verbal component of the GCS is divided into 5 questions of which need to be answered accurately. Any one wrong answer would score a 4/5. Incomprehensible words and sounds would score a 3/5 and 2/5 respectively.
- The maximum total A-WPTAS score is 18, 15 from the GCS and another 3 from the picture card component. Patients who score 18/18 are deemed not to be in PTA or had recovered from it.
- In the event that the patient fails the test, it is then repeated in a serial manner (each hour for 4 hours), enabling the medical team to gauge the approximate duration of PTA, which evidently is prognostic to the severity of underlying brain injury.
- The A-WPTAS suggests patients who are in persistent PTA to be considered for admission and formal cognitive / PTA assessment in the ward.

7.10 A-WPTAS

The GCS eye and motor assessment is performed as it is. The verbal assessment is elaborated with the patient having to accurately answer 5 questions, also known as the “5 orientation questions”.

i) What is your name?

ii) What is the name of this place?

iii) Why are you here?

iv) What month are we in?

v) What year are we in?

Q1. What is your name?

The patient needs to answer his or her full name. The right answer will score “1” and the wrong answer will score”0”.

Q2. What is the name of this place?

The answer should be, e.g. Hospital Kuala Lumpur. If the patient answers, I don’t know, then provide multiple choices e.g. Are you at home, at the hospital or at a hotel? If the patient answers, either home or hotel, then score them as “0”. If the answer is “Hospital”, then ask further, e.g. What is the name of this Hospital? If the answer is wrong, then the score is “0”. If the patient answers “I don’t know”, provide 3 choices of hospitals, e.g. Is this Hospital Kuala Lumpur, Hospital Universiti Malaya, or Hospital Sungai Buloh? Correct answers after prompting will score “1” but will need to be prefixed with the letter “P” next to the score.

Q3. Why are you here?

The patient needs to know why they were brought to the hospital, e.g. injured in a car accident, or had a fall climbing the staircase or slipped and fell backwards on a wet floor etc. If a patient doesn’t spontaneously answer, or provides a wrong reason, the score is “0”. If the patient answers “I don’t know”, the examiner needs to prompt with 3 options, which includes the correct answer. e.g. Are you here because you were injured in a car accident?, had a fall climbing the staircase? or slipped and fell backwards on a slippery floor? A correct answer will score “1” and a false answer scores “0”. A correct answer with prompting will be prefixed with a “P” next to the score.

Q4. What month are we in?

The patient would need to state the correct month, e.g. July. If the patient answers the wrong month, then the score is “0”. If the patient says the 7^{th} month, the examiner needs to clarify, e.g. what is the name of the 7^{th} month? The patient needs to answer July in order to score “1”.

Q5. What year are we in?

The patient needs to know the correct year, e.g. 2018. A wrong answer will score “0”. If the patient doesn’t spontaneously answer or says I don’t know, provide 3 years in sequence as a prompt, which includes the real answer. e.g. Is this 2017, 2018 or 2019 ? A right answer will score “1” and prefixed with a “P”.

If the patient scores “0” for any of the 5 orientation questions, the examiner needs to provide the patient with the correct answer. This is done before moving on to the next question.

<u>3-Picture Card Test & 9-Picture Recognition Chart</u>

- After completing the 5 orientation questions, the patient is then provided with the 3-picture cards (Refer Fig. 7.19). It should be clearly displayed and explained that these 3 cards are pictures of a ***cup,*** a ***bird*** and ***keys***. The patient is then requested to repeat while identifying the pictures shown. The patient is told to remember these 3 items and will be asked to recall them in 1 hours’ time.

- After 1 hour, the 5 orientation questions are re-assessed. Subsequently, the patient is asked to verbally recall the 3 picture items that were previously displayed. If the patient is not able to recall all 3 items, the examiner will display the 9-picture recognition chart (Refer Fig. 7.20). The 3 original pictures are part of the 9-picture recognition chart.

- The patient needs to name or point out the 3 original pictures. Every correct picture will score “1” mark. If they are unable to name all 3 correct cards, point out to the patient which cards were correct and incorrect. The process is then repeated with re-displaying the 3 picture cards (Fig. 7.19) and repeating the test after 1 hour.

- If the patient scores A-WPTAS 18/18, the test is ceased, and the patient is assumed to be out of “PTA” phase. Subsequently, the GCS assessment is continued as required

- The A-WPTAS and GCS score should be charted in a comprehensively designed score sheet, which enables clinicians to rapidly assess PTA and neurological status at a glance. Figure 7.21 demonstrates an example of a proposed mild-TBI observation chart, incorporating GCS, A-WPTAS scores and relevant neurological parameters. (Refer Fig. 7.21).

Figure 7.19: 3-Picture Card : Cup, keys and bird. Pictures used for PTA screening in A-WPTAS assessment
Adopted from Shores & Lammel (2007)- 3-Picture Card

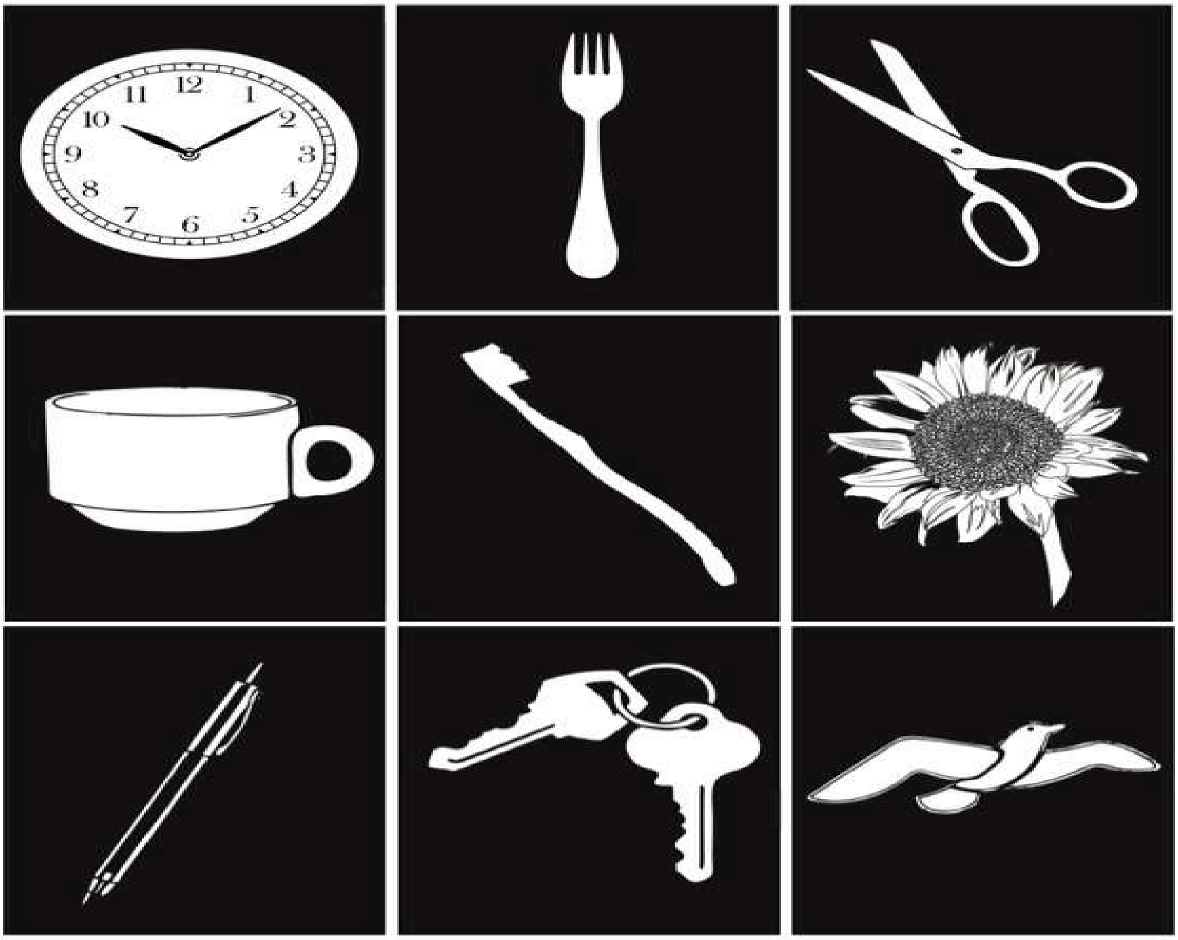


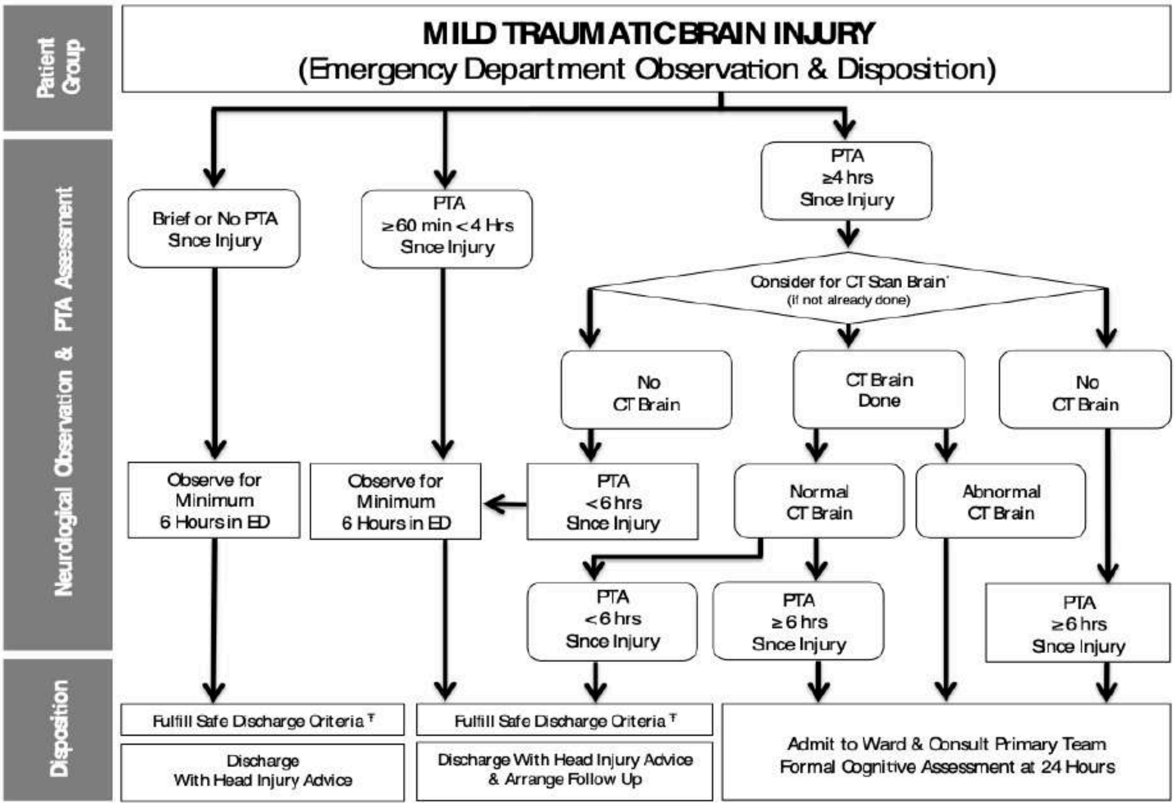
Figure 7.20: 9-Picture Recognition Chart. Pictures used for PTA screening in A-WPTAS assessment
Adopted from Shores & Lammel (2007)- 9-Picture Recognition Chart

NAME		**DATE**		**EMERGENCY DEPARTMENT MILD TRAUMATIC BRAIN INJURY OBSERVATION CHART (GCS & PTA ASSESSMENT)**
REG NUMBER		TIME OF ADMISSION		
IC NUMBER		TIME OF INJURY		

COMPONENT	**RESPONSE**		**SCORE**	T0 Time:	T1 Time:	T2 Time:	T3 Time:	T4 Time:	T5 Time:	T6 Time:
EYE OPENING	Spontaneously Opening		4							
	Open to Speech		3							
	Open to Pain		2							
	No Response		1							
MOTOR RESPONSE	Obeying to Command		6							
	Localising to Pain		5							
	Flexion Withdrawal		4							
	Abnormal Flexion		3							
	Extension		2							
	No Response		1							
VERBAL RESPONSE (English / Malay)	5 ORIENTATION QUESTIONS	Need to provide all accurate answers in order to score 5 points	5	✓ ✗	✓ ✗	✓ ✗	✓ ✗	✓ ✗	✓ ✗	✓ ✗
	i What is your name? / Apakah nama anda?									
	ii What is the name of this place? / Apakah nama tempat ini?									
	iii Why are you here? / Kenapa anda berada di sini?									
	iv What month are we in? / Bulan berapa kita berada?									
	v What year are we in? / Tahun berapa kita berada?									
	Confused		4							
	Inappropriate Words		3							
	Incomprehensible Sounds		2							
	No Response		1							
GCS	**Total Glasgow Coma Score**			/15	/15	/15	/15	/15	/15	/15
MEMORY ASSESSMENT	Picture 1 CUP / CAWAN		✓ ✗	Show Pictures & Review in 1 hour						
	Picture 2 KEY / KUNCI		✓ ✗							
	Picture 3 BIRD / BURUNG		✓ ✗							
A-WPTAS	**Total A-WPTAS Score**				/18	/18	/18	/18	/18	/18
Post Traumatic Amnesia (PTA) Present?			✓ ✗							
Pre-morbid or External Conditions That May Affect Assessment	Previous Cognitive impairment			Comments						
	Others			Comments						
Clinical Signs of Increase Intracranial Pressure (ICP) Note:										
Clinical Signs of Neurological Deficit / Limb Weakness Note:										
Pupil Size & Reactivity (S:Sluggish R:Reactive NR:Non-Reactive)				L R	L R	L R	L R	L R	L R	L R

Figure 7.21: Emergency Department Cerebral Concussion Observation Chart.

Reference: Incorporating Post Traumatic Amnesia Assessment In Malaysian Emergency Department Mild Traumatic Brain Injury Observation and Disposition. Shah Jahan , Fitzgerald M, Mathew J et al. M-JEM Vol 4 No.2 (2019)



* *The decision to perform CT Brain is dependent upon the availability of resources and sound clinical judgement*

Figure 7.22: Clinical decision guide in the management of patients with post traumatic amnesia in Emergency Departments.
Reference: Incorporating Post Traumatic Amnesia Assessment In Malaysian Emergency Department Mild Traumatic Brain Injury Observation and Disposition. Shah Jahan , Fitzgerald M, Mathew J et al. M-JEM Vol 4 No.2 (2019)

EMERGENCY DEPARTMENT MILD-TBI OBSERVATION AND DISPOSITION CLINICAL DECISION

- The cohort of patients subjected to this clinical decision tree are ED patients who have sustained closed mild-TBI within the first 24 hours, sustained impact to the head resulting in confusion, disorientation, loss of memory, loss of consciousness (LOC) and observed in the ED for head charting.
- This group of patients may or may have not had a CT brain Imaging done. The A-WPTAS score should be interpreted within the limitations of any previous cognitive impairment, history of drug abuse, intoxication, medication or clinical factors that may affect the assessment.
- The A-WPTAS is not a diagnostic test but a validated screening tool for identifying PTA within the first 24 hours of injury. Mild-TBI Patients with no indications of CT Brain who present with either brief (< 60 mins) or no PTA would be subjected to a minimum total of at least 6 hours observation in the Emergency Department.
- The minimum observation period is essentially to identify patients with signs and symptoms of increasing intracranial pressure (i.e. recurrent vomiting, persistent severe headache or giddiness, blurring of vision, presence of neurology or reduction in conscious level). If present, these patients will be subjected to a CT scan of the brain and managed accordingly.

- Symptom free patients will be discharged if they fulfill all safe discharge criteria (Refer Table 7.2). Head injury advice and written notes should be provided to all discharged patients and caregivers, advising them to return to ED in the event they develop delayed or worsening symptoms.
- Patients experiencing PTA for ≥ 60 mins < 4 hours should be subjected to the minimum 6 hours ED observation. Symptom free patients can similarly be discharged if they fulfill safe discharge criteria. However, this cohort of patients should be arranged for a follow-up appointment. They are at higher risk and therefore should be assessed for the presence of "post-concussion syndrome". Follow up appointments should be arranged within a week from discharge.
- Patients with ≥ 4 hours of PTA should be considered for a CT-Brain if this is not already done. Abnormal CT Brain with presence of clinically significant intracranial lesions should be managed as indicated. Patients with a normal CT brain should be continuously assessed using the A-WPTAS score. A persistent PTA of ≥ 6 hours (from time of injury) is an indication for prolonged observation (ward admission) and formal cognitive assessment at 24 hours.
- Patients with < 6 hours of PTA and a normal CT-Brain can be considered for discharge if they fulfill all safe discharge criteria. These patients are also at higher risk of developing "post-concussion syndrome" and therefore should have an arranged follow up appointment within a week from discharge.
- Without previous underlying cognitive impairments, a persistent PTA > 24 hours is indicative of an extensive brain injury. These patients would benefit from occupational therapy, neurorehabilitation, and neuro-psychological referral.
- Patients with ≥ 4 hours of PTA who are not subjected to a CT-Scan should be continuously assessed using the A-WPTAS score. If PTA is persistent ≥ 6 hours from time of injury, the patient is subjected for prolonged observation (ward admission) and formal cognitive assessment at 24 hours.
- If PTA is < 6 hours since time of injury, the patient will be subjected to complete a minimum total of 6 hours observation in the ED (In-line with recommendations from the Malaysian Clinical Practice Guidelines for Early Management of Head Injury Patients, 2015). Subsequently, if they are symptom free and fulfill safe discharge criteria, they can be discharged with an arranged follow up appointment within a week.

₸ SAFE DISCHARGE CRITERIA'S	
SOCIAL FACTORS	**CLINICAL FACTORS**
Presence of a willing and responsible adult care taker	No clinical signs and symptoms of increasing intracranial pressure (e.g. recurrent vomiting, blurring of vision, persistent severe headache or giddiness)
Easy access to initiate an emergency response call (e.g. 999)	No focal neurological deficits or reduction in conscious level (GCS 15/15)
Living within reasonable distance / access to medical care	Normal CT-brain (if indicated)
Available transport and responsible person to facilitate transfer	Clinically well, able to tolerate orally and ambulating independently
Not under the influence of drugs or alcohol	Passed PTA Screening test in Emergency Department (Score 18/18 in A-WPTAS)
Note 1 *Clinical judgment is required with regards to discharge and follow up of elderly patients and patients with known coagulopathy or bleeding disorder due to increased risk of delayed subdural hematoma*	
Note 2 *Patients who do not fulfill the "Safe Discharge Criteria's" may be admitted for extended observation and primary team consult*	

Table 7.2: Safe discharge criteria in Emergency Department for Patient with Cerebral Concussion

Reference: Incorporating Post Traumatic Amnesia Assessment In Malaysian Emergency Department Mild Traumatic Brain Injury Observation and Disposition. Shah Jahan , Fitzgerald M, Mathew J et al. M-JEM Vol 4 No.2 (2019)

7.11 SUMMARY

1. Mitigating secondary brain injury is of utmost importance with adequate resuscitation. Hypovolemia and hypoxemia must be prevented.
2. Shock should be treated promptly, and its underlying cause identified.
3. The administration of hypotonic solutions is contraindicated in cases of severe traumatic brain injury.
4. Comatose patients necessitate endotracheal intubation to ensure airway patency and provide cerebral protection, thereby preventing secondary brain insult.
5. Always assess for presence of post traumatic amnesia (PTA) in all mild TBI patients treated as “cerebral concussion”. A-WPTAS is a validated assessment tool that can be utilized safely to assess for post injury PTA in the Emergency Department.

7.12 REFERENCES

1. Malaysian CPG Early Management of Head Injury in Adults 2015
2. NICE Guideline, Head Injury: Assessment and early management 2014
3. Haddad SH, Arabi YM. Critical care management of severe traumatic brain injury in adults. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*. 2012;20:12. doi:10.1186/1757-7241-20-12
4. Guidelines for the surgical management of traumatic brain injury (https://braintrauma.org/coma/guidelines)
6. Drummond JC, Patel PM. Neurosurgical anesthesia. In: Miller RD, ed. Miller’s Anaesthesia. Philadelphia: Churchill Livingstone Elsevier; 2009:2045-2087
7. Incorporating Post Traumatic Amnesia Assessment In Malaysian Emergency Department Mild Traumatic Brain Injury Observation and Disposition. Shah Jahan , Fitzgerald M, Mathew J et al. M-JEM Vol 4 No.2 (2019)
8. Abbreviated Westmead PTA Scale (A-WPTAS) GCS & PTA testing of patients with MTBI following mild head injury. Shores & Lammel (2007)

CHAPTER
8

SPINE TRAUMA

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Able to anticipate, recognise, categorise and grade spinal injury
2. Able to perform spinal immobilisation and stabilisation
3. Able to understand the appropriate imaging modalities for investigation
4. Able to understand the need for referral and further management

8.1 INTRODUCTION

The outcome of a spinal injury depends upon the initial care, resuscitation, diagnosis and emergency intervention. When it comes to spinal cord trauma, "Time is Outcome". Vertebral column and spinal cord injury must always be considered in every polytrauma patient.

Head and spine injuries are commonly interrelated up to a quarter of cases while the cervical region is the most common site of spinal injuries.

Non-contiguous vertebral column fractures account for approximately 1/5th of all spine fractures.

- In an alert and neurologically intact patient, the absence of pain along the spinal column virtually excludes significant spine injury.
- In a patient with depressed mentation, an evaluation requires the adjunct use of radio-imaging.

- If the imaging performed is inconclusive, then the patient's spine should be protected pending further evaluation / advanced imaging modalities.
- However, prolonged spinal immobilization especially on the hard backboard can cause severe discomfort and pressure sores, especially if the spinal board is kept for more than 2 hours.
- Spinal boards are used for protecting the spine of trauma patients during the process of transportation.

8.2 APPLIED ANATOMY & PHYSIOLOGY

The spinal column consists of 7 cervical, 12 thoracic, 5 lumbar vertebrae as well as the sacrum and the coccyx bone (Figure 8.1). The typical vertebrae encompass the anteriorly placed vertebral bodies, which forms the main weight bearing column. They are separated from each other by the intervertebral discs. They are held together anteriorly and posteriorly by the anterior and posterior longitudinal ligament, respectively (Figure 8.2). Posterolaterally, two pedicles form the pillars on which two roofs of the vertebral canal (i.e the lamina) rests. Apart from the longitudinal ligaments which act as a main anchor, the vertebral stability is provided by the facets joint, ligamentum flavum, interspinous ligaments and paraspinal muscles (Figure 8.2 & 8.3).

The spinal cord is enveloped by the neural arch of the vertebra. Any trauma to the spine may traumatize the spinal cord leading to neurological deficit such as hemiplegia or tetraplegia. The cervical spine is the most vulnerable to injury, because of its mobility and exposure. Approximately 1/3 of patients with high cervical spine injuries (C5 and above) die at the scene due to loss of innervation to the phrenic nerve. Phrenic nerve supplies the diaphragm and ventilation may be impaired due to high cervical injuries.

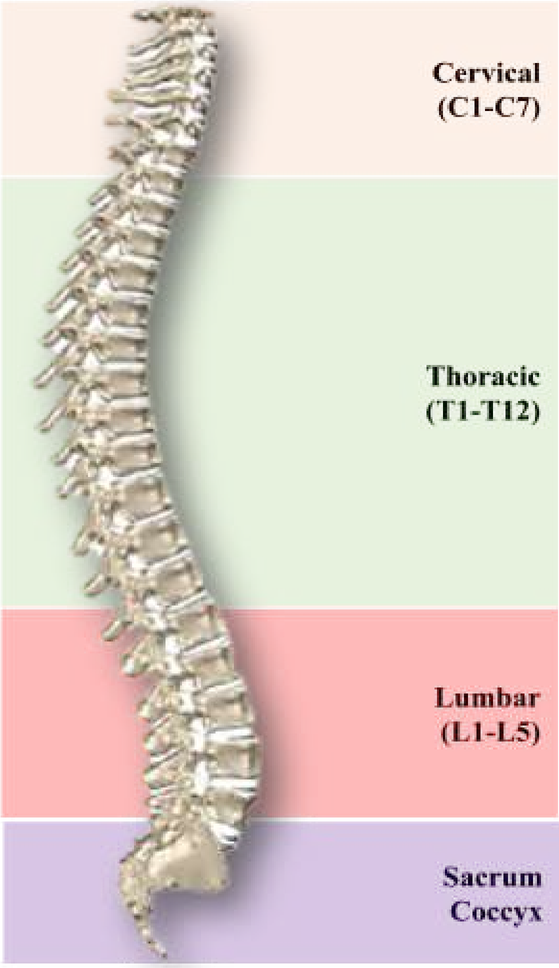


Figure 8.1: Vertebral Column

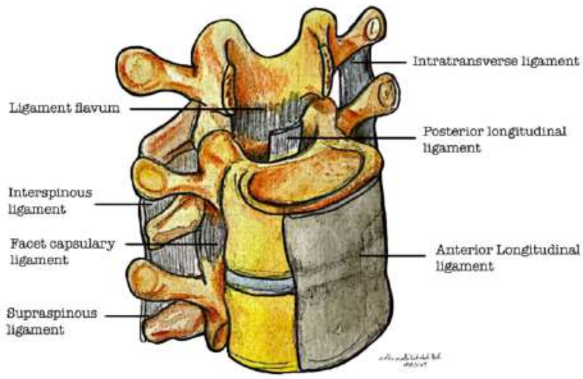


Figure 8.2: Spinal Ligaments

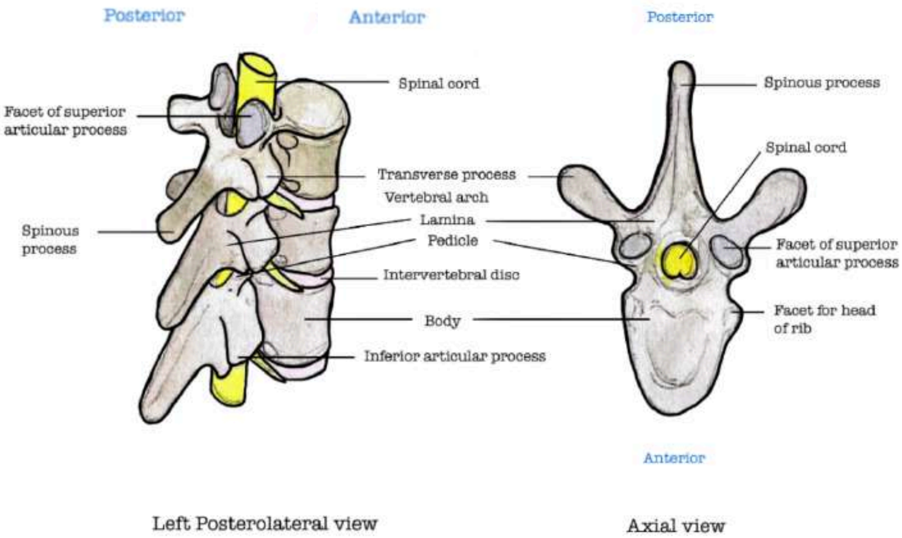


Figure 8.3: Anatomy of Vertebrae

The mobility of the thoracic spine is restricted due to the additional support from the rib cage hence lower incidence of fracture. However, in the event of fracture-dislocation, there is a high incidence of complete spinal cord injury. The thoraco-lumbar junction acts as a fulcrum between the inflexible thoracic vertebra and stronger lumbar region. These make it more vulnerable to injury (15% of all spinal injury).

The spinal cord originates from the caudal end of the medulla oblongata and usually ends around at L1 bony level as the conus medullaris in adults. Below this level is cauda equina which is more resistant to injury. Of the many tracts in the spinal cord (Figure 8.4), three can be assessed clinically:Corticospinal tract, Spinothalamic Tract and Dorsal column.

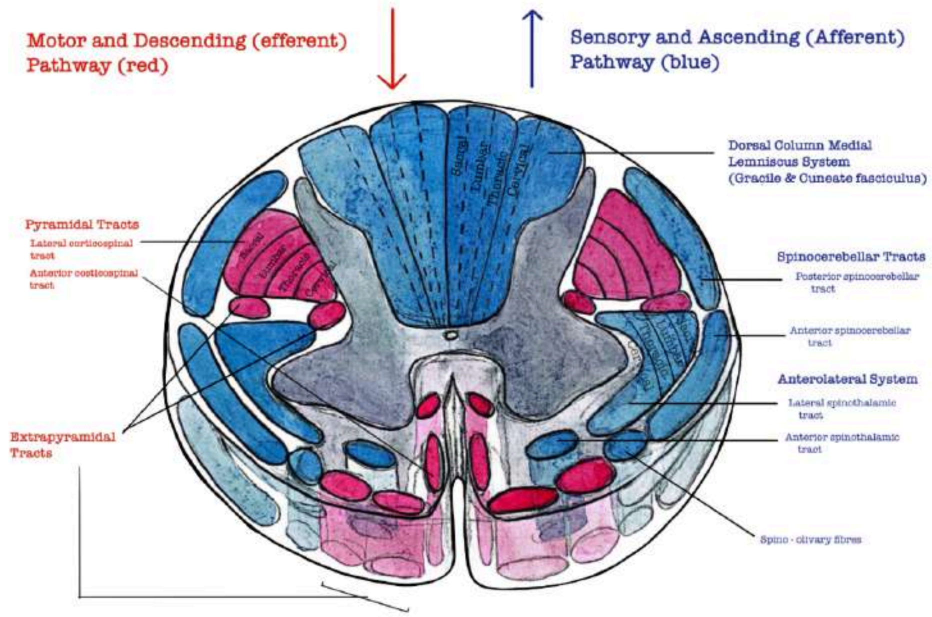


Figure 8.4: Spinal Cord Tracts

8.2.1 **Corticospinal tract** (also known as the pyramidal tract)

- It is made up of a lateral and anterior tract.
- The corticospinal tract controls primary voluntary motor activity for the somatic motor system from the neck to the feet.
- The tract begins in the primary motor cortex.
- Majority of fibres of the corticospinal tract cross over in the medulla oblongata, resulting in muscles being controlled by the opposite side of the brain
- The somatic motor pathways of the brain and spinal cord are divided into pyramidal and extrapyramidal systems.
- The extrapyramidal tracts originate in the brainstem, carrying motor fibres to the spinal cord. They are responsible for the involuntary and automatic control of all musculature, such as muscle tone, balance, posture and locomotion.
- Both these systems control the motor activities of body through lower motor neurons.

8.2.2 **Spinothalamic tract**

- The spinothalamic tract is an ascending pathway of the spinal cord and one of the most important sensory pathways of the nervous system
- It is responsible for the transmission of pain, temperature, and crude touch to the somatosensory region of the thalamus.
- The spinothalamic tract consists of two adjacent pathways;
    - Lateral Spinothalamic (pain and temperature)
    - Anterior Spinothalamic (crude touch)
- The pathway crosses over (decussates) at the level of the spinal cord
- Damage to the spinothalamic tract within the spinal cord, as seen in Brown Sequard syndrome, results in contralateral loss of pain and temperature

8.2.3 **Dorsal column** (posterior column / medial lemniscus pathway)

- The dorsal column is a sensory pathway of the central nervous system that conveys sensations of fine touch, vibration, two-point discrimination, and proprioception (position) from the skin and joints
- They decussate to the opposite side of the brain in the medulla
- Damage to the dorsal column below the crossing point of its fibres results in loss of vibration, soft touch and proprioception (joint sense) on the same side of the body as the lesion. Damage above the crossing point result a loss of sensation on the opposite side of the body to the lesion
- In Brown Sequard syndrome, vibration, discriminative fine-touch and proprioception will be affected ipsilaterally.

Primary spinal cord injury is an injury sustained during the initial trauma whereas **Secondary spinal cord injury** occurs as the result of secondary insults such as , hypoxia, hypotension, spinal cord ischemia or poor immobilization during transfer. Therefore, careful intervention to immobilize patients at near anatomical position is recommended.

8.3 PATHOPHYSIOLOGY

High index of suspicion is needed in managing trauma. Spinal injury should be ruled out in following cases;

- Unconscious patient.
- Multiple injuries.
- Neurological deficit.
- Spinal column pain/tenderness.
- High impact injury , dangerous mechanism of injuries such as;
    - Whiplash injury (flexion and extension injury).
    - Direct trauma.
    - Vertical loading (e.g. fall from height).
    - Seat Belt injury (e.g. Chance Fracture).
    - High-speed crash.

It is estimated that 10% of all polytrauma patients have spinal injury. Patients require systematic resuscitation, evaluation, treatment and early spine intervention.

8.3.1 Spinal shock ("spinal cord concussion")

- Is a physiological response to spinal cord injury resulting in *temporary* loss of both cutaneous and deep tendon reflexes below the level of injury.
- It may be accompanied by flaccid paralysis, autonomic dysfunction, loss of sympathetic outflow, resulting in incontinence, hypotension and bradycardia. Spinal shock may last from within 24 to 72 hours to several days or weeks.
- In spinal injury with co-existing "spinal shock", the true neurological deficit is determined once the spinal shock is resolved. This can be ascertained by the return of cutaneous and deep tendon reflexes.
- Reflexes generally return in a specific pattern with cutaneous reflexes returning prior to deep tendon reflexes. The reflexes commonly return in the following order; Firstly the return of abnormal plantar reflexes (Babinski's sign) followed by the bulbocavernosus reflex (BCR), cremasteric reflex and finally the ankle and knee jerk reflexes.
- The bulbocavernosus reflex is commonly checked to mark the ending of the "spinal shock". This reflex is elicited by squeezing the penile glans or the clitoris and feeling for an involuntary contraction of the anus. It can also be elicited by tugging the Foley's catheter to expect the similar reflex.
- The Babinski's sign can be elicited by up-stroking the lateral plantar aspect of the foot starting from the heel by using a blunt instrument.
- The normal Babinski's sign consists of flexion of the great toe or no response. With dysfunction of the corticospinal tract, a positive Babinski sign is expected, which consists of dorsiflexion of the great toe with an associated fanning of the other toes.
- Diagnostic testing of the reflex arcs in acute traumatic spinal cord injury is only of limited value. Immediately after injury, "spinal shock" may develop below the level of injury resulting in reflexes being diminished or even absent.

8.3.2 Neurogenic shock (a true hypotensive shock state)

- Neurogenic shock is a form of distributive shock.
- It refers to the hemodynamic triad of hypotension, bradycardia, and peripheral vasodilation resulting from severe autonomic dysfunction and interruption of the sympathetic nervous system in acute spinal cord injury.
- It is a result of damage to the central nervous system, such as spinal cord injury and traumatic brain injury
- Loss of sympathetic outflow results in a vasoplegic hypotensive state commonly seen when the level of the injury is above T6 and associated bradycardia when the level of injury is above T1-T4.
- Neurogenic shock is fatal if left untreated causing irreversible tissue damage from hypoperfusion and contributing to worsening of secondary injuries.
- Hemodynamic resuscitation can be established by administering volume together with adjunct use of inotropic, chronotropic and vasopressor support.
- Neurogenic shock generally last from 1 to 3 weeks however have been reported to persist for as long as 4 to 5 weeks.

8.4 TYPES OF SPINAL INJURY

8.4.1 Complete Spinal Cord Injury

- A complete spinal cord injury occurs when a person loses all sensory and motor function below the level of the spinal cord injury.
- Pathophysiologically, the impulse communication within nerves of the spinal cord to the brain below the point of injury is completely severed.
- In the initial phase, it may overlap with manifestation of co-existing spinal shock.
- Subsequently after the resolution of spinal shock, complete spinal cord injury is characterized by loss of sacral sparing (absence of anal contraction and/or perianal sensation).
- Patients with a complete spinal cord injury have less than 5% chance of recovery.
- In the event of complete paralysis persisting more than 72 hours after injury, recovery is unlikely.

8.4.2 Incomplete Spinal Cord Injury

- An incomplete spinal cord injury occurs when a person retains some residual sensory or motor function below the level of injury.
- It is the commonest type of spinal cord injury.
- Some motor or sensory functions still remain below the level of injury.
- Aside from palpable or visible muscle contraction below injury level, presence of voluntary anal contraction and/or perianal sensation (sacral sparing- S4/S5) is used to differentiate incomplete versus complete injury.
- Carries a better prognosis.

8.4.3 Types of Incomplete Spinal Cord Injuries

8.4.3.1 Central Cord Syndrome

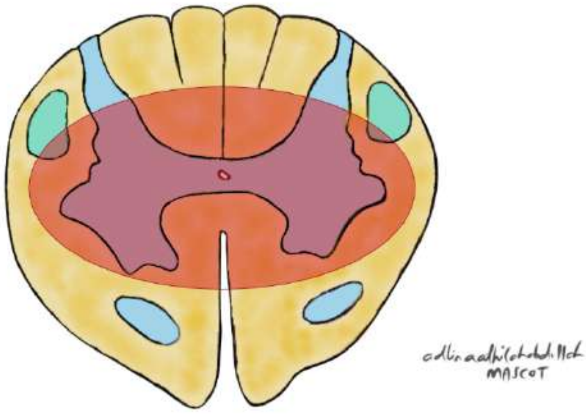


Figure 8.5: Central Cord Syndrome

- Characterised by disproportionately greater loss of motor power in the upper limbs compared to the lower limbs as well as by bladder dysfunction with varying degree of sensory loss below the injury level.
- MRI , CT-Scans and plain radiographs of the cervical spine facilitate the diagnosis of central cord syndrome.
- The commonest form of cervical spinal cord injury caused by major injury to the central corticospinal tract of the spinal cord
- Usually due to the hyperextension injury in preexisting spinal canal stenosis.
- It is thought to be due to the compromise of anterior spinal artery which supplies the central cord region
- Due to the arrangement of the motor fibers which are typically arranged towards the centre of the cord, the arms and hands are the most severely affected.
- The common mechanism is a forward fall with a facial impact with or without cervical spine fracture.
- The recovery normally begins from the lower limb followed by the upper limb.
- It has the best prognosis among all incomplete spinal cord injuries, although full functional recovery is rare.
- Recovery occurs in an ascending pattern starting from the lower extremity, bowel and bladder function, proximal upper extremity and finally the hand functions.
- Complete recovery of upper extremities and hands is unpredictable which may result in permanent disability.

8.4.3.2 Anterior Cord Syndrome

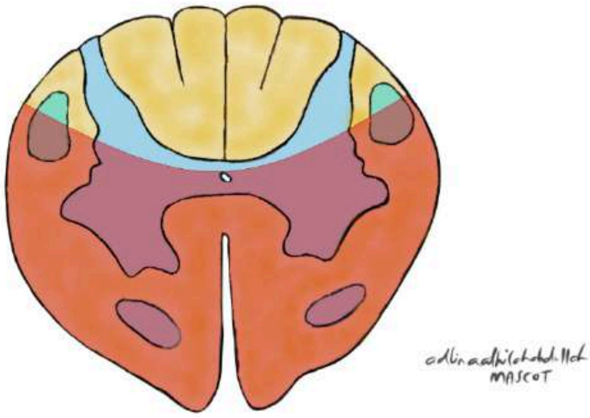


Figure 8.6: Anterior Cord Syndrome

- Anterior Cord Syndrome is a form of incomplete spinal cord injury that predominantly affects the anterior 2/3rd of the spinal cord.
- This injury has the poorest prognosis of all incomplete cord injuries with an estimated only 10-20% chance of motor recovery.
- This injury is characterized by paraplegia (loss of motor power) and dissociated sensory loss (loss of pain, temperature and non-discriminative crude-touch) below the level of injury.
- The presentation most likely to mimic a complete cord injury.
- The lower extremities are affected more than the upper extremities.
- The posterior column function such as proprioception, vibration and discriminative fine- touch is preserved.
- The pathophysiology of injury involves direct compression (osseous) of the anterior spinal cord or anterior spinal artery injury. Mechanism of injury is commonly a result of flexion /compression injury.
- The anterior 2/3rd of the spinal cord is supplied by the anterior spinal artery.

8.4.3.3 Brown-Sequard Syndrome

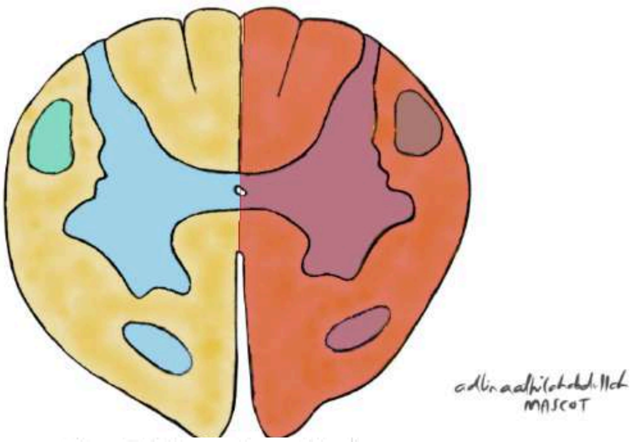


Figure 8.7: Brown-Sequard Syndrome

- This is a partial spinal cord injury that results from hemitransection of the cord.
- It is commonly caused by penetrating trauma.
- In its pure form, the presentation is characterized by ipsilateral loss of motor (corticospinal tract), proprioception, vibration sense, discriminative fine-touch (dorsal column), with contralateral loss of pain, temperature, non-discriminative crude-touch (spinothalamic tract) below the level of injury.
- This is due to the spinothalamic tracts that cross at the spinal cord level (classically 2-levels below) and the corticospinal and dorsal column tracts cross at the thalamic level.
- This injury carries an excellent prognosis.

8.4.3.4 Posterior Cord Syndrome

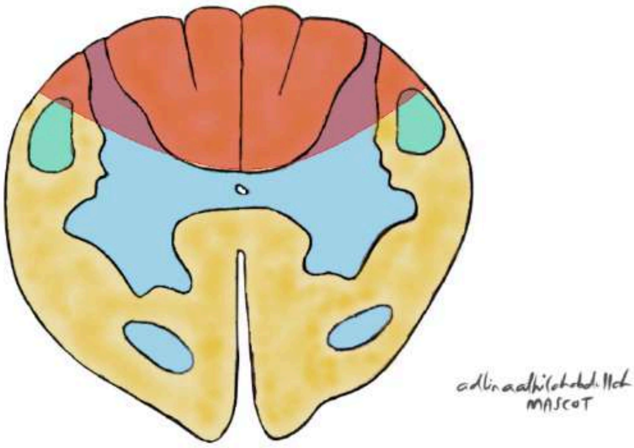
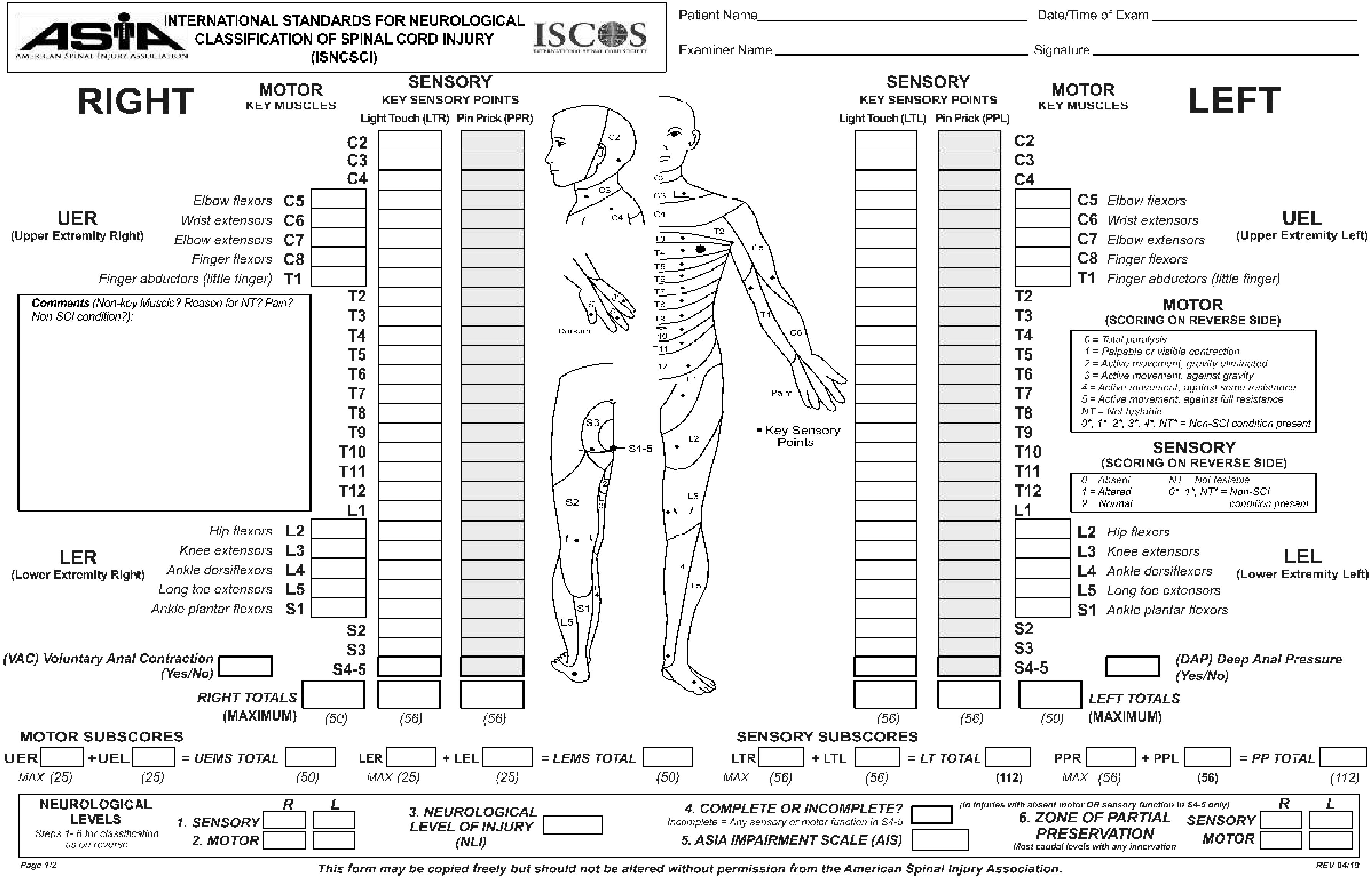


Figure 8.8: Posterior Cord Syndrome

- Is a very rare form of incomplete spinal cord injury that affects the posterior column of the spinal cord.
- This injury is characterized by loss of proprioception, vibration sense, discriminative fine-touch below the level of injury (dorsal column function).
- The motor, non-discriminative crude touch, pain and temperature is preserved.
- Aside from trauma, this syndrome is seen in individuals with vitamin B_{12} deficiency, syphilis infection, multiple sclerosis, and neurodegenerative disorders.
- Patients with posterior cord syndrome present with poor balance, unsteady gait, and frequent falls, which typically is worse during the night /dark environment.

8.5 NEUROLOGICAL ASSESSMENT USING ASIA DERMATOME CHART & IMPAIRMENT SCALE

The American Spinal Injury Association (ASIA) Standard Neurological Classification of Spinal Cord Injury is a standard method of assessing the neurological status of a person who has sustained spinal cord injury. Scale assessments can be carried out using the ASIA Dermatome chart and Impairment Scale worksheet.



INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY (ISNCSCI)

ASIA – AMERICAN SPINAL INJURY ASSOCIATION | ISCOS

Patient Name ______ Date/Time of Exam ______

Examiner Name ______ Signature ______

RIGHT

MOTOR – KEY MUSCLES

SENSORY – KEY SENSORY POINTS – Light Touch (LTR) | Pin Prick (PPR)

C2, C3, C4

UER (Upper Extremity Right): Elbow flexors C5; Wrist extensors C6; Elbow extensors C7; Finger flexors C8; Finger abductors (little finger) T1

Comments (Non-key Muscle? Reason for NT? Pain? Non SCI condition?):

T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12, L1

LER (Lower Extremity Right): Hip flexors L2; Knee extensors L3; Ankle dorsiflexors L4; Long toe extensors L5; Ankle plantar flexors S1

S2, S3, S4-5

(VAC) Voluntary Anal Contraction (Yes/No)

RIGHT TOTALS (MAXIMUM) (50) (56) (56)

LEFT

SENSORY – KEY SENSORY POINTS – Light Touch (LTL) | Pin Prick (PPL)

MOTOR – KEY MUSCLES

C2, C3, C4

UEL (Upper Extremity Left): C5 Elbow flexors; C6 Wrist extensors; C7 Elbow extensors; C8 Finger flexors; T1 Finger abductors (little finger)

MOTOR (SCORING ON REVERSE SIDE)

0 = Total paralysis
1 = Palpable or visible contraction
2 = Active movement, gravity eliminated
3 = Active movement, against gravity
4 = Active movement, against some resistance
5 = Active movement, against full resistance
NT = Not testable
0*, 1*, 2*, 3*, 4*, NT* = Non-SCI condition present

SENSORY (SCORING ON REVERSE SIDE)

0 = Absent
1 = Altered
2 = Normal
NT = Not testable
0*, 1*, NT* = Non-SCI condition present

T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12, L1

LEL (Lower Extremity Left): L2 Hip flexors; L3 Knee extensors; L4 Ankle dorsiflexors; L5 Long toe extensors; S1 Ankle plantar flexors

S2, S3, S4-5

(DAP) Deep Anal Pressure (Yes/No)

LEFT TOTALS (MAXIMUM) (56) (56) (50)

• Key Sensory Points

MOTOR SUBSCORES

UER ___ + UEL ___ = UEMS TOTAL ___ | LER ___ + LEL ___ = LEMS TOTAL ___

MAX (25) (25) (50) | MAX (25) (25) (50)

SENSORY SUBSCORES

LTR ___ + LTL ___ = LT TOTAL ___ | PPR ___ + PPL ___ = PP TOTAL ___

MAX (56) (56) (112) | MAX (56) (56) (112)

NEUROLOGICAL LEVELS (Steps 1-6 for classification as on reverse): 1. SENSORY R ___ L ___; 2. MOTOR R ___ L ___

3. NEUROLOGICAL LEVEL OF INJURY (NLI) ___

4. COMPLETE OR INCOMPLETE? ___ Incomplete = Any sensory or motor function in S4-5

5. ASIA IMPAIRMENT SCALE (AIS) ___

6. ZONE OF PARTIAL PRESERVATION (In injuries with absent motor OR sensory function in S4-5 only) – Most caudal levels with any innervation: SENSORY R ___ L ___; MOTOR R ___ L ___

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REV 04/19

Figure 8.9: International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) : ASIA Dermatome Chart Attribution: © 2021 American Spinal Injury Association. Reprinted with permission

Muscle Function Grading

0 = Total paralysis

1 = Palpable or visible contraction

2 = Active movement, full range of motion (ROM) with gravity eliminated

3 = Active movement, full ROM against gravity

4 = Active movement, full ROM against gravity and moderate resistance in a muscle specific position

5 = (Normal) active movement, full ROM against gravity and full resistance in a functional muscle position expected from an otherwise unimpaired person

NT = Not testable (i.e. due to immobilization, severe pain such that the patient cannot be graded, amputation of limb, or contracture of > 50% of the normal ROM)

0*, 1*, 2*, 3*, 4*, NT* = Non-SCI condition present *

Sensory Grading

0 = Absent **1** = Altered, either decreased/impaired sensation or hypersensitivity

2 = Normal **NT** = Not testable

0*, 1*, NT* = Non-SCI condition present *

Note: Abnormal motor and sensory scores should be tagged with a '' to indicate an impairment due to a non-SCI condition. The non-SCI condition should be explained in the comments box together with information about how the score is rated for classification purposes (at least normal / not normal for classification).

When to Test Non-Key Muscles:

In a patient with an apparent AIS B classification, non-key muscle functions more than 3 levels below the motor level on each side should be tested to most accurately classify the injury (differentiate between AIS B and C).

Movement	Root level
Shoulder: Flexion, extension, adduction, adduction, internal and external rotation **Elbow:** Supination	C5
Elbow: Pronation **Wrist:** Flexion	C6
Finger: Flexion at proximal joint, extension **Thumb:** Flexion, extension and abduction in plane of thumb	C7
Finger: Flexion at MCP joint **Thumb:** Opposition, adduction and abduction perpendicular to palm	C8
Finger: Abduction of the index finger	T1
Hip: Adduction	L2
Hip: External rotation	L3
Hip: Extension, abduction, internal rotation **Knee:** Flexion **Ankle:** Inversion and eversion **Toe:** MP and IP extension	L4
Hallux and Toe: DIP and PIP flexion and abduction	L5
Hallux: Adduction	S1

ASIA Impairment Scale (AIS)

A = Complete. No sensory or motor function is preserved in the sacral segments S4-5.

B = Sensory Incomplete. Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-5 (light touch or pin prick at S4-5 or deep anal pressure) AND no motor function is preserved more than three levels below the motor level on either side of the body.

C = Motor Incomplete. Motor function is preserved at the most caudal sacral segments for voluntary anal contraction (VAC) OR the patient meets the criteria for sensory incomplete status (sensory function preserved at the most caudal sacral segments S4-5 by LT, PP or DAP), and has some sparing of motor function more than three levels below the ipsilateral motor level on either side of the body. (This includes key or non-key muscle functions to determine motor incomplete status.) For AIS C – less than half of key muscle functions below the single NLI have a muscle grade ≥ 3.

D = Motor Incomplete. Motor incomplete status as defined above, with at least half (half or more) of key muscle functions below the single NLI having a muscle grade ≥ 3.

E = Normal. If sensation and motor function as tested with the ISNCSCI are graded as normal in all segments, and the patient had prior deficits, then the AIS grade is E. Someone without an initial SCI does not receive an AIS grade.

Using ND: To document the sensory, motor and NLI levels, the ASIA Impairment Scale grade, and/or the zone of partial preservation (ZPP) when they are unable to be determined based on the examination results.

AMERICAN SPINAL INJURY ASSOCIATION

INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

ISCOS

INTERNATIONAL SPINAL CORD SOCIETY

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Steps in Classification

The following order is recommended for determining the classification of individuals with SCI.

1. Determine sensory levels for right and left sides.
The sensory level is the most caudal, intact dermatome for both pin prick and light touch sensation.

2. Determine motor levels for right and left sides.
Defined by the lowest key muscle function that has a grade of at least 3 (on supine testing), providing the key muscle functions represented by segments above that level are judged to be intact (graded as a 5).
Note: in regions where there is no myotome to test, the motor level is presumed to be the same as the sensory level, if testable motor function above that level is also normal.

3. Determine the neurological level of injury (NLI).
This refers to the most caudal segment of the cord with intact sensation and antigravity (3 or more) muscle function strength, provided that there is normal (intact) sensory and motor function rostrally respectively.
The NLI is the most cephalad of the sensory and motor levels determined in steps 1 and 2.

4. Determine whether the injury is Complete or Incomplete.
(i.e. absence or presence of sacral sparing)
*If voluntary anal contraction = **No** AND all S4-5 sensory scores = **0** AND deep anal pressure = **No**, then injury is **Complete**.*
*Otherwise, injury is **Incomplete**.*

5. Determine ASIA Impairment Scale (AIS) Grade.

Is injury <u>Complete</u>? If YES, AIS=A

NO ↓

Is injury <u>Motor Complete</u>? If YES, AIS=B

NO ↓ (No=voluntary anal contraction OR motor function more than three levels below the <u>motor level</u> on a given side, if the patient has sensory incomplete classification)

Are <u>at least</u> half (half or more) of the key muscles below the <u>neurological level of injury</u> graded 3 or better?

NO ↓ **AIS=C**

YES ↓ **AIS=D**

If sensation and motor function is normal in all segments, AIS=E
Note: AIS E is used in follow-up testing when an individual with a documented SCI has recovered normal function. If at initial testing no deficits are found, the individual is neurologically intact and the ASIA Impairment Scale does not apply.

6. Determine the zone of partial preservation (ZPP).
The ZPP is used only in injuries with absent motor (no VAC) OR sensory function (no DAP, no LT and no PP sensation) in the lowest sacral segments S4-5, and refers to those dermatomes and myotomes caudal to the sensory and motor levels that remain partially innervated. With sacral sparing of sensory function, the sensory ZPP is not applicable and therefore "NA" is recorded in the block of the worksheet. Accordingly, if VAC is present, the motor ZPP is not applicable and is noted as "NA".

Figure 8.10: International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) : Impairment Scale and Assessment Attribution: © 2021 American Spinal Injury Association. Reprinted with permission

8.6 RESUSCITATION

Primary Survey [<c> ABCDE]

8.6.1 Airway Assessment

Assess the need for intubation in cases of:

- Hypoventilation (Diaphragm involvement is commonly seen in tetraplegic patients).
- Respiratory distress (weak cough and shallow rapid breathing are early signs).
- Inadequate ventilation. Hypoxia is a late sign.
- Reduced conscious level (GCS < 8 ,unable to protect airway with concomitant head injury that needs cerebral protection).

8.6.2 Cervical Spine Immobilization

- Apply a hard collar to immobilise the cervical spine. Rigid Cervical Collar reduces flexion and extension of neck but with limited rotational immobilisation.
- Further immobilisation requires the addition of head immobiliser, application of sand bags and head tape or manual inline immobilisation.
- Remove the rigid spine board as soon as possible by transferring the patient onto a trauma bed.

8.6.3 Breathing & Ventilation

- Look for shallow and irregular breathing patterns.
- Keep SPO_2 > 92%, give supplemental oxygen as needed.
- If intubated,employ protective lung ventilation strategy. (Refer to Chapter 2: Airway and Ventilation)

8.6.4 Circulation & Haemorrhage Control

- Always rule out **Hemorrhage** as a cause of possible hypotension.
- Haemorrhage is still the commonest cause of hypotension in trauma until proven otherwise.

- Neurogenic shock can be treated with initial fluid boluses. Vasopressors and inotropic support can be initiated after adequate volume resuscitation / replacement is provided.
- In suspected or confirmed spinal cord injury , always target to maintain adequate organ perfusion (MAP >80-90 mmHg,normal mentation, warm peripheries and urine output >0.5 mL/kg/h).
- Be aware of vagal stimuli (e.g. suction, NG Tube insertion and intubation) which may exacerbate neurogenic shock.

HYPOVOLAEMIC SHOCK
Is the commonest shock in trauma
NOT neurogenic shock

8.6.5 Disability

Standard Neurological examination, that include pupils size, Glasgow Coma Scale (GCS) or AVPU, upper limbs and lower limbs movement

8.6.6 Exposure

Exposing the whole body to look for gross deformities, injuries and abnormalities that may need urgent intervention while ensuring the patient is protected from the environment and hypothermia.

8.7 EVALUATION

8.7.1 History

- Allergies
- Medications
- Past medical history
- Last meal or other intake
- Mechanism of Injury

8.7.2 Secondary Survey Examination

- Head to toe examination.
- Motor level
- Sensory level
- Spinal examination: step deformity, haematoma, open fracture (during log roll).
  - Perineal examination: External Anal Sphincter contraction (motor) and perianal sensation (sensory)
  - Do not routinely perform digital rectal examination (DRE) unless indicated with co-existing neurology.
  - Perform bulbocavernosus reflex when neurology deficit is present to look for evidence of co-existing spinal shock.
- If neurology deficit is present, determine whether the injury is complete or incomplete spinal injury.
- Priapism can be a symptom of spinal injury.
- Examine for the presence of cord syndrome (Central, Anterior, Brown-Sequard, Cauda Equina).
- Utilise American Spinal Injury Association classification (ASIA) (A-E) during the assessment of spinal injury patients.

8.7.3 Investigations

- Extended FAST to look for intra-abdominal free fluid and haemothorax.
- Chest X-Ray, Pelvis X-Ray and Lateral cervical/thoracic/lumbar X-ray, if indicated.
- CT scan spine as indicated. (refer to C-spine rule such as Canadian C-Spine rule, Nexus C-Spine Rule)
- MRI spine as indicated.

8.8 TREATMENT

The initial treatment is the same as managing any trauma patients. However, once ongoing haemorrhage has been ruled out and fluid management addressed, begin vasopressor/ inotropic support and aim for MAP >80-90 mmHg for adequate spinal cord perfusion.

- Analgesia as indicated.
- Head immobilisation with cervical collar and head immobiliser / towel roll.
- The role of methylprednisolone is not routinely recommended.

8.9 DISPOSITION

- Early spine team consultation and intervention.

8.10 ASSESSMENT OF THE CERVICAL SPINE

- In the event of a trauma, excluding a potential C-spine injury is crucial
- Early cervical immobilization with a rigid cervical collar is appropriate and needs to be re-evaluated during the primary & secondary survey.
- In order to avoid secondary spine injuries and immobilization side effects, it is crucial to limit unnecessary prolonged application of rigid cervical collar.
- Using a validated algorithm to exclude significant C-spine injuries such as the Canadian C-Spine Rule (Refer Figure 8.11) & NEXUS Criteria would simplify patient's management and avoid complicated costly evaluation in the alert and awake trauma patients.
- A negative CT is sufficient to clear the C-spine except when gross motor symptoms are highlighted, radio-clinical discrepancies are present or when reliable clinical examination is not feasible.
- Rigid cervical collars should be removed as early as possible to reduce the risk of;
    - Increase intracranial pressure (ICP) due to jugular venous compression
    - Mechanical respiratory restriction
    - Harmful unfitted immobilization ie : ankylosing spondylitis
    - Poor access to clinical assessment and intervention over the neck region
    - Pain and discomfort for the patient causing further restlessness

- Risk of aspiration and airway obstruction in event of patient vomiting in supine upright position
- Pressure sore formation

- The rigid cervical collar should be kept in place in the event of a suspected or confirmed unstable cervical injury/vertebral fracture.
- In fully alert patients, mild neck pain despite a clearly negative & pristine CT imaging is not a reason to delay removal of a “stiff” cervical collar.
- In such cases, pain relief or immobilisation options may be provided by placing a soft collar.
- In intubated patients with evidence of a normal CT cervical spine with no gross neurological deficits, immobilisation can be alternatively provided by a towel roll or a head immobiliser. However, this clinical decision should only be performed by an experienced clinician.
- These options cause lesser complications and are better tolerated by patients.

The following should be performed if a patient has a clinically significant cervical spine injury identified on radiographic imaging

1. C-Spine protection should be maintained with an appropriate rigid cervical collar
2. Consider application of additional immobilization such as a head block or towel roll
3. The patient should be kept non-ambulatory
4. Appropriate pain management should be administered
5. Oral intake should be withheld until a treatment plan is decided
6. Early involvement of the spine team is crucial.
7. Emergent intervention should not be delayed when required.

8.11 THE CANADIAN C-SPINE RULE

- The Canadian C-Spine Rule (CCR) is a highly sensitive decision-making tool used to determine when cervical spine radio-imaging should be utilized in patients following trauma.

- CCR is applicable for patients who are alert (GCS 15/15)) and in stable condition following trauma where a potential cervical spine injury may be of concern.

- The Rule is not applicable for non-trauma cases, patients with unstable vital signs, presenting with acute paralysis, known underlying vertebral disease, previous history of Cervical Spine surgery and for patients who are aged <16 years.

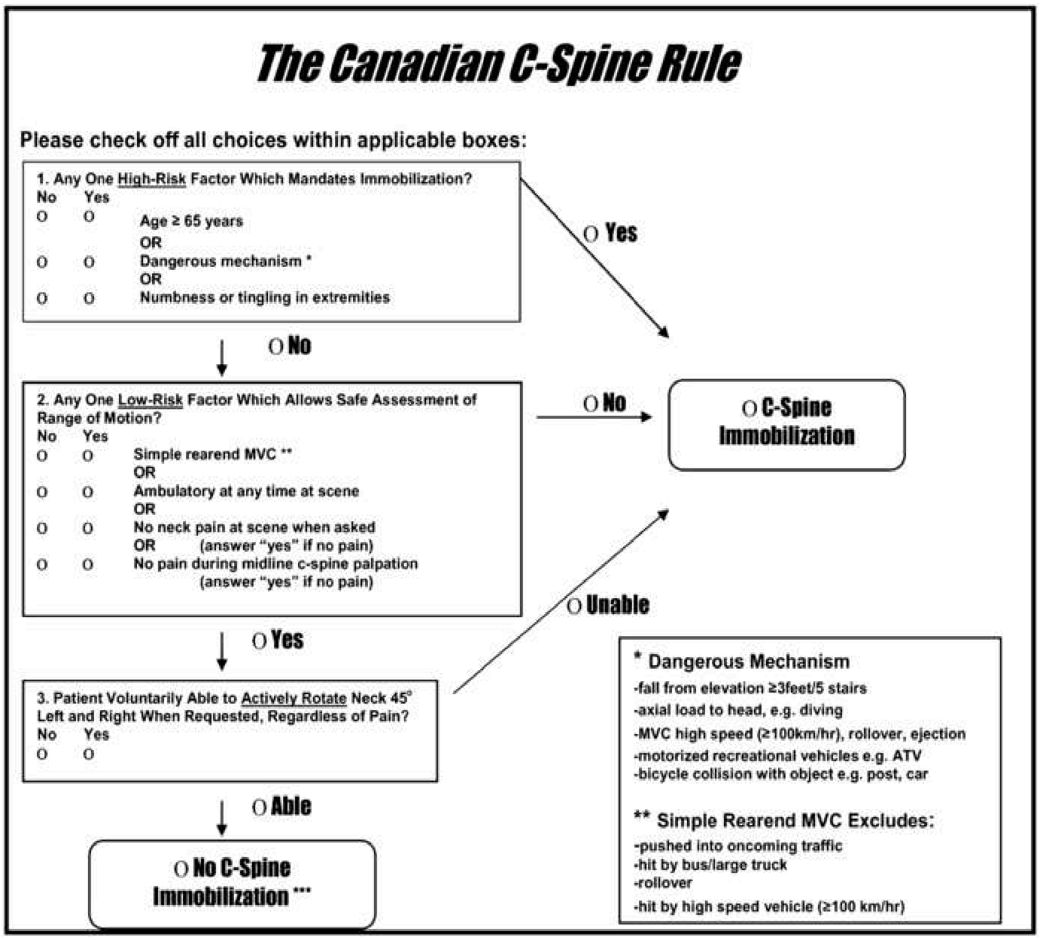

Figure 8.11: The Canadian C-Spine Rule
Attribution: Vaillancourt C, Charette M, Kasaboski A, Maloney J, Wells GA, Stiell IG., CC BY 2.5 <https://creativecommons.org/licenses/by/2.5>, via Wikimedia Commons

8.12 THE NEXUS CRITERIA

- The NEXUS Criteria is a validated tool utilised to clinically “clear” the cervical spine of significant injuries in the fully alert trauma patients.
- This criteria doesn’t define an age cut off and is validated for use for all patients aged > 1 years old.
- Significant cervical spine injury can be ruled out if the following criteria are present;

8.12.1 No Midline Cervical Tenderness

- Midline cervical tenderness is present when pain is expressed upon palpation of the posterior midline neck from the nuchal ridge to the spinous process prominence of the first thoracic vertebra

8.12.2 No Altered Mental Status

- Glasgow Coma Scale score of < 15
- Disorientation to time, place , person and events
- A delayed / inappropriate response to external stimuli
- Other clinical findings that deem the patient sub-conscious

8.12.3 No Focal Neurologic Deficit

- focal neurological complaints by patient or clinical findings of motor or sensory deficits

8.12.4 No Evidence Of Intoxication

- A recent history provided by the patient or observed intoxicating ingestion
- Evidence of intoxication upon examination
- Body fluids positive for drugs including blood alcohol level greater than 0.08 mg/dL

8.12.5 No Painful distracting injury

- There is no precise definition for distracting painful injuries

- Consider any condition assumed by the clinician to produce pain sufficient to distract a co-existing neck injury such as;
    - i) Long bone fracture
    - ii) Visceral injury requiring surgical intervention
    - iii) Large degloving laceration or crush injuries
    - iv) Large surface burns
    - v) Injuries resulting in functional impairment
    - vi) Physicians clinical assessment suggest impaired ability to appreciate other injuries

NEXUS CRITERIA
(NSAID)

N – Neurological deficit
S – Spinal tenderness
A – Altered mental status
I - Intoxication
D – Distracting Injuries

- Clinically significant cervical spine injury can be excluded if all criteria are met.
- Assessment of the Cervical Spine with possible co-existing Distracting Injuries
    - Co-existing injuries may distract the patient from being able to appreciate pain upon assessment of the cervical spine.
    - Due to varying pain thresholds and injury patterns, it is very difficult to ascertain which injury would be deemed as a “distraction” in various patients.
    - It is crucial to ascertain the patient's ability to appreciate pain.
    - The examiner establishes a pain threshold by gently squeezing the base of the neck (Trapezius muscle) to assess if the patient is able to appreciate the sensation of induced pain. (Always explain to the patient prior to initiating this examination)

- If the patient is sensitive to pain, the examiner can proceed to assess the neurology based on the pain threshold assessment established earlier.
- If the patient is not "sensitive" to "induced pain", then this examination should be averted and assessment should proceed for further imaging. These groups of patients can be deemed as experiencing distracting pain.
- This assessment should be performed by an experienced clinician.

8.13 ASSESSMENT OF THE THORACIC & LUMBAR SACRAL SPINE

"Clearing the T and L's spine"

Imaging is required, if any of the following is present:

- Presence of for spinal tenderness
- Presence of for step deformity
- Presence of neurological findings consistent with a thoracic or lumbar injury
- High impact injury/mechanism (i.e. fall from height and in the presence of distracting injuries)
- Significant thoracolumbar spine and sacral injury may still be present in the absence of midline tenderness (maintain high index of suspicion)

8.14 SUMMARY

- Time is Neuron.
- Spine protection by appropriate immobilization.
- The commonest cause of hypotension in trauma is hemorrhagic shock rather than neurogenic shock.
- Always ensure airway protection in high spinal injuries.
- Maintain high vigilance and suspicion of spine injury in a high risk mechanism.
- A normal cervical x-ray is unable to rule out clinically significant cervical injury.
- During the assessment of the spine, adjunct usage of a lubrication (i.e. medical purpose gel/water based lubricant) will increase the sensitivity of the clinical finding.

8.15 REFERENCE

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8.16 SKILL STATION

8.16.1 Cervical X-ray interpretation (lateral view)

<c> ABCDE approach

Adequacy, Alignment

Adequacy: C1 till upper border of T1 (if inadequate view, obtain Swimmer's or Shoulder Pull view)

Alignment: 4 lines (spinous process line, spino-laminal line, posterior longitudinal ligament line, anterior longitudinal ligament line

Bony abnormality, Base of skull

Look at the spinous process, facet joint and vertebral body. Trace cortical outline for height and integrity of base of skull.

Cartilage, Contours

Look for intervertebral disc spaces. Heights of vertebrae should be equal.

Dens

Examine outline of the dens

Pre-dental space or atlanto-dens interval (ADI) ≤ 3mm In adults and ≤ 5 mm in Paediatrics (between C1 and Odontoid peg)

Extra-axial soft tissue

Soft tissue overlying

C2 ≤ 6mm

C6 ≤ 2cm

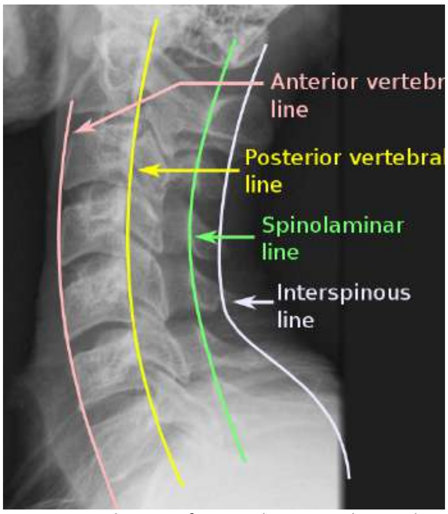


Figure 8.12: Normal X-Ray of Cervical Spine with Vertebrae Lines
Attribution: Mikael Häggström, M.D. - Author info - Reusing images, CC0, via Wikimedia Commons

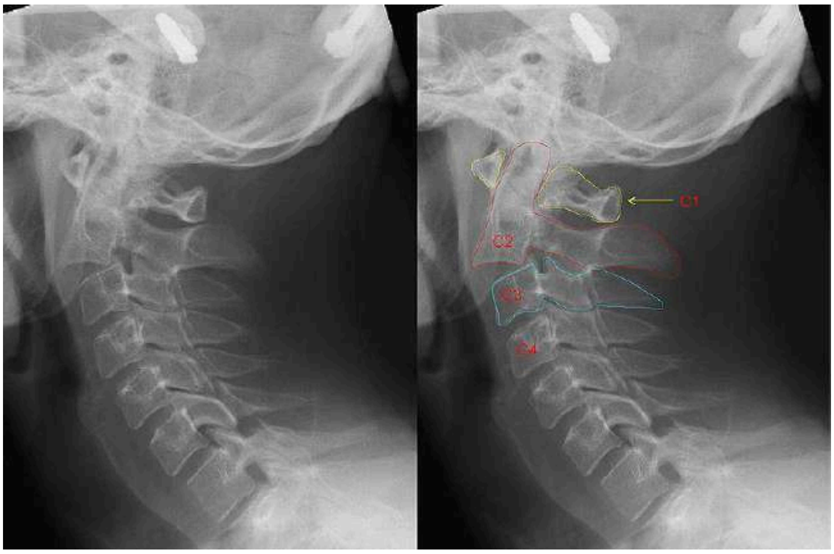


Figure 8.13: X-ray of the cervical spine with a Hangman's fracture.
Left without, right with annotation. Clearly can be seen that C2 (red outline) is moved forward with respect to C3.
Attribution: Lucien Monfils, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons

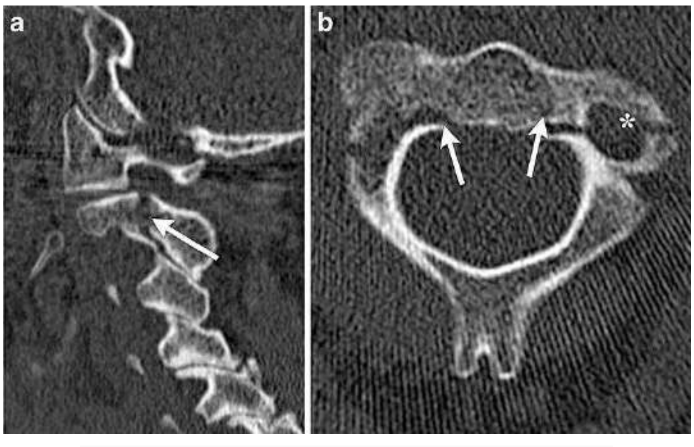


Figure 8.14 : Hangman’s Fracture on CT axial and Sagittal view
Attribution: Michael Utz, Shadab Khan, Daniel O’Connor & Stephen Meyers, CC BY 4.0 <https://creativecommons.org/licenses/by/4.0>, via Wikimedia Commons

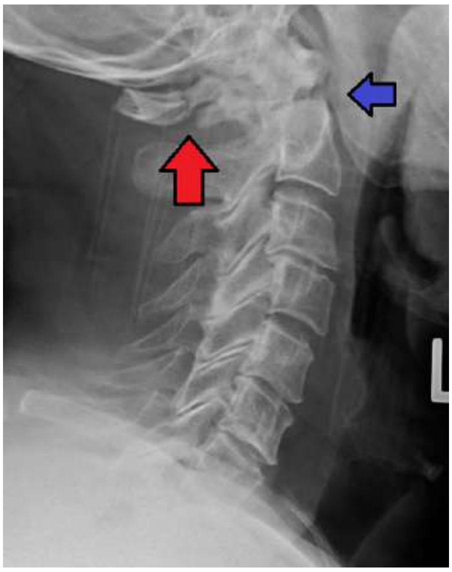


Figure 8.15: Jefferson Fracture
Attribution: James Heilman, MD, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

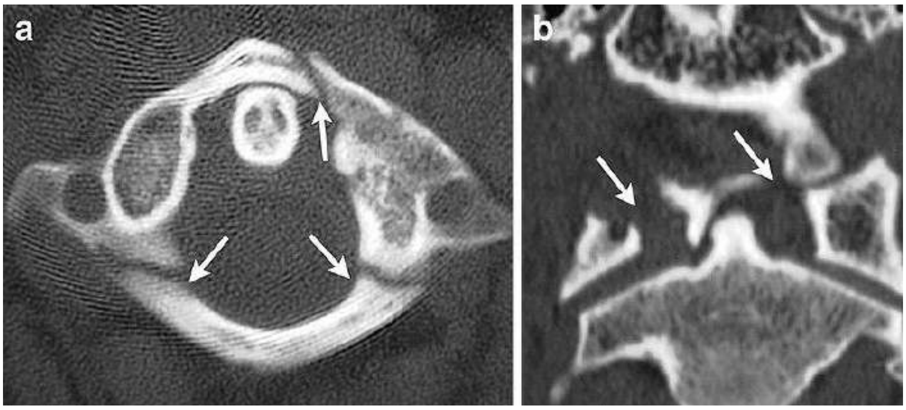
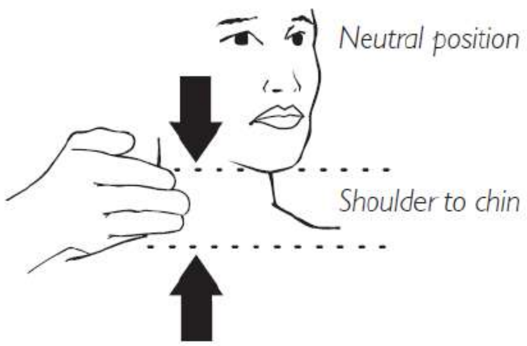
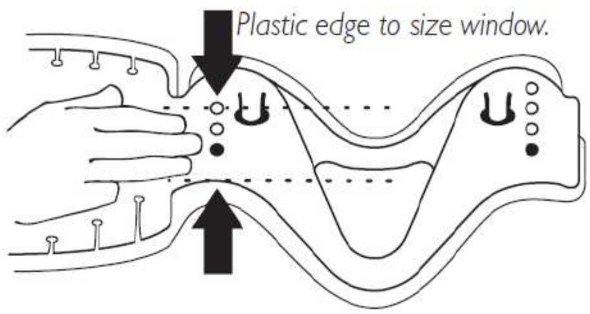
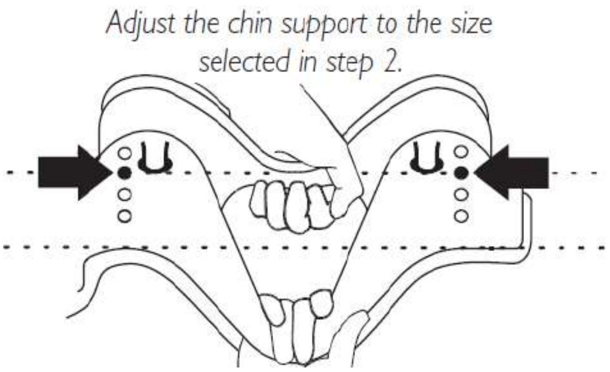
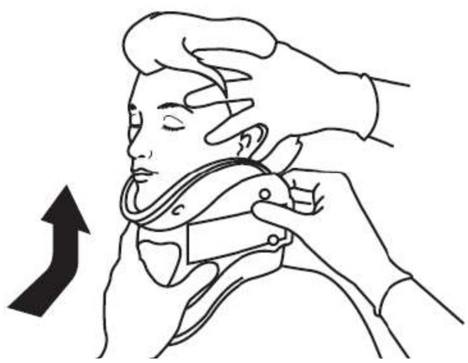


Figure 8:16: Jefferson Fracture on CT Cervical Spine Axial View
Attribution: Michael Utz, Shadab Khan, Daniel O'Connor & Stephen Meyers, CC BY 4.0 <https://creativecommons.org/licenses/by/4.0>, via Wikimedia Commons

8.16.2 Application of Cervical Collar

STEPS	ILLUSTRATION	DIRECTIONS
STEP 1		Measure the patient. Align the head to neutral position or “eyes forward” unless contraindicated.
STEP 2		Match the collar size to the patient’s neck
STEP 3		Adjust and lock the adjustable collar.
STEP 4		Apply the collar while maintaining a neutral head position. Place the chin support under the chin. If a different size is needed, remove, resize and reapply the collar.

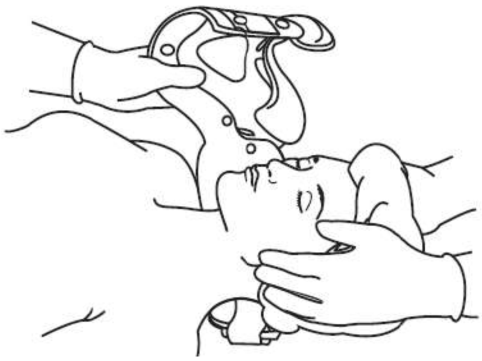
STEPS	ILLUSTRATION	DIRECTIONS
STEP 5		Pull the back of the collar snug while holding the front in place, and then fasten.
STEP 6		For supine patients, slide the rear panel behind the neck before placing the chin support.

Table 8.1 Application of cervical collar

Adopted from: Stifneck Select. Select and Pedi-Select Extrication Collar. Directions for use by Laerdal (http://cdn.laerdal.com/downloads/f2546/stifneck_select/_pedi_select.pdf) 3rd May 2021

Scan QR code or click here to watch the **Immobilisation (Cervical Collar and Spinal Board Application Skill Station)** video

CHAPTER
9

OSTEOMUSCULAR TRAUMA

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Able to prioritize identification of life threatening and limb threatening injuries with regards to musculoskeletal trauma
2. Able to understand the clinical principles in management of musculoskeletal trauma
3. Able to describe the stepwise approach in evaluation of musculoskeletal injuries

9.0 INTRODUCTION

Trauma to the extremities represents one of the most common injury patterns in the Emergency and Trauma Department. Achieving the best outcome in patients with severe musculoskeletal injuries requires a multidisciplinary approach. The etiology ranges widely from falls, motor vehicle collisions, industrial accidents, assaults, and others. Musculoskeletal injuries may range from simple minor bruising to severe imminent life-threatening hemorrhage. Rapid and accurate assessment is crucial in ensuring the best patient outcomes, preventing morbidity and mortality.

9.1 PRIMARY SURVEY AND RESUSCITATION

Assessment of the circulation and the ability to attain effective immediate hemorrhage control is vital in the management of severe musculoskeletal trauma. Early musculoskeletal assessment will focus on detecting the presence of immediate life or limb threatening injuries. Appropriate early intervention and resuscitation is essential to prevent consequent limb ischemia, hemorrhage and/or coagulopathy. Effective hemorrhage control may be attained by various means including the application of direct pressure, musculoskeletal wound packing, hemostatic sutures, or arterial tourniquets in catastrophic hemorrhage.

Early fracture immobilization reduces the incidence of cyclical bleeding with new clot formation, inadvertently reducing consequent consumptive coagulopathy and the inadvertent risk of life-threatening hemorrhage. Early reduction of joint dislocations is essential in concomitant cases with associated vascular compromise. Such injuries should prompt the clinician to perform further relevant investigation to assess vascular patency and injury as well as to administer close monitoring of distal perfusion.

9.2 ADJUNCTS TO PRIMARY SURVEY

9.2.1. Fracture immobilization

Goals of fracture immobilization

- Realign injured extremity as close to anatomical position as possible
- Decrease movement induced pain
- Avoid dislodgement of established blood clots and bleeding
- Prevent secondary injuries

9.2.2. X-ray examination

The Pelvic X-Ray should be performed as early as possible to rule out unstable fractures. Unstable pelvic fractures may cause catastrophic life threatening hemorrhage. It is one of the primary adjunct x-ray.

Extremity skeletal x-ray examinations are commonly performed during the secondary survey. However, the decision to obtain x-rays is dependent upon the attending physician's clinical judgement, mechanism of injuries, hemodynamic status, and clinical findings.

9.3 SECONDARY SURVEY

9.3.1. History of Presentation

The MAPLE history is part of the Secondary Survey. This mnemonic is devised for obtaining a rapid and focused history pertaining to the presenting injury and related treatment.

MAPLE HISTORY

M - Medicines and Medical conditions
A - Allergy history
P - Pregnancy
L - Latest meal and time
E - Encounter / Experience / Event

The secondary survey examination is a systematic approach to identify potential life threatening or any other associated injuries or fractures. This examination is performed from the head to toes. It should be performed after the primary survey, and initial stabilization has been completed.

9.3.2 Mechanism of injury

Identifying the mechanism of injury is crucial in patients who present with traumatic injuries. The mechanism of injury would suggest and provide the attending clinician with adequate information to identify all possible underlying injuries.

Example of critical history that should be elicited from patients presenting with motor vehicle accidents;

- Position of the patient within the vehicle pre collision
- Post-collision location of patient
- Use of restraints in the vehicle
- Deployment of airbag
- Extent of external damage to vehicle, type of vehicle
- Front, rear or side collision
- History of vehicle roll over
- Extrication and duration of extrication if any
- Any death within same vehicle

- Patients presenting with falls
    - Cause of the fall
    - Height of the fall
    - Surface of landing area / fall
    - Position of patient during landing
    - Condition of patient after the fall
    - Conscious level prior to fall

- Crush injuries
    - Mechanism leading to crush injury
    - Type of object and estimated weight
    - Duration of entrapment
    - Site of Injury

Certain trauma mechanisms tend to present with a classical pattern or series of predictable injuries. The Waddell's triad is a pattern of injury seen in pedestrian children who are struck by motor vehicles. The relative height of a child to the front bumper of the car provides a predictable pattern of injury. The injury patterns consist of fractured femoral shaft, intra-thoracic or intra-abdominal injuries with a contralateral side head injury.

> Waddell's Triad:
>
> Predictable Injury Patterns of Pedestrian Children Struck by Motor vehicles;
> - Fractured femoral shaft
> - Intrathoracic / intra-abdominal injury
> - Contralateral side head injury

The speed and circumstances of impact may determine different patterns of injury. Attention to the details in the presenting history of the patient or witness will provide the clues to suspected injuries. The following are examples of anticipated injury patterns with common mechanisms of injury.

9.3.3 Environmental Factors

Environmental factors related to the mechanism of injury should be identified. Examples of critical environmental factors include and not limited to associated contamination, exposure to extreme temperatures, shrapnel etc. Such information may be derived from prehospital care personnel. It will assist clinicians to anticipate potential complications.

9.3.4 Pre Injury or Predisposing Factors

- Comorbidity or functional disability
- Exercise or activity level
- Alcohol or substance abuse
- Previous associated injuries

9.3.5 Prehospital Observation and Intervention

Information and findings at the scene would assist in identifying potential injuries.

- Position in which patient was found
- Estimated blood loss
- Exposed bone or fracture fragments
- Open wounds
- Deformity or dislocation
- Duration in extrication
- Neurovascular assessment of the limbs
- Reductions of fracture and dislocations
- Dressings and splints applied
- Time of injuries, vital signs, scene time
- Age and gender.

9.4 PHYSICAL EXAMINATION

9.4.1 Inspection

- Inspect the patient to identify sites of major external bleeding, pooling of blood, or blood soaked clothing.
- Assess the colour of the limb. Pale extremities suggest vascular insufficiency. Swelling, hematoma and bruising may suggest evidence of muscular injuries and/or fractures, thus at risk of developing subsequent rhabdomyolysis and/or compartment syndrome.
- Inspect the position of the limb which may suggest specific injuries. For example, a wrist drop with a mid-shaft humerus fracture is likely associated with radial nerve injury.
- Observe spontaneous movements of the limbs. For example, spinal cord injuries may present with paraplegia.
- Observe for obvious limb deformities, immobilize with appropriate splints as soon as possible if present.

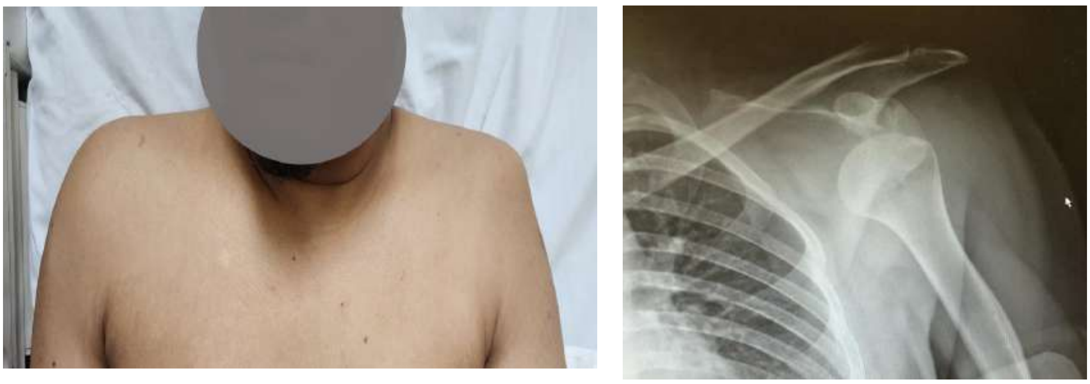


Figure 9.1: Example of a left anterior shoulder dislocation presentation with a "squared off" appearance. (i.e. boxlike). Inspection will reveal loss of deltoid contour compared with the contralateral side.

9.4.2 Palpation

Conduct clinical examination by palpation of the entire musculoskeletal system to identify injuries that may be subtle or less obvious during inspection. Palpation is crucial in identifying signs of circulatory compromise.

- Circulatory evaluation of the limbs

Assess all distal limb pulses to identify disparity as compared to the uninjured limb or presence of signs suggestive of vascular injury / insufficiency. Assess for temperature (cold or warm) of the limb distal to injury site, capillary refill time and pallor. Adjunct Doppler assessment / studies and Ankle Brachial Index will guide to determine possibility of vascular insufficiency. An Ankle / Brachial index of less than 0.9 may indicate abnormal arterial flow secondary to injury or peripheral vascular disease.

- Muscle compartment and skeletal integrity

Palpate for presence of tenderness, swelling and skin temperature over the limbs. Examine every muscle compartment of both upper and lower limbs to elicit signs of fractures , soft tissue injuries or clinical evidence suggestive of compartment syndrome.

- Joint stability and function

Examine the functional ability of all limb joints. Assess for active / passive range of motion, presence of joint tenderness, swelling, intra articular fluids and functional stability. Assess for any bony or ligamentous soft tissue injuries.

- Neurological examination

Perform a thorough neurological motor, sensory and tendon reflex examination. Elicit for any evidence suggestive of spinal cord or peripheral nerve injuries. Perform repeated and frequent assessment of the neurological function as necessary. Power grading, dermatome sensory and reflexes are evaluated.

- Log roll

Perform log roll manoeuver to identify any additional potential limb or life threatening injuries. This manoeuver must be performed carefully with appropriate spinal immobilisation advocated at all times. Perform this manoeuvre only once the possibility of concomitant unstable pelvic fracture has been ruled out. Inspect for obvious deformity / injury. Palpate the spine for tenderness, swelling or step deformity. (Advocating the use of lubricant gel on gloved hands may improve the ability to identify subtle injuries during palpation of the spine and paraspinal regions). Carefully examine the paraspinal and posterior trunk for evidence of injuries. The log roll examination is performed to complete the entire body examination. The log roll is commonly performed during the secondary survey. When the presence of an unstable pelvic fracture cannot be immediately ruled out, a “back sweep” maneuver can be performed to identify the presence of any obvious immediate life threatening injuries over the posterior torso.

9.4.3 Imaging Adjuncts In Secondary Survey

The skeletal x-ray series or appropriate radio imaging modality can be performed once the secondary survey has been completed. The choice of radio imaging modality performed will be determined by the clinical findings and planned interventions. X-rays of suspected limb fractures should include the joint above and below the site of injury. The radio imaging investigations in secondary surveys should only be carried out when the patient is clinically stable.
The primary series x-ray is performed during the primary survey and it includes the chest and pelvis x-ray. The primary series x-ray is an adjunct used to rule out the presence of immediate life threatening injuries. This x-ray is preferably performed onsite after the primary survey, avoiding distant travel to radiology department/services when possible.

9.5 LIFE THREATENING EXTREMITY INJURIES

I. Major Arterial Haemorrhage
II. Crush Syndrome & Rhabdomyolysis

9.5.1 Major Arterial Haemorrhage

External bleeding arising from a major artery can result in exsanguinating and immediately life threatening haemorrhage (i.e. axillary artery, femoral artery, subclavian artery). Immediate control of haemorrhage should be attained in order to avoid the deleterious consequence of haemorrhagic shock and death.

Assessment

Hard signs of arterial injury include;

- Pulsatile and active high pressure haemorrhage (often with bright red coloured blood)
- Expanding or pulsatile swelling
- Bruit or thrill over swelling
- Absent of distal pulses
- Extremity ischemia (pain, pallor, paralysis, cool to touch)

In a large observation study of penetrating extremity trauma, the presence of a hard sign of arterial injury was nearly 100 percent predictive of a vascular injury warranting surgical intervention. Ankle brachial index, Doppler tone, CT angiography and arteriography are modalities used in evaluation of vascular injury.

Initial Management

- Intervention to attain immediate control of active haemorrhage, simultaneous appropriate circulatory resuscitation and surgical consultation is carried out

- Depending on the location and injury pattern, intervention to attain immediate control of active haemorrhage can be achieved by means of applying direct pressure compression, performing wound packing with compression dressing, applying adjunct use of haemostatic agents, performing haemostatic suturing and application of arterial limb tourniquets.

- Emergency intervention to attain immediate control of the bleeding should be performed in the Emergency Department, failing which will result in consequent hypovolemic shock, coagulopathy and death prior to enabling subsequent surgical repair / definitive haemorrhage control procedures to be carried out.

9.5.1.1 Arterial Tourniquet

Arterial tourniquets are applied for non-compressible exsanguinating haemorrhage as a temporary lifesaving intervention, bridging time for definitive repair or control to be performed. Prolonged use of an arterial tourniquet will result in distal segment ischemia and its resultant consequences. Definitive hemorrhage control measures should be performed as soon as possible, tourniquet application should not exceed 2 hours.

9.5.1.2 Associated Fracture & Dislocation

- In suspected arterial injuries with associated long bone fractures, immobilisation in anatomical position should be performed as soon as possible. Continuous movement of the fracture site will result in recurrent clot disruption, bleeding and resulting coagulopathy. Immobilisation in anatomical position may ensure sustained distal perfusion.

- Joint dislocations may cause interruption of distal limb perfusion due to associated arterial compression or intimal injury. All such dislocations should be addressed immediately and dislocations reduced as soon as possible. Post reduction, continuous distal perfusion assessment should be advocated and appropriate imaging investigations may be required to assess for possible associated vascular injuries. (ie. Popliteal artery damage caused by a spontaneously reduced posterior knee dislocation, may present with delayed absence of distal pulses due to progressive arterial intimal tear).

9.5.1.3 Junctional Haemorrhage

- Junctional haemorrhage is described as overt bleeding occurring from a junction of the torso and extremities, (i.e. base of neck, axilla , perineum, shoulder, buttocks, gluteal region and groin). Bleeding from these regions can be challenging to control. The use of common extremity arterial tourniquets may not be feasible due to the anatomical considerations/limitations of the bleeding site.

- Junctional haemorrhages may be controlled by means of applying direct pressure and compression, or when possible performing haemostatic wound packing with combined haemostatic suturing.

Figure 9.2: a) Junctional haemorrhage with exsanguinating arterial bleed over the base of the neck with associated open fracture of left clavicle. b+c) Performing wound packing using haemostatic agents and providing subsequent compression. d+e+f) Haemostasis attained after prolonged compression, haemostatic packing secured in-situ with haemostatic suturing. Immediate Emergency control of junctional haemorrhage attained, patient clinically stabilised, subsequently underwent successful surgical vascular repair.

9.5.2 Crush Syndrome & Traumatic Rhabdomyolysis

Systemic manifestations that are induced by crush injury are often referred to as crush syndrome, potentially leading to rhabdomyolysis and its harmful consequences. Rhabdomyolysis is a complex disorder involving the rapid dissolution of injured skeletal muscle. This disruption of skeletal muscle integrity leads to the direct release of intracellular muscle components, including myoglobin, creatine kinase (CK), aldolase, and lactate dehydrogenase into the systemic circulation. Rhabdomyolysis is manifested by marked elevations in creatinine kinase level with consequent acute renal injury, leading to disseminated intravascular coagulation (DIVC), multi organ dysfunction and even death.

9.5.2.1 Clinical Assessment

- **Compartment syndrome:** Compartment syndrome is a potential sequelae to crush injuries. It is a localized rapid rise of pressure within a muscle compartment, which inevitably leads to metabolic disturbances, inflammation, cellular hypoxia and death, akin to rhabdomyolysis.

- **Hypovolemia:** Excessive bleeding, prolonged extrication time, ongoing third space fluid loss and inadequate fluid replacement may result in hypovolemia and shock.

- **Renal insufficiency:** The severity of renal insufficiency ranges widely from a mild elevation in the serum creatinine concentration to oliguric AKI requiring immediate hemodialysis.

- **Dark urine:** The characteristic manifestation of heme pigment-induced acute tubular necrosis (ATN) is discolored urine. Marked release of myoglobin leads to red or brown (or even black) urine.

- **Biochemical abnormalities:** The biochemical abnormalities that characterize rhabdomyolysis-associated AKI include hyperkalemia (life threatening), hyperphosphatemia, hypocalcemia and metabolic acidosis.

- **Others:** Other systemic manifestations of crush syndrome may include, disseminated intravascular coagulation, bleeding diathesis, cardiac failure, arrhythmias, and psychological trauma.

9.5.2.2 Management Considerations

Intravenous Fluids

Aggressive fluid resuscitation and hydration is vital in the management of crush injuries. Intravenous fluids infusion is best initiated in entrapped subjects prone to develop the crush syndrome, even before or during extrication. In severe crush injuries, intravenous isotonic fluids is administered at high rates (may require up to

6-10 litres in first 24 hours) depending on age, body weight, associated injuries, ambient temperature, urine production, amount of overall estimated fluid losses and pre-existing medical conditions. Symptoms of fluid overload need to be diligently monitored.

Use of bicarbonate

Forced alkaline diuresis can be considered on a case-by-case basis and requires close monitoring of the patient. Alkalinization of the urine by giving sodium bicarbonate may provide renal protection by preventing precipitation of myoglobin in the renal tubules. Disadvantages to systemic alkaline therapy include hypocalcaemia by shifting ionized calcium to its non-ionized form, increasing likelihood of calcium phosphate precipitation. Isotonic bicarbonate solutions may be used for these purposes when required.

Urine output goal

A Foley's catheter should be placed for patients treated for crush syndrome. Once patients can be closely monitored, the administration of intravenous fluid should be adjusted to maintain a urinary output at approximately 200 to 300 mL/hour (1.5-3 ml/kg/h) in adults. Close monitoring of electrolyte balance should be advocated. Presence of hyperkalaemia, hypocalcaemia, and hyperphosphatemia should prompt immediate necessary treatment.

9.6 LIMB THREATENING INJURIES

1. Open fractures and joint injuries
2. Traumatic amputations
3. Compartment syndrome
4. Vascular injuries
5. Neurologic injuries secondary to fracture dislocation
6. Mangled limb

9.6.1 Open Fractures and Joint Injuries

Figure 9.3 : Open fracture of the right femur with bone fragment extrusion

Open fractures are defined as presence of direct communication between the fracture and the environment due to traumatic disruption of the intervening soft tissue and skin. Open fractures are associated with higher incidence of infection as compared to closed fractures.

Assessment

Open fractures are diagnosed by physical examination and radio imaging of the involved limb. Assess the wound, associated soft tissue injuries, circulatory and neurologic function. All active bleeding should be secured and contaminated wounds should be irrigated immediately in the Emergency Department.

In the initial assessment phase, a wound overlying a joint should be assumed to be in communication with the joint until proven otherwise. If a wound is overlying the fracture segment, the fracture should be treated and considered as an open fracture until proven otherwise. Do not attempt blind probing of the wound.

Initial Management

- Appropriate analgesia
- Irrigation and decontamination
- Antibiotics
- Tetanus prophylaxis as indicated
- Immobilization

9.6.2 Traumatic Amputation

Traumatic amputation refers to a major injury inflicted upon an extremity limb leading to physical detachment or loss of the distal limb fragment from the body.

Initial Management

1. Refer to Major Arterial Hemorrhage
    - Attain haemorrhage control immediately.

2. Clean the amputated limb off dirt and debris with clean water whenever possible. Wrap the amputated limb in sterile damped gauze / clean cloth and place it in a plastic wrapper. Ensure the plastic wrap is waterproof. Provide indirect cooling by placing the wrapped & protected limb in a container containing iced-saline. Do not allow the amputated limb to come in direct contact with ice. Transport the amputated part with the patient.

3. Reimplantation surgery may be performed up to 12 hours for finger amputations and lesser periods for lower and upper limbs (6-8 hours in general). Shorter interval time to reimplantation provides improved success rates.

9.6.3 Acute Compartment Syndrome

Acute compartment syndrome (ACS) often develops after significant trauma, particularly involving long bone fractures and it is an acute limb threatening emergency. Increased pressure within a compartment impairs the circulation and function of the tissues within the space.

High risk injuries are:

- Tibial plateau and forearm fractures
- Injuries immobilized in tight dressing or cast
- Severe crush injuries to muscle
- Localized prolonged pressure to extremities
- Increased capillary permeability secondary to reperfusion injuries
- Burns

Initial Assessment

Examination findings suggestive of Acute Compartment Syndrome include the following:

- Pain out of proportion to apparent injury or on passive stretch of muscles
- Pallor from vascular insufficiency (uncommon and late finding)
- Paraesthesia and diminished sensation
- Paralysis (late finding)
- Pulseless, poor pulse volume

Compartment pressures

Clinical findings associated with Acute Compartment Syndrome correlate with the degree of tissue pressure within the affected compartment.

- Normal pressure within the tissue compartment is between 0 and 8 mmHg.
- Muscle blood flow is severely compromised when intramuscular pressure rises above 30 mm Hg.
- Pain may develop as tissue pressures reach between 20 and 30 mmHg.
- Ischemia occurs when tissue compartment pressures approach diastolic pressure.

- The delta pressure is found by subtracting the compartment pressure from the diastolic pressure. With suggestive clinical correlation, a difference of <30 mmHg is used as the guide to determine the need for fasciotomy.

- These values are of approximation. Higher compartment pressures may be necessary before injury occurs to peripheral nerves in patients with systemic hypertension, while Acute Compartment Syndrome may develop at lower pressures in those with hypotension or peripheral vascular disease.

ACS Delta Pressure = Diastolic BP – Measured Compartment Pressure

Initial Management

Immediate management of suspected Acute Compartment Syndrome includes **relieving all external pressure** on the compartment. Any dressing, splint, cast, or other restrictive covering should be removed. The limb should neither be elevated nor placed in a dependent position. Placing the **limb level with the heart** helps to avoid reductions in arterial inflow and also avoid increases in compartment pressures from dependent swelling, both of which can exacerbate limb ischemia.

Analgesics should be given. Hypotension reduces perfusion, exacerbating tissue injury, and should be treated / addressed appropriately. **Fasciotomy should be performed** to decompress and relieve compartmental pressures.

The diagnosis of acute compartment syndrome is a clinical diagnosis, combining patients presenting history, physical examination, clinical signs and not only determined by pressure measurements. Compartment pressure measurements can be used as adjuncts in diagnosing acute compartment syndrome.

Acute Compartment Syndrome is a Clinical Diagnosis

9.6.4 Vascular Injuries

Figure 9.4 : Rapidly expanding hematoma. Over the right thigh

Figure 9.5 : CT Angiography shows right superficial femoral artery injury with mid-shaft femur fracture

Initial Assessment

Vascular (arterial) injuries may present with associated fractures, crush injuries and penetrating trauma to the limbs. Vascular compromise may be partial or complete. Involved limb may appear viable due to presence of collaterals which may provide reconstitution of distal flow. Prolong capillary refill time, diminished peripheral pulses and abnormal Ankle/Brachial Systolic Index (ABSI) may suggest vascular injury / compromise. Vascular (arterial) injuries with poor collateral reconstitution may manifest as cold, pale and pulseless limb.

Initial Management

- Early recognition of avascular extremity is crucial
- Arterial injuries associated with joint dislocation require early reduction
- Fracture deformity should be realigned gently and splinted in order to restore distal vascular flow
- Computed tomography (CT) angiography may be helpful in establishing accurate diagnosis and planning treatment approach

Ankle Brachial Index (ABI)

The ankle-brachial index (ABI) is the ratio of the systolic blood pressure measured at the ankle to that measured at the brachial artery.

Ankle Brachial Systolic Index (ABI)

- In supine position, record the systolic pressure of the uninjured arm.
- Using a Doppler ultrasound probe with a standard manual blood pressure cuff, record the systolic pressure of posterior tibial artery (PTA) or dorsalis pedis artery (DPA) of the injured leg. (Use the higher recorded pressure for this purpose)
- Divide the systolic blood pressure of the injured ankle by the Brachial systolic pressure of either arm (Use the arm with the higher pressure for this purpose)
- Ankle /brachial index <0.9 is indicative of an abnormal distal arterial flow secondary to peripheral arterial injury or peripheral vascular disease
- The ABI normal range is 0.9-1.4

9.6.5 Neurologic Injuries Secondary to Fracture Dislocation

Fractures and dislocations can cause nerve injury due to the anatomy and proximity of the bone and nerve. Early identification and appropriate treatment is crucial in order to assure best outcomes.

Initial Assessment

All fractures require a thorough neurological assessment and documentation. Neurological assessments involve sensory, motor and tendon reflex examinations. Perform serial examinations to enable early detection or progression in nerve injury / compression.

Neurological examination

Spinal Nerve Segment	Dermatome & Examination Region
C5	Upper arm – lateral aspect (also Axillary nerve)
C6	Thumb and index finger – palmar aspect (median nerve)
C7	Middle finger – palmar aspect
C8	Little finger – palmar aspect (ulnar nerve)
T1	Forearm – medial aspect
L3	Thigh – medial aspect
L4	Lower leg – medial aspect especially over medial malleolus
L5	Between the 1st and 2nd toes – dorsum aspect (common peroneal nerve)
S1	Foot – lateral aspect

Table 9.1: Spinal Cord Sensory Dermatome Examination of Limbs

Spinal Nerve Segment	Innervation & Motor Function Assessment
Axillary nerve ,C5	Shoulder abduction
Musculocutaneous nerve, C5,C6	Elbow flexion
Radial nerve, C6, C7, C8	Elbow extension
Radial nerve, C6	Power grip test Wrist dorsiflexion
Median nerve, ulnar nerve, C7,C8	Fingers flexion
Ulnar nerve, C8, T1	Finger adduction / abduction
Deep peroneal nerve, L5	Great toe and ankle dorsiflexion
Posterior tibial nerve, S1	Plantar flexion

Table 9.2: Spinal Cord Motor Innervation and Examination of Limbs

Assessment of peripheral nerves with associated common injury patterns are described in the table below.

NERVE INJURY	SENSORY ASSESSMENT	MOTOR ASSESSMENT
Ulnar	5th finger	2nd & 5th finger abduction
Median (distal)	2nd finger	Contracture of thenar with opposition
Median (anterior interosseous)	-	Index tip flexion
Radial	1st dorsal web space	Thumb, finger metacarpophalangeal extension
Axillary	Lateral shoulder	Deltoid
Musculocutaneous	Radial forearm	Elbow flexion
Femoral	Anterior knee	Knee extension
Obturator	Medial thigh	Hip adduction
Posterior tibial	Sole of foot	Toe flexion
Superficial peroneal	Lateral dorsum foot	Ankle eversion
Deep peroneal	Dorsal 1st-2nd web space	Ankle dorsiflexion
Sciatic	Foot	Plantar dorsiflexion
Superior gluteal	Upper gluteal region	Hip abduction
Inferior gluteal	Lower gluteal region	Gluteus maximus hip extension

Table 9.3 : Extremities nerve assessment

Initial Management

In the initial phase, the injured limbs should be immobilized to the most comfortable and pain free resting position. Appropriate analgesia should be administered as soon as possible. Assessment for immediate limb threatening signs should be performed, including assessment of peripheral perfusion and neurology. After diagnostic imaging has been completed, reduction of the fractures and or dislocation should be performed. Depending upon the injury pattern, patient clinical state, available resources and expertise, the reduction can either be performed in the Emergency Department, ward or the operation theatre. The neurological assessment should be documented prior and after the reduction procedure is completed. Post reduction, appropriate series of radio imaging (x-rays) should be performed.

Figure 9.6: Lateral dislocation of left knee with corresponding x-ray

Figure 9.7: Clinical left ankle dislocation

9.6.6 Mangled Limb

A mangled limb is defined as an injury to at least three out of four systems (soft tissue, bone, nerves, and vessels) in an injured limb. High amputations rate had been associated with the mangled limbs.

Mangled Extremity Severity Score (MESS) may assist in the initial evaluation and identification of patients who will benefit the most in cases of limb salvaging interventions versus amputations. This score utilizes clinical variables that are readily available during the assessment of the injured limbs.
MESS can be applied to adult patients who sustained extremity trauma, particularly the lower limb.
A MESS of more than 7 has a poorer prognosis with increased probability of surgical amputation of the limbs. However, with advancement of trauma care and surgical intervention a higher MESS may also benefit from surgical intervention.

MANGLED EXTREMITY SEVERITY SCORE (MESS)

COMPONENT	CLINICAL FINDING	SCORE
Limb Ischemia *	Reduced pulse but normal perfusion	1
	Pulseless, Paresthesia, Delayed Capillary Refill	2
	Cool, Paralysis, Numb/Insensate	3
Patient Age Group (in years)	< 30	0
	30-50	1
	≥ 50	2
Shock	SBP > 90 mmHg consistently	0
	Transient Hypotension	1
	Persistent Hypotension	2
Injury Mechanism	Low Energy (Simple Fracture, Stab , Gunshot)	1
	Moderate Energy (Dislocation, Open, Multiple Fractures)	2
	High Energy (High Velocity Motor Vehicular Accident)	3
	Very High Energy (High Speed Trauma with gross contamination	4

***In the presence of Limb ischemia >6 hours, limb ischemia points are multiplied by 2.**

Table 9.4 Mangled Extremity Severity Score

Figure 9.8 Mangled limb

9.7 ASSOCIATED INJURIES

In major trauma, multiple injuries may co-exist upon initial presentation. It is crucial that attending physicians do not miss significant associated injuries. Certain injury patterns are closely associated with specific concomitant injuries. Such injuries may not be immediately apparent. Clinicians should be well aware of these injury patterns to reduce incidences of missed injuries. Frequent re- assessment and recognition are deemed necessary. The following table demonstrates specific injuries with its common associated injuries.

9.8 PAIN MANAGEMENT

1. Immobilisation reduces pain by limiting motion.

2. Appropriate administration of parenteral analgesia should be provided (multimodal analgesia)

3. Patients with persistent pain (> 4/10 pain score) despite optimisation of parenteral analgesia may benefit from regional blocks / anaesthesia. Regional blocks provide means of advocating effective analgesia as well as a modality used to facilitate fracture reductions and early effective wound irrigation. The procedure should be performed by trained personnel.

9.9 MOREL – LAVALLEE LESIONS

In a post-traumatic closed degloving soft tissue injury, this lesion occurs deep to the subcutaneous tissue plane separating the deep fascia from the underlying muscle plane. Shear injury disrupts perforating vessels and lymphatics creating potential space filled with blood, serosanguinous fluid, lymphatics fluid and necrotic fats.

Commonly seen in the trochanteric region and proximal thigh area. It may occur at the trunk, lumbar, pre-patellar and scapular regions too. Usually presented with enlarging painful lesions with soft tissue swelling and fluctuance.

In acute trauma, the diagnosis of Morel-Lavallee lesion is often missed or delayed, due to the slow progression of the lesion. Differential diagnoses include fat necrosis, coagulopathy related hematoma and traumatic myositis ossificans. Left untreated, this lesion will become infected, progressively leading to severe sepsis and extensive skin necrosis.

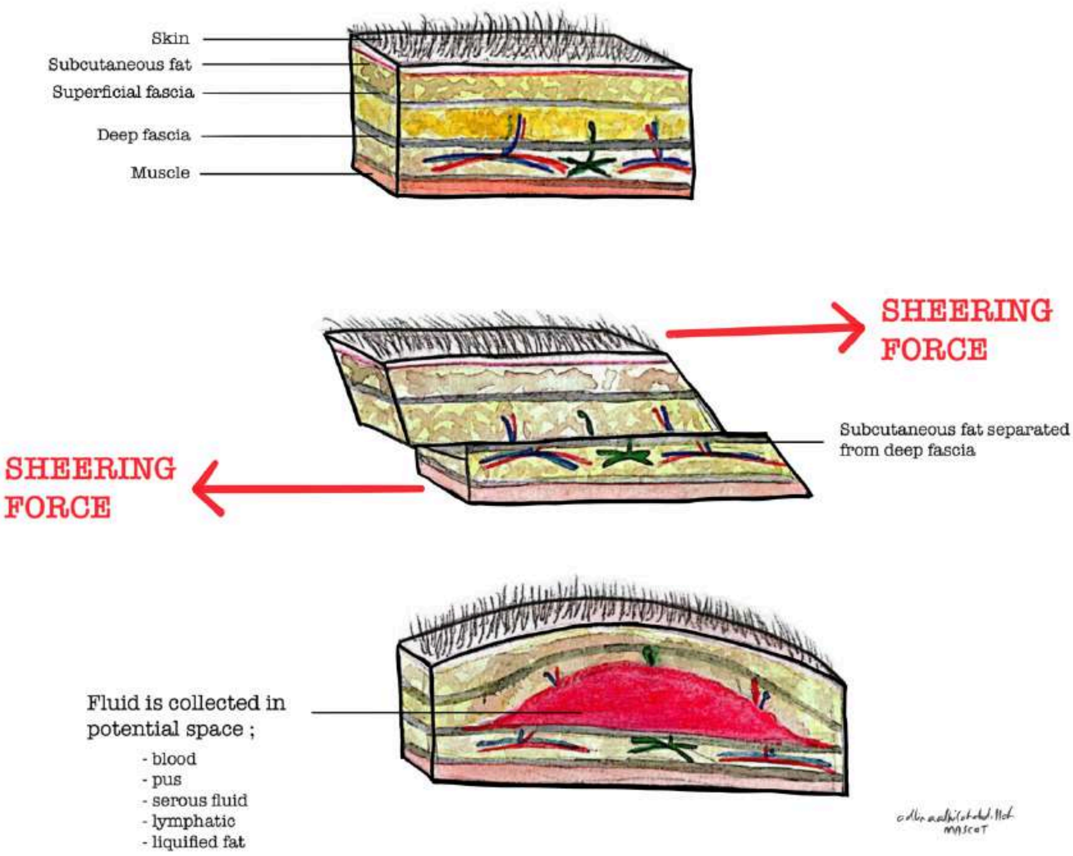


Figure 9.9 : Morel-Lavallee Injury

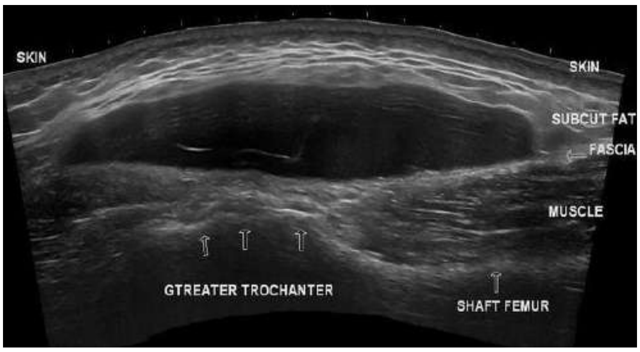


Figure 9.10 : Ultrasound image of Morel-Lavallee lesion at the thigh

9.10 SUMMARY

- Musculoskeletal injuries may result in acute limb and life-threatening consequences.
- In massive bleeding, haemorrhage control should be attained immediately.
- Serial examination and early recognition of neurovascular compromise is crucial.
- Consider compartment syndrome in high-risk predisposing injuries.

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9.12 SKILL STATION

9.12.1 SKILL STATION 1

PHYSICAL EXAMINATION

Look and general overview

Step 1

Visual inspection of the entire patient to identify sites of major external bleeding, pooling of blood, blood soaked clothing. Wound assessment should be performed as well.

Step2

Assess the color of the limb. Pale extremities suggest vascular insufficiency. Swelling, hematoma and bruising may suggest evidence of muscle injuries, underlying fractures or compartment syndrome.

Step3

Position of the limb is noted as it can determine the pattern of injuries. For example, wrist drop is associated with radial nerve injuries.

Step 4

Spontaneous activity of the limbs is observed. For example, suspicion of thoracic or lumbar injuries in patients who are unable to move bilateral lower limbs.

Step5

Splint and immobilize any deformed limb as soon as possible

Feel

The paramount purpose in limb examination is to exclude life and limb threatening injuries.

Step 1 : Circulatory evaluation of the limbs.

Assess the pulses in each limb looking for disparity in pulse volume.

Temperature (cold or warm) peripheries, capillary refill time and pallor are noted. These abnormal findings may suggest vascular insufficiency.

Doppler studies and ankle brachial index will guide further in determining vascular insufficiency. Ankle / Brachial index of less than 0.9 may indicate abnormal arterial flow secondary to injury or peripheral vascular disease.

Step 2 : Muscle compartment and bones.

Feel for any tenderness and swelling over the limbs.

Palpate each muscle compartment looking for fractures or any evidence of compartment syndrome.

Step 3 : Joint stability.

Request the patient to move the joint through a range of motion that is tolerated.

Palpate joints for tenderness, swelling, intra articular fluids and instability.

Any deformed or dislocated joints should be x-rayed before testing for instability.

9.12.2 SKILL STATION 2

Principles of Extremity Immobilization

1. Assess **ABCDE**s and address life threatening conditions.
2. Completely expose and remove all accessories worn by patients. However, subsequent steps to prevent hypothermia must be advocated.
3. Assess neurovascular status of the limb prior to splint application.
4. Open wounds are covered with sterile dressings.
5. Appropriate size of splint is selected. It should immobilize a joint above and below the injured extremity.
6. Apply padding over bony prominences that will be covered by the splint.
7. Realign extremity if possible before splinting. Do not forcefully realign a deformed limb (eg: Dislocated Joint).
8. Re- examine neurovascular status of the limbs after splint application. Realign the limb if neurovascular status of the limbs worsens after splinting.
9. Obtain orthopedic consultation.
10. Administer appropriate tetanus prophylaxis, analgesia and antibiotics.

Figure 9.11 : Limb immobilization application

Scan QR code or click here to watch the **Immobilisation (Limb Splint) Skill Station** video

9.12.3 SKILL STATION 3

Traction Splint Application

1. Upon recognizing the injury, Rescuer One should stabilize leg in the position found.
2. Rescuer Two will then expose the injured leg. Assess neurological function distal to injury site. Assess circulatory function distal to injury site.
3. Rescuer Two should prepare a traction splint. Position splint against uninjured leg. Place the ischial pad against the iliac crest. Adjust splint to length, extending the splint so that the bend is even with the heel of the foot. Tighten locking collars. Open and position the Velcro straps along the splint. Release the ratchet, extending the entire length of the traction strap. Place the splint next to the injured leg.
4. Rescuer Two should apply the ankle hitch to the patient.
5. Rescuer Two should apply gentle but firm traction.
6. Rescuer One will now move the splint into position. A. The splint should be firmly seated against the ischial tuberosity.
7. Rescuer One secures the pubic strap. The strap is brought over the groin and high over the thigh and secured.
8. Rescuer One attaches the ankle hitch to the traction strap.
9. The traction strap is taken in, applying mechanical traction until the pain and muscle spasms are relieved. Maintain manual traction until the mechanical traction takes over. Traction can be stopped when the injured leg is approximately the same length as the uninjured leg.
10. Secure the remaining Velcro straps around the leg.
11. Reevaluate all of the straps. When the splint is properly applied, the patient's foot should be upright.
12. Reassess circulatory and neurological function distal to injury site. Compare to original findings and note any changes.
13. Transport patients on a firm surface, such as a long spine board, so that the splint is supported.

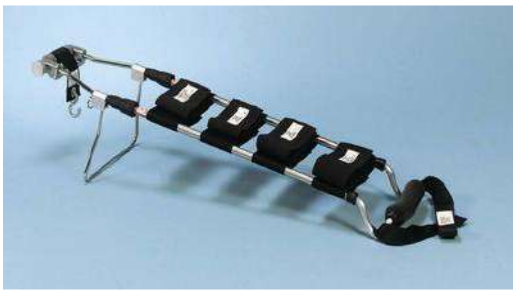


Figure 9.12 : Lower Limb Traction Splint

Figure 9.13 : Application of Traction Splint

CHAPTER 10

BURNS

At the end of this chapter the candidates will be able to attain the following knowledge:

- Able to conduct the initial assessment and deliver the treatment of burn injuries rapidly and systemically
- Able to estimate the burn size and determine the presence of associated injuries.
- Able to identify the criteria for referral of patients with burn injuries to Burns Unit.

10.0 INTRODUCTION

Burns are a common form of trauma. Common causes of burns include flame, scald, chemical, and electrical burn injuries. While many burn injuries are minor and can be safely managed in primary care, severe burns require hospitalization and are life-threatening. Rapid and systematic assessment can be life-saving. Timely application of emergency measures can reduce the morbidity and mortality caused by burn injuries. The basic principles include recognising the presence of inhalational injury and maintaining hemodynamic stability with adequate fluid resuscitation. A decompression procedure, known as escharotomy, produces a significant difference in the burned extremities or torso's final functional outcome.

10.1 ANATOMY OF SKIN

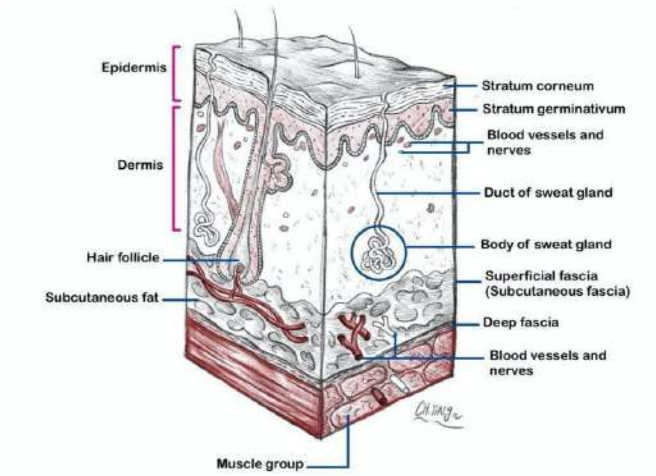


Figure 10.1: Anatomy of skin

The skin consists of two parts, the epidermis and the dermis. The epidermis is the superficial, thinner layer responsible for limiting the evaporation of water from the body and is constantly being produced by the division of the basal layers of the epidermis.

The dermis is the deeper, thicker layer that provides strength and durability of the skin. The dermis contains the blood supply and sensory nerves of the skin. The dermis also contains epidermal adnexal structures: hair follicles, epidermal lining, sebaceous glands, and sweat glands with their ducts.

These adnexal structures act as the reservoir of epithelial cells. Under the control of growth factors, it will undergo mitosis and produce an epithelial covering that will heal a superficial-dermal to mid-dermal thickness wound.

Therefore, it is essential to understand the structural anatomy of the skin. The burn depth classification is divided into four categories based on the increasing depth of the tissue damage going from epidermal to superficial partial thickness, deep partial thickness to full-thickness burns.

10.2 PATHOPHYSIOLOGY OF BURNS

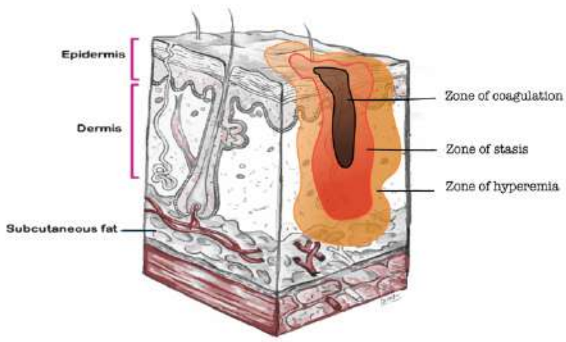


Figure 10.2: Schematic presentation of Jackson's burn model

Jackson's Burn Model, described in 1953, divides the area of burn into three zones of injury:

a) Zone of Coagulation.

This is the primary injury site. This zone has irreversible tissue necrosis at the centre of the burn due to exposure to heat, chemicals, or electricity. The extent of this injury is dependent on the temperature (or concentration) and the duration of exposure.

b) Zone of Stasis

Tissue damage in this zone of stasis is less severe than in the zone of coagulation. However, circulation in this area of skin and subcutaneous tissue is compromised and sluggish. If left untreated, this ischaemic zone area may progress to irreversible and worsening tissue necrosis. Vasoconstriction, oedema and infection should be prevented, and adequate fluid resuscitation is advocated to salvage the tissue injury within this zone.

c) Zone of Hyperemia

At the periphery of the burn is the zone of hyperaemia, which has a reversible increase in blood flow and inflammation. This zone contains viable cells, with vasodilation mediated by local inflammatory mediators. Tissue in this zone usually recovers unless complicated by infection or hypoperfusion. In a burn which covers more than 10% total body surface area (TBSA) in children or 20% TBSA in adults, the zone of hyperaemia may virtually involve the whole body.

10.3 PRIMARY SURVEY

The initial management of a severely burnt patient is similar to that of any trauma patient. The trauma life support primary survey is performed, emphasizing the airway and breathing assessment. The burn injury must not distract the healthcare provider from this sequential assessment. Otherwise, associated severe injuries may be missed.

10.3.1 AIRWAY & CERVICAL SPINE PROTECTION

The airway should be assessed for patency. Inhalation injury should be suspected. It can cause airway edema leading to airway obstruction which may be absent or subtle at initial presentation.

Signs of inhalation injuries are as follows:

- History of impaired mentation/confinement/entrapment in a burning environment
- Facial burn or circumferential burns of the neck
- Carbonaceous sputum
- Soot in the nose and mouth
- Singeing of the eyebrows and nasal hair
- Stridor, wheeze, rales, rhonchi, and hoarseness of voice
- Carbon deposits and acute inflammatory changes in the oropharynx
- Carboxyhaemoglobin level greater than 10% in the patient who was involved in a fire incident

If signs of inhalation injuries are present, early endotracheal intubation should be considered. If the transport time is prolonged, airway intervention should be performed prior to transport to protect the airway. Stridor is a sign of immediate airway compromise requiring emergency intubation.

Cervical collar application may be required in specific cases of burns which involve a high impact mechanism of injury**.**

10.3.2 BREATHING & VENTILATION

Inhalational burn patients should receive 100% oxygen through a humidified non-rebreathing mask. Intubation is required when the airway is compromised. For further assessment of breathing and ventilation, please refer to Chapter 2.

Patients with full-thickness burns of the anterior and lateral chest wall may have severely restricted chest wall motion, which in turn impairs chest expansion. In this situation, emergency escharotomy is indicated (figure 10.6).

Patients in an enclosed place, such as in a building, may have carbon monoxide (CO) poisoning. The diagnosis of carbon monoxide poisoning is made from a history of exposure and measurement of carboxyhaemoglobin. The symptoms of high CO levels depend on the percentage of CO levels:

- Headache and nausea
- Confusion
- Coma
- Death

- Carbon monoxide affinity for hemoglobin is 240 times higher than oxygen. It shifts the oxyhemoglobin dissociation curve to the left. The hemoglobin tends to bind with carbon monoxide rather than oxygen. This leads to tissue hypoxia causing cellular damage.
- Patients with carbon monoxide poisoning should receive high-flow oxygen via a non-rebreathing mask. This should reduce carboxyhemoglobin half-life from 250 minutes (when patient breathing in room air) to 40 minutes (when patient breathing 100% oxygen).
- Arterial blood gas will reveal a normal Pa02 because it calculates the dissolved oxygen in the blood, not the amount of oxygen bound to hemoglobin. Therefore, it is crucial to get the baseline of carboxyhemoglobin level while 100% oxygen is administered. Arterial blood will reveal metabolic acidosis with high lactate levels due to hypoxia.
- The pulse oximeter will not be able to differentiate between carboxyhemoglobin and oxyhemoglobin. A normal or high SpO2 does not rule out cellular hypoxia.

10.3.3 CIRCULATION WITH HAEMORRHAGE CONTROL

- Check the peripheral pulse for rate, volume, and rhythm
- Apply capillary blanching test to the centre and peripheral burnt, and unburnt areas (normal value < 2 seconds). Prolonged capillary refill time indicates poor perfusion.
- Monitor peripheral circulation of the limbs and look for circumferential burn. Elevate the limbs to reduce oedema and improve circulation to the limbs. If the vascularity of the limbs is compromised, an escharotomy will be required (figure 10.6).

> Surgical release of the burn wound by incising the burned skin (eschar) down to the subcutaneous fat is called escharotomy.
>
> Consider escharotomy in a circumferential, deep-partial to full-thickness burns, especially in the presence of:
>
> - Impending or established vascular compromise of the extremities or digits
> - Impending or established respiratory compromise due to circumferential torso burns

- Insert two large bore, peripheral IV lines, preferably through unburnt tissue.
- Collect blood simultaneously for trauma blood panels.
- Others: consider drug/alcohol screen/Carboxyhaemoglobin level.
- Insert indwelling urinary catheter for close monitoring of urine output during fluid resuscitation.
- In major burn injuries, fluid resuscitation should commence immediately. The indications to start the fluid resuscitation and its formula is highlighted below on page 274.
- To determine the total amount of fluid to be given, the TBSA of the burn needs to be calculated. This can be estimated using the Rule of Nines (Figure 10.3). For smaller burn areas, we can use the patient's hand's palmar surface (including fingers), which approximates to 1% TBSA (Figure 10.4). Alternatively, the Lund & Browder chart provides a more accurate method of calculating the TBSA and should be the standard method for assessment (Figure 10.5).

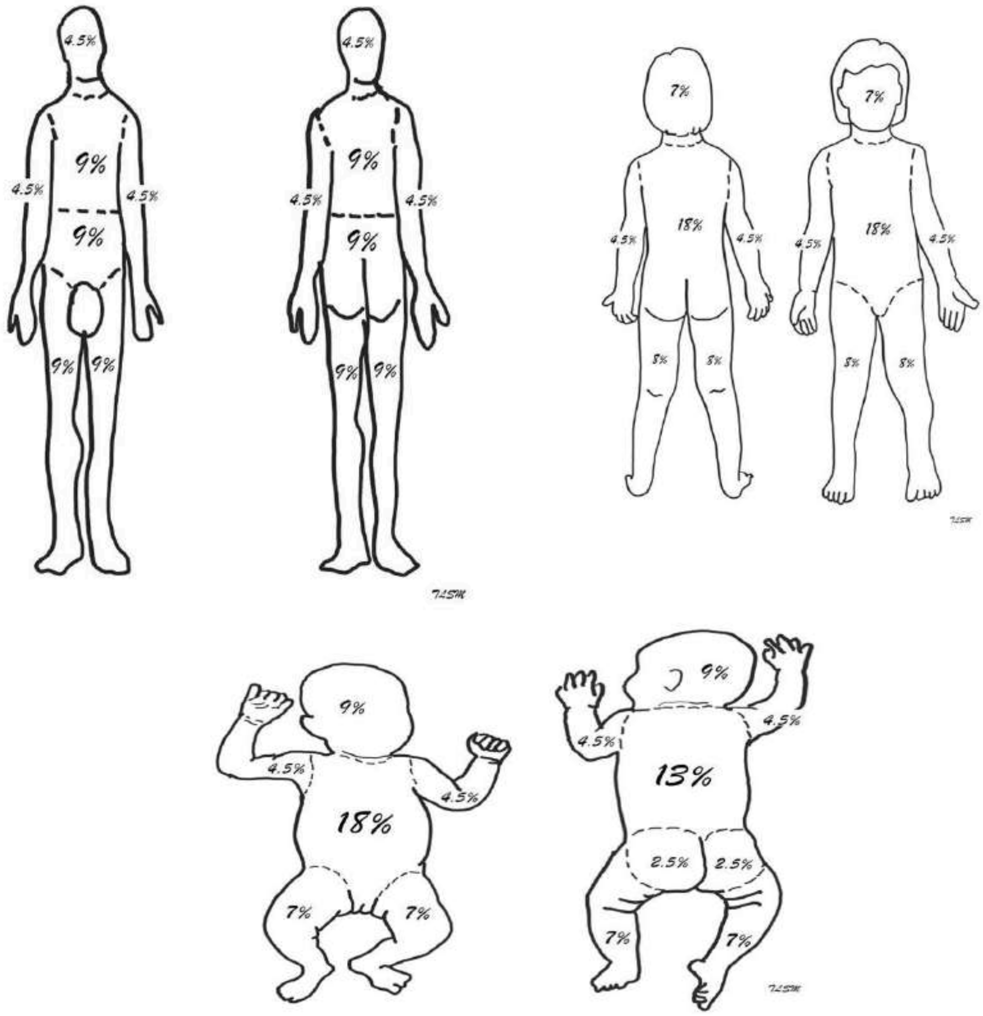


Figure 10.3: Rule of nine

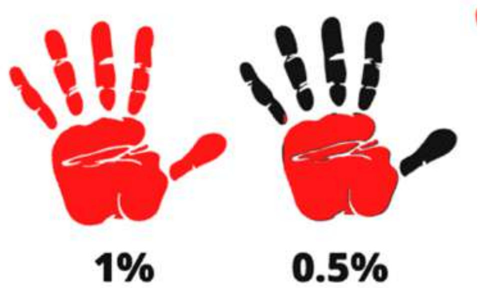
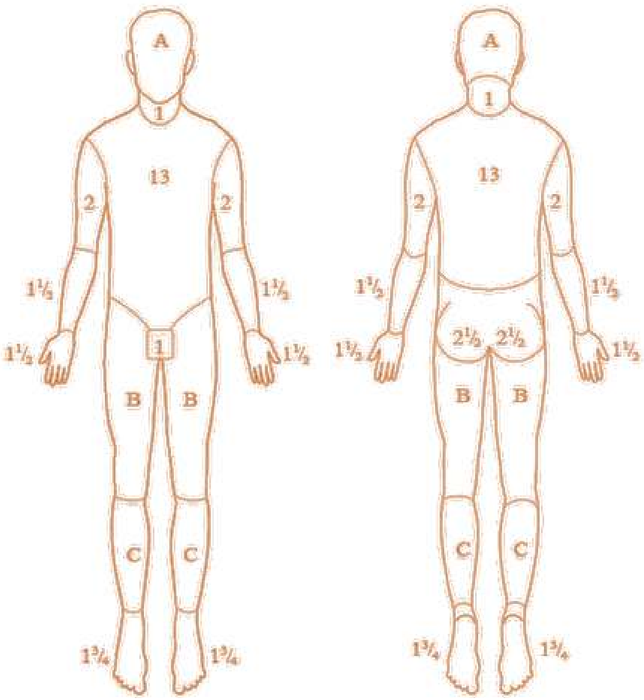


Figure 10.4: Palm surface rule (including fingers)

LUND & BROWDER CHART



REGION	PARTIAL THICKNESS (%)	FULL THICKNESS (%)
Head		
Neck		
Anterior Trunk		
Posterior Trunk		
Left Upper Limb		
Right Upper Limb		
Buttocks		
Genitalia		
Left Lower Limb		
Right Lower Limb		
TOTAL TBSA PERCENTAGE		

AREA	AGE 0	1	5	10	15	ADULT
A = ½ of head	9 ½	8 ½	6 ½	5 ½	4 ½	3 ½
B = ½ of one thigh	2 ¾	3 ¼	4	4 ½	4 ½	4 ¾
C = ½ of one lower leg	2 ½	2 ½	2 ¾	3	3 ¼	3 ½

*** Do Not Include Area of Superficial or Epidermal Burn

Figure 10.5: Lund & Browder chart

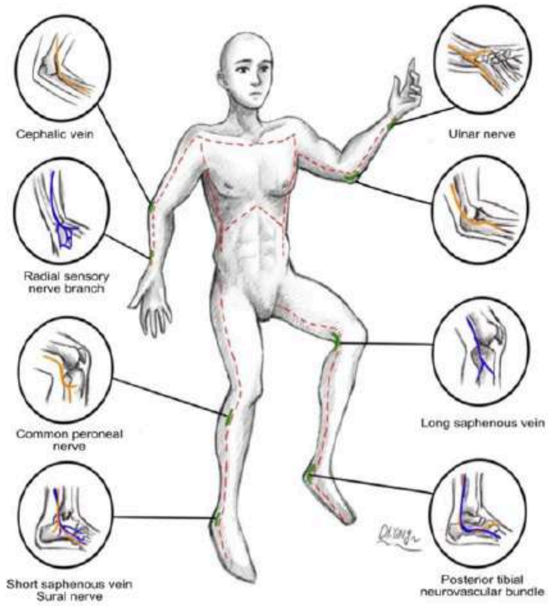


Figure 10.6: Dotted lines representing surgical incision for escharotomy

Fluid Resuscitation will be required for patients who has sustained burns with:

- >10% TBSA for children
- >15% TBSA for adults

First degree or epidermal burn is not considered as part of the TBSA calculation

The most commonly used fluid resuscitation formula is the modified Parkland Formula:

4 mls x body weight (kg) x % TBSA = amount of IV Lactated Ringer's or Hartmann's solution to be given in 24 hrs following the injury

Give ½ of this fluid in the first 8 hrs from the time of injury
Give ½ of this fluid in the following 16 hrs

PARAMETERS	THERMAL INJURY			ELECTRICAL INJURY
AGES	Infants and young children (<30kg)	Children (<12 years old)	Adults and older children (> 12 years old)	All ages
COMMENCEMENT	10% TBSA	10-15% TBSA	15-20% TBSA	-
ADJUSTED FLUID RATES	2-4ml x Weight x %TBSA Administer a dextrose-containing intravenous solution for maintenance	2-4ml x Weight x %TBSA	4ml x Weight x %TBSA	4ml x Weight x %TBSA
URINE OUTPUT	0.5ml/kg/Hr	1ml/kg/Hr	1ml/kg/Hr	1 - 1.5ml/kg/Hr until urine becomes clear

Table 10.1: The Burn fluid Resuscitation formula and The Target Urine Output

- Commence resuscitation fluids by using Hartmann's solution at an initial rate of the Modified Parkland Formula and titrate according to urine output.
- The urine output should be maintained at a rate of ***0.5 to 1.0 ml/kg/hour for adults,*** *and at a rate of* ***1.0 to 2.0 ml/kg/hour for children weight <30kg.***
- Children under 30kg require intravenous fluids containing glucose, e.g., 5% dextrose / Normal Saline (NSD5%) for maintenance fluids in addition to resuscitation fluids.
- The calculation of fluid requirements commences **from the time of burn**, not from the time of presentation to the Emergency Department.
- The resuscitation formula is a guide to initiate the volume and rate of fluid resuscitation. Fluid requirements may vary according to the clinical situation. The amount of fluid given should be titrated according to the individual patient's response.
- The infusion rate of fluids will be titrated based on the hourly reading of the urine output:
    - If urine output <0.5mls/kg/hr, suggest increasing IV fluids by 1/3 of current IV fluid amount.
    - If urine output >1ml/hr for adults or >2 ml/kg/hr for children, suggest decrease IV fluids by 1/3 of current IV fluid amount

- Fluid boluses should be avoided unless the patient is hypotensive.

- Adequate fluid resuscitation is paramount. Under-resuscitation results in hypo perfusion, greater burn depth, an extension of shock period, and end-organ injury.

- Over-resuscitation results in increased oedema, which can lead to complications such as burn depth progression, abdominal and extremity compartment syndrome, acute pulmonary edema, ARDS, and cerebral edema.

10.3.3.1 DEPTH OF BURN

The assessment of burn depth is an important clinical parameter in the management of burn patients. It determines the severity of the injury and hence, the treatment of choice for the patient.

It is also one of the primary determinants of a patient's long-term health, appearance, and functional outcome.

The depth of burn can be divided into (figure 10.7 and table 10.2):

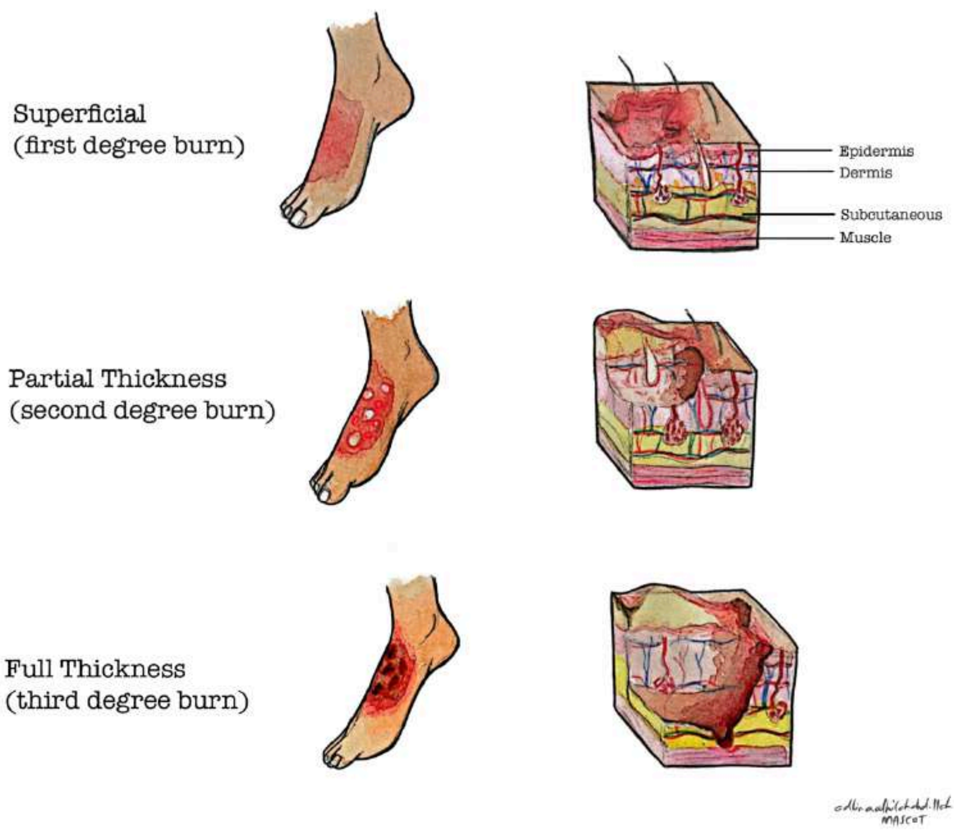


Figure 10.7: Depth of burn

Degree of Burns	Depth of Burns	Remarks
First degree	Superficial or epidermal	▪ Involve only the epidermis. ▪ Characterized by erythema, pain and absence of blisters. ▪ Non life-threatening and do not require intravenous fluid replacement
Second degree	Superficial partial-thickness	▪ Involve epidermis and papillary (upper) dermis layer ▪ It is characterized by a pink and red appearance with associated swelling and blister formation. **The capillary refill is brisk (blanching)** ▪ The wound can have a weeping, moist appearance and is painfully hypersensitive
	Deep partial-thickness	▪ Involve epidermis and reticular (lower) dermis layer ▪ It is characterized by either white, pink, or red in colour, and has dry appearances with associated blister formation ▪ The wound is **non-blanching** or has sluggish capillary return ▪ The wound has reduced sensation
Third degree	Full thickness	▪ Involve the epidermis and the entire dermis layer ▪ It usually appears white, brown, dry and leathery. The coagulated dead skin which has leathery appearance is called **eschar** ▪ The wound is **non-blanching** and has loss of sensation.
Fourth degree	Full thickness	▪ Involve the entire epidermis and dermis, down to the subcutaneous fat, and may involve the underlying fat, fascia, muscle and/or bone ▪ This burn wound is characterized by necrotic skin with an exposed deep tissue ▪ Commonly seen in high voltage electrical injury

Table 10.2: Classification of burn depth and its respective clinical features

10.3.4 DISABILITY: NEUROLOGICAL STATUS

- Establish the level of consciousness by using AVPU.

  A - **A**lert
  V - Response to **V**ocal stimuli
  P - Responds to **P**ainful stimuli
  U - **U**nresponsive

- Examine the pupillary response to light for reaction and size.

- Restlessness and decreased levels of consciousness that may indicate hypoxemia, Carbon Monoxide poisoning, shock, alcohol, and drug intoxication.

10.3.5 EXPOSURE & ENVIRONMENTAL CONTROL

- Remove all clothing and jewellery
- Keep the patient warm. Hypothermia can have detrimental effects on the patient.
- Upon ruling out any coexisting unstable pelvic fractures, perform a log roll for the patient. Subsequently, remove all wet sheets, examine the posterior torso for other injuries and perform a thorough burns surface assessment.

10.4 SECONDARY SURVEY

A secondary survey is a comprehensive, head-to-toe examination that commences after life-threatening conditions have been excluded or treated. It consists of:

1. History (MAPLE):

   M – Medicines and Medical conditions
   A – Allergy history
   P – Pregnancy
   L – Latest meal and time
   E – Encounter / Experience / Event

2. Mechanism of Injury
   - Date and time of burn injury, date and time of the first presentation.
   - Source of injury and length of contact time.
   - Temperature and nature of fluid in scalding burn injury
   - Type of clothing worn.
   - Activities at time of burn injury.
   - Adequacy and duration of first aid.

3. Physical Examination (Head to Toe Assessment)

4. Investigation

    - Trauma blood panel
    - Carboxyhaemoglobin level (if available)
    - Chest radiograph
    - Electrocardiogram

5. The wounds should be covered with clean linen to protect, deflect air currents and subsequently minimize pain. Any applied medications must be removed or cleaned before topical antibacterial agents are applied

6. Pain Management

    - Administer intravenous analgesics and sedatives regularly and in small doses, adhering to local hospital guidelines.

        - o The dose should be titrated to the patient's response, including the pain score and respiratory rate.
        - o Oral analgesia may be administered to patients with minor burns.

7. Antibiotics - Prophylaxis is not indicated in the early post-burn period. Antibiotics are only indicated if there is evidence of infections or gross contamination.

8. Anti-tetanus toxoid should be given where applicable, depending on the patient's immunization and vaccination status.

9. Record and document all treatments and medications given to the patient before transfer.

10.5 CHEMICAL BURN

- More than 25,000 chemicals have been identified as having the potential to cause burns. Chemical burns can occur due to laboratory accidents, civilian assaults, industrial mishaps, or inexpert application of agents in carrying out household activities.
- Chemical agents that cause cutaneous burns fall into three categories: acids, alkalis, mixed, or organic compounds (phenols, petroleum products).
- Most acids produce coagulative necrosis, forming a coagulum that limits the penetration of the acid.
- Alkaline burns produce tissue injury by liquefactive necrosis and are generally more severe than acid burns because alkali penetrates more deeply.

- Several factors influence the severity of the chemical injury:
    - Duration of contact
    - The concentration of the chemical
    - Quantity of the chemical burn agent.
    - Mechanism of action of the chemical
- Protection – all healthcare providers need to protect themselves from contaminants, e.g., by wearing gloves, aprons, and protective eyewear.
- Initial treatment of all chemical burns consists of the following:
    - Remove contaminated clothing
    - Brush off particulate debris and dry chemical
    - Continuous irrigation with a copious amount of water as soon as possible, and should be continued until the pain subsides
- Although copious water irrigation should be used for all chemical burns, there are few exceptions. Some chemicals create exothermic thermal reactions and cause further tissue destruction when in contact with water. These agents include elemental sodium, aluminum, potassium, and lithium.

10.6 ELECTRICAL BURNS

- Electrical injuries occur when the body comes in contact with an electrical source. It can be categorized into three groups: low voltage (<1000V), high voltage (>1000V), and lightning strike.
- The body serves as a volume conductor of electrical energy and produces heat, resulting in tissue injury. This thermal injury causes deep muscle necrosis and subsequently rhabdomyolysis, leading to acute renal failure.
- The initial management of electrical burns starts with pre-hospital first aid, followed by primary & secondary surveys. The trauma care providers should obtain intravenous access, perform electrocardiographic monitoring, and insert a urinary catheter.
- Observe the colour of the urine for the presence of haemochromogens and start the treatment for rhabdomyolysis early. Fluid administration should be optimised to ensure a urinary output of 75-100mls/hour in adults or 1-2mls/kg/hr in children until the urine is clear. Acidosis should be corrected by maintaining adequate perfusion.

10.7 CRITERIA FOR REFERRAL TO BURN UNIT

1. Partial/full-thickness burns of special areas involving the face, hands, feet, joints, and genitalia
2. All full-thickness burns
3. Partial-thickness burns of >10% TBSA in children and >20% TBSA in adult
4. Burns with inhalational injury
5. Circumferential burns
6. Electrical burns
7. Chemical burns
8. Burn injury in patients with a pre-existing medical disorder that could complicate management, prolong recovery, or affect mortality
9. Any patients with burns and concomitant trauma
10. Burned children in the hospital without qualified personnel or equipment for the care of children
11. Burn injury in patients who will require special social, emotional, or rehabilitative intervention

10.8 SUMMARY

1. In managing burn patients, the size & depth of burns, time of injury and body weight are important in calculating fluid resuscitation.

2. The size & depth of burns can be calculated using the Lund & Browder chart. Alternatives are the Rule of Nine and Rule of Palm.

3. Early recognition of inhalational injury is critical in the management of burn patients to avoid delays in securing the airway.

4. All patients that fulfill the criteria for referral to the Burns unit should be transferred early with complete documentation.

5. An electrical burn may be associated with extensive occult myonecrosis.

6. Circumferential, deep-partial and full-thickness burns may require escharotomy.

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10.10 SKILL STATION

Escharotomy Procedure

- Escharotomy is a relatively simple surgical procedure involving an incision through a skin eschar to the depth of the subcutaneous fat.
- This superficial incision permits the expansion of the subcutaneous tissue and decompression of the underlying compartments.
- Escharotomies may be performed on multiple body parts, including the extremities, the digits, the chest, the abdomen, the neck, and the penis.
- Escharotomy of the chest that is most likely to be indicated on an emergent basis in the out-of-hospital setting.

Major neurovascular structures to avoid when incising at the following sites include

Elbow: Ulnar nerve
Wrist: Radial nerve
Fibular head: Superficial peroneal nerve
Ankle: Posterior tibial artery
Neck: Jugular veins
Penis: Dorsal vein

10.10.1 Indication

Eschar compressing or potentially compressing tissue in or surrounding the burn area

Compressed tissue is identified by any of the following:

1. Absent distal arterial flow as determined with a Doppler ultrasonic flow meter in the absence of systemic hypotension
2. Oxygen saturation below 95% in the distal end of the extremity as shown by pulse oximetry in the absence of systemic hypoxia
3. Measurement of compartment pressure > 30 mm Hg
4. Impending or established respiratory compromise due to the circumferential torso or neck burns
5. Circumferential chest and neck burn, if intubated, increased peak airway pressures; dyspnoea in the awake patient.

Physicians should have a high index of suspicion and a low threshold for doing escharotomy.

10.10.2 Equipment

1. Sterile drapes
2. Cleansing solution, such as povidone-iodine or chlorhexidine
3. 25- and 21-gauge needles
4. 10-mL syringes
5. Local anaesthesia - 2% lignocaine
6. size 10, 23 scalpel and blade, electrocautery device

7. Sterile gauze
8. Modern hemostatic dressing if available e.g. Alginate dressing – Kaltostat
9. Sterile gloves
10. Skin marker

10.10.3 Steps

1. Position patient comfortably in supine and neutral position with excellent exposure of the burned areas
2. Clean the site with povidone-iodine or chlorhexidine solution.
3. Drape with sterile drapes.
4. If burns are particularly painful, give systemic opioid analgesia, such as fentanyl 1 to 2 mcg/kg IV or morphine 0.1 to 0.2 mg/kg IV, then titrate as needed.
5. Non-sedated patients benefit from local anaesthesia of viable tissue at the proximal and distal non-burned edges.
6. Mark the desired points and line of incision with a skin marker.

<u>Limbs</u>

1. Using a sterile technique, incise the lateral and medial aspects of the involved extremity with a scalpel or electrocautery device, from 1 cm proximal to the burned area to 1 cm distal to the involved area of constricting burn.
2. Avoid vital structures such as major arteries and nerves (e.g., ulnar nerve at the elbow, the radial nerve at the wrist, the superficial peroneal nerve near the fibular head, the posterior tibial artery at the ankle).
3. Carry the incision only through the full thickness of the skin. The incisions should cross the joints.
4. This incision should result in immediate separation of the constricting eschar to expose subcutaneous fat. The 'give' of tissue is seen on adequate release.
5. In circumferential burns of the hands, extend the incisions to the thenar and hypothenar aspects of the hand.
6. In circumferential burns of the feet, extend the incision to the great toe medially and the little toe laterally.
7. Reassess perfusion: A properly done escharotomy result in:
   - near-immediate softening of the tissue,
   - improved distal tissue perfusion,
   - improved sensation,
   - improved Doppler flow signal strength,
   - and improved pulse oximetry values.
8. If perfusion fails to improve after the procedure, reassess the escharotomy depth and location and re-incise any insufficiently deep incisions.

<u>Chest</u>

1. Using a sterile technique, incise the chest wall from the clavicle to the costal margin in the anterior axillary line bilaterally; avoid breast tissue in females (see figure Escharotomy incision sites).
2. Consider joining this by transverse incisions to result in a chevron-shaped subcostal incision.
3. Assess response: Increased airway pressure or an inability to ventilate is evidence of the need to re-incise the eschar.

<u>Neck</u>

1. Neck escharotomy should be done laterally and posteriorly to avoid the carotid and jugular vessels.

<u>Penis</u>

2. Penile escharotomy is done mid-laterally to avoid the dorsal vein.

10.10.4 Post Procedure

1. Loosely pack incisions with sterile gauze with adrenaline, paraffin gauze or modern dressing (Kaltostat) that promotes haemostasis, apply gamgee and bandage firmly.
2. Transfer to a local or regional burn center for coordinated and definitive care, including pain control and tissue perfusion monitoring.

10.10.5 Caution and Complications

1. Because of edema and shock, skin temperature is a poor indicator of limb ischemia. Use objective measures whenever possible.
2. Escharotomy incisions are at risk of infection.
3. Treat the incisions made as part of the burn wound.
4. Do not confuse escharotomy with fasciotomy; escharotomy incisions remain above the fascia.
5. Complications from the procedure include
   - -Bleeding
   - -Infection
   - -Damage to underlying neurovascular structures
   - -Inadvertent fasciotomy

CHAPTER

11

TRAUMA & PAEDIATRICS

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Able to identify unique characteristics of the paediatric patient with regards to pattern of injuries, anatomy, and its physiology.
2. Able to describe the structured approach to manage paediatric trauma.
3. Able to recognize non-accidental injuries in paediatric population.
4. Able to understand the importance of injury prevention.

11.0 INTRODUCTION

Trauma is the commonest cause of mortality and morbidity in the paediatric age group, making it the largest public health and healthcare burden in this population. In 2012, total deaths due to trauma was 740,062 children worldwide constituting 9.25% of deaths in all paediatrics age groups, with the highest involvement affecting the 5 to 14-year-old age group. Common causes of paediatric trauma include motor vehicle accidents, falls, drowning, burns, and even non-accidental injuries.

The principles of trauma management in children are similar to adults. However, it is crucial to note the distinct anatomy and physiology differences as compared to adults. A targeted history emphasising on the mechanism of injury may help to identify possible injuries sustained by the child during resuscitation.

The paediatric trauma population has the ability to compensate for volume loss as well as ventilatory failure. However, if the ongoing clinical compensatory mechanism/response is not recognised early in the phase of ongoing blood loss/hypoxia, the paediatric patient will deteriorate rapidly leading to serious complications and mortality. Thus, it is important to initiate timely intervention with the involvement of experienced clinicians.

Figure 11.1: Child with blunt abdominal trauma due to a bicycle handlebar injury

11.1 ANATOMICAL, PHYSIOLOGICAL & SPECIAL CONSIDERATIONS

11.1.1 AIRWAY CONSIDERATIONS

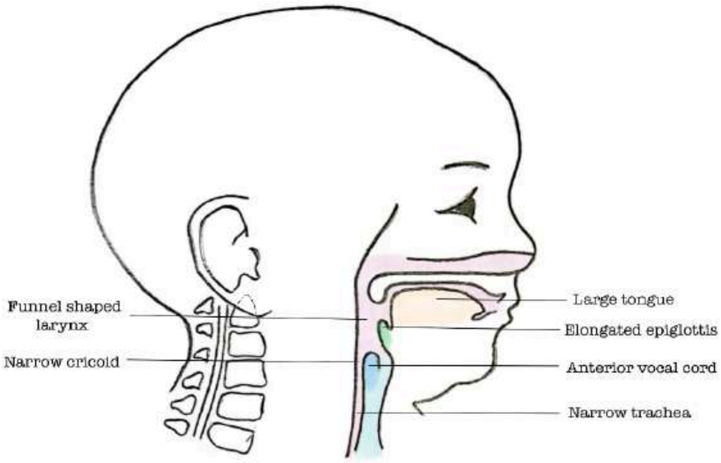


Figure 11.2: Paediatric airway

- As compared to adults, infants and young children have larger adenoidal tissue.
- The vocal cords are more anterior and cephalad as compared to adults, which make visualisation of the vocal cords challenging in the supine or anatomical position.
- Funnel shaped larynx may lead to accumulation of secretions.
- The shorter length of trachea may predispose to right main stem bronchus intubation.
- The epiglottis is more cephalad, elongated, and flexible.
- The head and occiput are proportionally larger compared to adults.
- Smaller nares.

- Larger and more flaccid tongue.
- The narrowest part of the paediatric airway is the cricoid cartilage as compared to the glottis in adults.

11.1.2 Blood Volume

- The volume of blood (mls/kg) of body weight decreases with the increase of age.
- Total body blood volume is dependent on the physique and child's body weight, therefore the total blood volume in children is much lesser as compared to adults.
- A full term neonate is estimated to have 80-90 mls of blood volume/kg body weight.
- An infant would have 75-80 mls/kg and a child > 2 years old is estimated to have 70-75 mls/kg of blood volume. (Adults : 65-70 mls/kg)
- A relatively small amount of blood loss can be very critical and may lead to serious consequences in children

11.1.3 Surface Area

- The higher surface area in relation to body weight as compared to adults, predisposes to rapid heat loss and development of hypothermia especially in burns and trauma.

11.1.4 Size and Shape

- The smaller body mass leads to a greater traumatic force applied per unit of body area.
- Larger head to body ratio predisposes the child to a higher chance of sustaining traumatic brain injuries.

11.1.5 Skeleton and soft tissues

- The soft tissues usually sustain significant injuries without obvious evidence of gross external trauma.
- The skeleton is incompletely calcified and pliable, therefore bone fractures are less likely to occur. However, when fractures are present, it may imply a high force of impact.
- The presence of ribs/skull fractures suggest a high impact mechanism, thus when present, underlying pulmonary contusions/traumatic brain injuries should be suspected.
- Growth plate injuries may lead to bone development abnormalities or stunted bone growth.

11.1.6 Psychological Factors in Paediatrics Trauma Approach

- Stranger apprehension, fear and anxiety may lead to uncooperative behaviour during clinical assessment.
- Presence of parents or guardians during the clinical assessment and resuscitation may be beneficial.

11.1.7 Resuscitation Adjuncts

- Appropriately sized paediatric equipment/consumables/instruments are critical in providing care and resuscitation in the paediatric trauma patients.
- The Broselow Paediatric Emergency Tape is a useful tool for quickly determining appropriate equipment sizes, fluid volumes, and drug dosages in pediatric resuscitation, as it is a length-based resuscitation tape.

Figure 11.3: Usage of Length-based resuscitation tape (ie. Broselow Pediatric Emergency Tape)

11.1.8 Long Term Consequences

- Injuries to epiphyseal growth plates may affect the child's growth.
- Traumatic brain injury may result in prolonged cerebral disability.
- Psychological strain of trauma may lead to social, affective, and learning difficulties.
- Excessive ionising radiation advocated during radio imaging investigations may increase risk of long-term malignancy and should be advocated only when necessary.

11.2 APPROACH TO PEDIATRIC TRAUMA RESUSCITATION

Major trauma in a child may result in both respiratory failure and hypovolemic shock, leading to a high risk of morbidity and mortality. The early recognition of a severely injured child with an appropriate and timely resuscitation leads to a better prognosis and outcomes. Early involvement of the trauma team during resuscitation facilitates rapid definitive treatment for the child. In the emergency department, primary and secondary surveys must be done to look for life threatening and potentially life or limb threatening injuries, similar to the resuscitation of an adult trauma patient.

11.2.1 Primary Survey and Resuscitation

PRIMARY SURVEY PRINCIPLES

<C> A B C D E

<C> - Catastrophic external haemorrhage

Any obvious external exsanguinating haemorrhage should become an immediate priority. A simple direct pressure, wound packing, specialised haemostatic dressings or a tourniquet should be applied on the wound to stop the bleed. Tranexamic acid 15 mg/kg should be given within 3 hours of injury.

A - Airway Management and Cervical Spine Stabilization

1. The large occiput of a child leads to passive flexion of the cervical spine of a supine patient. Aim to maintain the child in a neutral position by placing a padding beneath the torso (Figure 11.4).

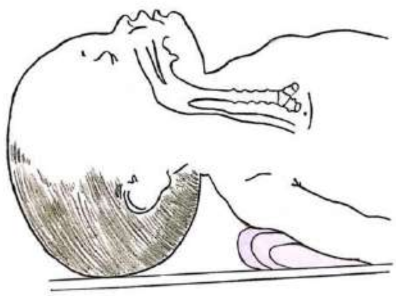


Figure: 11.4: Larger occiput in paediatric

2. Look for potential causes that may compromise the airway e.g.
   i. Foreign body, vomitus, blood or secretion.
   ii. Intraoral trauma – mouth, tongue, larynx or trachea.
   iii. External compression – compression from prevertebral hematoma of the neck or maxillary fracture.

Open the mouth, suction, and remove any debris/vomitus by direct visualization.

3. Open the airway by jaw thrust manoeuvre. The manual in-line stabilisation (MILS) should be performed for a child who suffered from any mechanism capable of causing spinal injury until it can be cleared. Alternatively, a head block with a strap may be used.

4. Application of a correctly sized cervical collar or **tapes and blocks/head immobiliser devices** (in accordance with local protocol) is necessary to maintain cervical spine stability and avoid further injury in patients with suspected spinal injury.

5. Supplemental high flow oxygen should be given for severely injured children including head injury.

6. An oropharyngeal airway (OPA) should be inserted if a child is **unconscious with absence of gag reflex**. Choose an appropriate size of OPA by placing the flange at the centre of incisors, then curved around the face until the angle of mandible. The oral airway should be gently inserted **directly** into the oropharynx. The use of a tongue blade to **depress** the tongue may be helpful (Figure 11.5).

Figure 11.5: Oropharyngeal airway insertion

7. Endotracheal intubation (ETT) is indicated when the child needs controlled ventilation e.g., in severe traumatic brain injury, unable to maintain a patent airway or predicted airway obstruction in inhalational injury. An appropriate size of uncuffed/cuffed endotracheal tubes should be selected to give a relatively tight fit in the larynx. However, it should not be too tight that may lead to mucosal damage. If a cuffed tube is used, the cuff pressure should be measured when possible. Cuff pressure should be 20-30cmH_2O.

8. It is a good practice to prepare one size larger and one size smaller than the predicted ETT size before intubation. To estimate ETT size for emergency intubation, the following formula can be used:

   Uncuffed ETT = (Age in years)/4) + 4

   Cuffed ETT = (Age in years/4) + 3.5

   In neonates less than 3kg, usage of uncuffed ETT is recommended. In other age groups, the choice of cuffed or uncuffed is a matter of availability, preference, and local practice.

The depth of the tube can be roughly estimated by **multiplying the ETT size by 3**. For example, a size 4.0 ETT would be properly positioned at 12 cm from the gum. Other formula includes:

ETT Depth (cm): (Age in years/ 2) + 12

9. The proper ETT placement can be confirmed by:
    a. Direct visualisation of vocal cord
    b. Vaporisation in ETT
    c. Equal chest rise
    d. 5-point of auscultation: auscultating stomach then both the lungs
    e. Measurement of end tidal CO_2 (if available)

POST INTUBATION VENTILATOR TROUBLESHOOT

D - Dislodgement
O - Obstruction
P - Pneumothorax
E - Equipment failure

It serves as a quick reminder for the common causes of deterioration in intubated patients.

10. For infants and children experiencing difficult intubation, laryngeal mask airways are the preferred option.

11. Cricothyroidotomy is rarely required in paediatric trauma patients but may be necessary in the event of can't intubate, can't oxygenate (CICO).

12. The cricothyroid membrane is difficult to palpate in children under the age of 5 and nearly impossible in infants.
    - Children up to 1-year-old should have an emergency tracheostomy.
    - In children 1 to 5-year-old either emergency tracheostomy or a needle cricothyroidotomy is performed (performed only if the cricothyroid membrane can be identified).
    - In children more than 5-year-old, either the needle or surgical cricothyroidotomy can be used.

B – Breathing and Ventilation

1. A child's respiratory rate reduces with increasing age. Infants typically exhibit a respiratory rate of 30-40 breaths per minute, whereas older children maintain a rate of 15-20 breaths per minute.

2. Paediatric bag-valve-mask devices used are designed to limit the pressure exerted manually on the child's airway. However, excessive volume or pressure during assisted ventilation substantially increases the potential for iatrogenic barotrauma. If an adult bag-mask device is used to ventilate a paediatric patient, the risk of barotrauma is significantly increased. Use of a paediatric bag-mask is recommended for children under 30 kg.

3. Chest injuries such as haemothorax and pneumothorax have similar consequences in children and adults. These injuries are managed with pleural decompression, preceded in the case of tension pneumothorax by needle decompression at the second intercostal space in the midclavicular line or fifth intercostal space between anterior axillary and mid- axillary line. Alternatively finger thoracostomy can be performed. Tube thoracostomy size needs to be proportionally smaller. The site of tube thoracostomy insertion is the same in children as in adults: the safety triangle where the fifth intercostal space crosses just anterior to the mid-axillary line.

4. Ventilation of the injured child may be compromised by gastric distension. Therefore, early insertion of the orogastric tube is recommended to decompress the stomach. **Nasogastric tube insertion is a relative contraindication if the base of skull fracture is suspected.** Insert orogastric tube instead.

5. By the end of primary survey, these conditions should have been recognised and treatment should be initiated as early as possible – **ATOMTC**

Immediate life - threatening injuries
(ATOM - TC)

A - Airway Obstruction
T - Tension Pneumothorax
O - Open Pneumothorax
M - Massive Hemothorax
T - Tracheobronchial Injury
C - Cardiac Tamponade

C – Circulation and Haemorrhage Control

1. Injuries in children may result in significant blood loss. A child's increased physiological reserve allows for maintenance of systolic blood pressure in the normal range, even in the presence of shock. Loss of up to 30% of blood volume may be required to manifest a decrease in systolic blood pressure. Useful formulas for paediatric blood pressure are:
   a. The lower limit of normal systolic blood pressure is defined as 70 mmHg plus twice the patient's age in years. [70 + (2 x Age) mmHg]
   b. Diastolic pressure typically represents approximately two-thirds of the systolic blood pressure.

PARAMETERS	PHYSIOLOGICAL INDICATORS	
Vital Signs	Blood Pressure Heart Rate Respiratory Rate Pulse Volume	↓ ↑ ↑ ↓
Skin Changes	Temperature Capillary refill	↓ ↓
Mental State	Alertness	↓
Urine Output	Reduced	↓
PARAMETERS	BIOCHEMISTRY INDICATORS	
Biochemistry	Lactate Base excess pH Bicarbonate	↑ ↓ ↓ ↓

Table 11.1: Physiological and biochemical response to bleeding in children

2. Determine a child's weight in order to accurately calculate fluid volumes and drug dosages by asking the caregiver or using a length-based resuscitation tape (ie. Broselow Tape).

3. Establish the venous access by inserting appropriate large bore catheters via the peripheral percutaneous route. Sent blood for the trauma panel.

4. If percutaneous access is difficult, consideration should be given to the insertion of an intraosseous access. (Refer to Skill Station)

5. If the child is stable without sign of shock, an immediate fluid bolus is not required. The principle behind this is **'the first clot is the best clot'.**

6. Major haemorrhage following injury is not common in children. Currently there is a lack of evidence to support the best transfusion method in children suffering from major trauma if compared to adults. Its management requires an understanding of concepts that have become standard in adult trauma care (Refer to Figure 11.6) including early usage of tranexamic acid, optimal ratios of red cells to other blood products, implementation of haemorrhage protocols, and damage control resuscitation.

7. Urgent referral to the primary teams such as paediatric/general surgery or orthopaedics for definitive surgery is required.

8. Urine output varies with age. The urine output goal for infants up to 1 year of age is 2 mL/kg/hr, for younger children 1.5 mL/kg/hr, and for older children 1 mL/kg/hr.

D - Disability

1. Assess the initial child's neurological status by using simple and rapid AVPU. Check pupillary size, equality, and reaction to light.

A	**Alert**
V	**Respond to Verbal Stimulus**
P	**Respond to Pain Stimulus**
U	**Unresponsive**

2. The Children's Glasgow Coma Scale (GCS) should be performed as soon as possible

	GCS (4 - 15 years)	Children's GCS (< 4 years)	Score
Eye Opening	Spontaneously	Spontaneously	4
	To verbal command	To shout	3
	To pain	To pain	2
	No response	No response	1
Best Motor Response	Obeys verbal command	Spontaneous or obeys verbal command	6
	Localises to pain	Localises to pain or withdraw to touch	5
	Withdraws from pain	Withdraws from pain	4
	Abnormal flexion to pain (decorticate)	Abnormal flexion to pain (decorticate)	3
	Abnormal extension to pain (decerebrate)	Abnormal extension to pain (decerebrate)	2
	No response to pain	No response to pain	1
Best Verbal Response	Orientated and converses	Alert, babbles, coos words to usual ability	5
	Disorientated and converses	Less than usual words, spontaneous irritable cry	4
	Inappropriate words	Cries only to pain	3
	Incomprehensible sound	Moans to pain	2
	No response to pain	No response to pain	1

Table 11.2: Paediatrics Glasgow Coma Scale

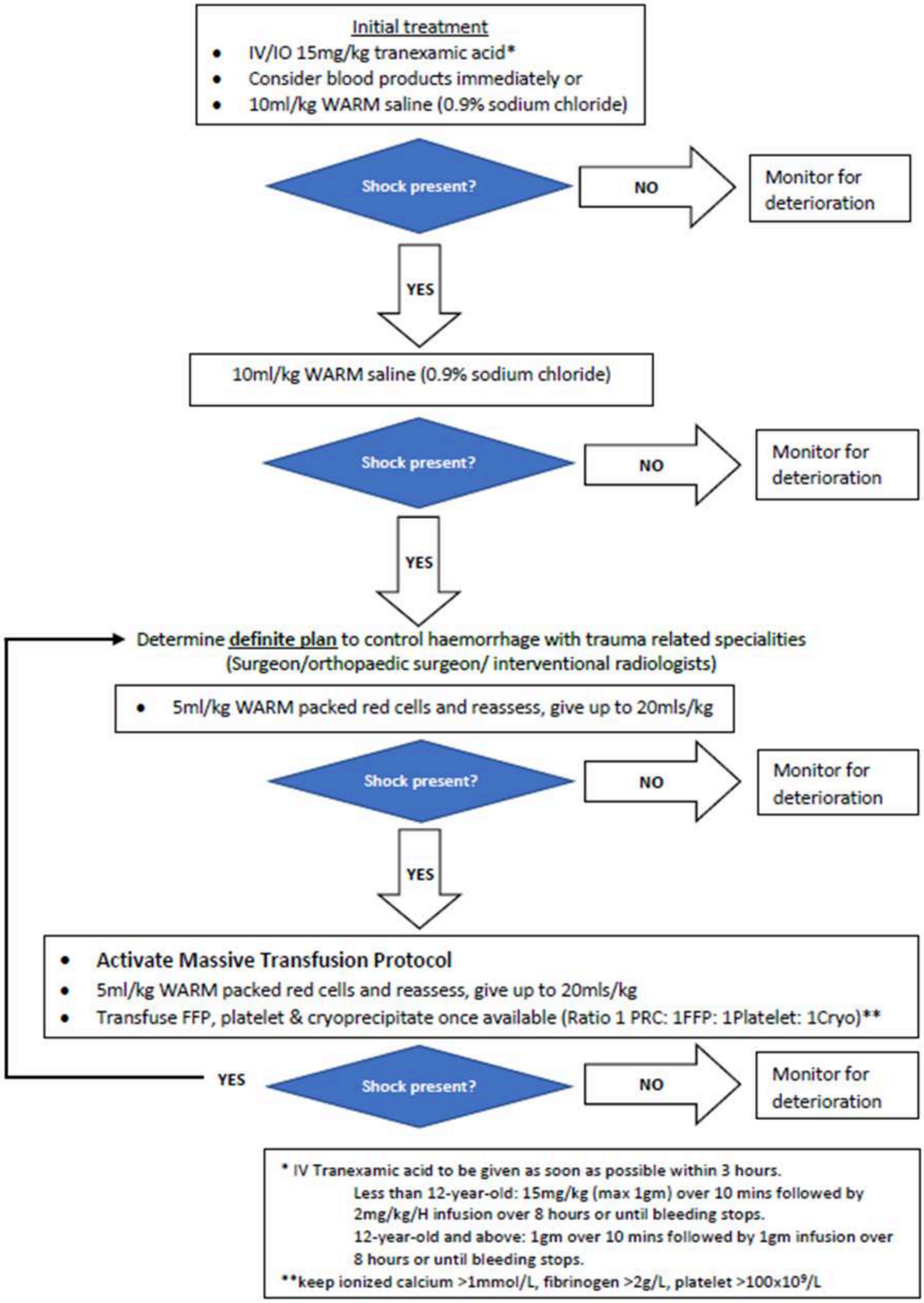


Figure 11.6: Blood and fluid therapy in severe uncontrolled haemorrhage after trauma.

E – Exposure and Environment Control

1. Expose the child appropriately to detect potential life or limb threatening injuries. Although exposure is necessary, the duration should be minimised to prevent hypothermia.

2. The high ratio of body surface area to body mass in children affects the body's ability to regulate core temperature. Increased metabolic rates, thin skin, and the lack of substantial subcutaneous tissue contribute to increased evaporative heat loss and caloric expenditure.

3. Hypothermia may render the child's injuries refractory to treatment, worsen coagulopathy and acidosis, and adversely affect central nervous system function.

4. Overhead heat lamps, heaters, or thermal blankets are necessary to preserve body heat. It is also advisable to warm the intravenous fluids and blood products.

Diagnostic Adjuncts

1. The principle of imaging in paediatric trauma is to keep radiation dose **'as low as reasonably achievable' (ALARA).**

2. A routine imaging (cervical, chest, pelvis x-ray) is no longer considered appropriate. Recommended imaging is a chest x-ray, and cervical x-ray if the injury is unable to be cleared clinically. Pelvic radiograph should be considered carefully as children rarely have significant pelvic fractures. However, if there is strong clinical suspicion of pelvic injury then a pelvic x-ray is indicated together with chest x-ray.

3. Most paediatric spine injuries occur either through the discs and ligaments at the cranio-vertebral junction (C1-C3) or at the C7/T1. Algorithms for cervical imaging, referral and clearance can be referred to Figure 11.7.

4. If the CT cervical is indicated:
   - o < 10-year-old: the recommendation is for CT upper cervical spine from the occipital condyles and foramen magnum until C3 as this is the most common site of fracture in the age group and it excludes the radiation of thyroid gland.
   - o > 10-year-old: the recommendation is same as adult

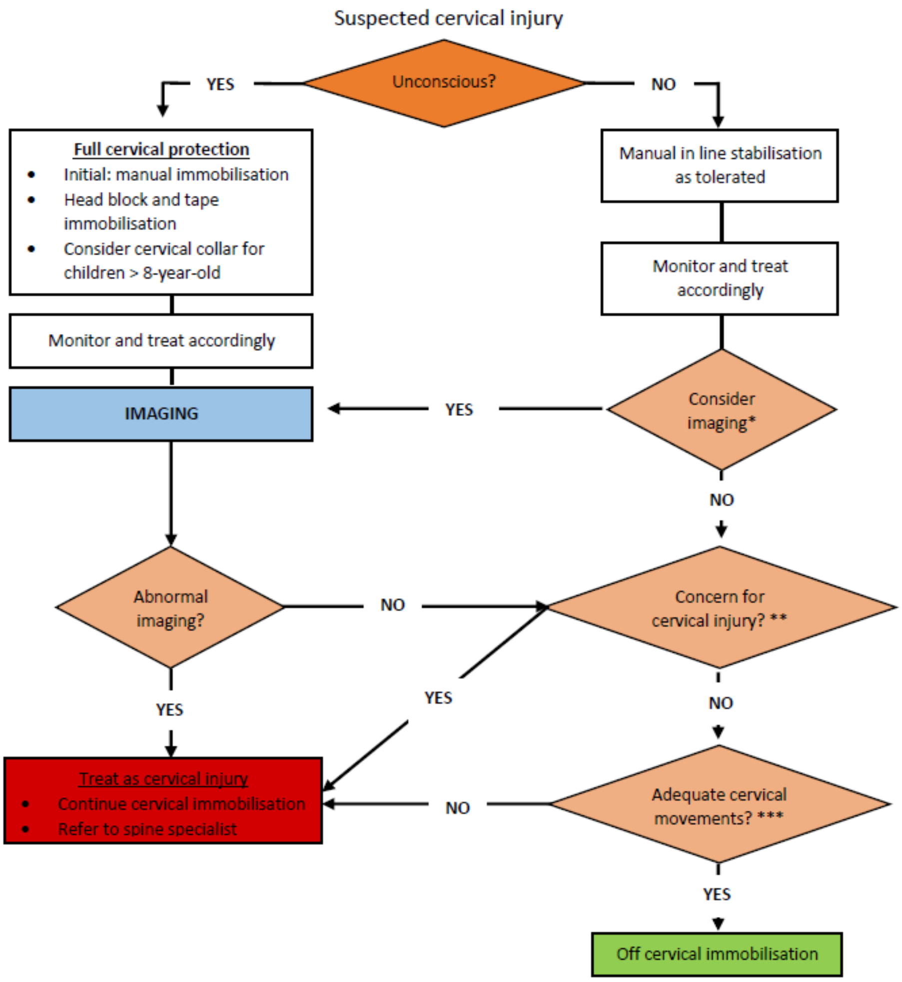
5. Extended Focused Assessment with Sonography in Trauma (e-FAST) should be performed.

6. A CT scan should be performed early for hemodynamically stable patients, if available, for injuries such as traumatic brain injuries and intra abdominal injuries and must not cause delay in treatment. The identification of intra abdominal injuries by

CT scan in paediatric patients with no haemodynamic abnormalities can allow for non-operative management by the surgeon.

7. When CT evaluation is necessary, radiation must be kept as low as needed. Scan only the area of interest which might change the management with the lowest radiation dose possible.

8. Early involvement of the surgeon is essential to establish a baseline that will allow the surgeon to determine if an operation is indicated.



*Consider imaging if there is any of the following:

- Posterior midline cervical tenderness
- Focal neurological deficit /pain
- Use of sedative medications
- Painful distracting injury
- Reduced mental state

** Concern for cervical injury

- Focal pain or tenderness
- Abnormal or uncertain imaging
- Drowsy or uncooperative child
- Unable to fully assess cervical

***Cervical movements: Assess 45° neck rotation to left and right. Control head movements appropriately, tolerates rotation of trunk and bears weight when vertical.

Figure 11.7: Algorithm for spinal imaging and clearance

11.2.2 Secondary Survey

After the primary survey is done and life-threatening injuries are ruled out, a focused history from the relatives/caregiver/witness should be obtained. All vital signs should be assessed and a complete head to toe examination should be performed to look for other injuries. The patient should be examined systematically so that no injuries would be missed.

Focused History

The mnemonic MAPLE can be used to obtain relevant information:

M – Medicines & Medical conditions
A – Allergy History
P – Pregnancy
L – Last meal and Time
E – Encounter/ Experience /Events

Vital Signs:

The reference ranges of paediatric vital signs for different age groups are listed in Table 11.3. Primary survey must be repeated whenever the patient becomes hemodynamically unstable followed by appropriate resuscitation.

Age group	Weight (kg)	Resp rate (min)	Heart rate (min)	Systolic rate (mmHg)
Newborn	2-3	30-50	120-160	50-70
Infant (1-12 months)	4-10	20-40	100-140	70-100
Toddler (1-3 years)	10-14	20-30	80-130	80-110
Preschooler (4-6 years)	14-18	20-30	80-120	80-110
School age (7-12 years)	20-40	20-30	70-110	80-120
Adolescent (>13 years)	>40	12-20	60-100	110-120

Table 11.3: Normal values for vital signs in pediatric patients

adapted from Malaysian Paediatrics Life Support (MPLS) Provider Manual 1st edition 2022, Ministry of Health, Malaysia

Head to Toe Physical Examination

11.2.2.1 Head and Neck

- Examine the scalp and face for skull fracture, laceration,abrasion, swelling or haematoma. Vomiting and amnesia are common after traumatic brain injury in children. However, persistent vomiting in a child raises a major concern and mandates a CT brain. Seizures are more common in children than adults after head injuries and require further investigation with a CT brain to rule out intracranial bleeding. Anti epileptic may be required in repeated seizures to avoid secondary insult to the brain.

- The outcome of children who suffer severe traumatic brain injury is better than adults, but they are very susceptible to secondary brain injuries caused by decreased cerebral perfusion due to hypovolemia or hypoxia. Adequate and rapid restoration of an appropriate circulating blood volume and avoidance of hypoxia are mandatory. Consider early endotracheal intubation.

- The Paediatric Glasgow Coma Scale can be used to assess the child's neurological status. Early neurosurgical referral should be obtained for severe traumatic brain injuries with GCS ≤ 8, or polytrauma with head injuries. Indications for CT brain in paediatric patients are shown in Figure 11.8.

- Spinal injuries are less common in children but should be suspected especially in major trauma with head injury (refer figure 11.5). Note that children may present with **"spinal cord injury without any obvious radiological abnormality (SCIWORA)"** more commonly than adults. Thus, it is important to maintain the spine and initiate an early referral to the spine surgeon. MRI should be obtained in cases suspected of SCIWORA.

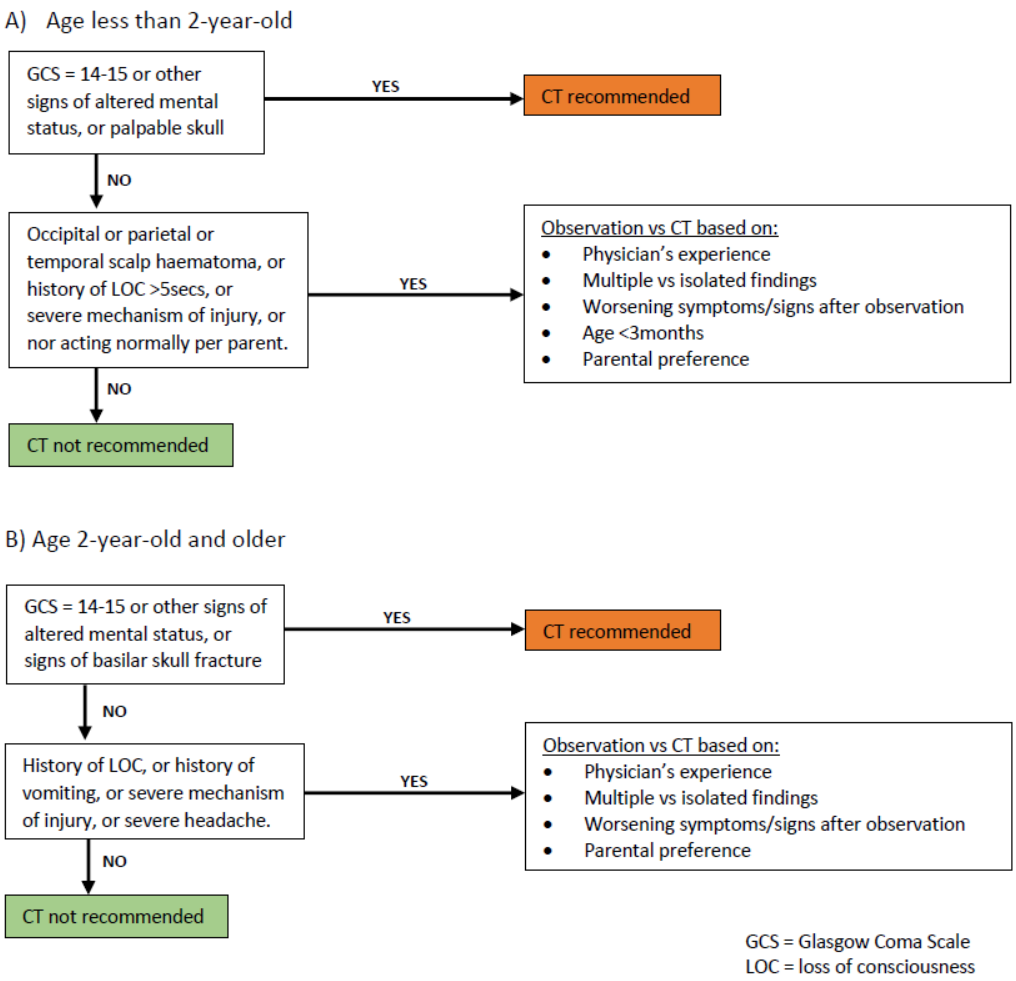


Figure 11.8 Indication of CT Brain in paediatrics
Adapted from Pediatric Emergency Care Applied Research Network (PECARN) Criteria for Head CT.

11.2.2.2 Chest, Abdomen and Pelvis

- The paediatric chest wall is more pliable; thus, rib fractures are rare. Injuries to the organs of the thorax such as lung and heart may be more severe. Lung contusion or laceration, haemothorax, diaphragmatic rupture and pericardial tamponade may develop. Examine for open wound, haematoma, asymmetry of chest wall movement, chest wall percussion and auscultation of breath sounds. The presence of rib fractures indicates high energy transfer.

- Suspect chest injuries in a child who is breathless or hypoxic. Myocardial contusion can present as arrhythmias in a child with a history of trauma to the anterior chest wall. Tracheobronchial injuries, diaphragmatic rupture and great vessel injuries are rare but should be ruled out.

- Blunt intra-abdominal injury is common in children. The liver and spleen are the commonly injured organs. Trauma can also occur to the kidneys, pancreas, small and large bowels, bladder, lumbar spine, and pelvis.

- Systematic and detailed assessment of a child with possible intra-abdominal injury is to be carried out. A child who is hemodynamically normal or who stabilises with fluid resuscitation may be managed nonoperatively. The majority of the children with solid organ injury can be managed nonoperatively. Urgent intervention is required if solid organ injury is present with persistent hemodynamic instability despite adequate blood replacement, or for penetrating abdominal injury or signs of perforated viscus.

- In the event of nonoperative management,the child must be treated and monitored in a facility with paediatric intensive care capabilities and related experienced clinicians.

- Log roll is performed to examine the posterior torso or spinal tenderness in the absence of unstable pelvic fracture. In cases of suspected unstable pelvic fracture, a suitable pelvic binder should be applied. Digital rectal examination is not routinely performed in children.

11.2.2.3 Upper and Lower Limbs

- Examine the upper and lower limbs for wound, swelling or deformity. Assess the neurovascular status of fractured limbs.

- Proper irrigation of wounds, broad spectrum antibiotics and anti-tetanus toxoid (in under immunised children) must be given for open fractures.

- Adequate analgesia based on the dose per body weight should be given.

- Immobilisation of fractured limbs with splints should be done for pain relief and prevention of further injury. Radiographs of the affected limbs should be done after life and limb threatening injuries have been ruled out.

- Suspected limb emergencies such as arterial injury or compartment syndrome requires urgent primary team referral for definitive treatment.

11.3 NON-ACCIDENTAL INJURY (NAI)

The diagnosis of non-accidental injury is difficult to make and involves legal implications. Early involvement of the Suspected Child Abuse and Neglect (SCAN) team is important. A good history and physical examination of the patient are critical in making the diagnosis. Suspect non-accidental injury if:

- Inconsistent history between parents or the child
- Discrepancy between the history and the severity of the injury
- Delayed presentation of the child after the injury
- History of repeated trauma or multiple visits to the hospital
- Parents or caregiver respond inappropriately to the severity of the child, or lack of concern
- Abnormal parent and child interaction
- Multi-coloured bruises in different stages of healing
- Multiple subdural haematomas, especially without a fresh skull fracture
- Intra-abdominal injury without recent history of major trauma
- Retinal haemorrhages
- Perioral injuries
- Genital or perianal injuries
- Bite marks, cigarette burns or rope marks
- Fractures of long bones in children less than 3 years of age, especially if the child is not able to walk yet
- Evidence of frequent previous injuries, old scars, or fractures

11.4 PREVENTION

There are three levels of injury prevention:

1. Primary injury prevention is any measure designed to reduce the incidence of injury (e.g., speed limits, motorcycle lanes, road safety campaigns).
2. Secondary prevention is any measure designed to minimise the injury even though the incident had happened (e.g., proper use of seat belts, bicycle helmets, PPE).
3. Tertiary injury prevention is any measure designed to limit the extent or consequences of an injury that has already occurred (e.g., damage control resuscitation).

Over the past few decades, injury prevention programs in some countries have succeeded in halving childhood death due to trauma. Up to 80% of childhood injuries can be prevented by simple strategies in the home.

PEARLS

Unique anatomy and physiology of a paediatric patient leads to its pitfalls in management of paediatric trauma e.g.

i. Unrecognized endotracheal tube dislodgement due to short trachea.
ii. Obstruction of endotracheal tube by secretion and blood due to its smaller diameter.
iii. Ability of a child to compensate thus the presentation of hypovolemic shock might be deceiving.
iv. Challenging intravenous access thus intraosseous access should be considered if peripheral venous access is difficult.
v. Frequent assessment is needed especially for children with conservative management.
vi. Presence of subtle injuries that are easily missed.

ALARA - As Low As Reasonably Achievable – Scan done only when deemed necessary and with lowest dosage possible.

SCIWORA – Spinal cord injuries without radiological abnormality is common in child

11.5 SUMMARY

- Structured approach to initial assessment and management of paediatric patients will allow the clinician to deliver effective care toward the injured patient.
- Inconsistent history and clinical findings should raise suspicion on possibility of child maltreatment.
- Most child injuries are preventable and early detection of injuries is crucial.

11.6 REFERENCES

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3. Kuppermann, N., Holmes, J. F., Dayan, P. S., & Pediatric Emergency Care Applied Research Network. (2009). Identification of children at very low risk of clinically important brain injuries after head trauma: a prospective cohort study. *The Lancet*, *374*(9696), 1160-1170.

11.7 SKILL STATION

11.7.1 INTRAOSSEOUS NEEDLE INSERTION

Step 1 – Identify indications for intraosseous needle insertion

- 2 or more failed attempts in obtaining a peripheral intravenous access for a patient which requires urgent resuscitation such as cardiac arrest or hypovolemic shock

Step 2 – Identify contraindications for intraosseous needle insertion

- Fracture of the same bone
- Infection over the affected area
- Bleeding tendencies
- Previous failed attempt over the same bone
- Abnormal bone quality such as osteogenesis imperfecta

Step 3 – Identify equipment needed and preparation and positioning of patient

- Patient supine with flexed knee and support behind knee
- Aseptic technique
- Prepare sterile area
- EZ-IO gun with needle / Cook catheter, syringes, normal saline, catheter, gauze, tapes

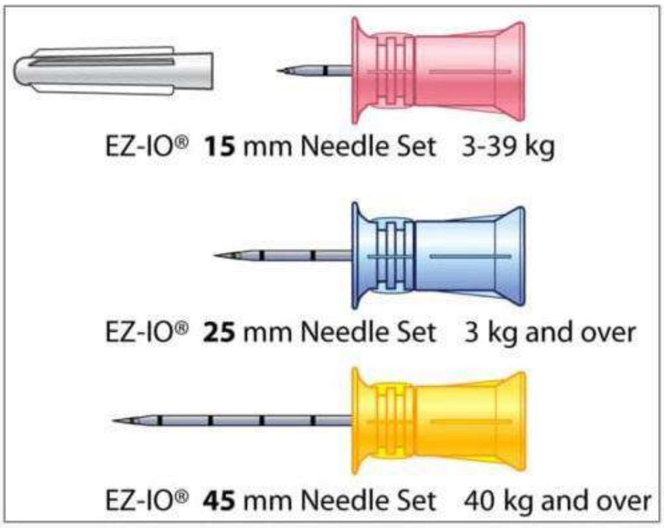
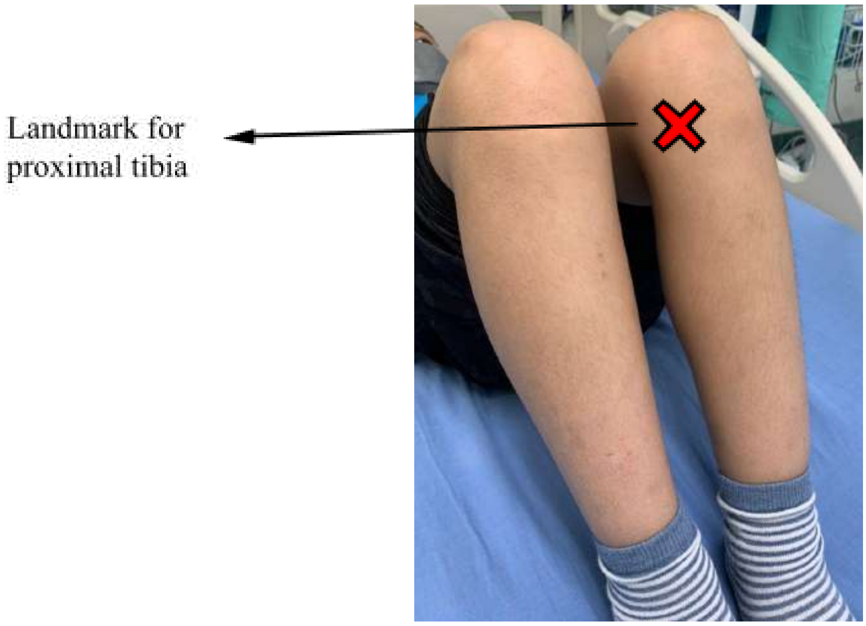


Figure 11.9 : EZ-IO needles size

Step 4 – Identify landmark for intraosseous needle insertion and alternative sites

- Proximal tibia (1 cm medial to tibial tuberosity, anterior surface)
- Distal femur (1 cm proximal to superior border of the patella, 1 cm medial to midline over the anterolateral surface)
- Distal tibia (1-2 cm proximal to medial malleolus)
- Proximal humerus (Refer to Chapter 3: Shock)



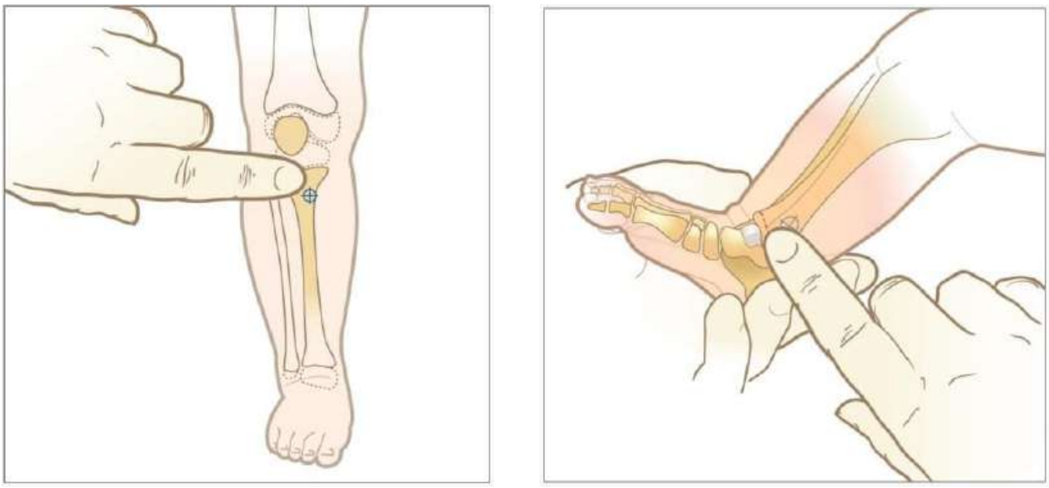


Figure 11.10 : Landmark for intraosseous insertion at proximal and distal tibia

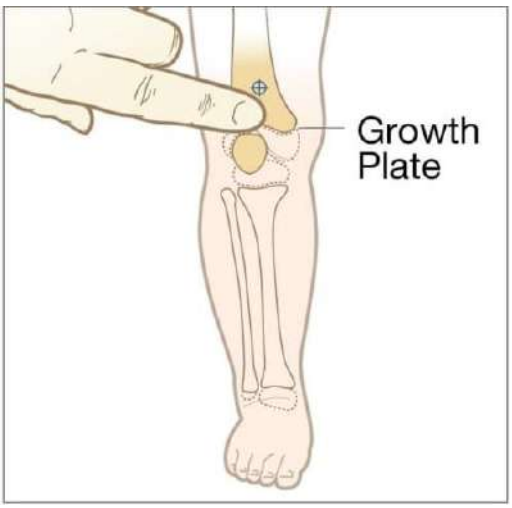


Figure 11.11 : Landmark for intraosseous insertion at distal femur

Step 5 – Perform intraosseous needle insertion

Figure 11.12 : Intraosseous needle insertion

Step 6 – Identify methods to confirm placement of intraosseous needle

- A ‘give’ is felt during insertion of the needle into the marrow space
- Aspiration of marrow contents with a syringe
- Able to infuse fluids into the needle without a localised swelling
- Firm and stable placement of needle in the bone

Step 7 - Identify type of fluids/medications that can be given through the intraosseous needle

- Intravenous medications including adrenaline; followed by a normal saline flush
- Intravenous fluids, using a pressure bag
- Blood products, using a pressure bag

CHAPTER 12

TRAUMA & PREGNANCY

At the end of this chapter the candidates will be able to attain the following knowledge:

- Describe the anatomic and physiologic changes at different phases of pregnancy.
- Identify the mechanism injury to mother and their fetus.
- Outline the treatment priorities and assessment methods for both mother and fetus.
- Indications for admission in trauma associated with pregnancy.
- Iso-immunization and immunoglobulin therapy in trauma associated with pregnancy

12.0 INTRODUCTION

Trauma in pregnancy is the leading cause of non-obstetrical maternal mortality. It involves two patients - the mother and the fetus. Treatment priorities should remain the same as for the non-pregnant patients.

The resuscitation and stabilization must be modified to accommodate the special anatomical and physiological changes of pregnancy with special consideration given to exposure to radiation, Rh iso-immunization, placental abruption, uterine rupture and preterm labour.

The main principle guiding therapy should be that; the resuscitation of the mother will help the resuscitation of the fetus as well. The obstetric doctor should be summoned immediately upon the arrival of the patient for consultation. Women may be unaware of their pregnancy status. One study showed that 3% of women admitted to a trauma unit were pregnant, and of these 11% were incidental pregnancies. Therefore, all women of child-bearing age should be anticipated to be pregnant until proven otherwise.

12.1 PREGNANCY

The pregnancy itself is divided into three trimesters.

- The First Trimester is the most critical stage of development. The fetal cell is most susceptible to damaging effects of drugs, infections, illnesses and radiation. Trauma during this phase can cause spontaneous or threatened abortion.

- The Second Trimester is where the fetus develops bony structures and the uterus enlarges and is palpable at about the level of the mother's umbilicus.

- In the Third Trimester, the uterus reaches its maximum expansion pushing into the mother's diaphragm and thoracic cavity. Trauma at this juncture can lead to serious complications since there are two separate patients here with different physiological requirements.

12.2 ANATOMIC & PHYSIOLOGICAL CHANGES IN PREGNANCY

12.2.1 Anatomical

- At the 12th week of gestation, the uterus begins to extend out of the pelvic region into the abdominal region.

- At 20 weeks, the uterus is palpable at the level of umbilicus,

- At 34 to 36 weeks, the uterus is palpable just below the costal margin.

- The gestational age of the fetus can be measured by the symphysis fundal height (SFH) in cm and it corresponds to the dates in weeks.

- During the first trimester, the uterus is a thick-walled structure whereas during the second trimester, it becomes an abdominal structure. However, by the third trimester, the uterus is large and thin-walled and pushes the diaphragm upwards.

- As the woman approaches term, the abdominal contents are also pushed upward into the upper abdomen. As the diaphragm is elevated, there is a higher incidence of abdominal injuries with chest trauma. Thus, the bowel is protected to a certain extent in blunt abdominal trauma, whereas the uterus and its contents become more susceptible. Penetrating trauma to the upper abdomen during late gestation may result in complex intestinal injury because of this upward displacement.

12.2.2 Cardiovascular System

- Plasma volume exhibits a consistent increase throughout gestation, reaching a plateau during the terminal phase of the third trimester. A relatively higher increase in plasma volume to red blood cells depicts the state of physiological dilutional anemia which is pronounced during this phase of pregnancy.
- The state of shock may be only recognised after a large volume loss due to increased physiological circulating volume as opposed to a non pregnant patient. Fetal distress may depict an early sign of hemorrhage in pregnant patients.
- The state of cardiovascular changes returns to pre pregnancy physiological state within the approximate period of 6 to 8 weeks.

- Pallor is an unreliable sign and only appears after significant blood loss. The conjunctiva and nail beds are normally vasodilated making them appear pink. When in shock, the protective mechanism of the body shunts the blood away from the uterus and placenta to the central circulation. This will cause fetal hypoxia.

- Supine hypotension is due to reduction of the venous return to the heart because of the compression of the inferior vena cava by the gravid uterus in the supine position. Supine positioning may lead to compression of the vena cava, resulting in an approximate one-third reduction in cardiac output due to diminished venous return from the lower extremities.he pregnant patient should be cared for in the left lateral position if there is no contraindication or a placement of a wedge underneath the spinal board.

- During pregnancy the volume of the blood increases by about 40% to 50% and the cardiac output by 1-1.5 liters. Uterus and placenta receive 20% of the patient's cardiac output during the third trimester. The heart rate increases gradually by 10 to 20 beats per min during pregnancy.

- During the second trimester of pregnancy, both the systolic and diastolic blood pressure typically reduces and returns to near-normal levels by term.

12.2.3 Coagulation physiology

Thrombosis is more likely to occur in pregnancy because pregnancy is a procoagulant state. Two of the components of Virchow triad, venous stasis and hypercoagulability are present. There is a physiological increase in clotting factors. Estrogen increases the hepatic production of coagulation factors, yielding a 30-50% increase in fibrinogen and factors VII, VIII, IX, and X. There is also decreased activity in the fibrinolytic system especially in the second and third trimesters. Therefore, the pregnant trauma patient is at increased risk for venous thromboembolic complications. The normal value for fibrinogen is often greater than 400 mg/dL. Table 12.1 compares coagulation profiles at different stages of pregnancy.

12.2.4 Respiratory System

There is a need to maintain adequate arterial oxygenation in the treatment of the pregnant trauma patient. The pregnant woman has a higher basal metabolism. The pregnant woman's oxygenation needs are 10 - 20% higher than normal. This is the cause of physiological hyperventilation. PaC02 is decreased (hypocapnia i.e. $PaCO_2$ 30mmHg) causing respiratory alkalosis as shown in Table 12.1. There is an increase in tidal volume and minute ventilation. Residual volume is decreased due to diaphragmatic elevation. Thus, reducing both total lung capacity and functional residual capacity (FRC). The fetus is very sensitive to maternal hypoxia, and maternal basal oxygen consumption is elevated at baseline.

The pregnant patient has a greater risk for difficult airway and difficult intubation. Weight gain, respiratory tract mucosal oedema, decreased functional residual capacity, reduced respiratory system compliance and increased airway resistance requirements are all pregnancy induced changes. Therefore pregnant patients are at risk for failure to maintain a patent airway and secured ventilation.

12.2.5 Gastrointestinal System

The intestines are pushed upwards as the uterus becomes an abdominal structure. The gastro-esophageal junction becomes relaxed, gastric tone and motility is reduced. There is also increased gastric juice secretion. Early decompression of the bowel is encouraged with the insertion of an orogastric tube to avoid gastric aspiration.

12.2.6 Musculoskeletal System

The effect of relaxin and hormonal changes onto the pelvic ligament results in the widening of the pubis symphysis and sacroiliac joints seen pronouncedly within the third trimester. Other expected changes include increased lumbar lordosis and thoracic kyphosis. There is an increase in blood flow to the pelvic region; thus a pelvic fracture can result in severe blood loss.

12.2.7 Genitourinary System

The bladder is displaced outside the pelvic cavity thereby increasing risk of injury. Pregnancy leads to increased glomerular filtration rate and renal blood flow, which in turn lowers serum creatinine and urea nitrogen. Additionally, decreased renal reabsorption of glucose can result in expected glycosuria, a condition that may also be present in cases of maternal gestational diabetes.

Value	Non-Pregnant	1st Trimester	2nd Trimester	3rd Trimester
Haemoglobin (g/dl)	12–16	11.5–14	10–15	9.5–15
Haematocrit (%)	35–44	31–41	30–39	28–40
WBC Count (x 10^9/L)	4–10	6–16	6–16	6–16
Platelet (x 10^9/L)	150–400	170–390	150–400	145–400
Fibrinogen (mg/dL)	150-400	238 – 444	240 – 597	280 – 590
D-Dimer (ng/ml)	< 500	<1090	357-1748	771-2410
Prothrombin Time (seconds)	11–15	9.7–12.5	8.5–13.2	8.6–12.4
Activated partial thromboplastin time (APTT) (seconds)	30–40	26–42	24–36	26–35
Arterial pH	7.35-7.45	7.40–7.44		7.41–7.45
Bicarbonate (mmol/L)	22-26	17 - 19		15 - 19
$PaCO_2$ (mmHg)	35 - 44	27 - 32		23 - 29
PaO_2 (mmHg)	95-100	99–111		100–112

Table 12.1 Comparing hematological and biochemistry parameters in pregnancy.

12.2.8 Neurologic System

While traumatic brain injury can manifest as generalized tonic-clonic seizures, clinicians must concurrently exclude eclampsia, especially after 20 weeks of pregnancy and up to six weeks postpartum. Eclampsia is commonly characterized by concomitant hypertension, proteinuria and hyperreflexia.

12.3 MECHANISM & SEVERITY OF INJURY

Two types of injuries are common in pregnant women; blunt and penetrating injuries.

12.3.1 Blunt Injury

a) Motor Vehicle Accidents

Motor vehicle accidents remain the most common cause of blunt injury in pregnancy. It is the leading cause of maternal death, and after placental abruption, maternal death is the leading cause of fetal death. Fetal death with maternal survival occurs most often in abdominal trauma with abruptio placenta. A lap belt worn too high over the uterus may produce uterine rupture. Determination of the type of restraint device worn by the pregnant patient is important in the overall assessment of trauma.

b) Falls

Injuries associated with falls in a pregnant woman are pelvic fractures which may cause abruptio-placenta. Fractures of the fetus are uncommon due to the cushioning effect of the amniotic fluid. Pelvic fractures can cause direct trauma to the uterus, bladder and ureters. Complications associated with falls include preterm labour, placental abruption, uterine rupture, fetal growth restriction and fetal death.

12.3.2 Penetrating Injuries

The probability of uterine and fetal injury increases as the pregnancy progresses and the uterus enlarges and becomes an abdominal organ. Fetal death is due to direct injuries to the membranes, cord or placenta. The enlarged uterus protects the pregnant patient from serious organ injury when lower abdominal stab injuries occur whereas stab wounds to the upper abdomen often carry a higher incidence of visceral injury especially to the small bowel.

12.4 EFFECTS OF TRAUMA TO THE UTERUS

Towards late pregnancy the uterus pushes the abdominal contents towards the upper abdominal area. Trauma to the uterus causes **abruptio placenta and placental bleeding**. The walls of the uterus often act as a cushion against direct effects of blunt trauma. However, the **acceleration deceleration effects** of motor vehicle accidents can cause **abruptio placenta** or **uterine rupture** resulting in fetal death. This in turn can lead to disseminated intravascular coagulopathy (DIVC).

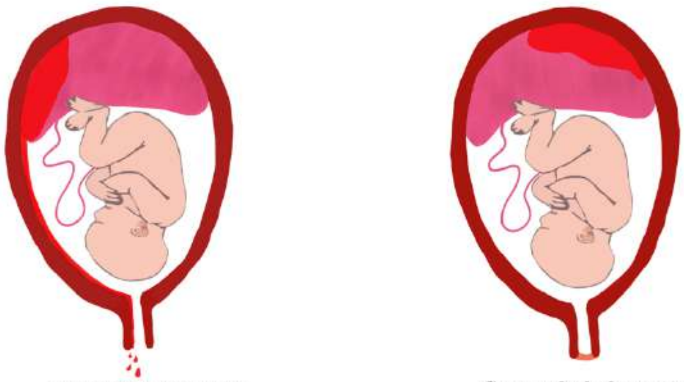


Figure 12.1: Revealed and concealed Placenta Abruptio

Any significant blood loss to the mother results in the mother's vascular system **shunting blood away from the fetal circulation**, often resulting in fetal distress. Trauma to the amniotic cavity can cause **amniotic fluid embolism**, DIVC and also premature rupture of membranes clinically evidenced by leaking liquor. **Uterine rupture** can occur especially if there has been a previous C section.

Traumatic placental injury can result in feto-maternal hemorrhage. This occurs in 10% to 30% of pregnant trauma patients. Rh Immunoglobulin therapy (**IM RhIG 1 ampule 300 g**) should be given to all Rh-negative pregnant trauma patients within **72 hours** of injury. Other consequences of feto-maternal hemorrhage include fetal anemia and death if the mother is Rh-negative.

More than 2/3rd of Rh-negative mothers can be sensitized with the exposure of any amount of Rh-positive blood

12.5 MANAGEMENT OF INJURIES

12.5.1 Initial Assessment

Assessment should emphasize on the mother as well as the fetus. However resuscitation should be focused on the mother as to improve the outcome of both mother and fetus.

12.5.2 Primary Survey

- **Airway**

  Administer oxygen as a pregnant woman's oxygen needs are 10-20% higher than normal. An early intubation should be considered whenever airway problems are anticipated. Early placement of an orogastric (Ryle's) tube is warranted in an unconscious or semiconscious pregnant patient. The incidence of aspiration is high due to decreased gastric motility, compression of the upper gastrointestinal tract, elevated gastric acid, decreased pH, and relaxation of the lower esophageal sphincter.

- **Breathing**

  Superior displacement of the diaphragm during pregnancy, may result in insertion of tube thoracostomy, one to 2 intercostal spaces higher than usual.

- **Circulation**

  A pregnant woman may lose a lot of blood before shock is manifested. A decrease in maternal circulating volume and catecholamine release may result in a significant increase in uterine vascular resistance, diminished placental blood flow, and a reduction in fetal oxygenation even in the presence of normal maternal vital signs. If there is acute blood loss, guided blood product transfusion is warranted. Examine for vaginal bleeding, leaking liquor, cord prolapse and tenderness of abdomen. Assess uterine contractions.

If there are no contraindications, place the mother (>20 weeks) in the left lateral position to alleviate Aorto-Caval Compression syndrome. This can be achieved by a simple wedge (i.e. using a pillow/blanket) which is placed on her right back to achieve a 15-30 degree Left lateral tilt (Figure 12.2 & 12.3)

Aorto Caval Compression Syndrome is a compression of abdominal aorta and inferior vena cava by the gravid uterus when lying supine.

Figure 12.2 : Blanket roll placed below the Spinal Board to enable Left Lateral tilt

Figure 12.3: Left Lateral Tilt at 15-30^{0} position.

12.5.3 Adjuncts to Primary Survey

- Maternal urine output
- ABG, pulse oximetry should be monitored.
- Gastric contents should always be decompressed.
- Continuous CTG monitoring should be done.
- Bedside ultrasound scan is a valuable tool in continuous assessment.
- Extended-FAST and a bedside ultrasound of the gravid uterus are valuable to assess fetal viability.
- Laboratory evaluation in the trauma patient should include a fibrinogen level. Fibrinogen level may double in late pregnancy thus a normal fibrinogen level may indicate early disseminated intravascular coagulation.
- Radiographic studies may be performed as indicated taking into consideration its risk versus benefit.

12.5.4 Secondary Survey

This is a head to toe examination of the body focusing on the uterus and abdominal region.

- Assess if the mother is in labour with contractions, 'show' or leaking liquor.
- Assess if there is placental abruption. It is the most common cause of fetal death in cases of blunt trauma. Most abruptions occur within 2 to 6 hours post injury. Clinically there may be severe abdominal pain, per vaginal bleeding, tender and rigid uterus.. The **fetal heart sound may be faint or absent**.
- Leaking of liquor may indicate possible membrane rupture.

12.6 DIAGNOSTIC MODALITIES

12.6.1 Ultrasound Scan

An ultrasound scan is mandatory in obstetric trauma to obtain information in regards to the following:

a. Gestation Age
b. Fetal heart
c. Placental abruption or clot
d. Amount of liquor
e. Fetal Presentation

12.6.2. Imaging in Pregnancy

Clinicians commonly worry that the ionizing radiation from CT and x-rays can potentially cause fetal anomalies especially in first trimesters. Teratogenic effects may be high during the **period of organogenesis (5–10 weeks)** and least during the third trimester. The risk of radiation to the fetus can be reduced by using abdominal lead shields during exposure.

Fetal exposure to low dose radiation of **less than 5 rads (50mGy)** does not increase risk of fetal death, mental defect or growth retardation. CT scan of the head, chest, abdomen and abdo-pelvis is estimated to cause fetal radiation absorption dose of 0 mGy, 0.2 mGy, 4mGy, and 25 mGy respectively. A WBCT protocol would essentially be less than 30 mGy.

In the event that the fetus is exposed to 50 mGy of absorbed radiation, evidence suggest that the estimated relative risk of fatal childhood cancer is doubled from a baseline of 1:2000 (0.05%) to 1:1000 (0.1%) and the child will have an overall lifetime risk of 2% for developing cancer.

TYPE OF PROCEDURE	DOSAGE IN RADS
Chest X ray with abdominal shield	<0.0001
Cervical Spine 2 views	<0.0001
Abdominal X ray 2 view	<0.2
Head CT	<0.05
Thorax CT	0.02 - 0.1
Abdomen/Pelvis CT	2.5 - 3.5
Pan CT (split bolus)	1.4 - 2.2

Table 12.2 : Dosage in Rads exposure according to type of radiological procedure.

12.6.3 Cardiotocography (CTG)

Continuous cardiotocography monitoring is required in patients (> 20 weeks of gestation) presenting with :

- Uterine contractions
- Abnormal fetal heart rate pattern
- Vaginal bleeding
- Significant uterine tenderness or irritability
- Severe maternal injury
- Abdominal pain

12.6.4 Laboratory Investigations

In addition to the trauma panel, the Kleihauer–Betke (KB) test should be obtained in all Rh-negative women to ascertain whether fetal blood has entered the maternal circulation in severely injured trauma patients.

12.7 RESUSCITATIVE HYSTEROTOMY (PERI-MORTEM CESAREAN SECTION)

Perimortem cesarean section is defined as surgical delivery of a fetus either during impending maternal cardiac arrest or during maternal cardiac arrest. Primary aim is to improve the chance of survival of the fetus while increasing the chance of successfully resuscitating the mother. Perimortem cesarean section improves maternal cardiac output by reducing uterine blood flow, relieves diaphragmatic pressure and aortocaval compression. Perimortem cesarean section may be successful if performed within 4 minutes of the arrest and can be considered for viable pregnancies (20 - 24 weeks) or fundal height 2 or more fingerbreadths above the umbilicus.

12.8 INDICATION FOR HOSPITALISATION FOR PREGNANCY ASSOCIATED CONDITIONS WITH TRAUMA

- Uterine tenderness
- Abdominal pain
- Vaginal bleeding
- Increase in frequency of contraction
- Post traumatic rupture of the membranes
- Abnormal CTG pattern
- High risk mechanism of injury

12.9 PEARLS

1. Suspect pregnancy in all women of childbearing age.
2. Consider anatomical and physiological changes during pregnancy.
3. Anticipate difficult airway and ventilation in pregnancy.
4. A normal $PaCO_2$ may indicate impending respiratory failure.
5. Recognize early blood loss and resuscitate accordingly.
6. In the absence of contraindication, perform left lateral tilt to alleviate aorta-caval compression syndrome
7. Understanding possible mimics of eclampsia
8. Recognize and manage RH Iso-immunization in pregnancy

12.10 SUMMARY

1. Anatomic and physiological changes that occur during pregnancy should be taken into account during the assessment and treatment of injured pregnant patients. Early referral is essential.

2. A pregnant woman may lose a significant amount of blood before signs and symptoms of shock are manifested. Resuscitation of the mother improves survival of the fetus.

3. Consider clinical conditions that are specific to the injured pregnant suchas uterine rupture, abruptio placentae, placental bleeding, amniotic fluid embolism, DIVC, RH isoimmunization, and premature rupture of membranes.

4. Always consider feto-maternal hemorrhage in all pregnant trauma patients. All pregnant Rh-negative trauma patients should be given Rh immunoglobulin therapy.

5. Consider Resuscitative Hysterectomy within 4 minutes of maternal arrest for all viable pregnancies.

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CHAPTER 13

TRAUMA & GERIATRIC CARE

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Able to identify unique characteristic of elderly trauma patient.
2. Able to know the anatomic and physiological differences as well as patterns of injury of elderly trauma patient.
3. Able to perform the primary management of critical injuries in geriatric patients.
4. Able to identify elements that lead to suspicion of abuse of elderly patients.

13.0 INTRODUCTION

The proportion of the population aged 65 years and over in Malaysia has increased to 6.7 per cent in 2019 as compared with 3.9 per cent in 2000. Trauma is the 7th leading cause of death in elderly. The prevalence of trauma is increasing in geriatric population. It is associated with higher morbidity and mortality as compared to younger patients.

13.1 PHYSIOLOGICAL CHANGES OF AGING

13.1.1 PHYSIOLOGY OF AGING BONE

As a result of aging, bone progressively undergoes changes predisposing to osteoporosis. This is coupled with degeneration of ligaments leading to stiffness and reduction of range of movement. Therefore, trivial trauma such as falls from standing height may result in significant injuries and morbidities.

13.1.2 PHYSIOLOGY OF AGING CARDIOVASCULAR

- Patients are less tolerant to hemodynamic stress due to decreased functional cardiac reserve which may result in lower cardiac output.
- Inefficient electrical conductivity of the heart as part of the physiological changes.
- Heart rate may be influenced by pharmacological activity such as beta-blockers or calcium blockers.

- Blunted inotropic and chronotropic response to trauma.
- Arterial compliance is reduced and the systolic blood pressure will be higher.
- Maximum tachycardic response decreases (maximal HR; 220 – Pt Age).
- The risk of cardiac events should be considered in every case of trauma in elderly.

Blunted inotropic and chronotropic response
Absent of compensatory tachycardia

13.1.3 PHYSIOLOGY OF AGING RESPIRATORY

- Chest wall and lungs become rigid and less compliance causing reduction of tidal volume and total lung capacity. This also causes an increase in work of breathing.
- Decreased in gas diffusion capacity
- Less response to hypoxemia and hypercapnia.

13.1.4 PHYSIOLOGY OF AGING CENTRAL NERVOUS SYSTEM

- Reduction in brain mass and neuronal density causing a stretch in bridging vessels.
- Reduction in cerebrovascular autoregulation.
- Increase in peripheral neuropathy.
- Reduction in salivation, taste buds, visual acuity and hearing.
- Reduction in baroreceptor response causing postural hypotension.

Figure 13.1 CT Brain of cerebral atrophy and intraventricular hemorrhage

13.1.5 PHYSIOLOGY OF AGING SKIN

- Reduction in elasticity of skin and thinning of epidermis.
- Reduced defense mechanism against microorganisms.
- Loss of temperature autoregulation.
- Delayed wound healing.

13.2 TYPES OF INJURIES

Elderly patients are more likely to have a higher morbidity and mortality due to injuries. It is due to physiological changes of aging, comorbidities and lack of understanding of their needs by the healthcare providers.

13.2.1 FALLS

- Fall is the most common mechanism of injury for this age group.
- Most falls are from ground level or stairs.
- Fall in the elderly is due to the aging physiological changes and the environmental hazards.
- The fall can be trivial but the patient can sustain very serious injuries.
- Major risk factors for fall will be female, older age, previous history of fall, unstable gait, arthritis and use of psychotropic drugs.

13.2.2 MOTOR VEHICLE ACCIDENTS

- Aging influences incidence of injury, morbidity and mortality.
- Medical co-morbidities and medication may alter attention, coordination and balance.

13.2.3 THERMAL INJURIES

- Elderly patients are more prone to thermal injuries and its complications.
- Most thermal injuries occur at home (i.e. kitchen, bedroom, bathroom, garage)
- Cognitive impairment and pre existing medical conditions may lead to delayed fight and flight response as well as decreased ability to assess the severity of the situation.

There are 5 Pre-existing medical conditions that has high impact on mortality and morbidity of elderly patients with trauma

- Chronic Obstructive pulmonary Disease(COPD)
- Diabetic Mellitus
- Ischemic Heart Disease
- Cirrhosis
- Coagulopathy

13.3 PRIMARY MANAGEMENT OF CRITICAL INJURIES

13.3.1 AIRWAY

- The basic principles of airway management remained the same. The first objective is to establish and maintain a patent airway to provide adequate oxygenation.
- Supplemental oxygen should be administered and early intubation should be considered.
- Features that affect management include dentition, cervical arthritis, nasopharyngeal fragility and macroglossia.

13.3.2 BREATHING AND VENTILATION

- Careful monitoring of geriatric patient's respiratory system is mandatory due to loss of respiratory reserve because of aging and chronic diseases.
- Administration of supplemental oxygen is mandatory but careful observation is needed as patients can lose their hypoxic drive, as many of them have underlying COPD.
- Mortality rate is higher in elderly patients with chest injuries.
- Rib fractures are more common in elderly and the mortality increases with the number of ribs fractured.
- Adequate pain control and vigorous pulmonary toilets are essential.
- Pulmonary complications (atelectasis, pneumonia and pulmonary edema) are much higher in elderly patients.
- Admission to hospital is necessary although with minor injuries.

13.3.3 CIRCULATION

- A common pitfall in the evaluation of geriatric trauma is the belief that normal blood pressure and heart rate indicates normal circulatory volume.
- A normal systolic blood pressure of 120 might be low for an elderly with pre-injury systolic blood pressure of 170.
- Significant blood loss may be masked by the absence of tachycardia due to changes in physiological response or medications that lowers heart rate.
- Early monitoring of the cardiovascular system must be instituted.
- Geriatric patients should be resuscitated in a similar manner as younger patients. However, they are more prone to fluid overload due to higher incidence of cardiac disease.
- The indication of blood transfusion is also the same as in younger patients.
- Elderly patients with pelvic fracture, even a seemingly stable fracture, have a higher need for blood transfusion than younger patients.
- Exsanguinating retroperitoneal hemorrhage may develop in elderly patients after a relatively minor pelvic or hip fracture.

- Mortality from pelvic fracture is 4 times higher in elderly patients than younger patients.
- Early recognition and correction of coagulation defects is important.

13.3.4 DISABILITY : BRAIN & SPINAL CORD INJURY

- Minor head trauma can result in Intracranial or Subdural Bleed due to reduction in brain mass (cerebral atrophy) that enables movement and shearing of parasagittal bridging veins.
- A significant amount of blood can collect in the subdural space before overt symptoms become apparent.
- The risk is higher in patients taking warfarin and other anticoagulants or antiplatelet agents.
- Liberal use of CT is warranted in this population.
- Spine and spinal cord are at higher risk for injury due to changes in shape of intervertebral disc and decrease in compressibility and flexibility.
- Cervical spine injuries are more common in elderly.
- Severe degenerative disease makes the diagnosis of cervical fracture more challenging.
- MRI is useful in diagnosing ligamentous injury.

Figure 13.2 CT Scan of cervical spine in elderly

13.3.5 EXPOSURE & ENVIRONMENTAL CONTROL

- The aging process results in loss of thermal regulatory ability, decreased barrier function against bacterial invasion and impaired in wound healing.
- Elderly patients must be protected against hypothermia by using warm blankets, warm fluids and monitoring the temperature regularly.
- Appropriate care to prevent infection must be instituted including assessing tetanus immunization.

13.3.6 MUSCULOSKELETAL SYSTEM

- Osteoporosis contributes to occurrence of spontaneous vertebral compression fractures and hip fractures.
- The most common locations of fractures in elderly are ribs, proximal femur, hip, humerus and wrist.
- The aim of treatment for musculoskeletal injuries should be the least invasive, most definitive procedure that will enable early mobilization.

13.4 SPECIAL CONSIDERATIONS

13.4.1 MEDICATIONS

- The patient's medications must take into consideration drug-drug interaction.
- Non-Steroidal Anti Inflammatory(NSAIDs) drugs may contribute to blood loss.
- Steroids may reduce the inflammatory and immune response.
- Long term anticoagulants may increase blood loss and cause brain injury.
- Narcotics are safe and should be given in small titrated doses.
- Elderly patients are more susceptible to the side effects of drugs given.

13.4.2 ELDERLY ABUSE

- Can be classified into 6 categories
  - i. Physical abuse
  - ii. Sexual abuse
  - iii. Psychological abuse
  - iv. Neglect
  - v. Financial and material exploitation
  - vi. Violation of rights
- Elderly abuse can go unnoticed as many only involve subtle signs e.g. dehydration and malnutrition.
- Physical abuse accounts for 14% of elderly abuse and can be suggested by these physical findings.
  - i. Injuries involving the inner arm, inner thigh, mastoid area, scalp, ear (pinna) or buttocks
  - ii. Abrasions on the wrist or ankle
  - iii. Nasal bridge and temple injury
  - iv. Unusual alopecia pattern
  - v. Untreated pressure ulcer
  - vi. Untreated fractures
  - vii. Fractures not involving the hip, humerus or vertebra
  - viii. Injuries in various stage of evolution
  - ix. Contact burns and scalds
- Any of the above findings must be investigated and a multidisciplinary approach should be taken.

Pitfalls in managing Geriatric Trauma

- Failure to recognize the indications of early intubation.
- Failure to recognize the complications of ribs fracture and lung contusion.
- Regard a normal vital signs equals to a normo-volaemia.
- Failure to do early and close cardiovascular monitoring.
- Failure to recognize that trivial trauma can cause in fractures and serious injuries.
- Failure to take medication history and correlate it with hemodynamic findings.

13.5 SUMMARY

- Mortality rate for elderly involved in trauma is higher compared to younger age.
- Anatomic and physiologic changes in elderly are associated with higher morbidity and mortality. Elderly patients also have more comorbidities. Use of medications also will change the body response and complicate assessment.
- Management of geriatric trauma is with the same principle as managing the adult population. But higher degree of suspicion, longer observation with closely monitored hemodynamic status should be instituted.
- Geriatric abuse should be suspected following patterns of injury and should include reporting to the authority.

13.6 REFENCES

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2. Department of Statistics Malaysia

CHAPTER 14

OUT OF HOSPITAL TRAUMA TRIAGE

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Able to describe triage criteria at our of hospital / field.
2. Able to describe triage criteria at hospital / emergency and trauma department.

14.0 INTRODUCTION

The word "Triage" is a French word meaning "to sort". Triage is the act of sorting patients according to their need for emergency treatment and evacuation.

14.1 OUT OF HOSPITAL

Trauma management can involve either a single trauma patient or multiple patients in a mass casualty incident/disaster. Management of these two groups of patients poses different challenges.

Triage utilizes clinical and physiological criteria to sort patients according to the severity of injury. Priority of treatment is given to patients who are in need of emergent medical attention and intervention. Triage is a dynamic process and patients should be reassessed frequently.

In hospital/emergency and trauma department triage, patients are triaged to a different zone in the emergency and trauma department, such as critical, semi-critical or non-critical zone, based on the severity and the urgency of care needed for the patient.

14.1.1 'Out of Hospital' trauma bypass:

The aim of 'Out of Hospital' triage is to reduce preventable death, permanent disability and to improve patient outcome by matching the needs of the injured patient to an appropriate level of care in a safe and timely manner. The out hospital care team and the receiving hospital should be well coordinated for a seamless and efficient trauma care process.

In the presence of a well-established trauma system, 'Out of Hospital' trauma bypass is commonly practiced. Such a system will benefit trauma victims who fulfill pre-set injury criteria to be swiftly transported to the hospital capable of managing the specific injury pattern of the victim. In the 'Out of Hospital' triage, patients are triaged at the field to predict the level of care needed for the patient and hence to determine the most appropriate transport destination for the patient. The patient should be transported to the nearest most appropriate hospital as opposed to simply the nearest hospital. This is known as the prehospital **trauma bypass**, i.e. isolated severe head injury patients with no immediate life threatening injuries will be transported to the nearest trauma center capable of providing definitive care as opposed to the nearest hospital.

This system is crucial, as the provision of effective trauma management is time critical. The availability of an 'Out of Hospital' trauma bypass system will enable the severely injured victim to receive appropriate medical care with minimal delay. Other than optimizing the recognition of major trauma patients, 'Out of Hospital' care triage aims to minimize over-triage of non-major trauma patients. This system would depend on the local setting of the healthcare facility availability and multidisciplinary involvement from the referring team to the accepting team.

The usual criteria utilized by many care systems for trauma bypass are based on 3 elements:

i. Injury pattern
ii. Mechanism of injury
iii. Vital signs

Other factors include patient factor, time and distance and the resources available at the destination facilities. There are many guidelines available globally, each developed to cater accordingly to the local system and healthcare landscape. The 'Out of Hospital' care team and the receiving medical facility need to follow the local guidelines or pre-existing protocols. However, at present, such as 'Out of Hospital' trauma bypass systems are not available widely in Malaysian 'Out of Hospital' care systems. This is due to logistics, resources and inter-facility integration inadequacies.

14.2 HOSPITAL / EMERGENCY & TRAUMA DEPARTMENT TRIAGE

A trauma patient will be triaged to the appropriate zone (red or critical, yellow or semi-critical, green or non-critical) in a healthcare facility.

Basic principle is to triage life threatening injuries to critical zone, limb-threatening injuries to semi critical injuries and non-life and limb threatening injuries to non-critical zone. The triaging is dependent on the availability of the local resources and manpower. In Malaysia, triaging follows the guideline from Malaysian Triage Category *(Emergency Triage Policy, EMTS, Ministry of Health Malaysia)*.

The goal of triaging a trauma patient within the trauma system is to ensure safe transfer and to improve patient outcome by matching the needs of the injured patient to an appropriate level of care in a safe and timely manner.

Example for triaging of trauma patients:

CRITICAL (RED)	SEMI CRITICAL (YELLOW)	NON CRITICAL (GREEN)
• Major trauma in shock • Severe head injury • Exsanguinations limb injuries • Severe crush injuries to limbs • Burns >25% BSA regardless of depth or > 20% 3rd full thickness burns • Gunshot wounds to head, neck, trunk or abdomen or undetermined • Near drowning	• Moderate head injury • Fractures long bones of lower limbs • Open fractures of upper limbs • Spine injuries but hemodynamically stable • Eye injuries with loss or impaired vision • Dislocation of major joints • Limb amputation: total or near total • Burns 15-25% regardless of depth or 15% full thickness • Vascular injuries but hemodynamically stable • Severe pain : trauma pain score : 8 -10	• Minor trauma • Minimal burns

Table 14.1: Example of triage criteria for trauma patients (Adapted from Malaysian triage category)

14.3 OUT OF HOSPITAL CARE

It is essential to maintain accurate pre hospital care clinical documentation for the following reasons:

- Providing a reliable source of clinical information pertinent to the patient's care provided within the out of hospital phase.
- Reduces clinical risk and potential errors during the provision of subsequent in hospital care.
- Provides a source of reference and data for subsequent total quality improvement interventions as well as clinical audits.

Pre Hospital clinical care documentation may include the following :

- Patient's Identification
- Injury Mechanism
- Injury Pattern
- Vital Signs
- Triage Categorization
- Clinical interventions performed
- Attending personnel information
- Response time (including dispatch time, enroute time, time of arrival at scene, etc)
- Additional clinical information (refusal of treatment, death on scene, mass casualty incident etc.)

14.4 CHAPTER SUMMARY

1. Triage is the act of sorting patients according to their needs for emergency treatment and evacuation.This is to improve patient outcome by matching the needs of the injured patient to an appropriate level of care in a safe and timely manner.

2. Triaging for trauma patients is determined by their mechanism of injury, physiological status, pattern of injuries and patient factors.

3. In 'Out of Hospital' triage, the patient is transported to the nearest most appropriate facility as opposed to simply the nearest hospital; as per local guideline/protocol.

4. In the Emergency and Trauma Department, patients are triaged to the respective clinical zones, as outlined by the Malaysian Triage Category.

14.5 REFERENCES

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2. Emergency Medicine and Trauma Services Policy 2012, Ministry of Health, Malaysia. MOH/P/PAK.228.12(BP)
3. Victoria Trauma : Pre of hospital Triage Guideline
4. EMT Pre of hospital care; Chapter 9 : Documentation ; Jones and Bertlett Publisher. 2011

CHAPTER 15

TRANSFERRING THE INJURED

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Able to identify category of patients who require early transfer for definitive care
2. Able to provide initial stabilization before the transfer process
3. Able to identify steps to initiate the transfer process and to establish communication between the referring and receiving facilities

15.0 INTRODUCTION

After initial assessment and stabilization has been done, the next step is to prepare the patient transport for definitive care.

The major principle of trauma management which is to ***DO NO ADDITIONAL HARM***, is applicable to patient transfer.

The decision to transfer the patient to another facility depends on the victim's injuries and the local resources. If definitive care cannot be rendered at the local facility, the patient may need to be transferred to an appropriate hospital providing definitive care.

The treating doctor should have a good understanding of his own and his institution capabilities. Transferring personnel should be adequately skilled to administer the required treatment.

15.1 CRITERIA FOR TRANSFER

Once the need for transfer is recognized, arrangement should be expedited as the patient's outcome is directly related to the time from injury to the time of receiving definitive care.

15.1.1 Patient selection

Injuries exceeded the current hospital's capabilities to treat.

In terms of:

- Injuries sustained – eg: advanced surgical intervention required
- Physiology status – eg: patient in profound shock
- Special needs – eg: ventilation, ICU care, specialised paediatric care

15.1.2 Indication for transport

- Step-up care : patient send to another hospital which is able to provide the required specialised care
- Same level care : when there is a temporary lack of resources at the referring hospital
- Step-down care : for continuation, rehabilitation, convalescence, long-term, referral back after stabilisation
- Patient's or family's request or for logistic reason

15.1.3 Location to transfer

Nearest appropriate hospital which has the capability to:

- Attain definitive diagnosis by providing:
    - diagnostic Imaging such as Computed Tomography scans
    - diagnostic procedures such as echocardiography, angiography
- Treat the injuries
    - by providing damage control resuscitation and appropriate surgical intervention
- Provide appropriate support services such as:
    - Intensive care
    - Surgical theatre
    - Clinical specialised care

15.1.4 Timing for transportation

As soon as the life-threatening injuries have been addressed, the receiving centre has to be alerted. The reasons are:

- Patient's outcome is directly related to the time of injury until definitive care
- Unnecessary diagnostic test may delay patient's transfer
- Transporting combative and uncooperative patients with altered mental status is a high risk event. If sedation is required, airway protection prior to transfer should be considered.

15.2 TRANSFER RESPONSIBILITIES

15.2.1 Referring team

The referring team should inform the receiving team. They should determine the appropriate mode of transportation (air, land or water whichever available at their local setting) and level of care required for optimal management of the patient en route, after discussion with the receiving doctor.

15.2.2 Receiving team

The receiving team should be alerted with regards to the transfer of a trauma patient to their hospital. The doctor must make sure that the receiving hospital is alerted and ready to receive the patient. The patient should be admitted either to the Emergency and Trauma Department (ETD) or preferably to a ward, intensive care unit or surgical theatre to facilitate prompt management of the patient.

15.3 MODES OF TRANSPORTATION

An appropriate mode of transportation is important for patient transfer. The choice of transport is based on the availability of trained personnel, equipment and safety of the mode of transportation.

Special modes of transport such as air transport may require special instructions to address physiological barometric related conditions such as insertion of the tube thoracostomy for pneumothorax before transfer to avoid expansion of pneumothorax and to replace water in endotracheal tube's (ETT) pilot balloon to avoid expansion of the ETT cuff. The management should be discussed with the receiving centre prior to transfer.

15.4 TRANSFER PROTOCOL

There should be an existing transfer protocol between the receiving and the referral hospital to facilitate the process. This can ensure there is a mutual understanding between the roles of the personnel involved.

The following guidelines are suggested:

a. Referring team

The referring team should speak directly to the receiving team and provide the following information:

i. Identification of the patient
ii. A brief history of the incident, mechanism of injury and any pertinent pre-hospital data.
iii. Initial findings and patient's response to interventions or therapy administered.

b. Information to the transferring personnel

The transporting personnel should be informed regarding the patient's condition and special needs during transfer.

The information should include:

i. Airway maintenance / ventilation
ii. Fluid therapy / volume replacement
iii. Special procedures
iv. Resuscitation procedures and any changes that may occur en route.

Proper documentation of clinical findings, treatment given, and patient status must accompany the patient. If available, all relevant documents including basic investigation or imaging should be sent along with the patient to the receiving hospital.

15.5 STABILIZATION & TREATMENT BEFORE TRANSFER

Patients should be resuscitated and attempts should be made to stabilize their condition as optimum as possible without causing delay in transport. Stabilization does not mean complete normalization of hemodynamic status as it may not be achievable without definitive care. In such instances, optimize patients without delaying transfer, balancing the risk versus benefit.

Airway
- Insert an airway adjunct or endotracheal tube, if needed
- Provide suction to clear the airway
- Insert a gastric tube to reduce the risk of aspiration

Breathing
- Determine oxygen requirement and prepare adequate oxygen supply
- Provide mechanical ventilation when needed
- Insert tube thoracostomy if indicated

Circulation
- Control external bleeding
- Establish two large bore cannulas
- Restore blood volume losses with warm fluids or blood products and continue fluid replacement during transfer if needed (allow permissive hypotension if indicated after discussing with the team specialist)
- Continuous hemodynamic monitoring
- Monitor urine output

Disability

- Immobilize any head, neck, thoracic, and lumbar spine injuries if indicated
- Immobilize fractured limbs

Exposure and environment

- Prevent hypothermia
- Cover with blanket

15.6 MANAGEMENT DURING TRANSPORT

- Continuous support of cardio-respiratory system
- Continuous blood volume replacement
- Monitoring of vital signs
- Use of appropriate medication during the transfer
- Maintenance of accurate records during the transport

15.7 SUGGESTED TRANSFER CRITERIA

Category of injury	Specific injuries and others
Chest	• Cardiac injury • Requiring prolonged mechanical ventilation • Major chest wall injury or lung contusions • Widened mediastinum or suspected great vessel injury
Abdomen and Pelvis	• Open pelvic injury • Unstable pelvic ring disruption • Pelvic ring disruption with shock • Solid organ injury
Central nervous system	• Head injury -penetrating injury or depressed skull fracture -Open injury with or without CSF leak -GCS < 15 or has neurology deficit -Lateralizing signs • Spinal cord or major vertebral injury
Extremities	• Major crush injury • Ischemia • Traumatic amputation with potential for replantation • Complex articular surfaces • Severe open fractures
Multiple system injuries	• Major burns or burns with associated injuries • Multiple, proximal long bones fractures • Injury to two or more body regions • Head injury with face, chest, abdomen, or pelvic injury
Comorbid factor	• Age > 65 years old • Children ≤ 5 years old

Category of injury	Specific injuries and others
	• Cardiac or respiratory disease • Insulin dependent diabetes • Morbid obesity • Pregnancy • Immunosuppressed
Secondary deterioration	• Requires mechanical ventilation • Sepsis • Major tissue necrosis • Single or multiple organ system failure

15.8 SUMMARY

1. After initial assessment and stabilization has been done, it is crucial to prepare the patient transport for definitive care without delay.

2. The receiving team should facilitate and prepare the hospital to avoid delay in providing definitive care for the patient.

3. The transfer process should be done in a systematic manner according to the pre-existing agreement / transfer protocol.

15.9 REFERENCES

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OUT OF HOSPITAL NOTIFICATION & TRAUMA TEAM ACTIVATION

CHAPTER 16

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Understand the importance and benefit of prehospital notification and trauma team activation.
2. Describe the prehospital notification and trauma team activation criteria.
3. Comprehend the roles and responsibilities of trauma team members.
4. Understand the work process of prehospital notification and trauma team activation.

16.0 DEFINITION

Prehospital Notification

A process which entails the prehospital team alerting the receiving Emergency and Trauma Department (ETD) prior to arrival with a major trauma patient.

Trauma Team

A team of experienced clinicians designated with pre-identified roles to provide immediate care to the major trauma patient by a trauma team activation process upon or prior to the arrival of the patient at the ETD.

16.1 INTRODUCTION

Two key components of Malaysian Trauma Chain of Survival are namely prehospital notification and trauma team activation. These are critical elements within a matured trauma care system and play an important role in determining the journey and outcome of major trauma patients. Such systems have been well established for many years amongst developed countries.

Prehospital notification will provide adequate time for ETD to activate relevant team members, organize resuscitation bays, prepare essential equipment, enable horizontal task allocation and facilitate thought processing thus avoiding a potentially chaotic primary clinical response. It has been found that errors affecting various aspects of trauma resuscitation, including task performance, clinical judgment and communication are more likely to occur when patients arrive without prior notification. It is also associated with increased workload, poor compliance to personal protective equipment and delays the arrival of many trauma team members.

The best clinical outcomes of a primary trauma response can only be achieved if a prehospital notification is followed by activation of the trauma team in ETD. The aim of the trauma team is to provide immediate comprehensive trauma care for the major trauma patient with slightest impact on the care of non-trauma patients and hospital resources. Presence of trauma team will enable :

1. Rapid horizontal approach during resuscitation
2. Enhance inter-specialty team communication
3. Accelerate clinical decision making

Numerous studies have shown that it cuts down time to effective intervention, imaging and diagnosis, leading to significant reduction in morbidity and mortality. Implementation of such processes will result in successful delivery of optimum and timely critical interventions leading to improved patient outcome.

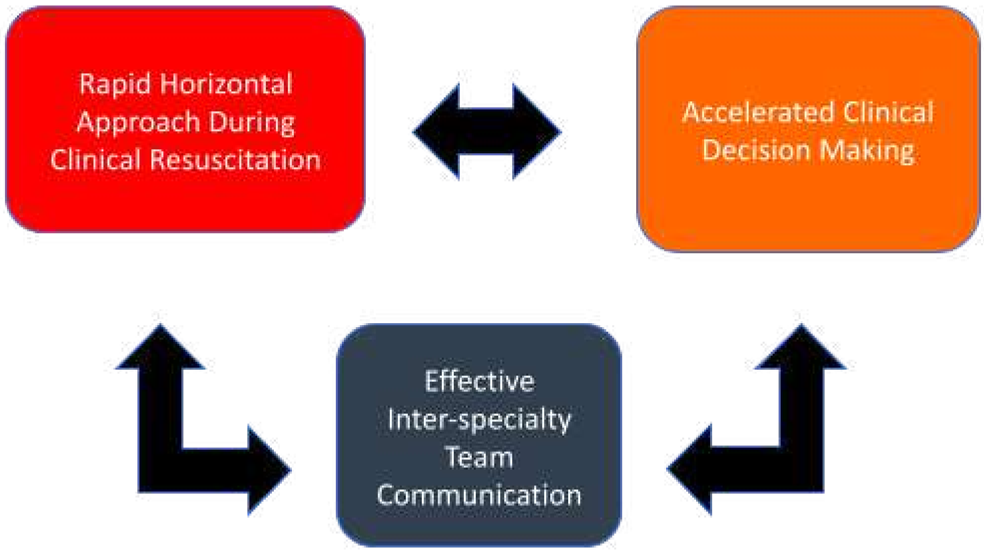

Figure 16.1: Factors Contributing to Trauma Team Activation Success

16.2 OUT OF HOSPITAL NOTIFICATION & TRAUMA TEAM ACTIVATION CRITERIA

A structured stepwise clinical assessment tool based upon physiological,anatomical criteria and mechanism of injury (refer table 16.1) may be used as a guide by:

1) Prehospital team at the scene to decide if a prehospital notification is required
2) ETD staff decides if a trauma team activation is required when a trauma patient arrives directly to ETD. (walk-in or arrival without prior notification)

PHYSIOLOGICAL CRITERIA	ANATOMICAL CRITERIA	MECHANISM OF INJURY
SPO_2 < 90%	Obvious exsanguinating external haemorrhage	Suspected fall > 3 meter
Respiratory rate <10 or >30 bpm	Flail chest or open chest wound	Prolonged extrication > 15 minutes
Systolic BP < 100 mmHg	Suspected unstable pelvic fracture	HIgh speed collision > 50 km/hour
Pulse Rate > 120/min	Hard signs of spinal cord injury	Fatality in the same vehicle
GCS ≤12	Positive FAST - if available	Ejection out of vehicle
Inappropriate behaviour post injury : too quiet or inconsolable (paediatrics)	Visible injury to > 1 body region (Head/ Neck/ Thorax / Abdomen/ Pelvis/ Long Bones)	Vehicle roll over
Abnormal vital signs not explained by other cause for example crying, pain responses (paediatrics)		Explosion

Table 16.1: Prehospital Notification and Trauma Team Activation Criteria

Presence of any **ONE** criteria will require a prehospital notification and/or trauma team activation. In certain cases, *"out of criteria"* trauma team activation can be performed by the Emergency Physician on duty.

16.3 TRAUMA TEAM ACTIVATION : TWO-TIER SYSTEM

A two-tier trauma team activation involves a tier-1 ETD team led by emergency physician, with capability to perform initial resuscitation and stabilization, with immediate access to tier-2 multispecialty team when required. The main advantage of this tiered response is that it reduces the impact of trauma calls on the non-ETD specialty staff, ensuring effective human resource management. Unnecessary activation of a multispecialty team will not only be a disadvantage to non-trauma patients who may have to wait longer to be seen by members of the trauma team, but it will also have a negative effect on morale and interdisciplinary collaboration. Furthermore, frequent over-activation will cause multispecialty team members to become desensitized and respond in a less urgent fashion during subsequent activation.

16.3.1 Tier-1 Trauma Team

The tier-1 trauma team comprises a pre-designated group of ETD staff from various categories . These members will be assigned to work in their respective ETD zones during their shift. They are only required to respond when there is a trauma team activation. The team may consist of a minimum set and a comprehensive set (Table 2). The minimum set are the team members that would comprise tier-1 team during any period of human resource inadequacies, i.e. after hours / public holidays etc. The comprehensive set is a complete team that would be most ideal. However, both sets will be able to manage trauma resuscitation with differences based upon distribution of duties and roles as described below:

Team Composition	Tier-1 Trauma Team (minimum set)	Tier-1 Trauma Team (comprehensive set)
MEMBER 1	Team Leader & Airway manager	Team Leader
MEMBER 2	Airway & Ventilation Assistant / Runner	Airway manager
MEMBER 3	Primary Survey	Airway & Ventilation Assistant / Runner 2
MEMBER 4	Circulation & Procedure 1	Primary Survey
MEMBER 5	Circulation & Procedure 2	Circulation & Procedure 1
MEMBER 6	Radiographer	Circulation & Procedure 2
MEMBER 7	-	Runner 1 / Scribe
MEMBER 8	-	Radiographer

Table 16.2 : Tier 1 Trauma Team Composition

16.3.2 Tier-2 Trauma Team

Tier-2 trauma teams are pre-designated members of the relevant trauma specialty teams (Table 3). These members will be selectively activated by case to case basis depending on the patient's injury pattern and clinical requirements. Their role is to assist resuscitation and facilitate subsequent disposition plans such as the requirement for surgery, interventional radiology, intensive care unit admission and identification of the primary team.

Anaesthesia	General Surgery
Orthopaedic	Neurosurgery
Vascular Surgery	Paediatric Surgery
Radiology / Interventional Radiology	Transfusion Medicine
Cardiothoracic Surgery	Maxillofacial Surgery
Plastics & Reconstructive Surgery	Otorhinolaryngology (ENT)
Obstetrics & Gynaecology	Other relevant specialties

Table 16.3 : Tier 2 Trauma Team Members

16.4 TRAUMA TEAM MEMBER ROLES & RESPONSIBILITIES

Understanding roles and responsibilities of each team member would contribute to optimizing efficiency through improvement in resource utilization, minimize human errors, reduce time wastage, improve communication, and reduce duplication.

ROLES	RESPONSIBILITIES
Team Leader	Ensure trauma call is appropriately activated Performs pre-arrival team briefing and role allocation Hands off and stand at the foot of the bed Takes overall control of the trauma resuscitation, makes critical decisions and prioritizes care Establishes closed loop communication between team members. Ensure safe, timely and thorough assessment of the trauma patient and all key personnel are aware of the task. Perform handover to appropriate specialist team for definitive care and ensure the role of team leader is formally handed over.
Airway Manager	Responsible for assessment and management of airway and ventilation. Ensures preparation for required airway management includes equipment and drugs. Ensures cervical spine immobilization at all time Communicates airway assessment to team leader
Airway and Ventilation Assistant	Assists doctor in preparing for airway intervention and its management Assists Circulation / Assist in other procedures after airway and ventilation management settled
Primary Survey	Undertakes the primary survey Communicates Vital Signs and relevant positive and negative findings to the trauma leader and scribe. Complete Secondary survey Request relevant investigations after discussion with the trauma leader. Ensure complete documentations: findings / drug prescription.
Circulation and Procedure 1	Prepare and responsible for IV/IO access and sampling Responsible for blood investigation and blood products prescription Responsible for drug prescription and administration Applies pelvic binder, cervical collar, tourniquet, chest compression, chest drain, CPR, e-FAST and other related procedures. Communicate the results of any POCT with the team leader. Ensure proper preparation for transfer.
Scribe/ Runner	Assembles all documentations pre-arrival of the patient, patient belongings and evidence packing.

ROLES	RESPONSIBILITIES
	Documents for trauma team members include arrival time and role allocation. Responsible for accurately recording timelines of events and interventions include drugs administration, physiology trends throughout the resuscitation process. Document salient findings from primary survey Document transfer time and location
Circulation and Procedure 2	Cuts and removes clothing Attaches monitoring equipment and temperature taking Communicate vital signs clearly to team leader and scribe Ensure identification band applied to patients. Assists procedure doctors for simple procedures – CPR, IV/IO cannulation, arterial or central line, NG insertion, urinary catheterization, external warming blanket set up and others. Assists with any required advanced procedures Assists administration of fluid boluses and drugs.
Runner	Directs trauma team members to the correct area. Ensure proper PPE is worn by all team members. Responsible for processing and organizing relevant blood tests to be relayed to labs as directed by the team leader. Responsible for obtaining Emergency O blood from the fridge as instructed. Responsible for collecting blood products from the blood bank as instructed by the team leader. Responsible for collecting any required kit from other area eg : OT / ICU
Radiographer	Performs primary trauma x-rays (chest and pelvis)

Table 16.4: Roles and Responsibility of Trauma Team Members

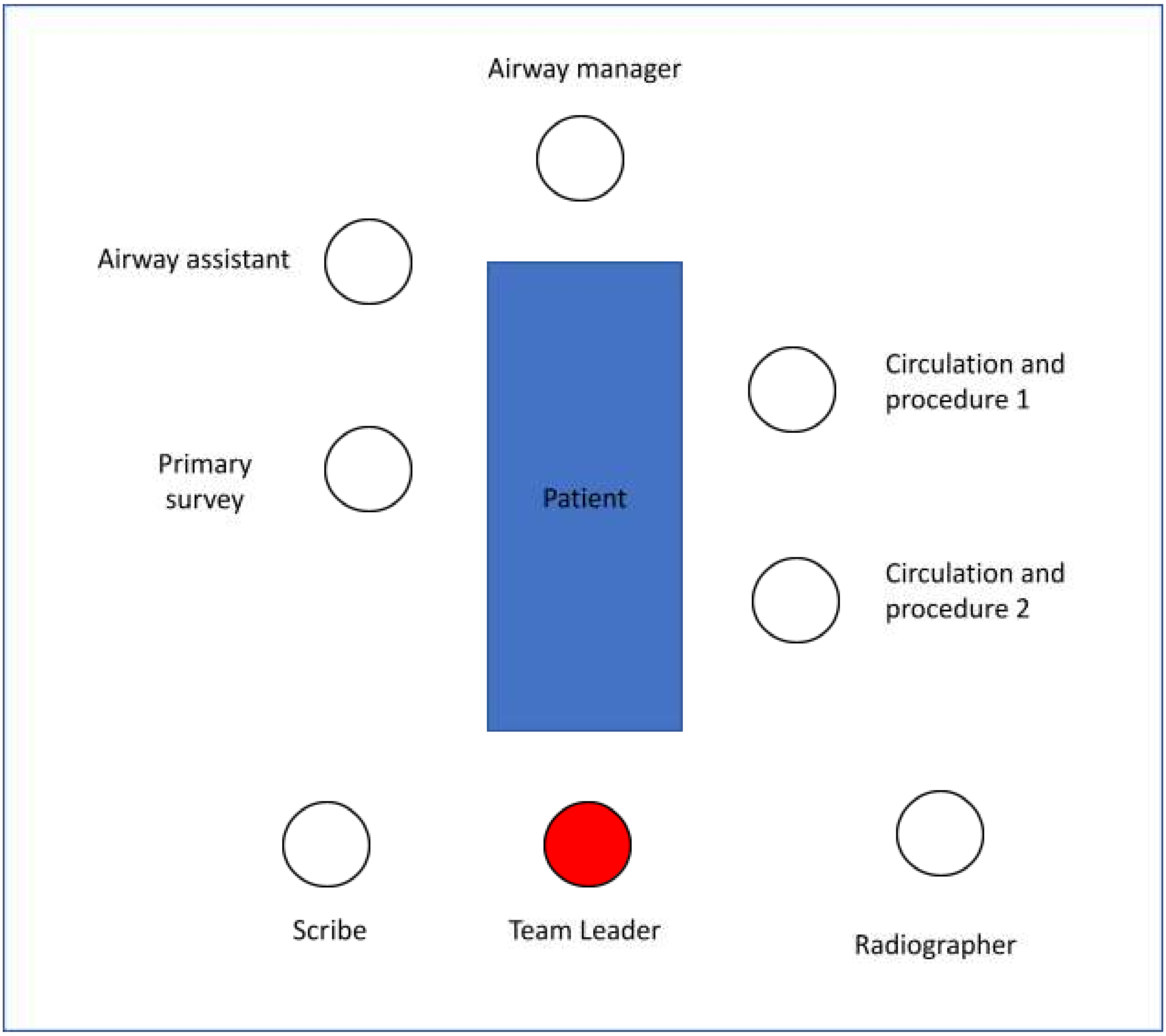

Figure 16.1: Trauma Team Member Roles

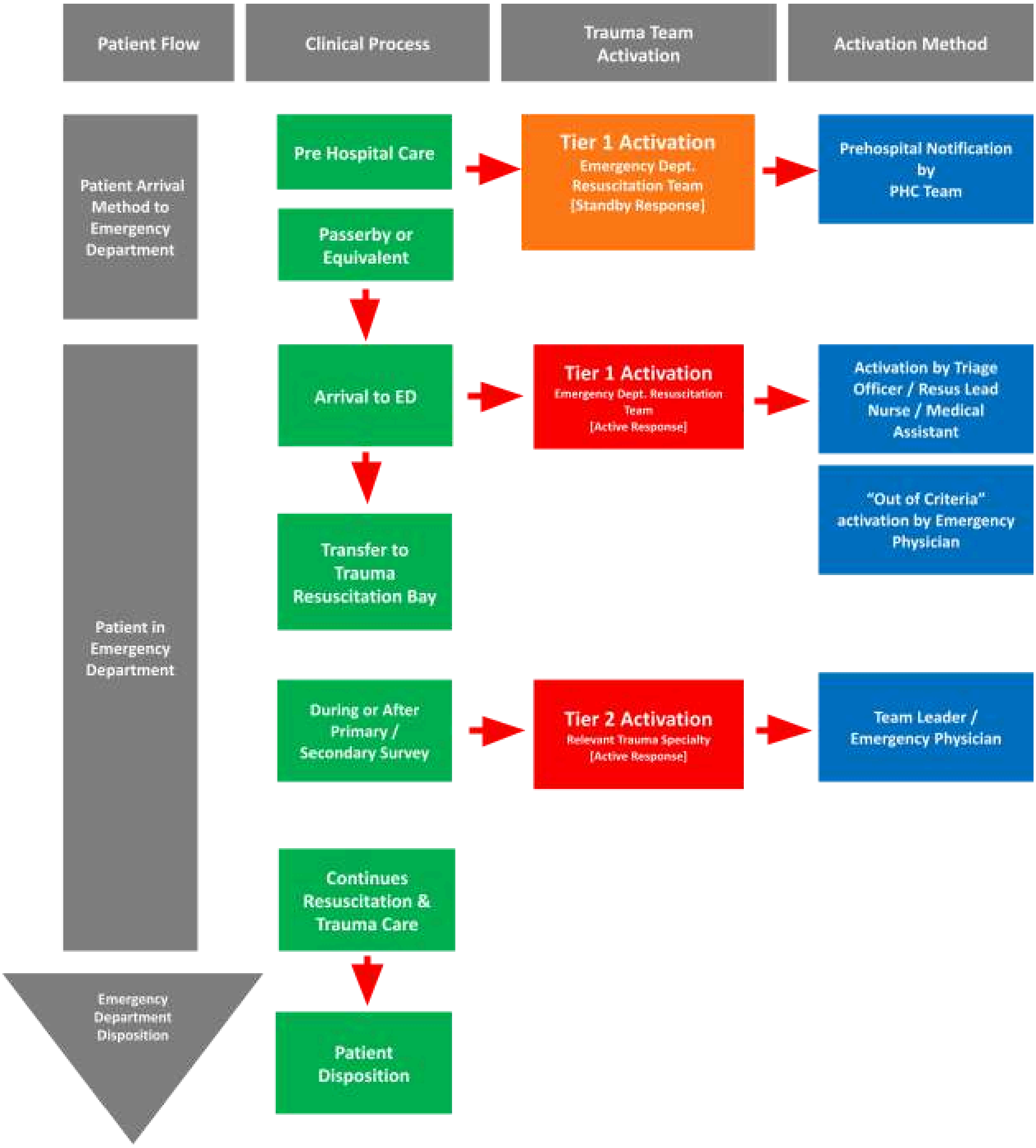

Figure 16.2: Relation of Trauma Patient's Flow and 2-Tier Trauma Team Activation System

16.5 SUMMARY

Prehospital notification and trauma team activation are two key components of the trauma chain of survival. These are critical elements within a matured trauma care system and play an important role in determining the journey and outcome of major trauma patients. It has been found to markedly reduce trauma related morbidity, mortality whilst improving resource utilization and efficacy of trauma care delivery. Thus understanding, implementing, and practicing such protocol is crucial to improve the outcome of major trauma patients in a local setting.

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CHAPTER 17

MASS CASUALTY INCIDENT MANAGEMENT

At the end of this chapter the candidates will be able to attain the following knowledge:

1. Able to define the term Mass Casualty Incident (MCI) and Disaster.
2. Able to describe the approach to disaster management and emergency preparedness including on scene management and hospital activation.

17.0 INTRODUCTION

Disaster emergency preparedness is divided into 2 phases:

- On scene management
- Hospital Activation

17.1 DEFINITION

DISASTER	• Disaster is an incident which occurs in a sudden manner, complex in nature and that causes losses of lives, damages to property or natural environment and brings disruption to local activities. • For operational purposes, a disaster can be defined as an event in which the emergency medical needs exceed immediately available resources.
MASS CASUALTY INCIDENT (MCI)	• Any incident in which emergency medical resources are overwhelmed by the numbers and severity of casualties.

Table 17.1 : Definition of Disaster and Mass Casualty Incident

17.2 DISASTER MANAGEMENT LEVEL

- **LEVEL I DISASTER**
  Local incident in which is manageable/controllable with no potential of spreading out. It is not complex and causes only a small scale damage to life and properties.
  The District Level Authority is capable of controlling/managing such incidents through district level agencies without or with limited external assistance.

- **LEVEL II DISASTER**
  The incident involves a wide area or exceeds two districts. The incident also affects local daily activities. More complex and difficult in aspect of search and rescue.
  State Level Authority involvement needed to control this level of disaster with or without limited external assistance.

- **LEVEL III DISASTER**
  The incident is more complex in nature, affecting a wide area or more than two states.
  Central Authority involvement handles with or without foreign help.

The classification relies on the district, state or central authority which will decide on its management or to suggest any other movement of taking over by another higher authority.

Figure 17.1: Disaster Management Tiers
(Adopted from National Security Council Directive No. 20 Policy and Mechanism of National Disaster Management and Relief)

17.3 ON SCENE MANAGEMENT

17.3.1 Command and Control

To ensure an effective and coordinated management of the disaster, two stages of order and control should be performed:

- **Control Post On Scene (*Pos Kawalan Tempat Kejadian-PKTK*)**
- **Disaster Operation Controlling Centre (*Pusat Kawalan Operasi Bencana -PKOB*)**

Control Post On Scene (PKTK)

- The authority or commander post will initially be given to the District Police Chief.
- The District Police Chief is entrusted to appoint members of the Royal Malaysian Police (PDRM) and other agencies to run the operation at the control post.
- A communication network should be laid out between PKTK and PKOB based on the level of incident.

The Commander of disaster operation at the scene is responsible to assess, control and coordinate all *Search and Rescue (SAR)* activities.

The Commander, together with the District Disaster Management and Relief Committee *(Jawatankuasa Pengurusan Bencana dan Bantuan Daerah, JPBBD)* would assess the disaster scene to determine the level of the disaster and ability of local agencies at District Level to handle it.

In instances where further assistance is needed, the State Disaster Management and Relief Committee (*Jawatankuasa Pengurusan Bencana dan Bantuan Negeri,* JPBBN) will be called for assistance and to manage the disaster.

17.3.2 Incident Command System

The Incident Command System (ICS) is a standardised hierarchical structure that allows a cooperative response by multiple agencies, both within and outside of government, to organise and coordinate response activities without compromising the decision-making authority of local command.

ICS could be used at the scene of incident and at the hospital phase (HICS)

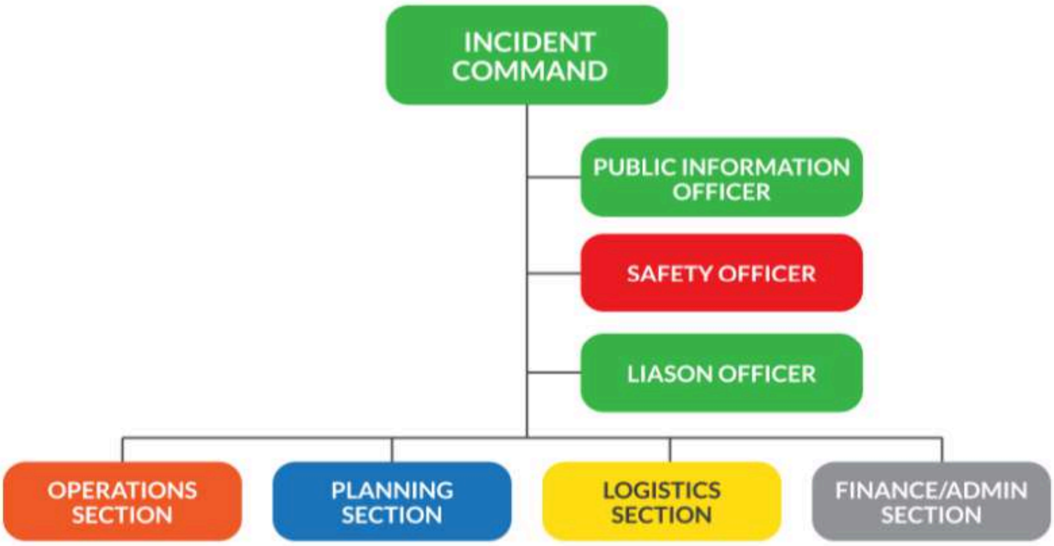

Figure 17.2: Incident Command System Hierarchy
(Adopted from National Security Council Directive No. 20 Policy and Mechanism of National Disaster Management and Relief)

INCIDENT COMMAND	• Responsible for developing, directing and maintaining communication and collaboration with the multiple agencies on site, and working with local officials, the public and the media to provide up-to-date information regarding the disaster. • Includes Incident Commander, Safety Officer, Liaison Officer and Public Information Officer.
OPERATIONS SECTION	• Handles tactical operations, coordinates the command objectives,organises and directs all resources to the disaster site.
PLANNING SECTION	• Provides the necessary information to the Command Centre and develops an action plan that will accomplish the objectives. • Collect and evaluate information as it is made available.
LOGISTICS SECTION	• Provides personnel, equipment, and support for the Command Centre. • Handles the coordination of all services involved in the response, including procurement of rescue equipment and coordination of rescue response for volunteering organisations.
FINANCE/ADMIN SECTION	• Responsible for accounting of funds during the response and recovery of the disaster. • Other responsibility includes issues regarding licensure requirements, regulatory compliance and financial accounting.

Table 17.2 : Roles of Command Section in Incident Command System
(Adopted from National Security Council Directive No. 20 Policy and Mechanism of National Disaster Management and Relief)

17.3.3 On Scene Management Based on Zone

On scene management and control of a disaster has to be systematic and structured. The scene of the incident will be divided into 3 zones: Red Zone, Yellow Zone and Green Zone.

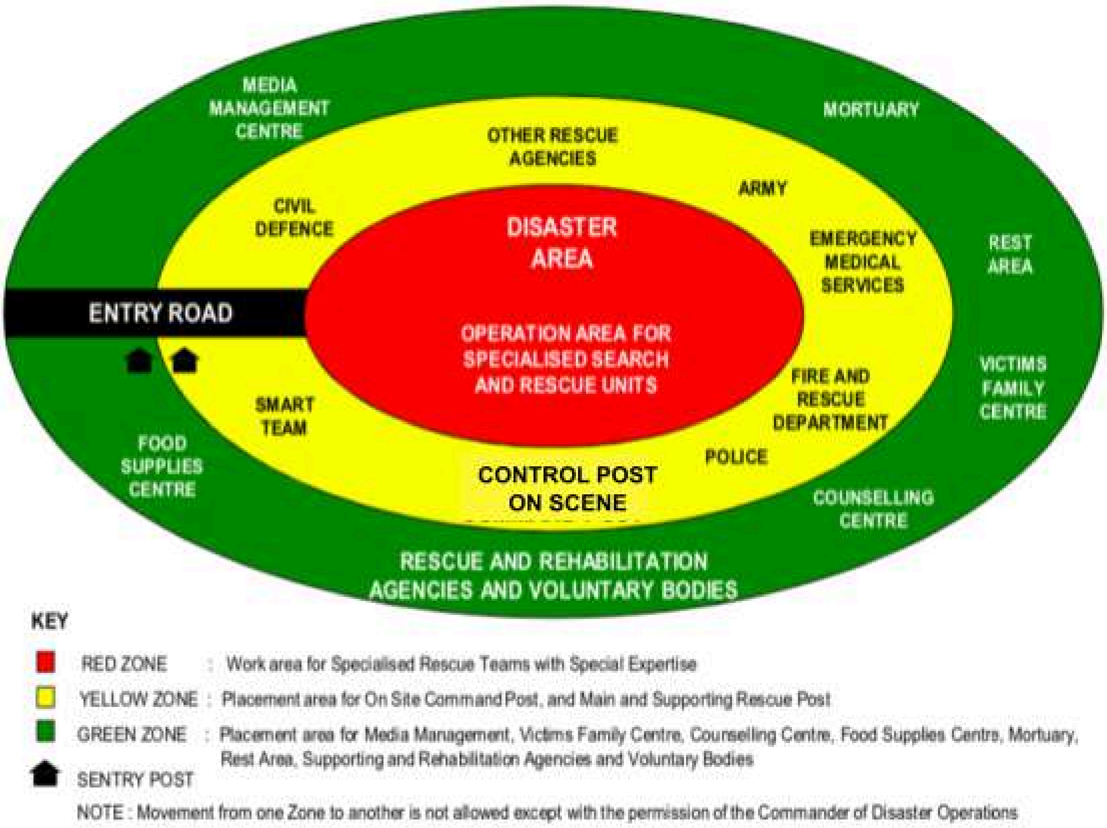

Figure 17.3: Zoning concept at the scene of incident
(Adopted from National Security Council Directive No. 20 Policy and Mechanism of National Disaster Management and Relief)

- **Red Zone**
  Covers an area surrounding the actual spot of incident.
  Entry to this zone is exclusively for the Search and Rescue (SAR) teams and special units from SMART, JBPM, ATM, including any special team formed by any agency.

- **Yellow Zone**
  Covers an area surrounding the Red Zone.
  This zone is the location for PKTK, **Medical Base** and any main rescue agencies, e.g. SMART, PDRM, JBPM, ATM.

- **Green Zone**
  Covers an area surrounding the Yellow Zone.
  This zone places the relief and recovery agencies including other voluntary bodies, e.g. RELA, PBSM, Media Management Centre, Victims Family Centre, Counselling Centre, Food Store and Morgue.

The distance between zones depends on the type and level of disaster and this will be decided by the On-Scene Commander.

Security and movement in all zones are controlled by PDRM and/or RELA, whereby only authorised personnel are allowed to move in and out.

MAIN RESCUE AGENCIES	SUPPORTING RESCUE AGENCIES	RELIEF AND RECOVERY AGENCIES
• SMART • PDRM • JBPM • ATM • Emergency Medicine and Trauma Service (EMTS) • Special force agencies with specialities	• Civil Defence Department • Special force formed for search and rescue	• Civil Defence Department • Social Welfare Department • Public Work Department (JKR) • RELA • Malaysian Red Crescent (BSMM) • St John Ambulance • Tenaga Nasional Berhad (TNB) • Telekom Malaysia (TM)

Table 17.3: List of Agencies Involved in Disaster Management
(Adopted from National Security Council Directive No. 20 Policy and Mechanism of National Disaster Management and Relief)

17.3.4 Role of Emergency Medicine and Trauma Services Team

- To provide emergency medical treatment during rescue operations alongside collaborations with other agencies.
- To provide ambulance, prehospital and hospital transport services.

17.3.5 Scene Management

5S	
SAFETY	Ensure scene safety *of the physician, staff and scene.*
SCENE SIZE-UP	**METHANE** **M** – Major incident declared? **E** – Exact location **T** – Types of incident **H** – Hazards (existing/potential presented or suspected) **A** – Access (routes that are safe to use and obstacles to avoid) **N** – Number of estimated casualties, types and severity of casualties **E** – Emergency services available and additional assistance required
SEND INFORMATION	**METHANE** information relayed to base/hospital
SET UP BASE	• Inform the on-scene Incident Commander (often the police) • Assign medical staffs with specific roles and duties • Send a liaison officer to the control post • Set up the medical base at the yellow zone area • Set up the triage system • Set up the decontamination area (if required) • Set up the drop zone
START/SALT TRIAGE	**Refer to triage algorithm**

Table 17.4: Scene Management and Major Incident Reporting Method – 5S
(Adopted from National Security Council Directive No. 20 Policy and Mechanism of National Disaster Management and Relief)

17.3.6 Medical Personnel Role

Ideal example of role and duties:

A. ON SCENE MEDICAL COMMANDER (OMC)

- Responsible for Coordination of all Medical Activities at the scene *of the incident*.

B. MEDICAL SEARCH AND RESCUE OFFICER (M.E.S.A.R.O)

- Coordinate Medical Rescue Service
- Liaise with Forward Field Commander
- Coordinate all rescue work

C. MEDICAL LIAISON OFFICER (M.E.L.O)

- Acts as the Liaison Officer between the OMC and the OSC
- Gather and relay information to all concerned

D. MEDICAL BASE COMMANDER (MBC)

- Responsible for the administrative management of activities at medical base station
- Communicates with Clinical Commander, Evacuation Officer, On-Site Medical Commander (OMC) and MECC Coordinating Hospital

E. CLINICAL COMMANDER (CC)

- A clinical specialist, preferably Emergency Physician
- Responsible for all clinical related activities, e.g. clinical management and disposition of casualties

F. MEDICAL TRIAGE COMMANDER

- Responsible for implementation of triage system at all points of contact
- All casualties must be continuously triaged at site, before and after transfer from point to point, ingress and egress points, before and during evacuation process
- Assisted by Medical Triage Officers (MTO)

G. MEDICAL TRIAGE OFFICER (MTO)

- Responsible to perform triage on every casualty using START/JUMPSTART system
- Ensure the continuous triage is performed on every casualty

H. RED TEAM LEADER

- Assist Clinical Commander at Medical Base Station
- In charge of Red Zone
- Responsible for all medical activities in Red Zone

I. YELLOW TEAM LEADER

- Assist Clinical Commander at Medical Base Station
- In charge of Yellow Zone
- Responsible for all medical activities in Yellow Zone

J. EVACUATION OFFICER (EO)

- Overall in charge of evacuation process of casualties
- Communicates with Clinical Commander and Transport Officer for ambulances
- Communicates with Base Medical Commander for needs of transportation

K. MEDICAL RESCUE PERSONNEL (MRP)

- Stretcher Bearers
- Assisting in all the specific section

L. TRANSCRIBER

- Responsible for the collective documentation of casualties
- Responsible for Victim tracking system

M. QUARTERMASTER

- Manage resources and logistic
- Organises food, refreshment and treatment of rescuers and victims

N. TRANSPORT OFFICER

- Vehicle management at Vehicle Staging Area
- Coordinate movement of vehicle

O. COMMUNICATION OFFICER

- Responsible for all communications

17.4 TRIAGE IN DISASTER

Mass casualty incidents triage systems are implemented to offer the greatest good to the greatest amount of people as healthcare resources are limited or strained due to the number of injured individuals.

The goal of the field triage process is to ensure that injured patients are transported to a trauma centre or hospital that is best equipped to manage their specific injuries, in an appropriate and timely manner, as the circumstances of injury might warrant.

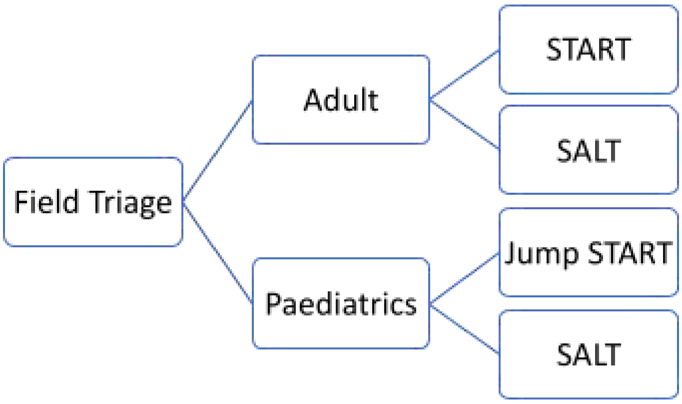

Figure 17.4: Triage used in adult and paediatric population

17.4.1 Start Triage (Simple Triage and Rapid Treatment)

Mnemonic: RPM (Respiration, Perfusion, Mental Status)

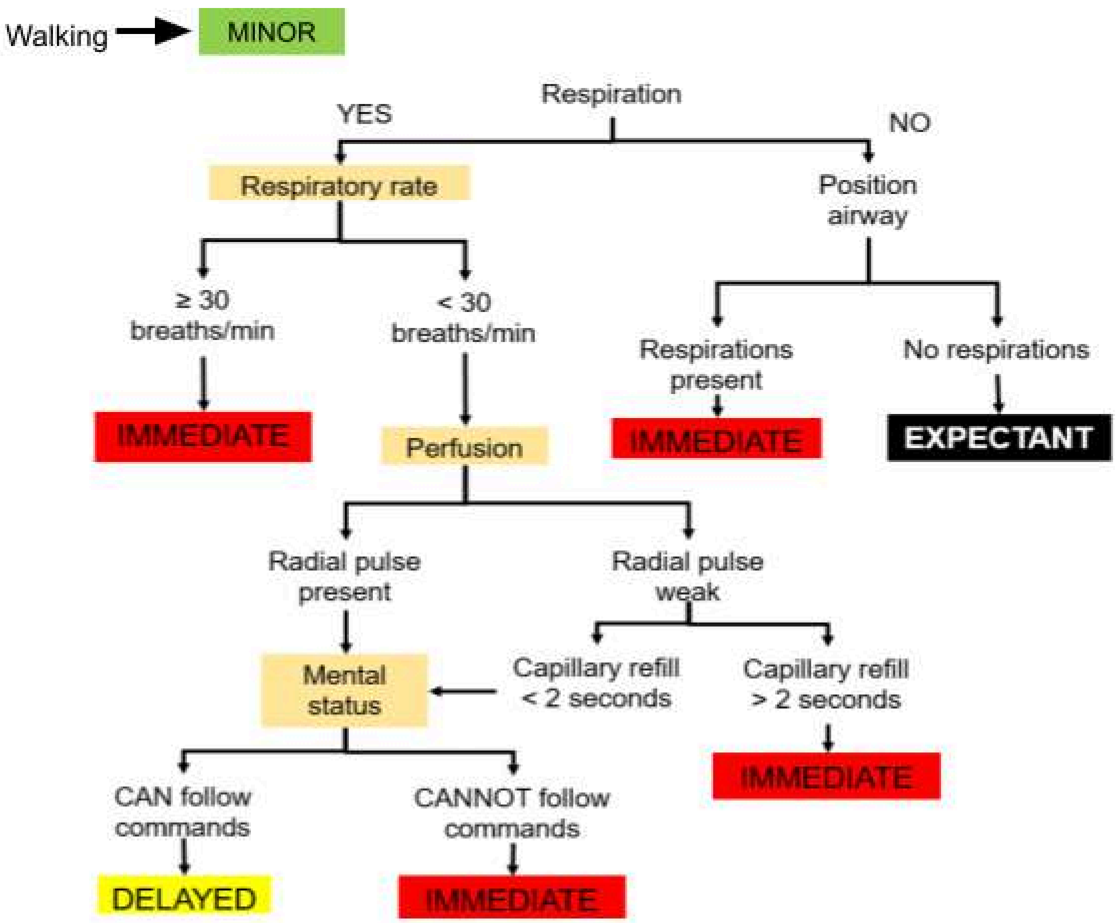

Figure 17.5: START Triage flow

17.4.2 SALT (Sort, Assess, Life-Saving Interventions, Treatment & Transport)

SALT Triage was developed as a national all-hazards mass casualty initial triage standard for all patients (e.g. adults, children and special populations) in the United States. It is more comprehensive and adds simple life-saving techniques to be done during the triage phase.

It is recommended by the Advanced Disaster Life Support (ADLS) for all disaster or mass casualty triage.

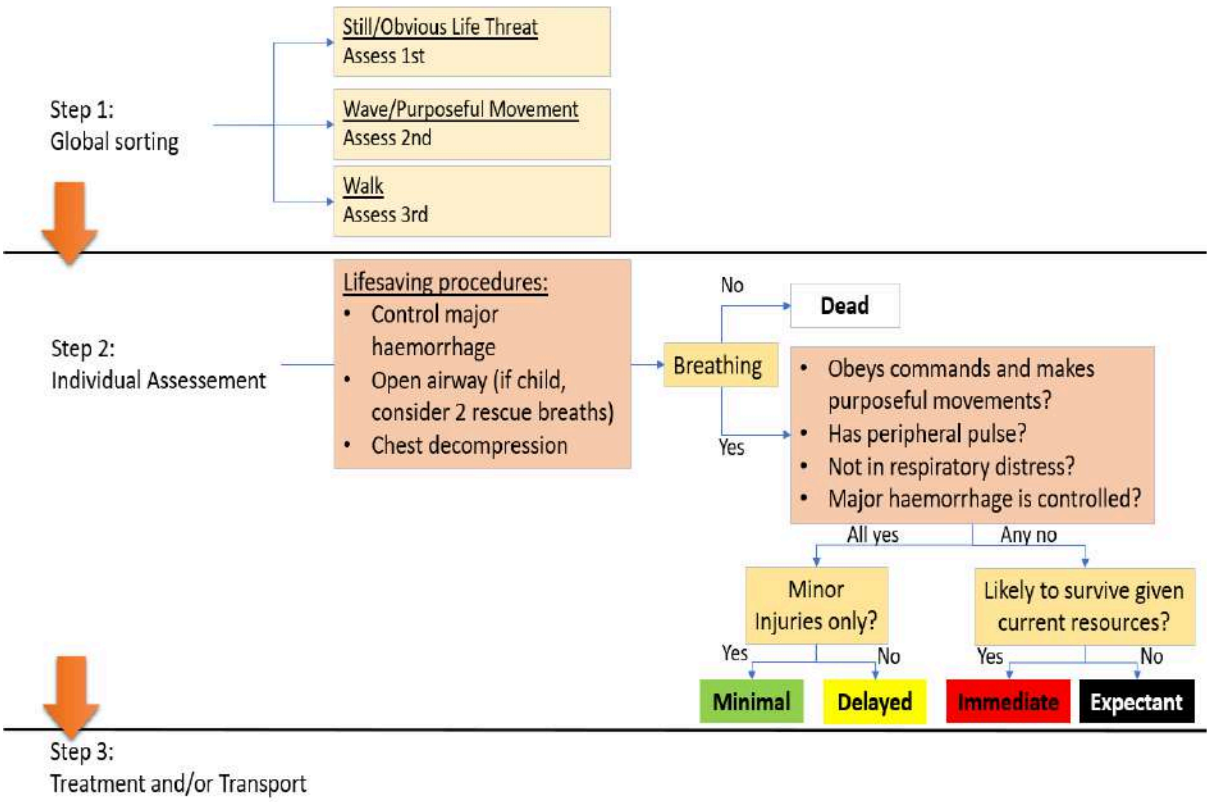

Figure 17.6: SALT Triage flow

17.4.3 JumpSTART

JumpSTART is a modification of the START system and takes into account the difference in “normal” respiratory rates for children. This tool acts to assess paediatric patients better. The age cut off for use is eight years old.

If the child’s age is unknown, the rescuer can assess underarm/ axillary hair in males or breast development in females as an indicator of adult age.

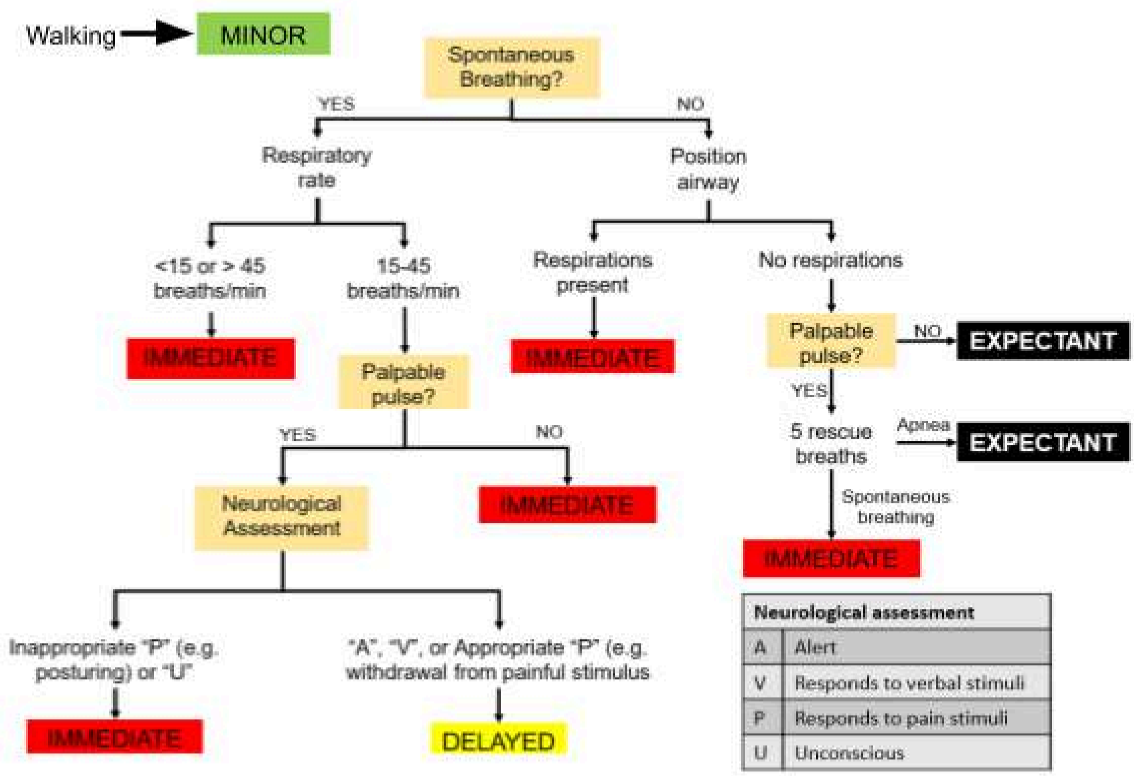

Figure 17.7: JumpSTART Triage Flow

17.4.5 Triage Tag

Mass casualty incident triaging systems use tags or colour destinations for categorising injured victims. You place the triage tag on each victim.

The person doing the initial START/ SALT triage does NOT fill out the tag. The actual filling out the tag happens in either the treatment area or in the ambulance, by the second stage personnel.

Figure 17.8: Triage Cards in Malaysian Emergency Medicine and Trauma Service
(Adopted from National Security Council Directive No. 20 Policy and Mechanism of National Disaster Management and Relief)

17.5 GENERAL

17.5.1 GENERAL ACTION PLAN AND EMERGENCY RESPONSE IN CIVIL EMERGENCIES

- The general emergency medical response to a major incident requires both administrative and clinical response.
- The pre-planned hospital incident command system (HCIS) should be implemented with assignment of duties to the hospital's key personnel
- The service is implemented at various phases:

  I. Hospital Activation Phase
  I. Emergency and Trauma Department / Hospital Response Phase
  II. Deployment of Hospital Support Services Phase
  III. Recovery Phase

17.5.2 HOSPITAL ACTIVATION PHASE

- During the hospital activation phase, a Standard Response format should be followed strictly. However, this should not affect the ongoing hospital service.
- Initial response – The activation of the Emergency Response Plan will be initiated once a call is made to the hospital informing about the incident.
- Once the information is received by the personnel from the call centre, the information will be analysed. All information as stated below must be documented:
    I. Identification of the caller
    II. Time of activation made
    III. Nature of incident
    IV. Exact location
    V. Time of incident
    VI. Estimation of number of casualties

- The hospital is put on **YELLOW ALERT** during which the Hospital Director and Head of Emergency Department are informed and put on alert.

- Once incidence is confirmed, a **RED ALERT** – Disaster Major Incident is declared. Further activation of the Hospital Alert System is carried out.

- If the situation is under control, or in the event of false alarm, a **STAND DOWN ALERT** order is declared.

17.5.3 EMERGENCY AND TRAUMA DEPARTMENT RESPONSE PHASE

- **Identify Key Personnel**
    - Activate key personnel as per local disaster/MCI plan. The personnel are mainly divided into administration, clinical or support duty.

- **Establishment of specific Zone/Centres**
    - Control Centre or 'Bilik Gerakan Bencana'
    - Centre for Families of Victims
    - Clinical Zones: ED/Designated Treatment Area
        - Patient Reception, Triage and Decontamination area
        - Resuscitation/ Critical Zone – The Trauma Team usually carries out the management of patients.
        - Semi-Critical Zone
        - Non-Critical Zone

- **Capacity**
  - **Surge capacity** is one of the most important components of hospital preparedness for responding to mass casualties or disasters.
  - Three key areas determine the ability of a facility in surge capacity:
    - **Space** – additional beds and flat-space areas should be identified. Are additional treatment areas needed? Is OR space needed? A reasonable goal may be to open 25% of a major hospital's critical care and operating room capacity while sizing up the situation.
    - **Staff** – how many and what type of staff needed may vary by incident. Many hospital staff will be called-in or volunteer to help with the incident. This personnel influx must be managed well as it can affect and obstruct the flow of patients.
    - **Supply** – Some resources must be cached and par levels increased, including central supply (IV fluids, chest tubes, PPE, etc) and pharmacy (analgesics, sedatives, antibiotics). Many of these items can be invaluable during a disaster and cannot easily be substituted for or obtained quickly.

17.5.4 DEPLOYMENT

- There will be deployment of other supportive personnel mainly:
  - Forensic Service – To handle dead casualties, identification of the bodies and temporary morgues service.
  - Mental Health Service – To provide counselling and support care to victims, relatives and later phase to all health personnel involved. (Psychological First Aid, PFA)

17.5.5 RECOVERY PHASE

- To support disaster affected communities through the restoration of emotional, social, and physical wellbeing.

17.6 SUMMARY

Disaster preparedness requires both the conviction that a disaster will occur, and the commitment to be ready when it happens. Emergency planning is vital to provide generic procedures for managing unforeseen impacts and should use carefully constructed scenarios to anticipate the needs that will be generated by foreseeable hazards when they strike. Hence, an emergency plan needs to be a living document that is periodically adapted to changing circumstances and provides a guide to the protocols, procedures, and division of responsibilities in disaster response and management.

Incident command system, regular effective disaster drills and tabletop exercises are the key to success of disaster response. The psychosocial issues that will arise must be recognized and dealt with to ensure adequate recovery of the individuals and community involved in the incident.

17.7 REFERENCES

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Trauma Life Support
Malaysia

Term of Reference

TLSM Training of Trainers
&
Provider Training Course

TLSM Training of Trainers Course (TLSM TOT)

Program Description

- The Trauma Life Support Malaysia Training of Trainers (TLSM TOT) Program is a Trainer and Facilitator certification course

- Trainers and facilitators will be trained to conduct the Trauma Life Support Malaysia Provider and TOT Course in a structured and standardized approach

- The Trainers would be responsible to conduct Trauma Life Support Provider & TOT training courses in the respective health care institutions / districts and state

- Facilitators will be responsible to assist the Trainers in organizing and conduct of the Trauma Life Support Provider & TOT training courses

Program duration

- The TLSM TOT course is a 3-Day training program (minimum standard) consisting of 1 day academic / skill station training and 2 days hands-on supervised practical training

- The 1-day academic and skill station training is conducted for Trainers and Facilitators to provide academic knowledge on teaching methodologies as well as skill station conduct & procedure training.

- The 2-day practical training consists of a supervised hands-on training session for participant Trainers and Facilitators in conducting a 2-day TLSM Provider course.

Program Schedule

- Please refer to Appendix 1 for The TLSM TOT program training schedule

- The TLSM TOT program schedule may be amended to best suit current requirements and specific objectives of the respective training course

- If any, amendments to the schedule will be proposed by the TLSM State Coordinator and requires endorsement by the Chairman of the Trauma Life Support Committee, National Committee on Resuscitation Training, MOH (NCORT, MOH)

TLSM TOT Participants

The participants of the TLSM TOT course consist of the following:

Clinical Specialist (Trained as TRAINER)

- All clinical specialist who has completed gazettement training under the Ministry of Health, Malaysia and possess a valid Annual Practicing Certificate (APC)

- All clinical specialist registered in the National Specialist Registry (NSR) of Malaysia and possess a valid Annual Practicing Certificate (APC)

Others (Trained as FACILITATOR)

- All staff nurses registered with the Malaysian Nursing Board (MNB) and possess a valid Annual Practicing Certificate (APC)

- All medical assistants registered with the Malaysian Medical Assistants Board and possess a valid Annual Practicing Certificate (APC)

- All non-specialist medical officers registered with the Malaysian Medical Council (MMC) and possess a valid Annual Practicing Certificate(APC)

TLSM TOT Course Trainers & Facilitators

- The Trainers for TLSM TOT will consist of Specialist who have been certified as TLSM Trainers by the Trauma Life Support Committee of the National Committee on Resuscitation Training, Ministry of Health Malaysia (NCORT MOH)

- The facilitators involved in the TLSM TOT training course will assist the Trainers in conducting the TLSM TOT training. The facilitators will consist of TLSM Facilitators who are certified by the Trauma Life Support Committee of the National Committee on Resuscitation Training, Ministry of Health Malaysia (NCORT MOH)

- The TLSM TOT program will be led by a Course Coordinator who is selected by the TLSM State Coordinator

- The TLSM TOT Course Coordinator will be a certified and experienced TLSM Trainer

Certification

- Trainer status will only be provided to clinical specialist who have successfully completed the TLSM TOT training program

- Facilitator status will be provided to non-clinical specialist participants who have successfully completed the TLSM TOT training program

- The assessment will be performed as a continuous evaluation process throughout the entire TLSM TOT training course based upon the participants professional conduct, dedication, aptitude, knowledge, ability to perform teaching and communication skills

- The assessment and decision of successful completion will be performed by the TLSM TOT Course Coordinator

- All certificates of certifications for Trainer and facilitators will be provided by the National Committee on Resuscitation training, Ministry of Health Malaysia (NCORT, MOH)

- All certifications will bear a unique serial number

Trainer & facilitator to Participant Ratio

- The minimum Trainer to participant ratio for the TLSM TOT training course is 1: 6 (1 trainer to 6 participants)

- The number of TLSM facilitators required / training course will be decided by the TLSM TOT course coordinator

Terms of Certification Renewal

- Certified Trainers are required to participate in the conduct of at least 1 (ONE)- TLSM provider or TLSM TOT Training course / calendar year

- Trainers who are unable to comply to the minimum requirements as above would be required to repeat the TLSM TOT training program in order to renew certification as Trainer

- The above does not apply for TLSM facilitators. TLSM facilitators are encouraged to participate in the conduct of at least 1- TLSM provider or TLSM TOT Training course / calendar year

Organizing Institution

- The TLSM TOT program can be organized / conducted by any wholly owned government health institution or medical related society approved by the Trauma Life Support Committee of NCORT MOH

- The conduct of the TLSM TOT training course will comply to the terms of reference as stated

Person in charge

- The person in charge (PIC) for the TLSM TOT training course will be the respective TLSM TOT Course Coordinator as selected by the State TLSM Coordinator

- All decisions by the TLSM TOT Course Coordinator pertaining to the conduct of the TLSM TOT course is considered as final

Quality Assurance Process

- The conduct of TLSM TOT training course will be subjected to random audit and review by The Trauma Life Support Committees, NCORT MOH

- Noncompliance to terms of training reference may subject to withdrawal of endorsement

- The conduct and training format of the TLSM TOT training course may be revised as necessary by the Trauma Life Support Committee, NCORT MOH in order to ensure continuous total quality improvement and clinical relevance

- Any such revision will be notified through all TLSM State Coordinators for further action and implementation

Stakeholders

- Trauma Life Support Committee, National Committee on Resuscitation Training, Ministry of Health Malaysia (NCORT, MOH)

- State Health Department

- The Malaysian Society for the Care of Trauma (MASCOT)

TLSM Provider Training and Certification Course (TLSM Provider)

Program Description

- The Trauma Life Support Malaysia provider course is a training and certification program for participants involved in the provision of trauma life support care for emergency victims of major trauma

- Participants will be trained in the standardized and structured approach of providing Trauma Life Support Care to adjunct and improve personal clinical competence

- Providers will be able to attain evidence-based knowledge and best clinical practices in improving the care of emergency trauma victims in the respective health care institutions / districts and state

Program duration

- The TLSM Provider training and certification course is a 2-Day training program consisting of academic lectures and practical hands-on skills training

- The TLSM Provider training and certification course can be conducted for a duration of > 2 days as decided by the respective TLSM Provider Course Coordinator and should not be conducted over a period of less than 2 days.

Program Schedule

- Please refer to Appendix 2 for the TLSM TOT program training schedule

- The TLSM TOT program schedule may be amended to best suit current requirements and specific objectives of the respective training course

- If any, amendments to the schedule will be proposed by the TLSM State Coordinator and requires endorsement by the Chairman of the Trauma Life Support Committee, National Committee on Resuscitation Training, MOH (NCORT, MOH)

TLSM Provider Course Participants

The participants to the TLSM Provider training and certification course consist of the following:

- All medical doctors who are registered with the Malaysian Medical Council and possess a valid Temporary (TPC) / Annual Practicing Certificate (APC)
- All staff nurses registered with the Malaysian Nursing Board (MNB) and possess a valid Annual Practicing Certificate (APC)

- All medical assistants registered with the Malaysian Medical Assistants Board and possess a valid Annual Practicing Certificate (APC)

- All Allied health professionals and students of medical related professions may attend the course as observers

- All foreign healthcare providers registered with their respective Medical or equivalent governing board and possess active annual practicing certificate or equivalent

TLSM Provider Course Trainers & Facilitators

- The Trainers for TLSM Provider training and certification course will only consist of Specialist who have been certified as TLSM Trainers by the Trauma Life Support Committee of the National Committee on Resuscitation Training, Ministry of Health Malaysia (NCORT MOH)

- The facilitators involved in the TLSM Provider training and certification course will assist the Trainers in conducting the TLSM Provider training. The facilitators will consist of TLSM Facilitators who are certified by the Trauma Life Support Committee of the National Committee on Resuscitation Training, Ministry of Health Malaysia (NCORT MOH)

- The TLSM Provider training and certification course will be led by a TLSM Provider Course Coordinator who is a TLSM Trainer certified by the Trauma Life Support Committee of the National Committee on Resuscitation Training, Ministry of Health Malaysia (NCORT MOH)

- The TLSM Provider Course Coordinator may include other (Non-TLSM certified trainers/facilitators) clinical specialists, medical officers, registered nurses and medical assistants to assist the TLSM Trainers & Facilitators to conduct and provide training during the TLSM Provider course. These personnel will be designated as Assistant Trainers and Assistant Facilitators respectively.

Certification

- The TLSM Provider status will only be provided to participants who have successfully completed the TLSM Provider training course.

- Participants are required to attend all lectures and skill stations as a prerequisite to obtain the certificate of attendance or be eligible for theory and clinical assessment.

- Successful completion of the TLSM Provider and certification course requires the participant to attain a PASS in BOTH the following assessment components:

  i) Theory assessment consisting of multiple-choice questions
  ii) Clinical assessment consisting of trauma moulage examination

- Participants who are not successful in attaining a PASS in EITHER or BOTH the above components will be issued with a *certificate of attendance* to the TLSM Provider training course.

- Participants who are successful in attaining a PASS in BOTH the above components will be awarded with a *certificate of successful completion* and endorsed as a certified TLSM Provider by the Trauma Life Support Committee, National Committee on Resuscitation Training, Ministry of Health Malaysia (NCORT, MOH)

- Participants who have PASS the Moulage examination and FAILED the theory examination may be provided with ONE opportunity to resit the affected component within 6 calendar months from the last day of the said course. Successful re-attempt at the said assessment component will evoke a PASS and the participant will be afforded with a *certificate of successful completion* dated on the day of the successful re-assessment

- The State Coordinator may choose to coordinate and conduct a dedicated Theory examination session for failed participants who are eligible for resit.

- The PASS mark threshold for assessments will be set equal for all categories of participants

- The TLSM Clinical assessment component (trauma moulage examination) will be conducted by a Certified TLSM Trainer

- The final assessment and decision of successful completion will be performed by the TLSM Provider Course Coordinator

- All certificates of attendance and successful completion will be provided by the National Committee on Resuscitation training, Ministry of Health Malaysia (NCORT, MOH)

- All certifications of *successful completion* will bear a unique serial number

Trainer & facilitator to Participant Ratio

- The minimum Trainer (Certified TLSM Trainer) to participant ratio for the TLSM Provider training course is 1: 6 (1 trainer to 6 participants)

- The number of TLSM facilitators (Certified TLSM Facilitators) required / training course will be decided by the TLSM Provider course coordinator

Terms of Certification Renewal

- The TLSM Provider certification is valid for 5 calendar years from the date of the issued certificate.

- Renewal of the TLSM Provider status can be done by undergoing either another TLSM Provider training course or by attending a TLSM Provider refresher course.

- Validity of TLSM Provider status after attending another TLSM Provider training and certification course is 5 years

- Validity of TLSM Provider status after attending a TLSM Provider refresher course is 3 years, subsequent to this the provider will be required to attend and pass a TLSM Provider training course for further renewal.

Organizing Institution

- The TLSM Provider training course can be organized / conducted by any wholly owned government health institution or medical related society approved by the Trauma Life Support Committee of NCORT MOH

- The conduct of the TLSM Provider training course will comply to the terms of reference as stated

Person in charge

- The person in charge (PIC) of the TLSM Provider training and certification course will be the respective TLSM Provider Course Coordinator

- All decisions by the TLSM Provider Course Coordinator pertaining to the conduct of the TLSM Provider training and certification course is considered as final

Quality Assurance Process

- The conduct of the TLSM Provider training and certification course will be subjected to random audit and review by The Trauma Life Support Committees, NCORT MOH.
- Noncompliance to terms of training reference may subject to withdrawal of endorsement
- The conduct and training format of the TLSM Provider training and certification course may be revised as necessary by the Trauma Life Support Committee, NCORT MOH in order to ensure continuous total quality improvement and clinical relevance
- Any such revision will be notified through all TLSM State Coordinators for further action and implementation.

Stakeholders

- Trauma Life Support Committee, National Committee on Resuscitation Training, Ministry of Health Malaysia (NCORT, MOH)
- State Health Department
- The Malaysian Society for the Care of Trauma (MASCOT)

DESIGNATION AND TERMS OR REFERENCES

TLSM NATIONAL COORDINATOR

The TLSM National Coordinator is the head of the TLSM Training program at the National level

He/She is responsible for all matters pertaining to the conduct of the training program

The TLSM National Coordinator will be the point of reference for resolving any matters requiring arbitrations and pertaining to training policies

The TLSM National Coordinator is answerable to the Chairman of the Trauma Life Support Committee, NCORT MOH and Chairman of the National Committee on Resuscitation Training, Ministry of Health Malaysia

TLSM STATE COORDINATOR

The TLSM State Coordinator is the head of the TLSM Training program at the State level

He/She is responsible for all matters pertaining to the conduct of the training program within the state.

The TLSM State Coordinator will be the point of reference for resolving any matters requiring arbitrations and pertaining to training policies

The TLSM State Coordinator is answerable to the National TLSM Training Coordinator

TLSM TOT / PROVIDER COURSE COORDINATOR

The TLSM TOT / PROVIDER Course Coordinator is the head of the TLSM TOT / TLSM PROVIDER Course respectively

He/She is responsible for all matters pertaining to the conduct of the said training course

The TLSM TOT / PROVIDER Course Coordinator will be the point of reference for any matters pertaining to the conduct and execution of the said training course

The TLSM TOT / PROVIDER Course Coordinator is answerable to the respective TLSM State Coordinator

Academic Reference Material

The TLSM TOT and TLSM Provider training course will utilize the following academic reference material :-

Trauma Life Support Malaysia Student Provider Manual

Developed by;

- Trauma Life Support Committee, NCORT MOH Malaysia &
- Malaysian Society for the Care of Trauma (MASCOT)

APPENDIX 1

TRAUMA LIFE SUPPORT TRAINING OF TRAINERS COURSE
(TLSM TOT COURSE)

Day-1 [Academia, Procedure Skills Enhancement, Station Preparation & Program Execution]

Time	Topics
0730 - 0800H	Registration and Breakfast
0800 - 0830H	Introduction to NCORT and Trauma Life Support -Malaysia (TLSM)
0830 - 0900H	Academic Pedagogy in Trauma Life Support Training
0900 - 0930H	Role of course Instructors, Instructor & Facilitator Database
0930 - 1000H	Station 1 : Surgical Airway
1000 - 1030H	Station 2: Intraosseous Access: Humerus & Tibia
1030 - 1100H	Tea Break
1100 - 1130H	Station 3 : Haemostatic Agents, Haemorrhage control
1130 - 1200H	Station 4 : Chest Tube Insertion, double mattress suturing and Mesenteric dressing
1200 - 1300H	Station 5 : Burns & Escharotomy
1300 - 1400H	Lunch Break
1400 - 1500H	Station 6 : Trauma Moulage
1500 - 1600H	Station 7 : Immobilization (Cervical Collar, Pelvic Binder, Back Sweep and Roll, Limb Splint)
1600 - 1700H	Station 8 : Theory and Practical (Moulage) Examination
1700 - 1730H	Results And Certificates
1730 - 1800H	Question & Answer Session
1800 - 1830H	Recap and Summary + Closing

Day-2 [TLSM TOT Practical Training @ Day-1 TLSM Provider & Certification Training Course]

Time	Topic
0730 – 0800H	Registration
0800 – 0810H	Introduction to the Course
0810 – 0830H	Early Management of Polytrauma
0830 – 0900H	Airway and Ventilation Management
0900 – 0930H	Management of Shock
0930 - 0950H	Tea Break
0950 – 1030H	Management of Trauma to the Abdomen and Pelvis

1030 – 1100H	Thoracic Trauma Management
1100 – 1130H	Spine Trauma Management
1130 – 1200H	Head Trauma Management
1200 – 1230H	Geriatric Trauma Management
1230 – 1300H	Trauma Moulage Demonstration
1300 – 1400H	Lunch Break
1400 – 1700H	Station A : Radiology Station B : Airway and Ventilation Station C : Immobilization 1 – Cervical collar, head immobilizer, Limb Splint Station D : Immobilization 2 – Pelvic binder, Back sweep, Tilt / Roll Station E : Burns TBSA Assessment & Escharotomy Station F : Trauma Moulage
1700 - 1730H	Question and answer
1730 – 1800H	Briefing

Day-3 [TLSM TOT Practical Training @ Day-2 TLSM Provider & Certification Training Course]

Time	Topic
0800 – 0830H	Triage, Stabilization and Transport of Trauma Patients
0830 – 0900H	Burn
0900 – 0930H	Obstetric Trauma Management
0930 – 1000H	Paediatric Trauma Management
1000 - 1030H	Trauma Moulage Demonstration
1030 – 1300H	Station A : Communication Station B : Surgical Airway Station C : Circulation, Intraosseous insertion, Haemorrhage control Station D : E-FAST & Pericardiocentesis Station E : Burns TBSA Assessment & Escharotomy Station F : Trauma Moulage
1300 – 1400H	Lunch Break
1400 – 1530H	Group A : Theory Examination Group B : Practical Examination (Trauma Moulage)
1530 – 1700H	Group A : Practical Examination (Trauma Moulage) Group B : Theory Examination
1700 – 1745H	Remedial Assessment
1745– 1800H	Course Summary & Feedback
1800 - 1830H	Closing

APPENDIX 2

TRAUMA LIFE SUPPORT PROVIDER TRAINING AND CERTIFICATION COURSE (TLSM PROVIDER COURSE)

Day-1 TLSM Provider & Certification Training Course]

Time	Topic
0730 – 0800H	Registration
0800 – 0810H	Introduction to the Course
0810 – 0830H	Early Management of Polytrauma
0830 – 0900H	Airway and Ventilation Management
0900 – 0930H	Management of Shock
0930 - 0950H	Tea Break
0950 – 1030H	Management of Trauma to the Abdomen and Pelvis
1030 – 1100H	Thoracic Trauma Management
1100 – 1130H	Spine Trauma Management
1130 – 1200H	Head Trauma Management
1200 – 1230H	Geriatric Trauma Management
1230 – 1300H	Trauma Moulage Demonstration
1300 – 1400H	Lunch Break
1400 – 1700H	Station A : Radiology Station B : Airway and Ventilation Station C : Immobilization 1 – Cervical collar, head immobilizer, Limb Splint Station D : Immobilization 2 – Pelvic binder, Back sweep, Tilt / Roll Station E : Burns TBSA Assessment & Escharotomy Station F : Trauma Moulage
1700 - 1730H	Question and answer
1730 – 1800H	Briefing

Day-2 [TLSM Provider & Certification Training Course]

Time	Topic
0800 – 0830H	Triage, Stabilization and Transport of Trauma Patients
0830 – 0900H	Burn
0900 – 0930H	Obstetric Trauma Management
0930 – 1000H	Paediatric Trauma Management
1000 - 1030H	Trauma Moulage Demonstration
1030 – 1300H	Station A : Communication Station B : Surgical Airway Station C : Circulation, Intraosseous insertion, Haemorrhage control Station D : E-FAST & Pericardiocentesis Station E : Burns TBSA Assessment & Escharotomy Station F : Trauma Moulage
1300 – 1400H	Lunch Break
1400 – 1530H	Group A : Theory Examination Group B : Practical Examination (Trauma Moulage)
1530 – 1700H	Group A : Practical Examination (Trauma Moulage) Group B : Theory Examination
1700 – 1745H	Remedial Assessment
1745– 1800H	Course Summary & Feedback
1800 - 1830H	Closing

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