MULTIDISCIPLINARY TRAINING IN

TRAUMA and EMERGENCY CARE (MTEC)

Basic Trauma Care

Developed by

All India Institute of Medical Sciences Bhopal

with assistance from

Department of Public Health and Family Welfare
Government of Madhya Pradesh

Multidisciplinary training in Emergency and Trauma Care (MTEC)

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A certificate course

developed and conducted by

All India Institute of Medical Sciences Bhopal

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TABLE OF CONTENTS

Foreword

Having completed my Masters in Surgery in 1980, I became a Surgical Registrar in an academic surgical department in Wales, UK. I became a full time surgical teacher in 1984 and started teaching – general surgery and systemic surgery. I have been a fond student of general surgical principles. We assiduously taught and learnt various types of wounds and their management. We were given didactic teaching on pre-operative assessment and post-operative care. There was hardly any concept of electronic monitoring of vital parameters and the science of critical care was not evolved. There were no specialist who called themselves as specialist in critical care. We did not understand the difference between acute care, critical care, long term acute care and long term critical care. Three decades ago the text book did not describe that critical care is a common science between all departments be it surgery, medicine, cardiology or nephrology. All of us compartmentalized our management of critically ill patients with hardly any concept that critical ill person required a common and perhaps an algorithmic management to support the vital functions of human body. That brain was to be sustained by an efficient circulatory system maintaining the body's pH and electrolytes and getting the body rid of its toxic products. There were no available gadgetry to measure the discrepancy between ventilation and perfusion. We were heavily dependent upon our clinical judgment and biochemical estimations done from time to time. The last two decades have turned a corner in clinical medical practice recognizing that be it major trauma, sepsis, post-operative care or metabolic derangement, the body required life sustainable efforts which were common to a diverse group of subjects with diverse systemic affection. This led to an evolution of a science of critical care and emergency medicine. Several types of paramedics were trained only later to understand that they all coalesce to do almost the same things. And thus was born the science of critical care and very rightly so a large number of courses and societies have come up in most countries internationally to take up this onerous task of creating human resource both of doctor and paramedics in the science of critical care and trauma and emergency medicine. It has somewhat diversified into acute trauma and life support care, critical care in intensive care units and critical care in cardiac, respiratory and kidney diseases. Critical care of pediatrics patients and neonates has also evolved as a new speciality in the past two decades. India was a bit slow initially to take up this emerging branch of medicine. One reason for this may have been a very high cost of the gadgetry and the invasive monitoring using gadgets like Swan Ganz Catheter in 1980s. New patho-physiologicalresearches in critically ill subjects, oscilloscope based non-invasive digital monitoring and discovery of new transducers led to a new genre gadgets and soon the science of critical care became a common science providing a common consultation and care to patients from various departments.

There was lot of teaching required in this area. More than teaching a large number of new motor skills were to be learnt by the providers. There were debates on algorithms. There were ABCD's, ABCCD's and CAB and there were debates as to how much?how to give? andhow much to give? There were disagreements, schools of thoughts and meetings and conglomerations to bring forth unified thinking. The last decade witnessed more unison in thinking bridging the gaps of semantics. Yet another gap that was witnessed that life support required frequent invasive procedures on seriously ill or injured. These procedures included access to peripheral and central vessels, cardio-pulmonary resuscitation (CPR), ventilatory support, clearing and creation of new artificial airway for example tracheostomy, removal of helmet and foreign bodies, caring for destabilized limb and torso, lifting and transport of injured or ill subjects in a critically ill situation. I learnt these as a boy scout and during my sojourn with St John's Ambulance Brigade and National Cadet Corps. The training was simple though very firmly taught me splinting the fractured limbs, use of triangular bandages, jugaad, and transport and evacuation. It led the classical teaching of "triage".

A yet another technology that has eminently bridged the gap in providing skilled manpower is availability of mannequins. These are tremendous innovations. Never in the science of medicine across its 40 odd practiced disciplines including coronary vessel stenting, there has been availability of simulation equipment.In the last decade systematic trainers have taken the responsibility of creating a human resource in some of the above skills. Interestingly this training has not only been given to but the trainers in critical care have been less partisan in training para-medicals and general public also. This has hoisted the flag of critical care medicine, the highest and just like computer science. It has evolved a common subject for all medical subjects. Critical care science in my opinion istruly a trans-disciplinary science with evolved principles of physiology, medicine, surgical skills, epidemiology, social psychology, primary prevention and tertiary care.

I was very keen to establish skills laboratories at the All India Institute of Medical Sciences Bhopal and we have proudly done so. Our faculty especially Dr JP Sharma and Dr Saurabh Saigal has taken the lead and conducted a large number of training programs. The program on ABG (Arterial Blood Gas) and Basic Mechanical Ventilation were all too popular. These programs were not simplya single shot show off but have become a feature and have been taken up as regular activity to create human resource in critical care. We have developed our own modules and have called these multidisciplinary training in trauma and emergency care (MTEC). The acronym MTEC was given to me by my mentor in Trauma and Emergency Medicine, Dr Vijay Gautam some three decades ago when he was a consultant in Accident & Emergency in a north London hospital. I visited him there and we conducted the first MTEC course at King George's Medical University (KGMU) Lucknow in 1996. The material we wrote for that workshop was never published and surely needed total re-writing in the light of new found knowledge of physiology in critical care. When I asked my faculty members at AIIMS Bhopal, they readily took up the challenge and here is a very well written text in front of you that I think is first attempt in India to create India specific algorithms and modules in our own hinglish. I am sure a some of you may frown upon us and say are we trying to show a mirror to ATLS, ACLS modules. But then the immunity of an author and a creator and the judgment of its reader will only determine the usefulness of this text. It may see the redundancy of the library shelves or it may soon be the essential referral module. We will soon translate in vernacular Hindi. Our writers - Dr Rajnish Joshi, Dr Vaibhav Ingle, Dr Sagar Khadanga, Dr Nirendra Rai, Dr Bhavna Dhingra, Dr Girish Bhatt, Dr Manal M Khan, Dr Vikas Jha, Dr Adesh Shrivastava, Dr Anshul Rai, Dr Sanjay Kumar, Dr JP Sharma and Dr Saurabh Saigal has worked round-the-clock to produce this high quality teaching & training module.

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Introduction

Trauma is the fourth leading cause of death in India and accounts for 8.5% of all deaths. India is the world's 10th most powerful country and ranks 3rd most rapidly growing economy. On a global scale injuries are responsible for 21.7% of global deaths and 31.1% of DALYs (disease adjusted life years).Injuries most commonly accrue from road traffic accidents, surface fall (mostly elderly) and fall from height (mostly children), burns, drowning, natural calamities (floods, earthquakes, landslides, tsunami and tornados), civilian and industrial accidents, sports, attempted suicide, civilian violence and combats of the armed forces. In India road traffic accidents are the leading cause of all the injuries. According to the World Health Organization (WHO), road traffic injuries are the sixth leading cause of death in India with a greater share of hospitalization, deaths, disabilities and socio-economic losses in the young and middle-aged population. Road traffic injuries also place a huge burden on the health sector in terms of acute care and rehabilitation.

During 2011, a total of 4,97,686 road accidents were reported by all States/UTs. The proportion of fatal accidents in the total road accidents has consistently increased since 2002 from 18.1% to 24.4% in 2011. The severity of road accidents measured in terms of persons killed per 100 accidents has also increased from 20.8 in 2002 to 28.6 in 2011. The state of Madhya Pradesh ranks third (10.3%) in overall list of road accidents in India and fourth in number of injuries (11%) as per data, published by Ministry of Road Transport & Highway 2012. Census of India published in 2011 reported 53 'million-plus' cities, of these 53 cities, 50 reported road accident data for 2012. These 50 cities accounted a share of 22.5 per cent in total road accidents in the country, 12.3 per cent in total persons killed in road accidents and 15.9 per cent in total persons injured. Among the 53 mega cities, the highest cases of road accidents were reported in Mumbai 24,592 which resulted in 4543 injuries and 471 deaths. The city of Bhopal ranks 7th in number of total road accidents (3623) and eighth in total persons injured.

India has lacked behind in providing infrastructure for high profile trauma care to its citizens. Apartfrom the trauma center at AIIMS Delhi, there is scarcity of dedicated and integrated apex trauma centers in India. Under Pradhan Mantri Swasthya Seva Yojna (PMSSY) - six new AIIMS have been established. AIIMS Bhopal being one of them is coming up with first of its kind Level-1 Trauma & Emergency Centre in Central India.

The first hour management i.e. golden hour management of these patients is of prime importance. Around 70% of the population of India resides in villages and small towns. Most of these patients during the first hour i.e. golden hour reach to their respective District Hospital which are not equipped with essential equipment's and manpower. As a result lots of these patients die before reaching the tertiary care hospital.The basic aim of AIIMS Bhopal is to fill in these gaps in trauma care systems and first step in this process is to train medical officers of Madhya Pradesh.The Basic Trauma Course will teach and train them in various aspects of trauma care from initial assessment, airway management, chest trauma, abdominal trauma, head injury, spine injuries, maxillofacial injuries and burn management. They will also be trained in various skills ranging from cervical collar placement, spine board placement, manual in line stabilization, log rolling, airway management, intubation and application of splints. Apart from this most importantly they will be taught about initial management of trauma patient i.e. Primary Survey in which each patient has to be approached in systematic way ie ABCDE way.

CHAPTER 1 BASIC TRAUMA LIFE SUPPORT

Definitions :

1. Injury:Acute exposure to physical agents such as mechanical energy, heat, electricity, chemicals and ionizing radiation interacting with the body in amounts or at rates that exceed the threshold of human tolerance. In some cases, injuries result from the sudden lack of essential agents such as oxygen or heat.

2. Trauma : An injury (as a wound) to living tissue caused by an extrinsic agent. As per definition we will be dealing in this manual variety of trauma ranging from head trauma, airway trauma, chest trauma, abdominal trauma, musculo skeltal trauma and trauma due to - burns, heat, electricity and ionizing radiation.

Basics steps in Trauma management

These are the basic steps which are to be followed in each and every case of trauma

A. Preparation

B. Initial survey and resuscitation

C. Secondary survey

D. Definitive care

A. Preparation:

1. Check oxygen : Availability of oxygen cylinders

2. Suction apparatus : check the functionality of the apparatus.

3. Airway equipment's are to be kept and checked like laryngoscopes, facemask, oropharyngeal airway, nasopharyngeal airway, Endo-tracheal tubes.

4. Intravenous cannula 16G, 18G, 20 G; warm intravenous fluids- including normal saline, ringer lactate and dextrose with normal saline.

5. Universal precautions to be taken like wearing caps, masks, gloves and gowns while handling the patients to protect against blood borne diseases like- Hepatitis, AIDS etc.

Prerequisites to primary survey : before initiating primary survey few prerequisites are to be followed

1. Assess consciousness; if consciousness is intact this means that his airway, breathing, circulation and sensorium are intact.

2. Apply oxygen and attach the monitors with monitoring of heart rate pulse blood pressure and saturation.

B. Initial survey and resuscitation

Primary survey is basically identification of life threatening injuries; these are injuries which are immediate danger to life. These are to be identified immediately and have to be corrected immediately. Dictum is to treat first that kills first. Immediate cause of death in a patient of trauma is hypoxia which followed by hypotension. The approach to the patient has to be done in a systematic way.

1. Airway maintenance with cervical spine protection

2. Breathing and ventilation

3. Circulation with bleeding control

4. Disability (neurological evaluation)

5. Exposure/Environmental control: Undress the patient completely, taking care of hypothermia.

6. Adjuvants during primary resuscitation

1) Airway maintenance with cervical spine protection:

Prior handling of the airway the cervical spine protection is a must. Cervical collar has to be applied. In airway management following steps

Figure1 : Jaw-Thrust

Figure 2: Proper length of Naso-pharyngeal Airway

Figure 3: Proper holding of Mask; C & E technique

Figure 4: Proper holding of Bag and Mask Ventilation

Figure 5: Manual in line Stabilisation (MILS)

are to be followed.

i. Suction the airway.

ii. Chin lift, jaw thrust manoeuvres are to be applied. Head tilt to be avoided in trauma patients.(Fig 1)

iii. Insert appropriate size oropharyngeal airway, avoid nasopharyngeal airway.(Figure 2)

iv. Check for Bag and Mask Ventilation- Proper mask holding with C&E technique.(Figure 3 & 4)

v. Definite airway: Is defined as tube [Endotracheal tube / Tracheostomy tube] in the trachea with inflated cuff below the vocal cords, the tube connected to some form of oxygen enriched device & airway secured with a tape.

vi. At time of intubation manual in line stabilisation is a must.(Figure 5)

2) **Breathing with ventilation** Six life threatening injuries in the chest and mediastianum are to be identified and treated immediately. Following steps are to be followed at the time of examination of the chest.

- **Inspection :** Look for neck veins whether they are distended or collapsed, injury marks- lacerations etc.
- **Auscultation :** Hear for breath sounds
- **Percussion :** Dull note in case of fluid and Resonant note in case of air.

There are six immediate life threatening injuries which impair ventilation:

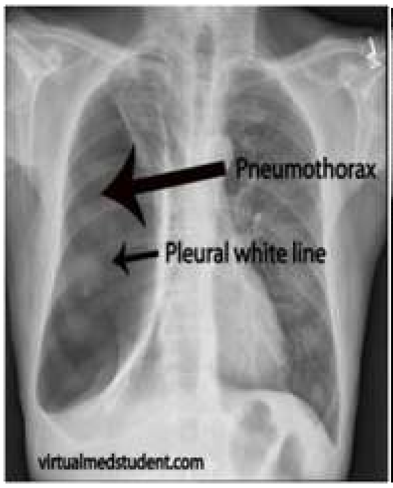
1. Open pneumothorax
2. Tension pneumothorax.
3. Flail chest with pulmonary contusion
4. Massive hemothorax.
5. Cardiac Tamponade
6. Laryngotracheal injuries

i. **Open pneumothorax :** Open pneumothorax is characterized by open wound in chest wall. The open wound in chest wall leads to an open defect through which air enters into the pleural cavity and creates a pneumothorax. The management is three sided occlusive dressing of the defect, this creates a one way valve mechanism which in turn prevents air entry in inspiration through that defect but during expiration a positive pressure is created which in turn leads to escape of gases through that defect. Definite management is chest tube insertion in 4th - 5th Intercostal Space just anterior to Mid-Axillary Line thereafter closing the defect.

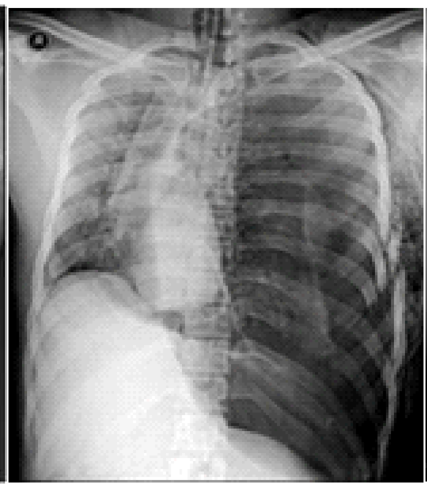
ii. **Tension pneumothorax:** As the word suggests tension, this tension is created in thorax. Air enters the pleural cavity which in turns creates so much pressure that mediastinum is pushed to opposite side with compression of heart and lung to opposite side. A creation of positive pressure hampers venous return which in turn leads to low cardiac output. Immediate treatment is needle decompression in second intercostal space in mid clavicular line.

iii. **Flail chest :** A flail chest occurs when a segment of the chest wall does not have bony continuity with the rest of the thoracic cage. This condition usually results from trauma associated with multiple rib fractures— that is, two or more adjacent ribs fractured at two or more sites. The presence of a flail chest segment results in disruption of normal chest wall movement. The definitive treatment is to ensure adequate oxygenation, administer fluids judiciously and provide analgesia to improve ventilation. The analgesia latter can be achieved with intravenous narcotics or local anesthetic administration. The use of local anesthetics avoids the potential respiratory depression which is common with systemic narcotics. The options for administration of local anesthetics include intermittent intercostal nerve block(s), intrapleural, extrapleural, or epidural anesthesia. When used properly, local anesthetic agents can provide excellent analgesia and prevent the need for intubation.

iv. **Massive hemothorax :** Accumulation of blood and fluid in a hemi-thorax can significantly compromise respiratory efforts by compressing the lung and preventing adequate ventilation. Such massive acute accumulations of blood more dramatically present as hypotension and shock. In patients with massive hemothorax, the neck veins may be flat as a result of severe hypovolemia, or they may be distended if there is an associated tension pneumothorax. Massive hemothorax is initially managed by the simultaneous restoration of blood volume and decompression of the chest cavity. Large-caliber intravenous lines and a rapid crystalloid infusion are begun, and type-

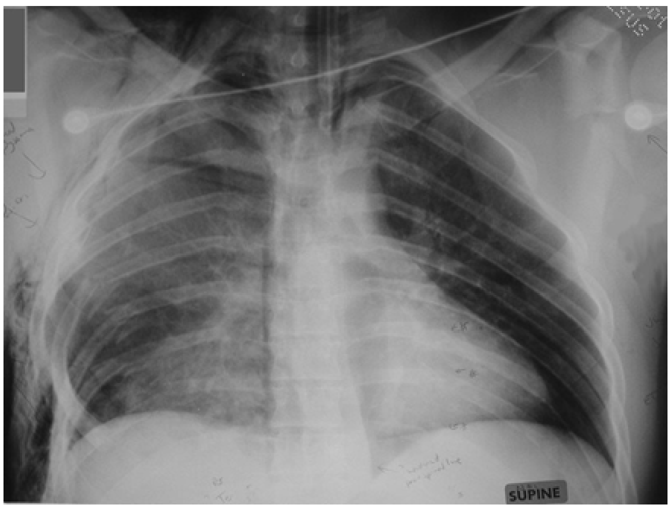


Open Pneumothorax



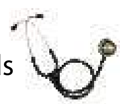
Tension pneumothorax

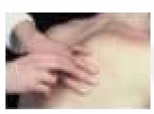
Massive Hemothorax



Flail chest with pulmonary contusion

Cardiac Tamponade

Breath sounds 

Absent/Diminished → Percussion 

Percussion → Dull note → Massive Hemothorax, Flail chest with pulmonary contusion

Percussion → Hyper-resonant note → Open Pneumothorax, Tension pneumothorax

Present-Diminished Heart sounds → Cardiac Tamponade

Figure 6: Identifying Six Life Threatening Injuries including laryngo-tracheal injury

specific blood is administered as soon as possible. A single chest tube (36 or 40 French) is inserted, usually at the nipple level, just anterior to the mid-axillary line, and rapid restoration of volume continues as decompression of the chest cavity is completed. If 1500 mL of fluid is immediately evacuated, early thoracotomy is almost always required. Patients who have an initial output of less than 1500 mL of fluid, but continue to bleed, may also require thoracotomy. This decision is not based solely on the rate of continuing blood loss (200 mL/hr for 2 to 4 hours), but also on the patient's physiologic status. Thoracotomy is not indicated unless a surgeon, qualified by training and experience, is present.

v. **Cardiac tamponade :** Cardiac tamponade most commonly results from penetrating injuries. However, blunt injury also can cause the pericardium to fill with blood from the heart, great vessels, or pericardial vessels. The human pericardial sac is a fixed fibrous structure; a relatively small amount of blood can restrict cardiac activity and interfere with cardiac filling. Cardiac tamponade may develop slowly, allowing for a less urgent evaluation, or may occur rapidly, requiring rapid diagnosis and treatment. The diagnosis of cardiac tamponade can be difficult in the setting of a busy trauma or emergency room. Cardiac tamponade is indicated by the presence of the classic diagnostic Beck's triad: venous pressure elevation, decline in arterial pressure, and muffled heart tones. However, muffled heart tones are difficult to assess in the noisy exam area, and distended neck veins may be absent due to hypovolemia.

FAST is a rapid and accurate method of imaging the heart and pericardium. It is 90–95% accurate for the presence of pericardial fluid for the experienced operator. Prompt diagnosis and evacuation of pericardial blood is indicated for patients who do not respond to the usual measures of resuscitation for hemorrhagic shock and in whom cardiac tamponade is suspected.

The diagnosis can usually be made with the FAST exam. If a qualified surgeon is present, surgery should be performed to relieve the tamponade. This is best performed in the operating room if the patient's condition allows. **If surgical intervention is not possible, Pericardiocentesis can be diagnostic as well as therapeutic, but it is not definitive treatment for cardiac tamponade.**

vi. **Laryngotracheal injuries**

This is rare, is characterised by persistent pneumothorax. Treatment of choices surgical repair of the rent.

3) Circulation with bleeding control

Main role is stoppage of bleeding along with replacement with warm intravenous fluids. We should not solely rely on blood pressure. Cool extremities and tachycardia are the earliest signs of impaired hypo perfusion (Figure 7). If there is blood on floor we should look for four more sites i.e. Chest, Abdomen, Pelvis & Extremities. If patient with trauma is hypotensive then cause is usually these four sites as mentioned above (Figure 8). On the other hand if head injury is present, it leads to intracranial bleed. The intracranial bleed if present will lead to raised ICP which in turn will lead to raised BP to maintain cerebral perfusion pressure.

a) **Chest :** Massive hemothorax leads to accumulation of blood in pleural space. This in turn leads to hypotension. Immediate treatment is rapid infusion of crystalloids followed by blood. The treatment of choice is wide bore chest tube insertion preferably 32-34 Fr in 4-5th ICS just anterior to Mid-Axillary Line.

b) **Abdomen :** Focused Assessment Sonography for Trauma is essential in patients with abdominal trauma. In Fast we have to look for fluid in four abdominal cavities i.e. Hepato-renal, Spleeno-renal, Pelvis and Pericardial spaces. If fluid is present in any of the four cavities then surgeon has to be called immediately.

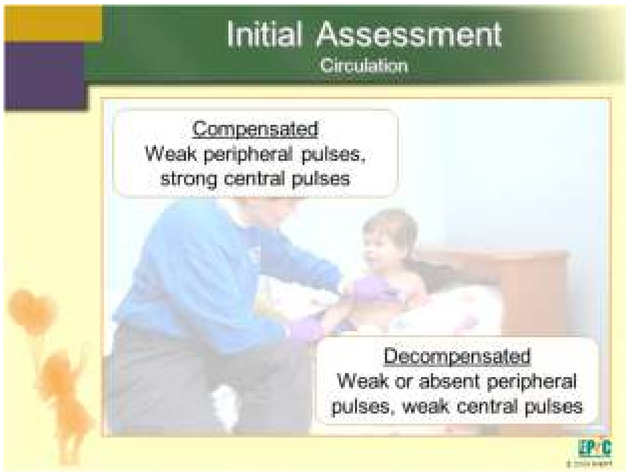


Figure 7 : Assessment of circulation

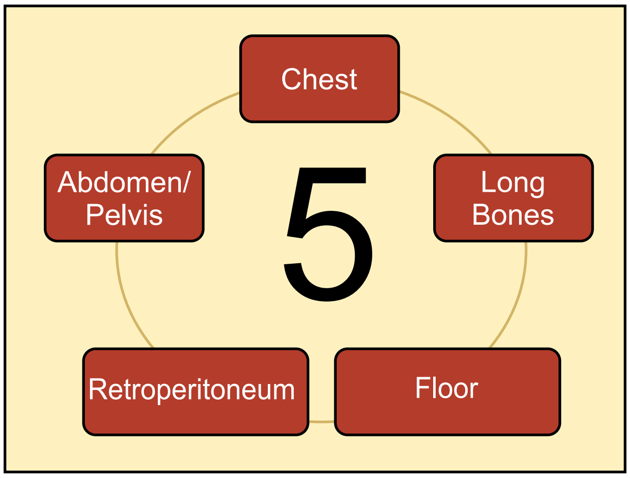


Figure 8 : Potential sites of bleed in case of trauma

c) **Pelvis :** Pelvic binder to be applied if pelvic binder not available then a simple bed sheet can be wrapped tightly around pelvis

d) **Extremity :** Immobilization and splinting is key to success. If the patient is bleeding then pressure bandage has to be applied

4) Disability assessment

It is assessed disability by AVPU score-

A-Alert

V-Responds to verbal commands

P- Responds to pain

U- Unresponsiveness

Patients who respond to verbal commands have mild head injury, one who responds to pain has moderate head injury and one with unresponsiveness has severe head injury.

5) Exposure

Proper and fast exposure of the patient to find hidden injuries, on the same hand prevention of hypothermia is the main aim. Log rolling the patient is an essential skill which in turn looks for injuries in back region.

6) Adjuvants, during initial assessment.

- Chest X- ray
- Pelvic X-ray
- Focussed Assessment of Sonography in Trauma.
- Blood investigations.
- Urinary catheter
- Gastric catheter
- No role of CT scan

Don't attempt urinary catheter if there is blood at meatus.

Better to put OG tubes in patients with nasal bleed, CSF otorrhea, and hemo-tympanum.

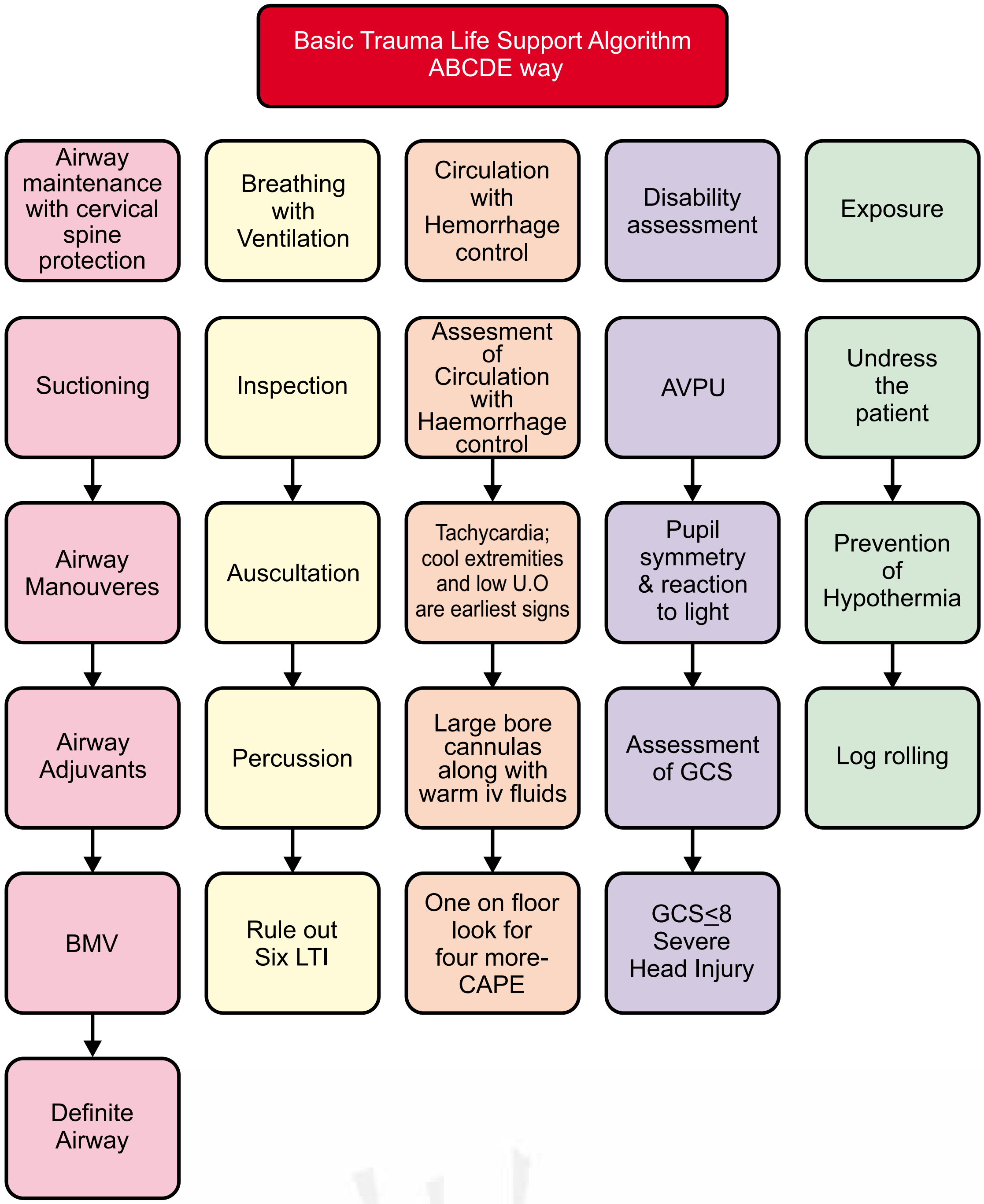
Once patient is physiologically stable you proceed to next step.

- **Secondary survey**

  Assessment of anatomical injuries, head to toe examination.

- **Definitive care**

  Once patient is stabilized you send the patient to nearest trauma cent


Basic Trauma Life Support Algorithm
ABCDE way
Airway maintenance with cervical spine protection
Suctioning
Airway Manouveres
Airway Adjuvants
BMV
Definite Airway
Breathing with Ventilation
Inspection
Auscultation
Percussion
Rule out Six LTI
Circulation with Hemorrhage control
Assesment of Circulation with Haemorrhage control
Tachycardia; cool extremities and low U.O are earliest signs
Large bore cannulas along with warm iv fluids
One on floor look for four more- CAPE
Disability assessment
AVPU
Pupil symmetry & reaction to light
Assessment of GCS
GCS≤8 Severe Head Injury
Exposure
Undress the patient
Prevention of Hypothermia
Log rolling

CHAPTER 2 AIRWAY MANAGEMENT IN TRAUMA

The inadequate delivery of oxygenated blood to the brain and other vital structures is the quickest killer of injured patients. Prevention of hypoxemia requires a protected, unobstructed airway and adequate ventilation, which take priority over management of all other conditions. For oxygenation of the patient the airway should be patent and be secured, oxygen delivered and ventilator support is provided. Supplementary oxygen must be administered to the all trauma patients.

The Early preventable deaths from airway problem after trauma often result from:

- Failure to identify the need for an airway intervention.
- Inability to establish an airway
- Lack of back up or alternative airway plan in the setting of failed intubation attempts.
- Failure to recognize an incorrectly placed airway.
- Displacement of a previously established airway.
- Failure to identify the need for ventilation.
- Aspiration of gastric contents during dealing with airway.

Airway and Ventilation are the first priorities:

First step in identifying the airway problems includes maxillofacial, neck ,laryngeal trauma and inhalational burn injuries.

Airway compromise may be sudden and complete, insidious and partial, and or progressive and recurrent. The early sign of airway or ventilator compromise is Tachypnea or inability to speak words or sentences. "Talking patient" provides reassurance for that period of time that the airway is patent and not compromised. Failure to respond or an inappropriate response suggests an altered level of consciousness, airway and ventilator compromise or both. Patient with the altered level of consciousness are at particular risk for airway compromise and aspiration, so they require definite airway.

Definitive airway : Is defined as a tube placed in the trachea with the cuff inflated below the vocal cords, the tube connected to some form of oxygen enriched assisted ventilation and airway secured in place with tape. Unconscious Patient with head injury, alcohol intoxication or other drugs and thoracic injuries can have ventilator compromise. In these patients the purpose of endotracheal intubation is to provide an airway, deliver supplementary oxygen, support ventilation and prevent aspiration. Maintaining oxygenation and preventing hypercarbia are critical in managing trauma patient, especially those who have sustained head injury.

It is important to anticipate vomiting in all injured patient and be prepared to manage the situation. The presence of gastric contents in the oropharynx represents a significant risk of aspiration with the patient's next breath. Therefore, immediate suctioning and rotation of the entire patient to the lateral positions are indicated.

Maxillofacial Trauma : The mechanism for this injury is exemplified by anunbelted automobile passenger who is thrown into the windshield and dashboard. Trauma to midface can produce fractures and dislocations that compromise the naso-pharynx and oropharynx. Facial fractures can be associated with hemorrhage, increased secretion and dislodged teeth. Fractures of mandible, especially bilateral body fractures, can cause loss of normal airway structural support(Figure 1). Airway Obstruction can result if the patient is in supine position.

Neck Trauma : Penetrating injury to neck can cause vascular injury with significant hematoma, which can result in displacement and obstruction of the airway. Emergency placement of a surgical airway may be required if this displacement and

Figure 1. Trauma to face needs expertise but challenging airway management

obstruction make endotracheal intubation impossible. Hemorrhage from adjacent vascular injury can be massive, and operative control may be required. Blunt or penetrating injury to the neck can cause disruption of the larynx or trachea, resulting in airway obstruction and severe bleeding into the tracheobronchial tree.

Disruption of larynx and trachea or compression of the airway from hematoma into the soft tissue of neck can cause partial airway obstruction.

Laryngeal trauma :

Fracture of larynx is a rare injury, but it can present with acute airway obstruction. Triad of clinical signs which are found in the patient of laryngeal injury.

1. Hoarseness
2. Subcutaneous emphysema
3. Palpate fracture

When dealing with the airway issues in laryngeal trauma patients endotracheal intubation may be needed if it is not successful then emergency tracheostomy may indicated. Tracheostomy in this group of patient may be difficult, then cricothyroidotomy , although not preferred, may be life saving. These injuries are often associated with trauma to the esophageus , carotid artery, or jugular vein as well as tissue destruction. Noisy breathing indicates partial airway obstruction that can suddenly become complete , where the absence of breathing suggests that complete obstruction already exists. When fracture of larynx is suspected computed tomography will help to identify this injury.

Objective signs of Airway Obstruction:

1. Observe the patient for agitation, and obtundation, suggest hypercarbia, cyanosis indicates hypoxemia due to inadequate oxygenation which can be identified by inspection of nail beds and circum-oral skin. However, cyanosis is a late finding of hypoxia. Pulse Oximetry is used early in the airway assessment to detect inadequate oxygenation prior to development of cyanosis. Look for retractions and use of accessary muscles of ventilation that, when present, provide additional evidence of airway compromise.
2. Listen for abnormal, noisy sound breathing is usually ,snoring, gurgling and crowing sound (stridor) can be associated with partial obstruction of the pharynx or larynx. Hoarseness (dysphonia) implies functional, laryngeal obstruction.
3. Feel for location of trachea and quickly determine whether it is in the midline position
4. Evaluate patient behavior. Abusive and belligerent patient may in fact have hypoxia and should not be presumed to be intoxicated (so R/o hypoxia, then only presume intoxication.

Ventilation :

Sometime it will happen that airway of the patient will be patent but ventilation will be inadequate so look for the objective signs of inadequate ventilation. Ventilation may be compromised by airway obstruction, altered ventilatory mechanics, and central nervous system depression. Following are the conditions where the ventilation may be compromised.

1. Direct trauma to the chest, like rib fractures, leading to severe pain during breathing and leads to shallow breathing and hypoxemia.
2. Elderly patients and other individual with pulmonary dysfunction are at significant risk for ventilator failure.

3. Intracranial injury can cause abnormal breathing patterns and compromise adequacy of ventilation.

4. Cervical spinal cord injury can result in diaphragmatic breathing and interfere with the ability to meet increased oxygen demands.

5. Complete cervical cord transection, which spares the phrenic and result in abdominal breathing paralysis of the intercostal muscles, and assisted ventilaton may be required.

Objective signs of inadequate ventilation:

1. Symmetrical rise and fall of the chest and adequate chest wall excursion indicate the adequate ventilation but asymmetrical rise and fall suggests splitting of rib cage or flail chest. Labored breathing may indicate an imminent threat to the patient's ventilation.

2. Listen for movement of air on both sides of the chest. Decreased or absent sounds over one or both hemi-thoraces should alert examiner to the presence of thoracic injury. Beware of rapid respiratory rate-tachypnea can indicate respiratory distress.

3. Use a pulse oximeter. This device provides information regarding patient's oxygen saturation and peripheral perfusion.

Airway management :

To assess airway patency and adequate ventilation quickly ad accurately pulse oximetry and end-tidal Co2 measurement are essential. There are some measures to improve the oxygenation. Include airway maintenance techniques, definitive airway measures or surgical airways. Because above mentioned measures include some movement of neck, so it is important to maintain cervical spine protection in all patient of trauma.

High flow oxygen is required both before and immediately after airway management measures are instituted. A rigid suction device is essential and should be readily available. Nasal route for endotracheal route should not be chosen in patient of patients with facial injury and midface injury. Patients who are wearing Helmet and require airway management need their head and neck held in a neutral position. For this two person procedure. One person provides manual inline stabilization from belwo while the seconds person expands the helmet laterally and removes it from above. Then inline stabilization is reestabilized from above. And patient,s head and neck are secured during airway management. Removal of the helmet using a cast cutter while stabilizing the head and neck can minimize c – spine motion in patients with known c – spine injury .

Predicting difficult airway:

It is important to assess the patient's airway prior to attempting intubation in order to predict the likely difficulty of the maneuver. Factors that may predict difficulties with airway maneuvers include C-spine injury, severe arthritis of the c spine, significant maxillofacial or mandibular veriations(receding chin, overbite and a short, muscular neck).

The mnemonic LEMON is helpful as a prompt when assessing the potential for a difficult intubation. Look for evidence of a difficult airway (small mouth or jaw, large overbite or facual trauma.). LEMON stands for

L= Look Externally. Look for characteristics that are known to cause difficult intubation or ventilation.

E= Evaluate the 3-3-2 Rule: To allow for alignmemt of the pharyngeal, laryngeal and oral axes and therefore simple intubation, following relationships should be observed.

- The distance between the patient's incisor teeth should at least 3 finger breadths.
- Distance between the hyoid bone and the chin should be at least 3 fingers.
- Distance between the thyroid notch and floor of the mouth should be at least 2 fingers.

M=Mallampati : The hypo-pharynx should be visualized adequately. To assess the Mallampati grade when possible the patient is asked to sit upright. Open the mouth fully and protrude the tongue as far as possible. The examiner then looks into the mouth with a light torch to assess the degree of hypo-pharynx visible . In supine condition , the Mallampati score can be estimated by asking the patient to open the mouth fully and protrude the tongue a laryngoscopy light is shone into the hypo-pharynx from above. (Figure 2)

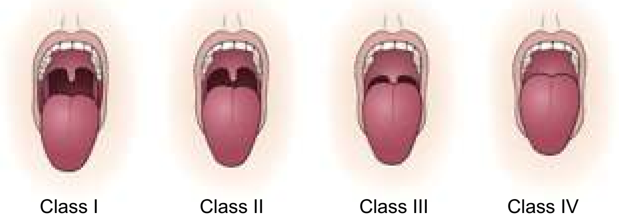


Figure. 2 : **Mallampati Classification: Class I:** Soft plate, Uvula, fauces, pillers visible

Class II : Soft plate, Uvula, fauces visible Class III: Soft Palate, base of Uvula visible Class IV: Hard palate only visible.

Obstruction :

Any condition that can cause obstruction of the airway will make laryngoscopy and ventilation difficult. e.g. epiglottitis, peri-tonsillar abscess and trauma.

N= Neck Mobiliity :

This is a vital requirement for successful intubation. It can be assess easily by asking the patient to place his or her chin onto the chest and then extending for nech so that he or she is looking towards the ceiling. Patient in hard collar neck immobilization obviously have no neck movement and are therefore more difficult to intubate.

Airway Decision Plan :

There is a algorithm to follow when is in acute need of an immediate airway management and in whom, a C-spine injury is suspected because of the mechanism of injury or suggested by the physical examination. The first priority is to ensure continued oxygenation with maintenance of C-spine immobilization. This is done initially by chin lft or jaw thrust maneuver and the preliminary airway techniques (i.e Oro-pharyngeal airway or nasopharyngeal airway). The aim is to avoid prolonged periods of inadequate or absent ventilation and oxygenation.

Airway Maintenance Techniques : In the unconscious patient tongue can fall backward ad obstruct the hypopharynx. This form of obstruction can be correctd readily by the "chin-lift or jaw thrust" maneuvers. These maneuvers may produce or aggravate c-spine injury, so inline immobilization of the c-spine is essential during these proceudres.

The chin lift or jaw thrust maneuvers to be done as taught in BLS survey.

When jaw thrust is being given with face mask device, a good seal and adequate ventilation can achieved. Care must be taken to prevent neck extension.

Oropharynx Airway (OPA) : OPA is always inserted into the mouth behind the tongue. The preferred technique is to use a tongue blade or depressor to depress the tongue and then insert the airway posteriorly, taking care not to push the tongue backward. This device should not be used in conscious patient because it can trigger gagging, vomiting and aspiration. Patient who tolerate an OPA airway are highly likely require intubation. An alternate technique is to insert the oral airway upside down, so its concavity is directed upward until the sort palate is encountered. At this point, with the device rotated 180 degrees, the concavity is directed inferiorly, and the device is slipped into the place over tongue. But this alternate method should not be used in children because rotation of the device can damage the mouth and pharynx. (Figure 3)

Figure. 3 : Oro-pharyngeal airway of different sizes.

Nasopharyngeal Airway (NPA) : NPA is inserted in one nostril and passed gently into the posterior oropharynx. They should be well lubricated and inserted into the nostril that appears to be unobstructed. If obstruction is encountered during introduction of the airway, stop and try the other nostril (Figure 4). This procedure should not be attempted in patient with suspected or potential cribriform plate fracture (Facial trauma specially midface and lower face.)

Figure. 4. Nasopharyngeal airways of different sizes.

Extra-glottic and Supra-glottic Devices: These devices (Combi tube, laryngeal tube, Laryngeal mask airway) have a role in dealing with airway crisis in trauma patient and they are also used to manage the airway when endotracheal intubation fails.

- **Laryngeal Mask Airway (LMA) :** There is an established role for the laryngeal mask airway in the treatment of difficult airway, particularly if attempts at endotracheal tube or bag-mask ventilation have failed. LMA does not provide you a definite airway but it helps in the problem of failed intubation to tide over the crisis period. LMA consists of a elliptical mask and tube. The LMA design provides an "oval seal around the laryngeal inlet" once the LMA is inserted and the cuff inflated. It lies at the crossroads of the digestive and respiratory tracts. This device is easier to insert than endotracheal tube but there is a need of training to learn how to insert the LMA (Figure 5).

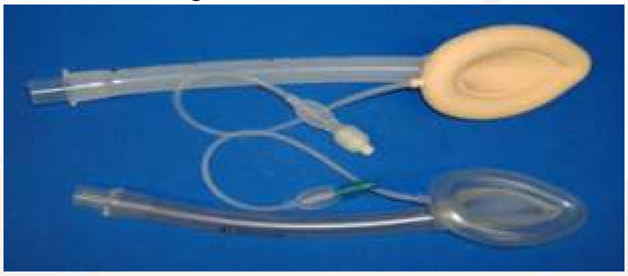


Figure. 5 : Laryngeal Mask Airway-Gadget to be used in difficult intubation scenario.

Laryngeal Tube AIrway (LTA) : LTA is an extra glottic device with capabilities similar to those of LMA in providing successful patient ventilation. LTA is not a definite airway and plans to provide a definite airway are necessary. As LTA is placed without direct visualization of the glottis and does not require significant manipulation of the head and neck for placement (Figure 6).

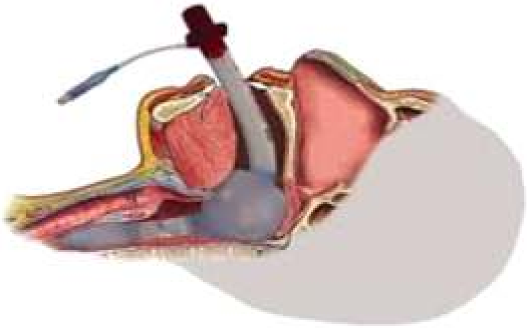


Figure. 6 : Showing how does Laryngeal tube airway accommodates in oropharynx and ventilate the victim.

Multi-luminal Esophageal Airway (COMBI Tube) :

This device is used by some of pre-hospital personnel to achieve an airway when a definite airway is not feasible. In this device there are two parallel lumen tube, one tube is having a hole at the patient end (esophageal port) which usually lies in oesophagus or trachea and other tube is having 6-8 fenestration (hole) which usually lies in pharynx. The personnel who use this device are trained to observe which port occludes the esophagus and which provides air to trachea. The esophageal port is then occluded with a balloon, and the other port is ventilated. A CO2 detector improves the accuracy of this apparatus (Figure 7).

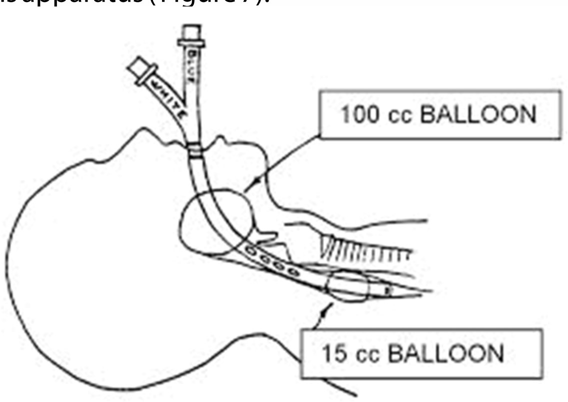


Figure. 7 : Illustrating how does Combi tube accommodates and ventilate the victim and also showing the balloon's capacities.

Definitive Airway: A definitive airway requires a tube placed in the trachea with the cuff inflated below the vocal cords, the tube connected to some form of oxygen-enriched assisted ventilation and airway secured in place with tape. There are three types of definitive airways, oro-tracheal tubes, naso-tracheal tubes, and surgical airways (crico-thyroidotomy or tracheostomy) (Figure 8). The criteria for establishing definitive airway are based on clinical findings and include (Table 1)

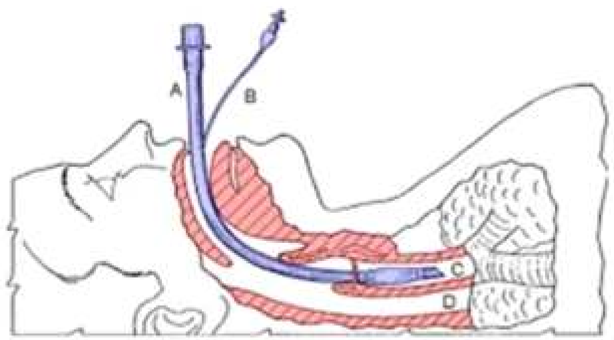


Figure. 8 Endotracheal tube in situ ventilating the victim.

- Airway problems- Inability to maintain a patent airway by other means with impending or potential compromise of the airway (e.g following inhalation airway injury, facial fractures or retropharyngeal hematoma).

- Breathing problems- Inability to maintain adequate oxygenation by face mask oxygen supplementation and presence apnea.

- Disability problems- Presence of a closed head injury requiring assisted ventilation (Glasgow Coma Scale –GCS of 8 or less than 8) need to protect the lower airway from aspiration of blood or vomitus or sustained seizure activity.

Table 1 :Indications for a definite airway

Sl No.	Need for Airway Protection	Need for Ventilation or Oxygenation
1.	Severe maxillofacial fractures	Inadequate respiratory Efforts ▪ Tachypnea ▪ Hypoxia ▪ Hypercapnia ▪ Cyanosis
2.	Risk for Obstruction ▪ Neck hematoma ▪ Laryngeal or trachea ▪ Stridor	Massive Blood loss and need for volume resuscitation
3.	Risk for aspiration ▪ Bleeding ▪ Vomiting	Severe closed injury with need for bried hyperventilation if acute neurologic deterioration occurs
4.	Unconscious	Apnea ▪ Neuromuscular paralysis ▪ Unconscious

Indications for Definitive Airway :

Endotracheal Intubation : It is important to establish the presence or absence of C-spine fracture , obtaining the radiological studies (CT, Cervical X-ray) , it should not delay or impede the placement of a definitive airway whenever indicated. When the need of airway management is not urgent then only the patient can be send for Radiological studies.

The most important determinants of whether to proceed with oro-tracheal or naso-tracheal intubation are the experience of the clinician and the presence of a spontaneously breathing patients. Both techniques are the safe and effective when perfomed properly, although orotracheal tube is more commonly used and has fewer intensive care unit complications. If patient is having apnea oro-tracheal tube is indicated.

Blind naso-tracheal intubation requires a patient who is spontaneously breathing and is contraindicated in patient with apnea, facial, frontal sinus, basilar skull and cribriform plate fractures are relatively contraindicated. Evidence of nasal fractures, raccoon eyes (bilateral ecchymosis in the peril-orbital region), Battle's sign (Post auricular ecchymosis) and possible cerebrospinal fluid keas (H/o Rhinorrhoea or Otorrhea) are all signs of these injuries.

If the decision to perform oro-tracheal intubation is made, the two person technique withmanual inline stabilization is necessary. Laryngeal manipulation by backward, upward, and rightward pressure (BURP) on the thyroid cartilage can aid in visualizing the vocal cords. An excellent tool, when faced with difficult airway is the Eschmann Tracheal Tube Introducer (ETTI) known as the gum elastic bougie (GBB). GEB is used when vocal cords cannot be visualized on direct laryngoscopy. With the laryngoscope in place, the GBB is passed blindly beyond the epiglottis, with the angled tip positioned anteriorly. Tracheal position is confirmed by the feeling clicks as the distal tip rubs along the cartilaginous tracheal rings.

Intubation and Confirmation of right placement of Endotracheal tube :

To intubate the patient laryngoscope is inserted through the right corner of mouth and oropharynx structures are identified. After reaching sufficiently deep in oropharynx epiglottis and glottis are visualized and appropriate size endotracheal tube is inserted through the glottis under direct vision. Cuff of tube is inflated and assisted ventilation is started. There are clinical method to identify the proper placement of endotracheal tube and rule out esophageal intubation. First, auscultate the chest bilaterally over five points Epigastrium, Right infraclavicular area, left infraclavicular area, right infraaxillary area and left infraaxillary area. In epigastrium area, if gurgling or rumbling sounds(Borborygmi) are heard then endotracheal tube is in esophagus, tube must be taken out and patient should pre-oxygenated with bag-mask ventilation and re-intubation attempt is made. If endotracheal tube is in properly in trachea, bilateral breath sounds are heard and tube is manipulated until equal bilateral breath sounds are heard. A CO2 detector (ideally a Capnograph nut if that is not available a caloroimetric CO2 monitoring device- this device is not a indicator of physiologic monitoring of adequacy of ventilation) is indicated to help in confirmation of proper placement of endotracheal tube. Proper placement of tube is best confirmed by chest X-ray, one the possibility of esophageal intubation is ruled out. To find out the adequacy of ventilation requires arterial blood carbon di oxide analysis or end tidal carbon dioxide. Whenever, patient is moved, tube placement is reconfirmed.

If the vocal cords are not fully visualized, then one can use GEB to intubate the patient.

Rapid Sequence Intubation : The use of anesthetic, sedative and neuromuscular blocking drugs for endotracheal intubation in trauma patient is potentially dangerous. In many patient an airway is acutely needed, during the primary, the use of paralyzing or sedating drugs is not necessary. The technique of rapid sequence intubation (RSI) is as follow:

1. Always have a plan for failure of intubation or ventilation.
2. Ensure that suction and the ability to deliver positive pressure ventilation are ready.
3. Pre-oxygenate the patient with 100% oxygen.
4. Apply pressure over the cricoid cartilage.
5. Administer an induction drugs in calculated doses (e.g etomidate 0.3 mg/kg) or sedate according to local protocol.
6. Administer 1-2 mg/kg Succinylcholine intravenously (Usual dose is 50-100 mg).
7. After patient relaxes intubate the patient oro-tracheally.
8. Inflate the cuff and confirm tube placement by auscultating the patient's chest and determining the presence of CO2 in exhaled air.
9. Release cricoid pressure.
10. Ventilate the patient.

Donor use succinylcholine in cases of crush injury, burns, and thermal injury because there is a risk of hyperkelemia and subsequent cardiac arrest. Succinylcholine is short acting drug, is administered. It has a rapid onset of paralysis (<1 minute) and a duration of 5 minutes or less.

Surgical Airway : surgical airway established when edema of glottis, fracture of larynx or severe oro-pharyngeal haemorrhage obstruct the airway or endotracheal tube can not be place through the vocal cords. A surgical crico-thyroidotomy is preferred to a tracheostomy to most patient who require establishment of an emergency airway, because it is easier to perform, associated with less bleeding and require less time to perform than an emergency tracheostomly.

Needle Cricothyroidotomy: Needle cricothyroidotomy involves insertion of needle through the crico-thyroid membrane or into the trachea in the an emergency situation to provide the oxygen on a short term basis until a definitive airway can be placed. This procedure can provide temporary, supplemental oxygenation so that intubation can be accomplished on an urgent rather than an emergent basis.

The jet insufflation technique is performed by placing a large catheter plastic cannula 12-14 gauge for adults, and 16-18 gauge in children, through the crico-thyroid membrane into the trachea below the level of the obstruction. The cannula is then connected to oxygen as 15L/Min (40-50 psi) with a Y connector or a side hole cut in the tuning between the oxygen source and the plastic cannula, intermittent insufflation, 1 second on and 4 seconds off can then be achieved by placing the thumb over open end of the Y connector or the side hole.

The patient can be adequately oxygenated for 30-40 min using this technique, and only patients with normal pulmonary function who donot have a significant chest injury may be oxygenate in this manner. During the 4 seconds that the oxygen is not being delivered under pressure, some exhalation occurs. Because of the inadequate exhalation, CO2 slowly accumulate limiting the use of this technique, especially in patients with head injuries.

Jet insulation must be used with caution when complete foreign body obstruction of the glottis area is suspected. Although high pressure can expel the impacted material into the hypopharnx where it can be removed readily, significant barotrauma can occur, including pulmonary rupture with tension penumo-thorax Therefore, particular attention must be paid to effectivwe airflow and low flow rates (5-7 L/min) should be used when persistent glottis obstruction is present.

Surgical Cricothyroidotomy : Surgical Cricothyroidotomy is performed by making a skin incision that extends through the cricothyroid membrane. A curved hemostat may be inserted to dilate the opening and a small endotracheal tube or tracheostomy tube (preferably 5-7mm). When an endotracheal tube is used, the cervical collar can be reapplied. It is possible for endotracheal tube to become malpositioned and therefore, advanced into a bronchus. Care must be taken, especially with children, to avoid damage to the cricoid cartilage which is only circumferetial support for the upper trachea. Therefore, surgical cricothyroidotomy is not recommended for children under 12 years of age.

In the recent years, percutaneous tracheostomy has been reported as an alternative open trachesostomy. This is not a safe procedure in the acute trauma situation. Because the patient's neck must be hyperextended to properly position the head to perform the procedure safely. Percutaneous tracheostomy requires use of a heavy guuidewire and sharp dilator, or a guidewire and multiple or single large bore dilators. This procedure could be dangerous and time consuming, depending on the type of equipment used. (Figure 10)

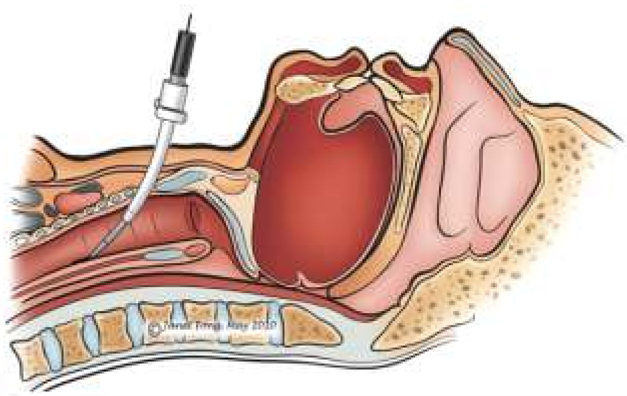


Figure.10 Crico-thyroidotmy using dilators and guidewire technique.

Monitoring of adequacy of oxygenation: Oxygenatyed inspired air is best provided a via tight fitting oxygen reservoir face mask with a flow rate of at least 11L/min. Other methods (e.g Nasal catheter and non-breather mask) can improve the inspired oxygen concentration. Pulse oximetry is a non-invasive method of continuously measuring the oxygen saturation (O2 sat) of arterial blood. It does not measure the partial pressure of oxygen (PaO2) and depending upon the position of oxy-hemoglobin dissociation curve, the PaO2 can vary widely. However a measured saturation of 95% or greater by pulse oximetry is strongly suggests adequate peripheral artery oxygenation (PaO2 > 70mmHg).

Figure.11 : Pulse Oximeter. (a) Pulse oximetry shows oxygen saturation, heart rate

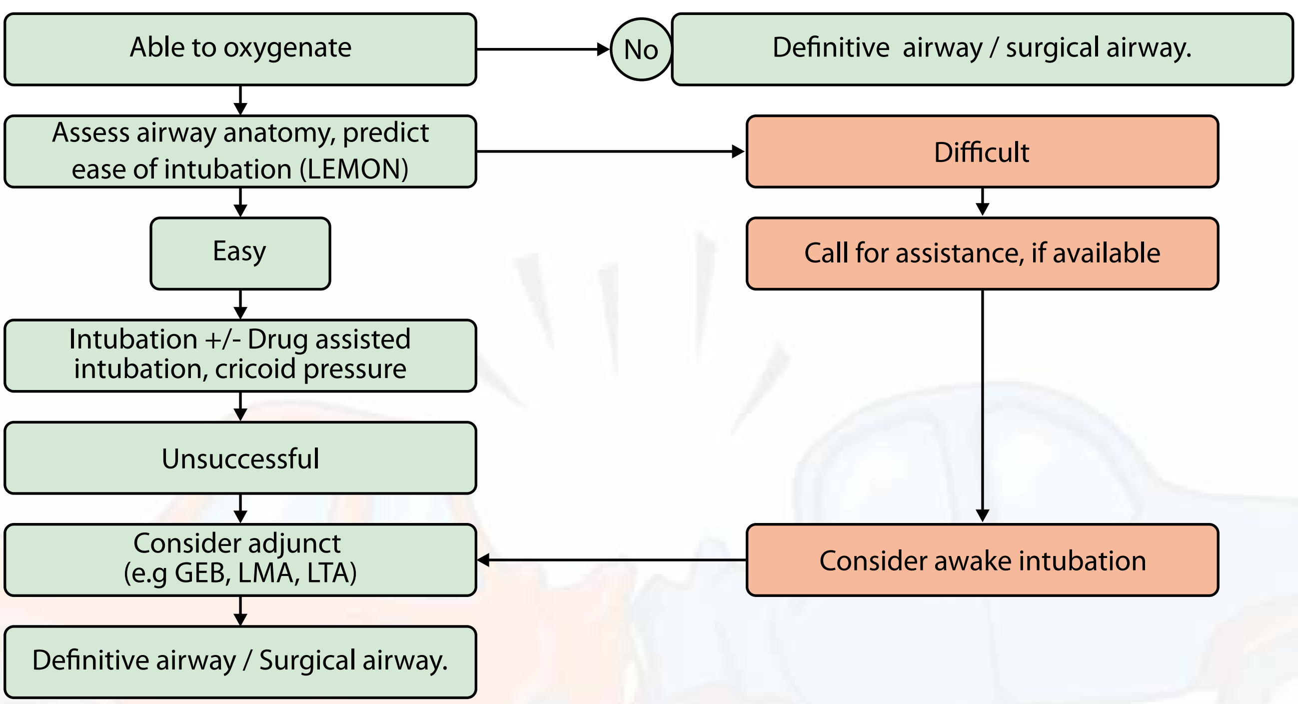
Pulse oximetry requires intact peripheral perfusion and can not distinguish oxy-hemoglobin from carboxy- hemoglobin or methemoglobin, which limits its usefulness in patients with severe vasoconstriction and those with carbon monoxide poisoning. Profound anemaia (Hb >5g/dl) and hypothermia (<30oC) decrease the reliability of the technique. However, in most patient pulse oximetry is useful as the continuous monitoring of oxygen saturation provides an immediate assessment of therapeutic intervention.

The simple formula for deducting PaO2 from the value of SpO2 is = % saturation of Hb - 30. But thus formula is valid only upto % saturation of Hemo-globin upto70.

Monitoring adequacy of Ventilation : Effective ventilation can be achieved by the bag-mask ventilation techniques. However, one person ventilation techniques using bag-mask are less effective than two person techniques in which both hands can be used to ensure a good seal.

Adequacy of ventilation can be checked clinically by ensuring the B/L equal chest air entry and seeing the color of the patient. Though, End-tidal CO2 is the gold standard for seeing the adequacy of ventilation but it may not be present in periphery hospitals so one has to rely on clinical monitoring and SPO2.

Be Prepared Equipment : Suction, O2, oropharyngeal and nasopharyngeal airways, bag-mask, laryngoscope, gum elastic bougie (GEB), supra-glottic devices, surgical or needle Crico- throidotomy kit, endendotracheal tube, pulse oximetry, CO2 detection device, drugs.



CHAPTER 3 SHOCK

The definition of shock—an abnormality of the circulatory system that results in inadequate organ perfusion and tissue oxygenation—globly. Basically when managing a patient with shock there are 9 queries or questions which are to be answered in a systematic way.

The first step in the initial management of shock is to recognize its presence. The shock is a clinical diagnosis which is characterised by group of science/ symptoms. No vital sign or symptom neither any laboratory test can diagnose shock . Shock is characterised by decreased blood flow to vital organs such as CNS, CVS, Kidney and hence characterised by following S/S (Figure 1).

1. Altered sensorium (CNS)
2. Tachycardia (CVS)
3. Cool Extremities are found in all types of shock except vasodilatory shock (CVS)
4. Capillary refilling time>10 seconds (Skin)
5. Low urine output (Kidney)
6. Low blood pressure (CVS)

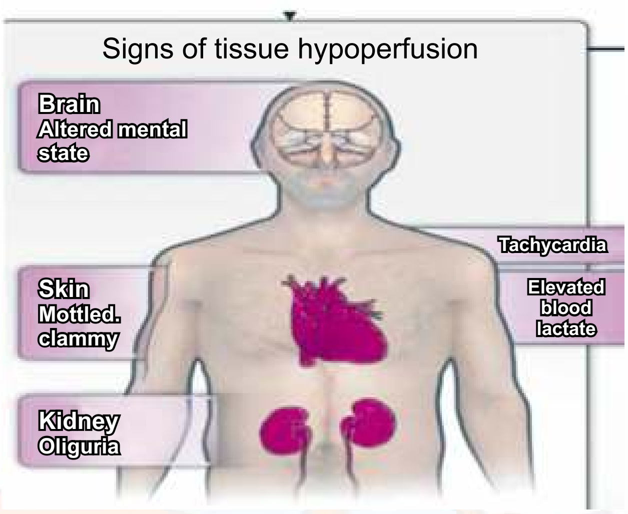


Figure 1: Signs of Tissue Hypo-perfusion

The reliance solely on systolic blood pressure as an indicator of shock can result in delayed recognition of the shock state. Compensatory mechanisms can preclude a measurable fall in systolic pressure until up to 30% of the patient's blood volume is lost. Specific attention should be directed to pulse rate, pulse character, respiratory rate, skin circulation, and pulse pressure (i.e., the difference between systolic and diastolic pressure).

Tachycardia and cutaneous vasoconstriction are the typical early physiologic responses to volume loss in most adults. Any injured patient who is cool and has tachycardia is considered to be in shock until proven otherwise. In addition, most non hemorrhagic shock states respond partially or briefly to volume resuscitation. Therefore, if signs of shock are present, treatment usually is instituted as if the patient is hypovolemic. However treatment is instituted, it is important to identify the small number of patients whose shock has a different cause (e.g., a secondary condition such as cardiac tamponade, tension pneumothorax, and spinal cord injury, or blunt cardiac injury, which complicates hypovolemic/ hemorrhagic shock).

The second step in the initial management of shockis to identify the probable cause of the shock state. The common varieties of shock are:

1. Hypovolemic
2. Vasodilatory shock: which includes septic, Neurogenic shock
3. Cardiogenic shock
4. Obstructive shock: includes
   a. Tension pneumothorax
   b. Cardiac tamponade

For all practical purposes, shock does not result from isolated brain injuries. Patients with spinal cord injury may initially present in shock resulting from both vasodilation and relative hypovolemia. Patient management responsibilities begin with

Table 1 : Classification of Hypovolemic Shock based on blood loss[1]

	CLASS I	CLASS II	CLASS III	CLASS IV
Blood loss (mL)	Up to 750	750-1500	1500-2000	>2000
Blood loss (% blood volume)	Up to 15%	15%-30%	30%-40%	>40%
Pulse rate (BPM)	<100	100-120	120-140	>140
Systolic b pressure	Normal	Normal	Decreased	Decreased
Pulse pressure (mm Hg)	Normal or increased	Decreased	Decreased	Decreased
Respiratory rate	14-20	20-30	30-40	>35
Urine output (mL/hr)	>30	20-30	5-15	Negligible
CNS/mental status	Slightly anxious	Mildly anxious	Anxious, confused	Confused, lethargic
Initial fluid replacement	Crystalloid	Crystalloid	Crystalloid and blood	Crystalloid and blood

[1]For a 70-kg man.

recognizing the presence of shock, and treatment should be initiated simultaneously with the identification of a probable cause. The response to initial treatment, coupled with the findings during the primary and secondary patient surveys, usually provides sufficient information to determine the cause of shock (Figure 2).

1. **Hypovolemic shock: Hemorrhage is the most common cause of shock in theinjured patient.** (Table 1) Hemorrhage is the most common cause of shock after injury, and virtually all patients with multiple injuries have an element of hypovolemia.

The primary focus in hemorrhagic shock is to promptly identify and stop hemorrhage. Sources of potential blood loss—chest, abdomen, pelvis, retroperitoneum, extremities, and external bleeding—must be quickly assessed by physical examination and appropriate adjunctive studies.

2. **Septic Shock :** The Septic shock occurs due to an infection is an example of Vasodilatory shock. The diagnosis is made by the following criteria SIRS+ INFECTION+ SHOCK. The shock is defined as SBP<90 mm Hg despite adequate fluid resuscitation of 1 liter. Patients with sepsis who also have hypotension and are afebrile are clinically difficult to distinguish from those in hypovolemic shock, as both groups can manifest tachycardia, cutaneous vaso onstriction, impaired urinary output, decreased systolic pressure, and narrow pulse pressure. However patients with early

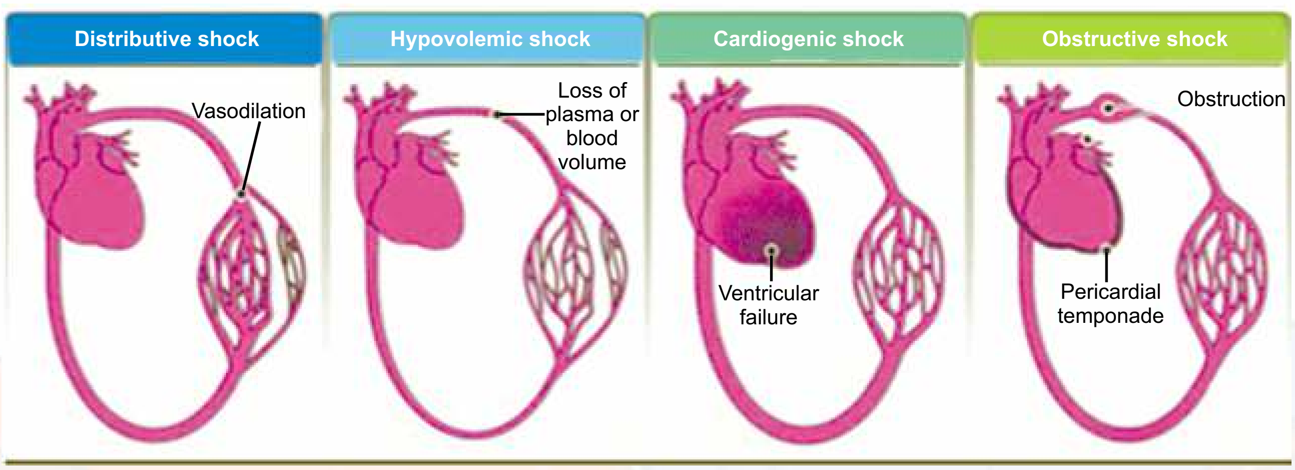


Figure 2: Different varieties of shock

septic shock can have a normal circulating volume, modest tachycardia, warm skin, systolic pressure near normal, and a wide pulse pressure.

3. **Cardiogenic Shock :** Myocardial dysfunction is commonly as a result of myocardial infarction or rarely, by blunt cardiac injury, cardiac tamponade, an air embolus. All patients with cardiogenic shock need constant electro cardiographic (ECG)monitoring to detect injury patterns and dysrhythmias. The blood creatine kinase (CK; formerly, creatine phosphokinase [CPK] iso-enzymes and specific isotope studies of the myocardium rarely assist in diagnosing or treating injured patients in the emergency department(ED).

4. **Obstructive shock: includes**

   a) **Tension pneumothorax :** Tension pneumothorax is a true surgical emergency that requires immediate diagnosis and treatment. It develops when air enters the pleural space, but a flap-valve mechanism prevents its escape. Intra-pleural pressure rises, causing total lung collapse and a shift of the mediastianum to the opposite side with the subsequent impairment of venous return and fall in cardiac output. The presence of acute respiratory distress, subcutaneous emphysema, absent breath sounds, hyper-resonance to percussion, and tracheal shift supports the diagnosis and warrants immediate thoracic decompression without waiting for x-ray confirmation of the diagnosis.

   b) **Cardiac tamponade :** Blood in the pericardial sac inhibits cardiac contractility and cardiac output. Tachycardia, muffled heart sounds, and dilated, engorged neck veins with hypotension resistant to fluid therapy suggest cardiac tamponade. However, the absence of these classic findings does not exclude the presence of this condition. Tension pneumothorax can mimic cardiac tamponade, but it is differentiated from the latter condition by the findings of absent breath sounds, tracheal deviation, and a hyper-resonant percussion note over the affected hemi-thorax.

5. **Neurogenic Shock :** Isolated intracranial injuries do notcause shock. The presence of shock in a patient with ahead injury necessitates the search for a cause other than an intracranial injury. Cervical or upper thoracicspinal cord injury can produce hypotension dueto loss of sympathetic tone. Loss of sympathetic tone compounds the physiologic effects of hypovolemia, and hypovolemia compounds the physiologic effects of sympathetic denervation. The classic picture of neurogenic shock is hypotension without tachycardia or cutaneous vaso constriction. A narrowed pulse pressure is not seen in neurogenic shock. Patients who have sustained a spinal injury often have concurrent torso trauma; therefore, patients with known or suspected neurogenic shock should be treated initially for hypovolemia. The failure of fluid resuscitation to restore organ perfusion suggests either continuing hemorrhage or neurogenic shock. CVP monitoring may be helpful in managing this complex problem

Third Step is to differentiate various types of shock : Initial determination of the cause of shock depends on taking an appropriate patient history and performing an expeditious, careful physical examination. Selected additional tests, such as monitoring centralvenous pressure (CVP), chest and/or pelvic x-ray examinations, and ultrasonography, can provide confirmatory evidence for the cause of the shock state, but should not delay appropriate resuscitation (Figure 3).

Fourth step is: What is the Management of shock: Patient management responsibilities begin with recognizing the presence of shock, and treatment should be initiated simultaneously with the identification of a probable cause (Table 2).

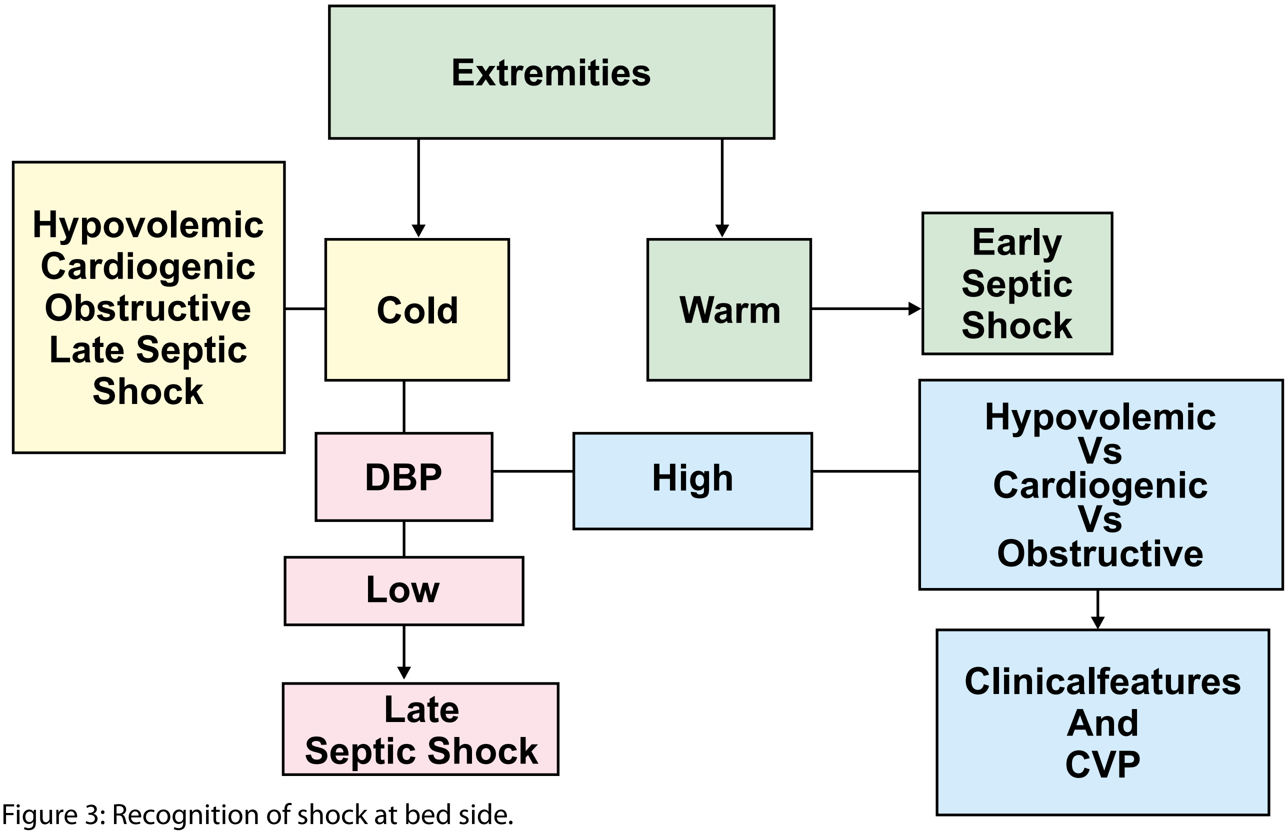


Figure 3: Recognition of shock at bed side.

1. **Hypovolemic shock:** The basic management principle is to stop the bleeding in hemorrhagic shock and replace the volume loss Similarly in hypovolemic shock due to other causes basic rule is to replace with intravenous fluids. Warmed isotonic electrolyte solutions, such as lactated Ringer's and normal saline, are used for initial resuscitation. This type of fluid provides transient intravascular expansion and further stabilizes the vascular volume by replacing accompanying fluid losses into the interstitial and intracellular spaces. An initial, warmed fluid bolus is given. The usual dose is 1 to 2 L for adults and 20 mL/kg for pediatric patients. Absolute volumes of resuscitation fluids should be based on patient response. It is important to remember that this initial fluid amount includes any fluid given in the pre-hospitalsetting. The patient's response is observed during this initial fluid administration, and further the rapeutic and diagnostic decisions are based on this response. It is most important to assess the patient's response to fluid resuscitation and identify evidence of adequate end-organperfusion and oxygenation (i.e., via urinary output, level of consciousness, and peripheral perfusion). Persistent infusion of large volumes of fluid and blood in an attempt to achieve a normal blood pressure is not a substitute for definitive control of bleeding. Excessive fluid administration can exacerbate the lethal triad of coagulopathy, acidosis, and hypothermia with activation of the inflammatory cascade.

2. **Septic shock:** In Septic Shock it is recommended that within 1 hour of patient's admission into the hospital, he has to be given antibiotics post blood cultures along with at least 1 liter (20 ml/kg) of i.v. fluids. The most important thing in management of septic shock issource control i.e. source of infection has to be removed.

3. **Cardiac tamponade:** Needle Pericardiocentesis using subxiphoid

approach may be used as a temporizing maneuver when thoracotomy is not an available option.

4. **Tension pneumothorax :** Appropriate placement of a needle into the pleural space in a case of tension pneumothorax temporarily relieves this life-threatening condition. The Needle – 14 G or 16 G has to be inserted into second intercostal space in mid-clavicular line and the following is connected to i.v. drip set attached to an underwater drainage set. The definite management is insertion of chest tube in 4-5 th intercostal space just anterior to Mid Axillary line.

5. **Neurogenic shock :** It is best managed by judicious fluid administration and vasopressors. It is a vasodilatory shock and is best managed by use of vasopressors.

Fifth step: Is my management adequate?

The same signs and symptoms of inadequate perfusion that are used to diagnose shock are useful

Table 2 : Brief management of different types of shock

Type of shock	Management	Special mention
Hypovolemic Shock	IV Fluids-NS/RL	
Septic Shock	Vasopressors	Norepinephrine, Adrenaline
Cardiogenic Shock	Inotropes	Dobutamine, Dopamine
Obstructive shock		
Tension Pneumothorax	Needle decompression	
Cardiac Tamponade	Pericardiocentesis	

determinants of patient response. The return of normal blood pressure, pulse pressure, and pulse rate are signs that suggest perfusion is returning to normal. However, these observations give no information regarding organ perfusion. Improvements in the CVP status and skin circulation are important evidence of enhanced perfusion, but are difficult to quantitate. The volume of urinary output is a reasonably sensitive indicator of renal perfusion; normal urine volumes generally imply adequate renal blood flow, if not modified by the administration of diuretic agents. For this reason, urinary output is one of the prime monitors of resuscitation and patient response. Adequate resuscitation volume replacement should produce a urinary output of approximately0.5 mL/kg/hr in adults, whereas 1 mL/kg/hr is an adequate urinary output for pediatric patients.

For children under 1 year of age, 2 mL/kg/hour should be maintained.

Sixth step :What type of iv access?

The important determinant for selecting a procedure or route for establishing vascular access is the clinician's experience and skill. Access to the vascular system must be obtained promptly (Figure 4). This is best accomplished by inserting two large-caliber (minimum of 16-gauge in an adult) peripheral intravenous catheters before placement of a central venous line is considered. The rate of flow is proportional to the fourth power of the radius of the cannula and inversely related to its length (Poiseuille's law). Hence, short, large-caliber peripheral intravenous lines are preferred for the rapid infusion of large volumes of fluid. The most desirable sites for peripheral, percutaneous intravenous lines in adults are the fore arms and ante-cubital veins. If circumstances prevent the use of peripheral veins, large-caliber, central venous(i.e.,

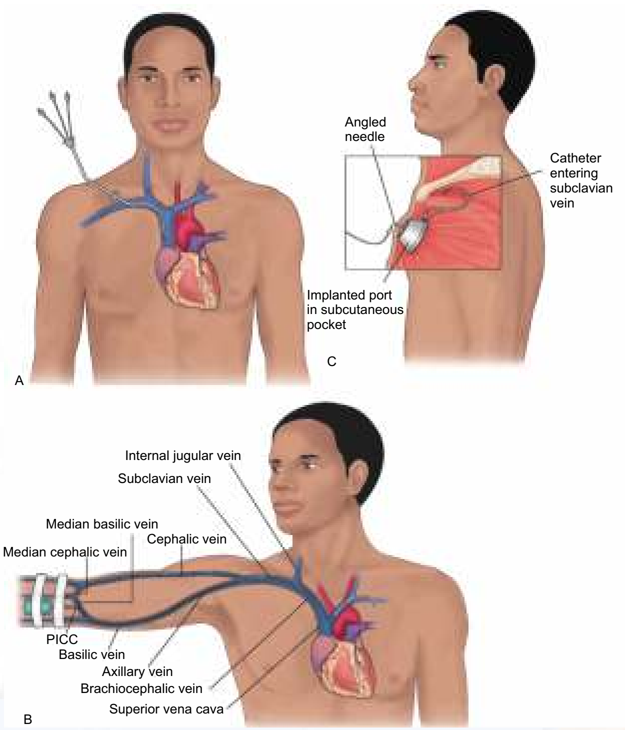


Figure 4 : Types of IV access

Femoral, Jugular, or Subclavian vein) access using the Seldinger technique or saphenous vein cut down is indicated, depending on the clinician's skill and experience.

Frequently in an emergency situation, central venous access is not accomplished under tightly controlled or completely sterile conditions. Therefore, these lines should be changed in a more controlled environment as soon as the patient's condition permits. Consideration also must be given to the potential for serious complications related to attempted central venous catheter placement, such as pneumothorax orhemothorax, in patients who may already be unstable.

As intravenous lines are started, blood samples are drawn for type and cross-match, appropriate laboratory analyses, toxicology studies, and pregnancy testing for all females of childbearing age. Arterial blood gas (ABG) analysis is performed at this time. A chestx-ray must be obtained after attempts at inserting a Subclavian or Internal jugular CVP monitoring line todocument the position of the line and evaluate for apneumothorax or hemothorax.

Seventh step : When to give blood?

The main purpose of blood transfusion is to restore the oxygen-carrying capacity of the intra vascular volume. Patients who are in Class III or Class IV hemorrhagic shock—will need pRBCs and blood products as a nearly part of their resuscitation. Fully crossmatched blood is preferable. However, the complete cross matching process requires approximately1 hour in most blood banks. For patients who stabilize rapidly, cross matched blood should be obtained and made available for transfusion when indicated.

Type-specific blood can be provided by most blood banks within 10 minutes. Such blood is compatible with ABO and Rh blood types, but incompatibilities of other antibodies may exist. If type-specific blood is unavailable, type O packed cells are indicated for patients with exsanguinating hemorrhage. To avoid sensitization and future complications, Rh-negative cells are preferred for females of child bearing age. As soon as it is available, the use of unmatched, type-specific blood is preferred over type O blood.

Eigthstep : Fluids warm/cold?

Hypothermia must be prevented and reversed if a patient has hypothermia on arrival at the hospital.The use of blood warmers in the ED is critical, even if cumbersome. The most efficient way to prevent hypothermia in any patient receiving massive volumes of crystalloid is to heat the fluid to 39°C (102.2° F) be foreinfusing it. This can be accomplished by storing crystalloids in a warmer or with the use of a microwave oven. Blood products cannot be warmed in a microwave oven, but they can be heated by passage through intravenous fluid warmers.

Ninth step : Current role of Calcium?

Most patients receiving blood transfusions do not need calcium supplements. When necessary, administration should be guided by measurement of ionized calcium. Excessive, supplemental calcium may be harmful.

CHAPTER 4 CHEST TRAUMA

A Clinical Case :

An adult male has been brought to casualty department following road traffic accident. He was driving a jeep and had hit a parked truck on road side. At arrival he is conscious but seems short of breath and holding on to his left side of chest. The pulse is feeble with tachycardia and tachypnoea.

Objectives

1. Suspecting chest trauma
2. Identifying life threatening injuries on primary survey and initiating management.
3. Secondary survey for potentially life threatening injuries and their management.
4. Decision making for further management.

Introduction :

Very often medical officers at PHC/CHC or district hospitals are faced with such clinical scenarios and prompt action is needed to save life. Less than 10% of blunt

chest injuries and only 15% to 30% of penetrating chest injuries require operative intervention (typically thoracoscopy or thoracotomy). In fact, most patients who sustain thoracic trauma can be treated by technical procedures within the capabilities of clinicians who take this course.

The major physiologic adverse effects of thoracic trauma are hypoxia, hyper-carbia and acidosis. The primary damage causes derangement of blood oxygenation leading to anaerobic metabolism and development of metabolic acidosis. Retention of carbon dioxide leads to respiratory acidosis.

Suspecting Thoracic Trauma and its type

Any patient with trauma due to impact over the torso (blunt or penetrating) should be suspected of sustaining chest trauma. A quick primary survey checking on the airway, followed by breathing and then circulation should be performed. It is prudent to address major injuries as they are identified.

Classification of chest trauma:

Injury to the Airways:

1. Airway obstruction
2. Tracheobronchial tree injury
3. Simple pneumothorax
4. Tension pneumothorax
5. Open pneumothorax
6. Haemothorax
7. Flail chest and pulmonary contusion
8. Massive haemothorax

Injury to Viscera

1. Blunt cardiac injury
2. Cardiac tamponade
3. Traumatic aortic disruption
4. Traumatic diaphragmatic injury
5. Blunt esophageal rupture

Immediately Life threatening chest injuries – to be identified and treated during primary survey

1. Airway obstruction
2. Tension pneumothorax
3. Open pneumothorax
4. Flail chest and pulmonary contusion
5. Massive haemothorax
6. Cardiac tamponade

Potentially Life threatening chest injuries – to be addressed during secondary survey

1. Simple pneumothorax
2. Haemothorax

3. Pulmonary contusion
4. Tracheobronchial tree injury
5. Blunt cardiac injury
6. Traumatic aortic disruption
7. Traumatic diaphragmatic injury
8. Blunt esophageal rupture

Following manifestations of thoracic trauma are indicative of a greater risk of associated injuries:

1. Subcutaneous emphysema
2. Crush injuries of the chest
3. Injuries to the upper ribs (1–3), scapula, and sternum

Managing Chest Trauma – Primary survey and life threatening injuries

The basic principles of management remain the same with the universal sequence of airway, breathing and circulation to be treated in that sequence.

AIRWAY:

It is necessary to recognize and address major injuries affecting the airway during the primary survey. Airway patency and air exchange should be assessed by listening for air movement at the patient's nose, mouth, and lung fields; inspecting the oropharynx for foreign-body obstruction; and observing for intercostal and supraclavicular muscle retractions. Laryngeal injury can accompany major thoracic trauma. Although the clinical presentation is occasionally delayed, acute airway obstruction from laryngeal trauma is a life-threatening injury.

Injury to the upper chest can create a palpable defect in the region of the sternoclavicular joint, with posterior dislocation of the clavicular head, which causes upper airway obstruction. Identification of this injury is made by listening for upper airway obstruction (stridor) or a marked change in the expected voice quality, if the patient is able to talk. Management consists of a closed reduction of the injury, which can be performed by extending the shoulders or grasping the clavicle with a pointed instrument, such as a towel clamp, and manually reducing the fracture. Once reduced, this injury is usually stable if the patient remains in the supine position.

BREATHING :

The patient's chest and neck should be completely exposed to allow for assessment of breathing and the neck veins. This may require temporarily releasing the front of the cervical collar following blunt trauma. In this case, cervical spine immobilization should always be actively maintained by holding the patient's head while the collar is loose. Respiratory movement and quality of respirations are assessed by observing, palpating, and listening. Important, yet often subtle, signs of chest injury or hypoxia include an increased respiratory rate and change in the breathing pattern, which is often manifested by progressively shallower respirations. Cyanosis is a late sign of hypoxia in trauma patients. However, the absence of cyanosis does not necessarily indicate adequate tissue oxygenation or an adequate airway. The major thoracic injuries that affect breathing and that must be recognized and addressed during the primary survey include tension pneumothorax, open pneumothorax (sucking chest wound), flail chest and pulmonary contusion, and massive haemothorax.

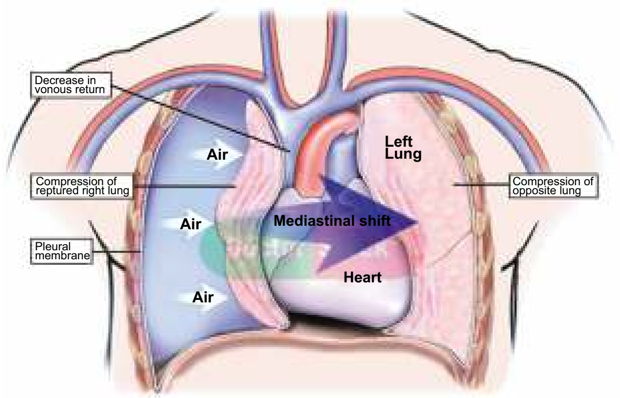
IMPORTANT : After intubation, one of the common reasons for loss of breath sounds in the left thorax is a right mainstem intubation. During the reassessment, be sure to check the position of the endotracheal tube before assuming that the change in physical examination is due to a pneumothorax or haemothorax.

Tension Pneumothorax

A tension pneumothorax develops when a "one-way valve" air leak occurs from the lung or through the chest wall. Air is forced into the pleural space without any means of escape, eventually completely collapsing the affected lung. The mediastinum is displaced to the opposite side, decreasing venous return and compressing the opposite lung. Shock results from the marked decrease in venous return causing a reduction in cardiac output and is often classified as obstructive shock (Figure 1). The most common cause of tension pneumothorax is mechanical ventilation with positive-pressure ventilation in patients with visceral pleural injury. However, a tension pneumothorax can complicate a simple pneumothorax following penetrating or blunt chest trauma in which a parenchymal lung injury fails to seal, or after a misguided attempt at subclavian or internal jugular venous catheter insertion. Occasionally, traumatic defects in the chest wall also can cause a tension pneumothorax if incorrectly covered with occlusive dressings or if the defect itself constitutes a flap-valve mechanism. Tension pneumothorax rarely occurs from markedly displaced thoracic spine fractures. Tension pneumothorax is a clinical diagnosis reflecting air under pressure in the affected pleural space.Treatment should not be delayed to wait for radiologicconfirmation. Tension pneumothorax is characterized by some or all of the following signs and symptoms:

- Chest pain
- Air hunger
- Respiratory distress
- Tachycardia
- Hypotension
- Tracheal deviation away from the side of injury
- Unilateral absence of breath sounds
- Elevated hemithorax without respiratory movement
- Neck vein distention
- Cyanosis (late manifestation)

Because of the similarity in their signs, tension pneumothorax can be confused initially with cardiac tamponade. Differentiation is made by a hyperresonant note on percussion, deviated trachea, and absent breath sounds over the affected hemithorax, which are signs of tension pneumothorax. Tension pneumothorax requires immediate decompression and may be managed initially by rapidly inserting a large-caliber needle into the second intercostal space in the midclavicular line of the affected hemithorax. However, due to variable thickness of the chest wall, kinking of the catheter and other technical or anatomic complications, this maneuver may not be successful. When successful, this maneuver converts the injury to a simple pneumothorax; however, the possibility of subsequent pneumothorax as a result of the needle stick now exists, so repeated reassessment of the patient is necessary. Chest wall thickness influences the likelihood ofsuccess with needle decompression. Recent evidence suggests that a 5 cm needle will reach the pleural space >50% of the time, whereas an 8 cm needle will reach the pleural space >90% of the time. Even with a needle of the appropriate size, the maneuver will not always be successful. Definitive treatment requires the insertion of a chest tube into the fifth intercostal space (usually at the nipple level), just anterior to the midaxillary line.



In a tension pneumothorax, air from a ruptured lung enters the pleural cavity without a means of escape. As air pressure builds up, the affected lung is compressed and all of the mediastinal tissues are displaced to the opposite side of the chest.

Figure 1 : Tension Pneumothorax, in this condition air from a ruptured lung enters the pleural cavity without a route of escape so it works as one way valve allowing air movement during inspiration only. As air pressure builds up, the affected lung is compressed and all of the mediastinal tissues are displaced to the opposite side of the chest.

Open Pneumothorax (Sucking Chest Wound)

Large defects of the chest wall that remain open can result in an open pneumothorax, which is also known as a sucking chest wound. Equilibration between intrathoracic pressure and atmospheric pressure is immediate. Air tends to follow the path of least resistance; as such, if the opening in the chest wall is approximately two-thirds of the diameter of the trachea or greater, air passes preferentially through the chest wall defect with each respiratory effort (Figure 2). Effective ventilation is thereby impaired, leading to hypoxia and hypercarbia. Initial management of an open pneumothorax is accomplished by promptly closing the defect with a sterile occlusive dressing. The dressing should be large enough to overlap the wound's edges and then taped securely on three sides in order to provide a flutter-type valve effect. As the patient breathes in, the dressing occludes the wound, preventing air from entering. During exhalation, the open end of the dressing allows air to escape from the pleural space. A chest tube remote from the wound should be placed as soon as possible. Securely taping all edges of the dressing can cause air to accumulate in the thoracic cavity, resulting in a tension pneumothorax unless a chest tube is in place. Any occlusive dressing (e.g., plastic wrap or petrolatum gauze) may be used as a temporary measure so that rapid assessment can continue. Subsequent definitive surgical closure of the defect is frequently required.

Figure 2 : Open sucking wound -suspect open pneumo-thorax and treatment is three sided bandage of open sucking wound.

Flail Chest and Pulmonary Contusion

A flail chest occurs when a segment of the chest wall does not have bony continuity with the rest of the thoracic cage. This condition usually results from trauma associated with multiple rib fractures— that is, two or more adjacent ribs fractured in two or more places (Figure 3). The presence of a flail chest segment results in disruption of normal chest wall movement. Although chest wall instability can lead to paradoxical motion of the chest wall during inspiration and expiration, this defect alone does not cause hypoxia. The major difficulty in flail chest stems from the injury to the underlying lung (pulmonary contusion). If the injury to the underlying lung is significant, serious hypoxia can result. Restricted chest wall movement associated with pain and underlying lung injury are major causes of hypoxia. Flail chest may not be apparent initially if a patient's chest wall has been splinted, in which case he or she will move air poorly, and movement of the thorax will be asymmetrical and uncoordinated. Palpation of abnormal respiratory motion and crepitation of rib or cartilage fractures can aid the diagnosis. A satisfactory chest x-ray may suggest multiple rib fractures, but may not show costochondral separation. Initial treatment of flail chest includes adequate ventilation, administration of humidified oxygen, and fluid resuscitation. In the absence of systemic hypotension, the administration of crystalloid intravenous solutions should be carefully controlled to prevent volume overload, which can further compromise the patient's respiratory status. The definitive treatment is to ensure adequate oxygenation, administer fluids judiciously, and provide analgesia to improve ventilation. The latter can be achieved with intravenous narcotics or local anesthetic administration, which avoids the potential respiratory depression common with systemic narcotics. The options for administration of local anesthetics include intermittent intercostal nerve block(s) and intrapleural, extrapleural, or epidural anesthesia. When used properly, local anesthetic agents can provide excellent analgesia and prevent the need for intubation. However, prevention of hypoxia is of paramount importance for trauma patients, and a short period of intubation and ventilation may be necessary until diagnosis of the entire injury pattern is complete. A careful assessment of the respiratory rate, arterial oxygen tension, and work of breathing will indicate appropriate timing for intubation and ventilation.

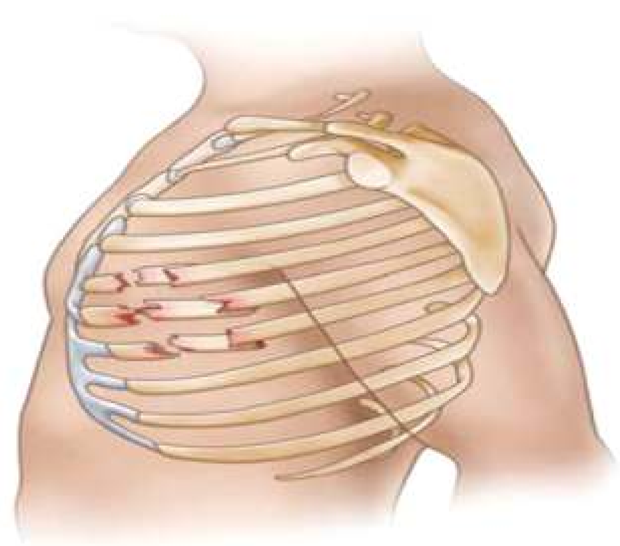


Figure 3 : Flail chest- where two or more subsequent chest ribs are broken at two or more sites give flail chest, which could be associated with pulmonary contusion specially in elderly age group.

Massive Haemothorax

Accumulation of blood and fluid in a hemithorax can significantly compromise respiratory efforts by compressing the lung and preventing adequate ventilation (Figure 4). Such massive acute accumulations of blood more dramatically present as hypotension and shock.

IMPORTANT: Both tension pneumothorax and massive haemothorax are associated with decreased breath sounds on auscultation. Differentiation on physical examination can be made by percussion; hyperresonance supports a pneumothorax, whereas dullness suggests a massive haemothorax. The trachea is often deviated in a tension pneumothorax, and the affected hemithorax can appear elevated without respiratory movement.

CIRCULATION :

The patient's pulse should be assessed for quality, rate, and regularity. In patients with hypovolemia, the radial and dorsalis pedis pulses may be absent

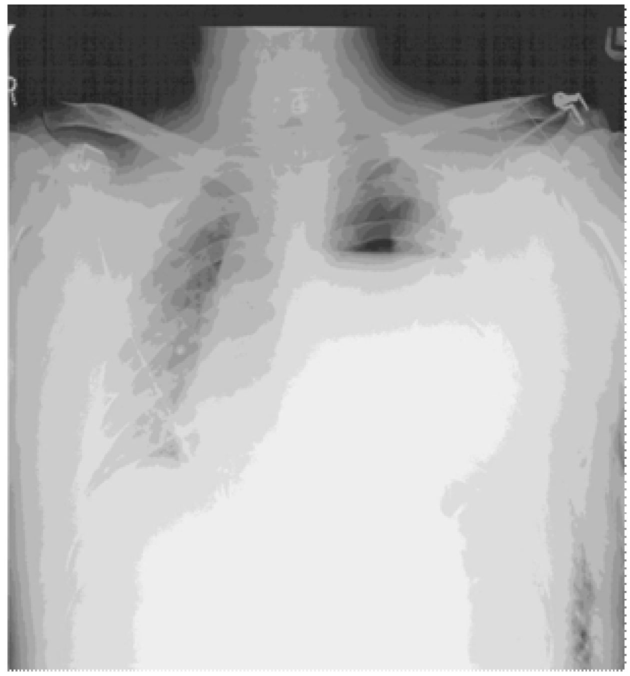


Figure 4 : In Massive hemo-thorax - chest X-rays showing whitening out of effected lung side.

because of volume depletion. Blood pressure and pulse pressure are measured and the peripheral circulation is assessed by observing and palpating the skin for color and temperature. Neck veins should be assessed for distention, however, keep in mind that neck veins may not be distended in patients with concomitant hypovolemia and either cardiac tamponade, tension pneumothorax, or a traumatic diaphragmatic injury. A cardiac monitor and pulse oximeter should be attached to the patient. Patients who sustain thoracic trauma especially in the area of the sternum or from arapid deceleration injury, are also susceptible to myocardial injury, which can lead to dysrrhythmias. Hypoxia and acidosis enhance this possibility. Dysrrhythmias should be managed according to standard protocols. Pulseless electric activity (PEA) is manifested by an electrocardiogram (ECG) that shows a rhythm while the patient has no identifiable pulse. PEA can be present in cardiac tamponade, tension pneumothorax, profound hypovolemia, and cardiac rupture. The major thoracic injuries that affect circulation and should be recognized and addressed during the primary survey are tension pneumothorax, massive haemothorax, and cardiac tamponade.

Massive Haemothorax

Massive haemothorax results from the rapid accumulation of more than 1500 mL of blood or one-third or more of the patient's blood volume in the chest cavity. It is most commonly caused by a penetrating wound that disrupts the systemic or hilar vessels. However, massive haemothorax can also result from blunt trauma. In patients with massive haemothorax, the neck veins may be flat as a result of severe hypovolemia, or they may be distended if there is an associated tension pneumothorax. Rarely will the mechanical effects of massive intrathoracic blood shift the mediastinum enough to cause distended neck veins. A massive haemothorax is suggested when shock is associated with the absence of breath sounds or dullness to percussion on one side of the chest. This blood loss is complicated by hypoxia. Massive haemothorax is initially managed by the simultaneous restoration of blood volume and decompression of the chest cavity. Large-caliber intravenous lines and a rapid crystalloid infusion are begun, and type-specific blood is administered as soon as possible. Blood from the chest tube should be collected in a device suitable for autotransfusion. A single chest tube (36 or 40 French) is inserted, usually at the nipple level, just anterior to the midaxillary line, and rapid restoration of volume continues as decompression of the chest cavity is completed. When massive haemothorax is suspected, prepare for autotransfusion. If 1500 mL of fluid is immediately evacuated, early thoracotomy is almost always required. Patients who have an initial output of less than 1500 mL of fluid, but continue to bleed, may also require thoracotomy. This decision is not based solely on the rate of continuing blood loss (200 mL/hr for 2 to 4 hours), but also on the patient's physiologic status. The persistent need for blood transfusions is an indication for thoracotomy. During patient resuscitation, the volume of blood initially drained from the chest tube and the rate of continuing blood loss must be factored into the amount of intravenous fluid required for replacement. The color of the blood (indicating an arterial or venous source) is a poor indicator of the necessity for thoracotomy. Penetrating anterior chest wounds medial to the nipple line and posterior wounds medial to the scapula should alert the practitioner to the possible need for thoracotomy because of potential damage to the great vessels, hilar structures, and the heart, with the associated potential for cardiac tamponade. Thoracotomy is not indicated unless a surgeon, qualified by training and experience, is present.

Cardiac Tamponade

Cardiac tamponade most commonly results from penetrating injuries. However, blunt injury also can cause the pericardium to fill with blood from the heart, greatvessels, or pericardial vessel. The human pericardial sac is a fixed fibrous structure; a relatively small amount of blood can restrict cardiac activity and interfere with cardiac filling. Cardiac tamponade may develop slowly, allowing for a less urgent evaluation, or may occur rapidly, requiring rapid diagnosis and treatment. The diagnosis of cardiac tamponade can be difficult in the setting of a busy trauma or emergency room. Cardiac tamponade is indicated by the presence of the classic diagnostic Beck's triad: venous pressure elevation (distended neck veins), decline in arterial blood pressure, and muffled heart sounds. However, muffled heart tones are difficult to assess in the noisy examination area, and distended neck veins may be absent due to hypovolemia. Additionally, tension pneumothorax, particularly on the left side, can mimic cardiac tamponade. Kussmaul's sign (a rise in venous pressure with inspiration when breathing spontaneously) is a true paradoxical venous pressure abnormality associated with tamponade. PEA is suggestive of cardiac tamponade, but can have other causes, as listed above. Insertion of a central venous line with measurement of central venous pressure (CVP) may aid diagnosis, but CVP can be elevated for a variety of reasons. Additional diagnostic methods include echocardiogram, focused assessment sonography in trauma (FAST), or pericardial window. In hemodynamically abnormal patients with blunt or penetrating trauma and suspected cardiac tamponade an examination of the pericardial sac for the presence of fluid should be obtained as part of a focused ultrasound examination performed by a properly trained provider in the emergency department (ED). FAST is a rapid and accurate method of imaging the heart and pericardium. It is 90–95% accurate for the presence of pericardial fluid for the experienced operator. Concomitant haemothorax may account for both false positive and false negative ultrasound exams. Prompt diagnosis and evacuation of pericardial blood is indicated for patients who do not respond to the usual measures of resuscitation for hemorrhagic shock and in whom cardiac tamponade is suspected. The diagnosis can usually be made with the FAST exam. If a qualified surgeon is present, surgery should be performed to relieve the tamponade. This is best performed in the operating room if the patient's condition allows. If surgical intervention is not possible, pericardiocentesis can be diagnostic as well as therapeutic, but it is not definitive treatment for cardiac tamponade. Although cardiac tamponade may be strongly suspected, the initial administration of intravenous fluid will raise the venous pressure and improve cardiac output transiently while preparations are made for surgery. If subxyphoid pericardiocentesis is used as a temporizing maneuver, the use of a plastic-sheathed needle or the Seldinger technique for insertion of a flexible catheter is ideal, but the urgent priority is to aspirate blood from the pericardial sac. If ultrasound imaging is available, it can facilitate accurate insertion of the needle into the pericardial space. Because of the propensity of injured myocardium to self-seal, aspiration of pericardial blood alone may temporarily relieve symptoms. However all patients with acute tamponade and a positive pericardiocentesis will require surgery to examine the heart and repair the injury. Pericardiocentesis may not be diagnostic or therapeutic when the blood in the pericardial sac has clotted. Preparation to transfer such a patient to an appropriate facility for definitive care is always necessary. Pericardiotomy via thoracotomy is indicated only when a qualified surgeon is available.

SIMPLE PNEUMOTHORAX

Pneumothorax results from air entering the potential space between the visceral and parietal pleura. Both penetrating and nonpenetrating trauma can cause this injury. Lung laceration with air leakage is the most common cause of pneumothorax resulting from blunt trauma. The thorax is normally completely filled by the lung, being held to the chest wall by surface tension between the pleural surfaces. Air in the pleural space disrupts the cohesive forces between the visceral and parietal pleura, which allows the lung to collapse. A ventilation/perfusion defect occurs because the blood that perfuses the nonventilated alveoli is not oxygenated. When a pneumothorax is present, breath sounds are often decreased on the affected side, and percussion may demonstrate hyperresonance. The finding of hyperresonance is extremely difficult to determine in a busy resuscitation bay. An upright, expiratory x-ray of the chest aids in the diagnosis. Any pneumothorax is best treated with a chest tube placed in the fourth or fifth intercostal space, just anterior to the midaxillary line. Observation and aspiration of a small, asymptomatic pneumothorax may be appropriate, but the choice should be made by a qualified doctor; otherwise, placement of a chest tube should be performed. Once a chest tube is inserted and connected to an underwater seal apparatus with or without suction, a chest x-ray examination is necessary to confirm reexpansion of the lung. Neither general anesthesia nor positive-pressure ventilation should be administered in a patient who has sustained a traumatic pneumothorax or who is at risk for unexpected intraoperative tension pneumothorax until a chest tube has been inserted. A simple pneumothorax can readily convert to a life-threatening tension pneumothorax, particularly if it is initially unrecognized and positivepressure ventilation is applied. The patient with a pneumothorax should also undergo chest decompression before transport via air ambulance due to the expansion of the pneumothorax at higher altitude, even in a pressurized cabin.

HAEMOTHORAX

The primary cause of haemothorax (<1500 mL blood) is lung laceration or laceration of an intercostal vessel or internal mammary artery due to either penetrating or blunt trauma. Thoracic spine fractures may also be associated with a haemothorax. Bleeding is usually selflimited and does not require operative intervention. An acute haemothorax large enough to appear on a chest x-ray film is best treated with a large-caliber (36 or 40 French) chest tube. The chest tube evacuates blood, reduces the risk of a clotted haemothorax, and, importantly, provides a method for continuous monitoring of blood loss. Evacuation of blood and fluid also facilitates a more complete assessment of potential diaphragmatic injury. Although many factors are involved in the decision to operate on a patient with a haemothorax, the patient's physiologic status and the volume of blood drainage from the chest tube are major factors. As a guideline, if 1500 mL of blood is obtained immediately through the chest tube, if drainage of more than 200 mL/hr for 2 to 4 hours occurs,or if blood transfusion is required, operative exploration should be considered. The ultimate decision for operative intervention is based on the patient's hemodynamic status.

PULMONARY CONTUSION

Pulmonary contusion can occur without rib fractures or flail chest, particularly in young patients in whom ribs are not completely ossified. However, in adults it is most commonly seen with concomitant rib fractures, and it is the most common potentially lethal chest injury. The resultant respiratory failure can be subtle, developing over time rather than occurring instantaneously. The plan for definitive management may change with time and patient response, warranting careful monitoring and reevaluation of the patient. Patients with significant hypoxia (i.e., PaO2 <65 mm Hg [8.6 kPa] or SaO2 <90%) on room air may require intubation and ventilation within the first hour after injury. Associated medical conditions, such as chronic obstructive pulmonary disease and renal failure, increase the likelihood of needing early intubation and mechanical ventilation. Pulse oximetry monitoring, ABG determinations, ECG monitoring, and appropriate ventilatory equipment are necessary for optimal treatment. Any patient with the aforementioned preexisting conditions who needs to be transferred should undergo intubation and ventilation.

TRACHEOBRONCHIAL TREE INJURY

Injury to the trachea or major bronchus is an unusual and potentially fatal condition that is often overlooked on initial assessment. In blunt trauma the majority of such injuries occur within 1 inch (2.54 cm) of the carina. Most patients with this injury die at the scene. Those who reach the hospital alive have a high mortality rate from associated injuries or delay in diagnosis of the airway injury. If tracheobronchial injury is suspected, immediate surgical consultation is warranted. Such patients typically present with haemoptysis, subcutaneous emphysema, or tension pneumothorax. Incomplete expansion of the lung after placement of a chest tube suggests a tracheobronchial injury, and placement of more than one chest tube often is necessary to overcome a significant air leak. Bronchoscopy confirms the diagnosis. Temporary intubation of the opposite mainstem bronchus may be required to provide adequate oxygenation. However, intubation of patients with tracheobronchial injuries is frequently difficult because of anatomic distortion from paratracheal hematoma, associated oropharyngeal injuries, and/orthe tracheobronchial injury itself. For such patients, immediate operative intervention is indicated. In more stable patients, operative treatment of tracheobronchial injuries may be delayed until the acute inflammation and edema resolve.

BLUNT CARDIAC INJURY

Blunt cardiac injury can result in myocardial muscle contusion, cardiac chamber rupture, coronary artery dissection and/or thrombosis, or valvular disruption. Cardiac rupture typically presents with cardiac tamponade and should be recognized during the primary survey. However, occasionally the signs and symptoms of tamponade are slow to develop with an atrial rupture. Early use of FAST can facilitate diagnosis. Patients with blunt myocardial injury may report chest discomfort, but this symptom is often attributed to chest wall contusion or fractures of the sternum and/or ribs. The true diagnosis of blunt myocardial injury can be established only by direct inspection of the injured myocardium. Clinically important sequelae are hypotension, dysrrhythmias, and/or wall-motion abnormality on two-dimensional echocardiography. The electrocardiographic changes are variable and may even indicate frank myocardial infarction. Multiple premature ventricular contractions, unexplained sinus tachycardia, atrial fibrillation, bundle-branch block (usually right), and ST-segment changes are the most common ECG findings. Elevated central venous pressure in the absence of an obvious cause may indicate right ventricular dysfunction secondary to contusion. It also is important to remember that the traumatic event may have been precipitated by a myocardial ischemic episode. The presence of cardiac troponins can be diagnostic of myocardial infarction. However, their use in diagnosing blunt cardiac injury is inconclusive and offers no additional information beyond that available from ECG. Patients with a blunt injury to the heart diagnosed by conduction abnormalities (an abnormal ECG) are at risk for sudden dysrrhythmias and should be monitored for the first 24 hours. After this interval, the risk of a dysrrhythmia appears to decrease substantially. Those without ECG abnormalities do not require further monitoring.

TRAUMATIC DIAPHRAGMATIC INJURY

Traumatic diaphragmatic ruptures are more commonly diagnosed on the left side, perhaps because the liver obliterates the defect or protects it on the right side of the diaphragm, whereas the presence of displaced bowel, stomach, and nasogastric (NG)tube is more easily detected in the left chest radiographically . Blunt trauma produces large radial tears that lead to herniation, whereas penetrating trauma produces small perforations that can take time, sometimes even years, to develop into diaphragmatic hernias. Diaphragmatic injuries are frequently missed initially when the chest film is misinterpreted as showing an elevated diaphragm, acute gastric dilatation, loculated hemopneumothorax, or subpulmonary hematoma. The appearance of an elevated right diaphragm on chest x-ray may be the only finding of a right-sided injury. If a laceration of the left diaphragm is suspected, a gastric tube should be inserted. When the gastric tube appears in the thoracic cavity on the chest film, the need for special contrast studies is eliminated. Occasionally, the condition is not identified on the initial x-ray film or subsequent CT scan. An upper gastrointestinal contrast study should be performed if the diagnosis is not clear. The appearance of peritoneal lavage fluid in the chest tube drainage also confirms the diagnosis. Minimally invasive endoscopic procedures (e.g., laparoscopy or thoracoscopy) may be helpful in evaluating the diaphragm in indeterminate cases. Operation for other abdominal injuries often reveals a diaphragmatic tear. Treatment is by direct repair.

BLUNT ESOPHAGEAL RUPTURE

Esophageal trauma most commonly results from penetrating injury. Blunt esophageal trauma, although very rare, can be lethal if unrecognized. Blunt injury of the esophagus is caused by the forceful expulsion of gastric contents into the esophagus from a severe blow to the upper abdomen. This forceful ejection produces a linear tear in the lower esophagus, allowing leakage into the mediastinum. The resulting mediastinitis and immediate or delayed rupture into the pleural space cause emphysema. The clinical picture of patients with blunt esophageal rupture is identical to that of postemetic esophageal rupture. Esophageal injury should be considered in any patient who has a left pneumothorax or haemothorax without a rib fracture; received a severe blow to the lower sternum or epigastrium and is in pain or shock out of proportion to the apparent injury; and has particulate matter in the chest tube after the blood begins to clear. The presence of mediastinal air also suggests the diagnosis, which often can be confirmed by contrast studies and/or esophagoscopy. Treatment consists of wide drainage of the pleural space and mediastinum with direct repair of the injury via thoracotomy, if feasible. Repairs performed within a few hours of injury lead to a much better prognosis.

Other Manifestations of Chest Injuries

Other significant thoracic injuries, including subcutaneous emphysema; crush injury (traumatic asphyxia); and rib, sternum, and scapular fractures, should be detected during the secondary survey. Although these injuries may not be immediately life-threatening, they have the potential to do significant harm.

SUBCUTANEOUS EMPHYSEMA

Subcutaneous emphysema can result from airway injury, lung injury, or, rarely, blast injury. Although it does not require treatment, the underlying injury must be addressed. If positive-pressure ventilation is required, tube thoracostomy should be considered on the side of the subcutaneous emphysema in anticipation of a tension pneumothorax developing.

CRUSH INJURY TO THE CHEST

(TRAUMATIC ASPHYXIA)

Findings associated with a crush injury to the chest include upper torso, facial, and arm plethora with petechiae secondary to acute, temporary compression of the superior vena cava. Massive swelling and even cerebral edema may be present. Associated injuries must be treated.

RIB, STERNUM, AND SCAPULAR FRACTURES

The ribs are the most commonly injured component of the thoracic cage, and injuries to the ribs are often significant. Pain on motion typically results in splinting of the thorax, which impairs ventilation, oxygenation, and effective coughing. The incidence of atelectasis and pneumonia rises significantly with preexisting lung disease. The upper ribs (1 to 3) are protected by the bony framework of the upper limb. The scapula, humerus, and clavicle, along with their muscular attachments, provide a barrier to rib injury. Fractures of the scapula, first or second rib, or the sternum suggest a magnitude of injury that places the head, neck, spinal cord, lungs, and great vessels at risk for serious associated injury. Because of the severity of the associated injuries, mortality may be as high as 35%. Sternal and scapular fractures are generally the result of a direct blow. Pulmonary contusion may accompany sternal fractures, and blunt cardiac injury should be considered with all such fractures. Operative repair of sternal and scapular fractures occasionally is indicated. Rarely, posterior sternoclavicular dislocation results in mediastinal displacement of the clavicular heads with accompanying superior vena caval obstruction. Immediate reduction is required. The middle ribs (4 to 9) sustain the majority of blunt trauma. Anteroposterior compression of the thoracic cage will bow the ribs outward with a fracture in the midshaft. Direct force applied to the ribs tends to fracture them and drive the ends of the bones into the thorax, increasing the potential for intrathoracic injury, such as a pneumothorax or haemothorax. As a general rule, a young patient with a more flexible chest wall is less likely to sustain rib fractures. Therefore, the presence of multiple rib fractures in young patients implies a greater transfer of force than in older patients. Fractures of the lower ribs (10 to 12) should increase suspicion for hepatosplenic injury. Localized pain, tenderness on palpation, and crepitation are present in patients with rib injury. A palpable or visible deformity suggests rib fractures. A chest x-ray film should be obtained primarily to exclude other intrathoracic injuries and not just to identify ribfractures. Fractures of anterior cartilages or separation of costochondral junctions have the same significance as rib fractures, but will not be seen on the x-ray examinations. Special rib-technique x-rays are not considered useful because they may not detect all rib injuries and add nothing to treatment decisions, whereas they are expensive and require painful positioning of the patient. The presence of rib fractures in the elderly should raise significant concern, as the incidence of pneumonia and mortality is double that in younger patients. Taping, rib belts, and external splints are contraindicated. Relief of pain is important to enable adequate ventilation. Intercostal block, epidural anesthesia, and systemic analgesics are effective and may be necessary. Early and aggressive pain control, including the use of systemic narcotics and local or regional anesthesia, improves outcome in this population. Increased use of CT has resulted in the identification of injuries not previously known or diagnosed, such as minimal aortic injuries and occult pneumothoraces and haemothoraces. Appropriate treatment of these occult injuries should be discussed with the relative specialty consultant.

CHAPTER 5 ABDOMINAL TRAUMA

Introduction

Accidents are a counter product of modernization and hasty life and are considered as a modern day epidemic. The statistical profile reflects a global estimate of 5.1 million deaths in 2000.Road Traffic Accident (RTA) is one among the top five causes of morbidity and mortality in South-East Asian countries. The fatality rate in road traffic accident in India is one of the highest in the world and reported to be 20 times more than that reported in developed countries. Blunt abdominal trauma (BAT) is one of the leading causes of mortality among trauma victims. It is the main cause of death in people under 35 years of age worldwide. Most common cause of blunt abdominal trauma in India is road traffic accident followed by pedestrian accidents, abdominal blows, and fall from heights. This ever-expanding epidemic targeting the young and productive generations is likely to take a heavy burden on the quality of life and socio-economic growth of the region.

I. Anatomy of Abdomen: various quadrants

The abdomen is divided into nine quadrants which are described in Figure 1 below. The knowledge of quadrant is important as it leads to identification of the organ injured, if that particular quadrant is involved.

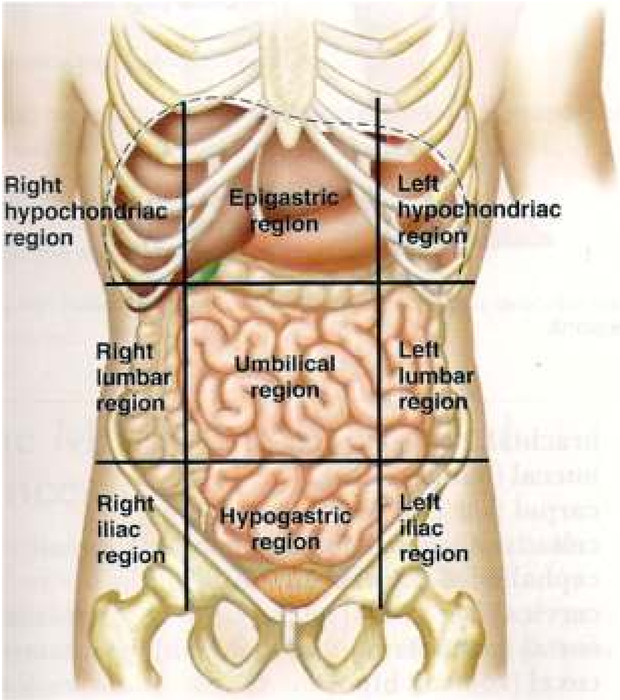


Figure 1: Anatomy of Abdominal quadrants

II. Classifications of abdominal injury

A. Based on aetiology abdominal trauma is divided into blunt and penetrating types. Penetrating trauma is further subdivided into stab wounds and gunshot wounds, which require different methods of treatment.

B. Injuries are often categorized by type of structure that is damaged:

1. Abdominal wall.
2. Solid organ (liver, spleen, pancreas, kidneys).
3. Hollow Viscus (Stomach, Small intestine, Colon, Ureters, and Bladder)
4. Vasculature

C. Based on severity of injury of abdominal viscera:

Injury scales have been devised that classify organ injury severity from grade 1 (minimal) to grades 5 or 6 (massive). The mortality and need for operative repair increase as grade increases. Scales exist for the liver, spleen and kidneys.

III. Mechanisms of injury

Intra-abdominal injuries secondary to blunt force are attributed to collisions between the injured person and the external environment and to acceleration or deceleration forces acting on the person's internal organs. Blunt force injuries to the abdomen can generally be explained by three mechanisms.

1. The first mechanism is rapid deceleration. Rapid deceleration causes differential movement among adjacent structures. As a result, shear forces are created and cause

hollow, solid, visceral organs and vascular pedicles to tear, especially at relatively fixed points of attachment. For example, the distal aorta is attached to the thoracic spine and decelerates much more quickly than the relatively mobile aortic arch. As a result, shear forces in the aorta may cause it to rupture.

2. The second mechanism involves crushing: Intra-abdominal contents are crushed between the anterior abdominal wall and the vertebral column or posterior thoracic cage. This produces a crushing effect, to which solid viscera (eg, spleen, liver, kidneys) are especially vulnerable.

3. The third mechanism is external compression-Whether from direct blows or from external compression against a fixed object (eg, lap belt, spinal column). The liver and spleen seem to be the most frequently injured organs, though reports vary. The small and large intestines are the next most frequently injured organs.

IV. Assessment:

If the patient is hypotensive our goal should be to rapidly determine whether any abdominal or pelvic injury is present and whether hypotension is due to that injury. This may need repeated examination to determine whether signs of bleeding or peritonitis develop over time.

a. History-

Can be provided by patient, passengers, police or medical emergency personnel. In motor vehicle accident speed of vehicle,type of collision, vehicle intrusion in passenger's compartment type of restraints, deployment of airbags becomes important.When assessing a patient with penetrating trauma time of injury, type of injury,type of weapon,distance from assailant becomes important.

b. Physical examination:-

To determine whether abdominal or pelvic injury physical examination should be done meticulously and systematically in standard sequence of inspection, auscultation palpation, percussion and Inspection-Undress the patient fully and look for abrasion,laceration,foreign bodies,and any penetrating wound over anterior or posterior aspect of abdomen lower part of chest,pelvis,if log roll needed it can be done to complete examination. Quick look over flank,scrotum, vagina,buttock, blood at urethral meatus should be inspected. Remember to prevent from hypothermia during whole procedure.

c. Auscultation-

Auscultate for bowel sounds as free intraperitoneal blood or gastrointestinal content or extra abdominal injury can cause ileus and loss of bowel sound.

d. Palpation and Percussion-

Percussion can be useful to elicit sign of peritoneal irritation, when present we should avoid rebound tenderness otherwise it may cause unnecessary pain.

e. Assessment of pelvic stability

Unexplained hypotension may be the only indication for pelvic assessment as pelvic hemorrhage occurs rapidlyand early recognition is must for appropriate resuscitative treatment. This procedure should be done only once during physical examination, as its repeated testing may further increase bleeding.

f. Urethral, perineal and rectal examination:- The presence of blood at meatus strongly suggests a urethral injury; Foley's catheters should not be placed in patients with perineal hematoma or high riding prostate.

g. Adjunct to physical examination

GastricTube-Therapeutic goals of inserting gastric tube is to relieve acute gastric dilatation.In case of severe facial fracture or suspected basilar fracture gastric tube should be inserted through the mouth to prevent accidental passage of the tube through cribriform plate into the brain.

Urinary catheter-The goals of inserting urinary catheter in resuscitation process is to relieve distension, allow for urinary output as an index for tissue perfusion. The inability to void,blood at meatus,high lying prostate,scrotal hematoma mandate urethrogram and a disrupted urethra needs supra pubic cystostomy.

V. Investigations:

a) Comparison of FAST,DPL AND CT in Blunt abdominal trauma

1. Hepatorenal
2. Lienorenal
3. Pelvis
4. Pericardial

b) Contrast studies-A number of contrast studies can be done to aid diagnosis but should not delay the care of patients who are hemodynamically unstable viz

a. Urethrography
b. Cystography
c. Intravenous pyelogram
d. Gastrointestinal contrast studies

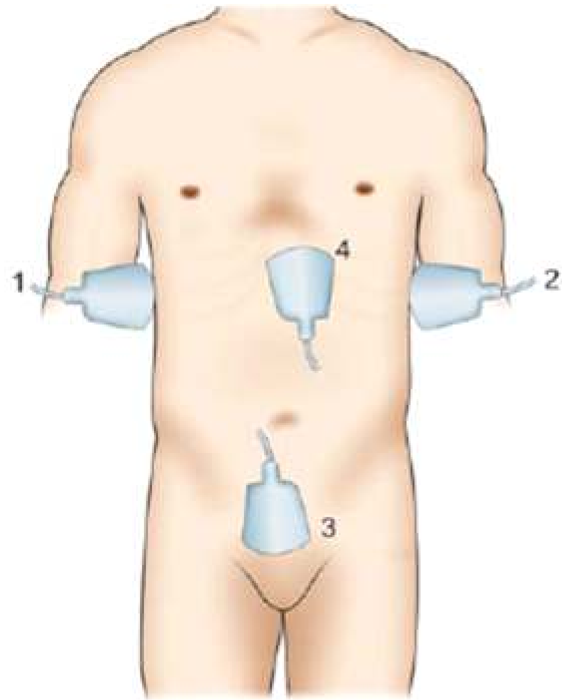


Figure 2 : Focussed Abdominal Sonography in Trauma: Four quadrants which have to be visualized

VI. Treatment

a) Prehospital care :

Focuses on rapidly evaluating life-threatening problems, initiating resuscitative measures and

	DPL	FAST (Figure 2)	CT SCAN
Advantages	**Early diagnosis.** **Performed rapidly** **No transportation required.** **Detects bowel injury** **98% sensitivity**	Early diagnosis. Performed rapidly No transportation required 86-96% sensitivity Non invasive	Non invasive 86-96% sensitivity Most specific
Disadvantages	Invasive Misses injury to diaphragm and retro peritoneum Low specificity	Depends on operator Misses bowel diaphragm, and pancreatic injuries	Costly Misses boweldiaphragm, and pancreatic injuries. Transportation required
Indications	Unstable blunt trauma Penetrating trauma	Unstable blunt trauma	Stable blunt trauma Penetrating trauma of back and flank

initiating prompt transport to a definitive care site. Hence, securing the airway, placing large-bore intravenous (IV) lines, and administering i.v. fluid must take place en route, unless transport is delayed.

b) In-hospital management :

The approach should be as a general dictum for each and every trauma case. Our approach should be ABCDE approach. In case of abdominal trauma special emphasis should be placed on circulation. External haemorrhage rarely is associated with blunt abdominal trauma. If external bleeding is present, control it with direct pressure. Titrate Intravenous fluid therapy to the patient's clinical response Intravenous fluids should be titrated to a systolic blood pressure of 90-100 mm Hg. Ongoing haemorrhageis suggested by worsening hemodynamic status, significant ongoing transfusion needs (e.g. more than 2 to 4 units over a 12-h period) significant decrease in Hct (e.g. by > 10 to 12%), patients suspected of significant ongoing haemorrhage should be considered for angiography with embolization or immediate laparotomy.Prophylactic antibiotics are not indicated when patients are managed without surgery. However, antibiotics are often given before surgical exploration when patients develop an indication for surgery.

c) Laparotomy

Indications for laparotomy in a patient with blunt abdominal injury include the following:

i. Blunt abdominal trauma with hypotension with a positive FAST

ii. Blunt or penetrating abdominal trauma with a positive DPL

iii. Hypotension with penetrating abdominal trauma

iv. Gunshot injury traversing the peritoneal cavity

v. Evisceration

vi. Peritonitis

vii. Bleeding from the stomach,rectum,or genitourinary tract from penetrating trauma.

d) **Angiographic embolization :** Ongoing bleeding can sometimes be stopped without surgery by embolizing the bleeding vessel using a percutaneous angiographic procedure (angiographic embolization). Haemostasis is obtained by injecting a thrombogenic substance (e.g., powdered gelatin) or metallic coils into the bleeding vessel.

PELVIC FRACTURES AND ASSESSMENT: Patients with hypotension and pelvic fractures have a high mortality so sound and quick decision is very important. Disruption of pelvic ring tears the pelvic venous plexus and occasionally disrupts the internal iliac arterial system. Mortality varies from 5-50% depends upon type of fracture and association of hypotension.

Management of pelvic fracture : Initial management of pelvic disruption with hypotension is haemorrhage control and fluid resuscitation. Haemorrhage control is achieved through mechanical stabilisation of pelvic ring and external counter pressure (Figure 3). Pelvic binder or sheet or any other device can apply sufficient stability for unstable pelvis at the level of greater trochanters of the femur (Figure 4). Definitive care of patients with hemodynamic abnormalities demands the cooperative efforts of a team.A treatment algorithm based on the hemodynamic status for emergency patient is shown below.

SUMMARY

1. Once the patient's vital functions have been restored, early consultation with surgeon is necessary.

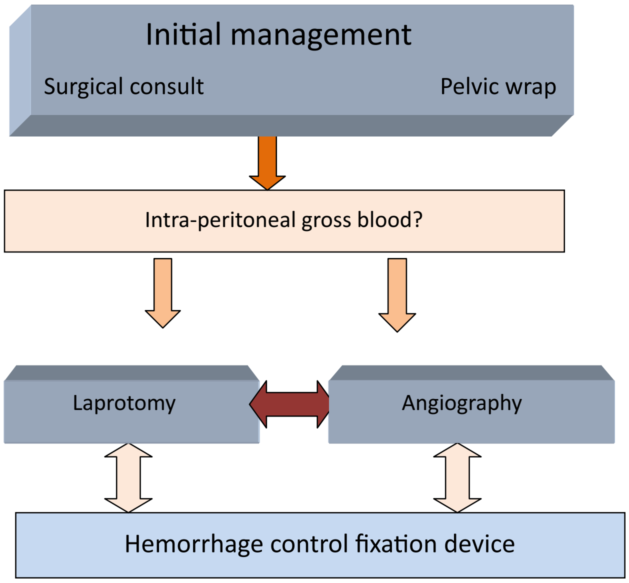


Figure 3: Pelvic fractures and hemorrhagic shock management algorithm.

Figure 4: Pelvic binder

2. Hemodynamically unstable patients with multiple blunt injuries should be rapidly assessed for intra-abdominal bleed by performing FAST or DPL.

3. Management of blunt and penetrating trauma to the abdomen and pelvis includesprompt recognition of sources of hemorrhage with effort to control either with laparotomy, pelvic stabilizations and angiographic embolization

4. Re-establish ABCDE: Meticulous initial physical examination at regular intervals & selecting special diagnostic maneuvers as needed.

Whenever in doubt that pelvic injury is there or not, it is always better to apply pelvic binder because it will not harm the patient

CHAPTER 6 HEAD INJURY

A Clinical Case :

A 25 year old man has been brought to your casualty in a tractor trolly. He was driving a motorcycle without wearing a helmet and was speeding up when he had a head on collision with a jeep. He was thrown off the highway. When you receive him he is unconscious and breating heavily. There is active bleeding from a scalp wound and the pulse is thready with tachycardia. The CT scan shows large extra dural haematoma (Figure 1)

Figure 1 : CT Scan showing extra dural haematoma

Objectives :

1. Deciding whether patient has head injury
2. Evaluating the severity of injury
3. Initial basic management of head injured patients
4. Prevention of secondary damage
5. Planning of transfer

Introduction

Every medical officer has to invariably face this sensitive situation very frequently during their practice. In the setting of acute head injury, give priority to the immediate assessment and stabilization of the airway and circulation. Following stabilization, direct attention to prevention of secondary injury.

The basic management of head injury rests on the ATLS principles where the sequence of steps remain as ABCDE. There may be a confusion with ACLS guidelines that the sequence should be CAB. It is to be noted here that in ACLS it is presumed that the patient already has a cardiac arrest and hence requires cardiac massage first. Whereas in trauma cases it is not known whether the patient has cardiac or a respiratory arrest. In such a circumstance the dictum is to treat that pathology first which kills first. And of course a lack of oxygen for four minutes can cause similar irreversible damage that can be caused by a 20 min hypotension (SBP<90mmHg). So always remember that whenever you are dealing with a case of trauma follow the ATLS principle of ABCDE.

Overview of cranial anatomy: as shown in figure 2

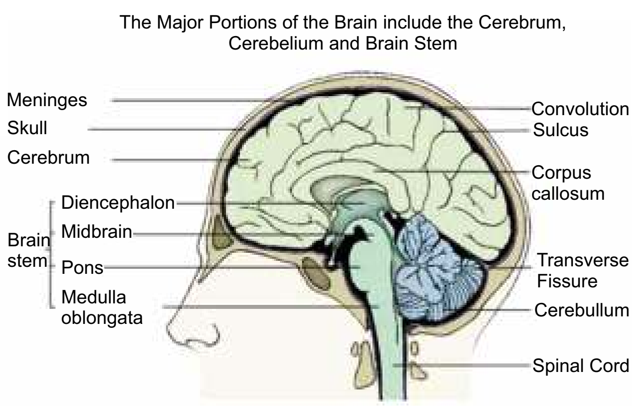


Figure 2 : Cranial anatomy

What constitutes head Injury :

Not every injury to the head and neck region constitute head injury. Only certain types of head and neck injuries qualify for this category.

- Skull fractures

- Vault
- Base of skull

• Meningeal injuries

• Vascular injuries

• Parenchymal Brain injury
  - Microscopic
  - Macroscopic

What does not constitute head Injury:

• Scalp injury
  - Lacerations and abrasions
  - Edema and subgaleal hematomas

• Facial injuries

• Purely orbital injuries without skull base #

Uniqueness of Head Injury:

Monro-Kellie Doctrine & Volume-Pressure Curve:

The cranium is a fixed volume cavity which is shared by three physiological components namely – brain, blood and cerebrospinal fluid (Figure 3). Any lesion which is caused by head injury displaces these normal components to accommodate itself, as shown in the figure.

Accordingly the pressure volume cure follows a parabolic curve with sudden decompensation after a certain level as shown in the graph. In clinical setting this leads to sudden deterioration in the patient condition which if goes unchecked becomes lifethreatening due to cerebral herniations.

Suspecting Head Injury:

The most important question which comes to mind in such situation is how do we suspect that the patient might have sustained head injury during the accident or assault. The dictum here is that any patient involved in an accident or fight and had one of the following features qualifies as a case of head injury:

- Having any signs of head or neck injury
- Bleeding from Ear, Nose and Throat
- Altered sensorium – confused, delerious, comatose....
- Had a seizure or episode of LOC
- Having symptoms or signs of neurological deficit

All these patients should be treated as having head

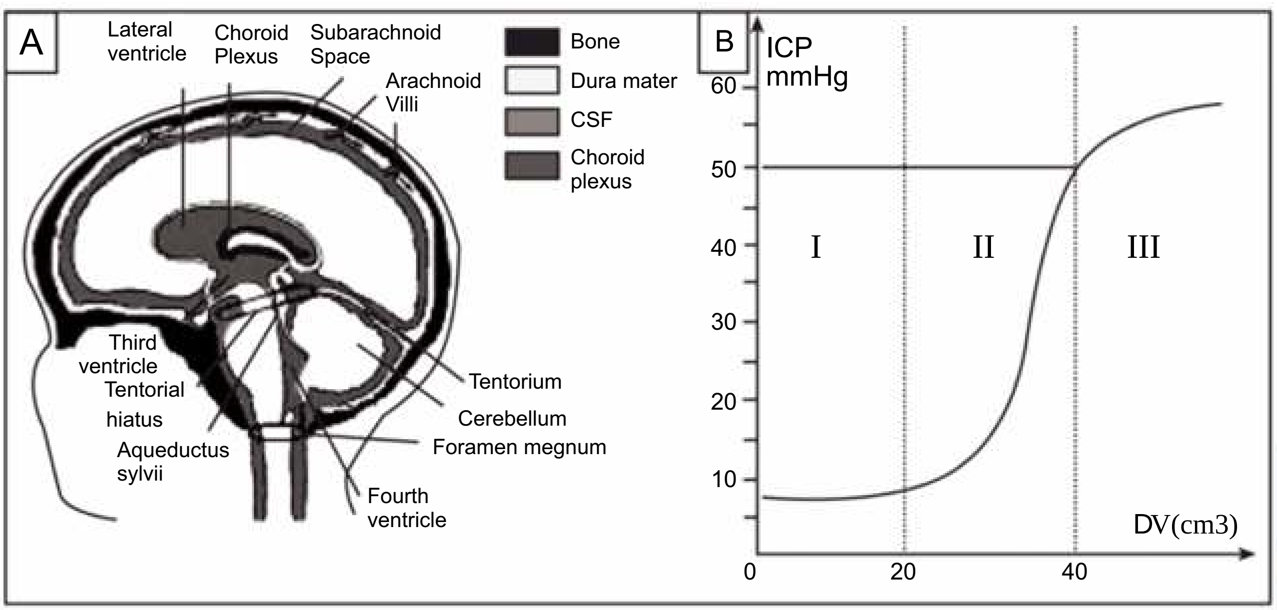


Figure 3: Monro Kellie Doctrine and Volume- Pressure Curve

injury unless proven otherwise and should be managed accordingly.

Pathology of head injury :

Before coming to the management of head injury in particular, the treating clinician should know what does it mean when we say that the patient had head injury. There are two aspects. The first is the primary injury which occurs at the time of impact. This injury caused by the direct physical force transmitted to the head and neck region and is present immediate after the event. This primary damage can be focal (Fracture ,Contusion, Hematoma (EDH/SDH)) or diffuse (DAI (Diffuse Axonal Injury), DVI (Diffuse Vascular Injury), Diffuse brain swelling) .

Managing head injury patients at primary health care centers:

REMEMBER WHO IS YOUR PATIENT: Mostly a healthy child or a working adult with no or minimal co-morbidities. These patient will respond best to your targeted treatment as their physiology has maximum compensatory capacity. They can fight back the insult best if given the correct management.

IMPORTANT: The primary injury needs specialist investigative, operative and neurointensive care procedures for management which are not available at primary care centers.

What we are concerned here is the secondary injury, which is caused by other factors that compound the effects or primary injury and lead to further damage. These compounding factors include those conditions which can be managed by you at your primary care center, thus preventing further brain damage. These include the six – H:

– BP -Hypotension
– Temp -Hyperthermia/Hypothermia
– Electrolytes -Hyponatremia
– B Sugar -Hyperglycemia/Hypoglycemia
– ABG -Hypoxia
-Hypercarbia

If these factors are managed successfully the chances of developing secondary injury are reduced thus increasing chances of survival (more importantly meaningful survival).

Table 1 : Glasgow Coma Scale (GCS)

Eye Opening Response	Sponteneous –open with blinking at baseline	4 points
	Open to verbal command, speech, or shout	3 points
	Open to pain, not applied to face	2 points
	None	1 point
Verbal Response	Oriented	5 points
	Confused conversation, but able to answer questions	4 points
	Inappropriate responses, words discemible	3 points
	Incomprehensible speech	2 points
	None	1 points
Motor Response	Obeys commands for movement	6 points
	Purposeful movement to painful stimulus	5 points
	Withdraws from pain	4 points
	Abnormal (spastic) flexion, decorticate posture	3 points
	Extensor (rigit) response, decerebrate posture	2 points
	None	1 points

Initial Examination and ABC:

- History
- Vitals – pulse , BP, Temp., Resp.
- External Signs of Injury
- Consciousness- GCS
- Pupils
- Vision
- Limbs Watch the moments of all limbs

U/L paralysis -- Injury to Brachial Plx or Cx. Spine

L/L paresis – Injury to spine

Repeat Examinations:

- GCS Every 4 -6 Hrs
- Pupil Size / Reaction – every 30minutes to 2 hours.
- Neurological Sign
- Vitals

Glasgow coma scale

The Glasgow Coma Scale or GCS is a neurological scale that aims to give a reliable, objective way of recording the conscious state of a person for initial as well as subsequent assessment (Table 1). A patient is assessed against the criteria of the scale, and the resulting points give a patient score between 3 (indicating deep unconsciousness) and either 14 (original scale) or 15 (the more widely used modified or revised scale).

Clinically grading head injury and decision making:

Minimal Head injury: GCS 15 at the time of examining the patient. H/o loss of consciousness (LOC) for less than 5 min. No deficits. Observe for 24 hours with repeated checks. In case of any deterioration, refer to higher center after stabilization.

Mild head injury : GCS 15 with LOC > 5 min. Observe for 48 hours. In case of any deterioration, refer to higher center after stabilization.

GCS 14 +/- LOC. Observe, if GCS not improving within 6 hours, stabilize and refer.

Moderate head injury : GCS 9 to 13. Stabilize and early referral to higher center.

Severe head injury : GCS <9. Stabilize and early referral to higher center.

Special circumstances

Children : Even small scalp lacerations or even subgaleal hematomas can lead to shock in case of small children. They may not be able to give specific complaints and neurological examination is not always easy. Thus always keep a low threshold to respond and refer early. But remember that promary management remains the same

Elderly: Due to blunting of autonomic reflexes and existing chronic diseases, elderly patients also need to be given special attention with a low response threshold for response and early referral.

Fluid management

In a case of head injury patient the blood brain barrier is physically as well as chemically disrupted. Thus the brain's capacity to keep out edema fluid is lost. In such situations any hypotonic fluid like 5% dextrose IV will lead to increased cerebral edema and accentuated secondary brain damage. The best fluid for any head injury patient in the primary setting is normal saline. In case if patient is also hypoglycaemic, calculated amounts of DNS can be given. All other hypotonic solutions are contraindicated. Even when treating shock use NS rather than RL.

Role of mannitol, steroids and antiepileptics

Mannitol

In a patient with suspected head injuty, the nature of pathology can be defined only after a CT scan brain has been done. Unless an extradural hemorrahage has been ruled out, mannitol should not be administered as it may lead to expansion of the EDH. Additionally in a patient who has been received with shock, mannitol infusion without bringing back systolic blood pressure to normal range can leas to sudden hypotension and further secondary damage.

Steriod

No scientific study has proven that there is any role of steroids in the management of head injury patients. These are more harmful than beneficial to the head injured patients. Hence for any patient with head injury, use of steroids is contraindicated.

Antiepileptics

When suspecting head injury:

Minimal – Do not start AEDs till need arises

Mild – One week course of AEDs

Moderate to severe – Start AEDs early and give adequate coverage during transfer.

The best AED which is easily available is phenytoin sodium which has a loading dose of 20mg/kg and maintenance dose of 3-5 mg/kg.

CHAPTER 7 BURNS, THERMAL AND ELECTRICAL INJURIES

Contents:

INTRODUCTION :

Burns are one of the most devastating conditions encountered in medicine. The injury represents an assault on all aspects of the patient, from the physical to the psychological. It affects all ages, from babies to elderly people, and is a problem in both the developed and developing world. Thermal injuries are responsible for high morbidity and mortality. To decrease the high morbidity and mortality associated with burns, it is necessary to apply the principles of initial trauma resuscitation and the timely application of simple emergency measures.

Burns are also a major problem in the developing world. Over two million burn injuries are thought to occur each year in India, but this may be a substantial underestimate. Mortality in the developing world is much higher than in the developed world.

This chapter provides an overview of the most important aspects of burn injuries for hospital and non-hospital healthcare workers.

ASSESSMENT OF BURN PATIENT

TOTAL BURN SURFACE AREA (TBSA)

There are three commonly used methods of estimating burn area, and each has a role in different scenarios. When calculating burn area, erythema should not be included.

Wallace Rule of Nines (Figure 1) — The "rule of nines" is a simple, quick and relatively accurate method of estimating TBSA burned in adults. The body is divided into areas of 9%, and the total burn area can be calculated. It is not accurate in children.

Palmar Surface— The surface area of a patient's palm (including fingers) is roughly 1% of total body surface area. Palmar surface can be used to estimate relatively small burns (< 15% of total surface area) or very large burns (> 85%, when unburnt skin is counted). For medium sized burns, it is inaccurate.

Lund and Browder Chart (Figure 2)—This chart, if used correctly, is the most accurate method. It compensates for the variation in body shape with age and therefore can give an accurate assessment of burns area in children.

It is important that all of the burn is exposed and assessed. During assessment, the environment should be kept warm, and small segments of skin exposed sequentially to reduce heat loss.

Head = 9% (Front & Basic)

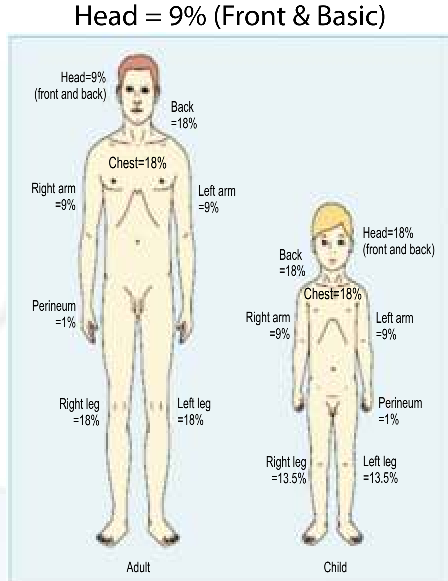
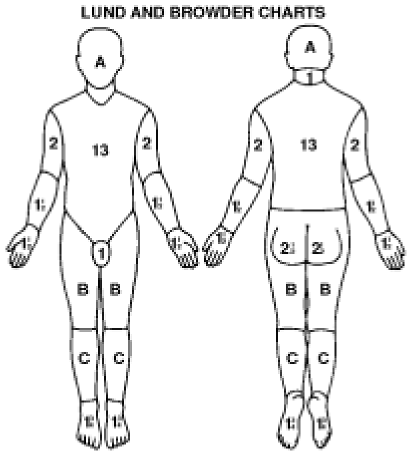


Figure 1 : Wallace Rule of Nines

A BURN CHART

NAME______________ WARD_______ NUMBER______ DATE__________

AGE _______



Ignore simple erythema.

Superficial

Deep

REGION	%
HAED	
NECK	
ANT. TRUNK	
POST. TRUNK	
RIGHT ARM	
LEFT ARM	
BUTTOCKS	
GENITALIA	
RIGHT LEG	
LEFT LEG	
TOTAL BURN	

RELATIVE PERCENTAGE OF BODY SURFACE AREA AFFECTED BY AGE

AREA	AGE 0	1	5	10	15	ADULT
A = 1/2 OF HEAD	9 1/2	8 1/2	6 1/2	5 1/2	4 1/2	3 1/2
B = 1/2 OF THIGH	2 3/4	3 1/4	4	4 1/2	4 1/2	4 3/4
C = 1/2 OF ONE LOWER LEG	2 1/2	2 1/2	2 3/4	3	3 1/4	3 1/2

Figure 2 : Lund & Browder Chart

CLASSIFICATION OF BURNS DEPTH

In order to classify burn depth, it is imperative to have the knowledge of normal anatomy of the skin. (Figure 3) the burn affects the healing of the wound, making assessment of burn depth important for appropriate wound management and, ultimately, the decision for operative intervention.

1. Superficial burns(First Degree) (Figure 4 & 5) involve the epidermis only and are erythematous and painful, but no blisters. These

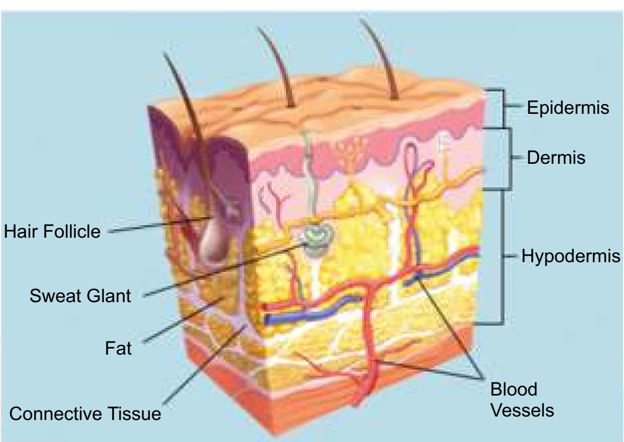


Figure 3 : Anatomy of the Skin

Figure 4 : Classification of Burns depth

Figure 5 : Superficial burns(First Degree)

Figure 6 : Superficial Partial-thickness burns (Second Degree- Superficial)

burns typically heal within 3 to 5 days. These burns are not included in burn assessment. E.g. Sunburn.

2. Partial-thickness burns (Second Degree) involve the entirety of the epidermis and a portion of the dermis.

   a) Superficial partial-thickness burns (Second Degree- Superficial) are typically pink, moist, and painful to the touch. Blisters,

Figure 7 : Deep Partial-thickness burns (Second Degree- Deep)

bullae, clear serous fluid is present. Epidermis and papillary region of dermis is involved. These burns typically heal within 2 weeks and generally do not result in scarring, but could result in alteration of pigmentation. E.g. Water scald burns, flame, flash & contact burns (Figure 6).

   b) Deep partial-thickness burns (Second Degree- Deep)involve the entirety of the epidermis and extend into the reticular portion of the dermis. These burns are typically dry and mottled pink and white in appearance and have variable sensation. If protected from infection, deep partial-thickness burns will heal within 3 to 8 weeks. They will typically heal with contraction, scarring, and possible contractures (Fig. 7).

Figure 8 : Full-thickness burns (Third Degree)

Figure 9 : Types of burns.

3. Full-thickness burns (Third Degree) involve the epidermis and the entirety of the dermis. These wounds are brown-black, leathery, and insensate. Occasionally, full-thickness burn wounds have a cherry-red color from fixed carboxyhemoglobin in the wound. These wounds can be differentiated from more superficial burns because they are usually insensate and do not blanch (Figure 8).

   The anatomical and clinical features of all the three major types of burn are summarised in figure 9.

FLUID RESUSCITATION/ THERAPY OF BURN PATIENT

Fluid losses from the injury must be replaced to maintain homoeostasis. There is no ideal resuscitation regimen, and many are in use. All the fluid formulas are only guidelines, and their success relies on adjusting the amount of resuscitation fluid against monitored physiological parameters.

Simple, safe and inexpensive formula for calculating resuscitation volume is 2 - 4 mL/kg/% TBSA of Lactated Ringer's solution over the first 24 hours of injury. Half of this volume is given over the first 8 hours and half over the next 16 hours after injury.

{Example: A 50 kg man with 80% total BSA burns requires (2 to 4 X 50 X 80 = 8000 to 16000 ml in 24 hours) One-half of that volume, 4000 to 8000 ml should be provided in the first 8 hours, so the patient should be started at a rate of 500–1000 ml/hr. Another half of the fluid volume is given in next 16 hours.}

It is important to keep in mind that the volume calculated is to be given from the time of injury and not from the time of initial evaluation of the patient. Also, these formulas are merely a starting point and that precise monitoring of the patient's status should be used to fine-tune fluid replacement. Urine output remains an excellent guideline for the adequacy of fluid replacement. An output of 0.5 ml/kg/hour for adults and greater than 1.0 ml/kg/hour for children is used as a guideline for adequate fluid resuscitation. Decrease or increase in IV fluid rate should be based on urine output.

MANAGEMENT OF A PATIENT WITH BURNS (Figure 10):

IMMEDIATE: (by rescue workers, at site of accident/ burn injury)

STOP the BURNING PROCESS - The heat source should be removed. Flames should be doused with water or smothered with a blanket or by rolling the victim on the ground. Rescuers should take care to avoid burn injury to them. Clothing can retain heat, even in a scald burn, and should be removed as soon as possible. Adherent material, such as nylon clothing, should be left on. Tar burns should be cooled with water, but the tar itself should not be removed. In the case of electrical burns the victim should be disconnected from the source of electricity before first aid is attempted.In the case of chemical burns, remove clothing, dry chemical powder dusted off if any, and then irrigate with copious amount of water.

COOLING THE BURN - Active cooling removes heat and prevents progression of the burn. This is effective if performed within 20 minutes of the injury.

Initial assessment of a major burn

Perform an ABCDEF primary survey:

A – Airway with cervical spine control

B – Breathing

C – Circulation

D – Neurological disability

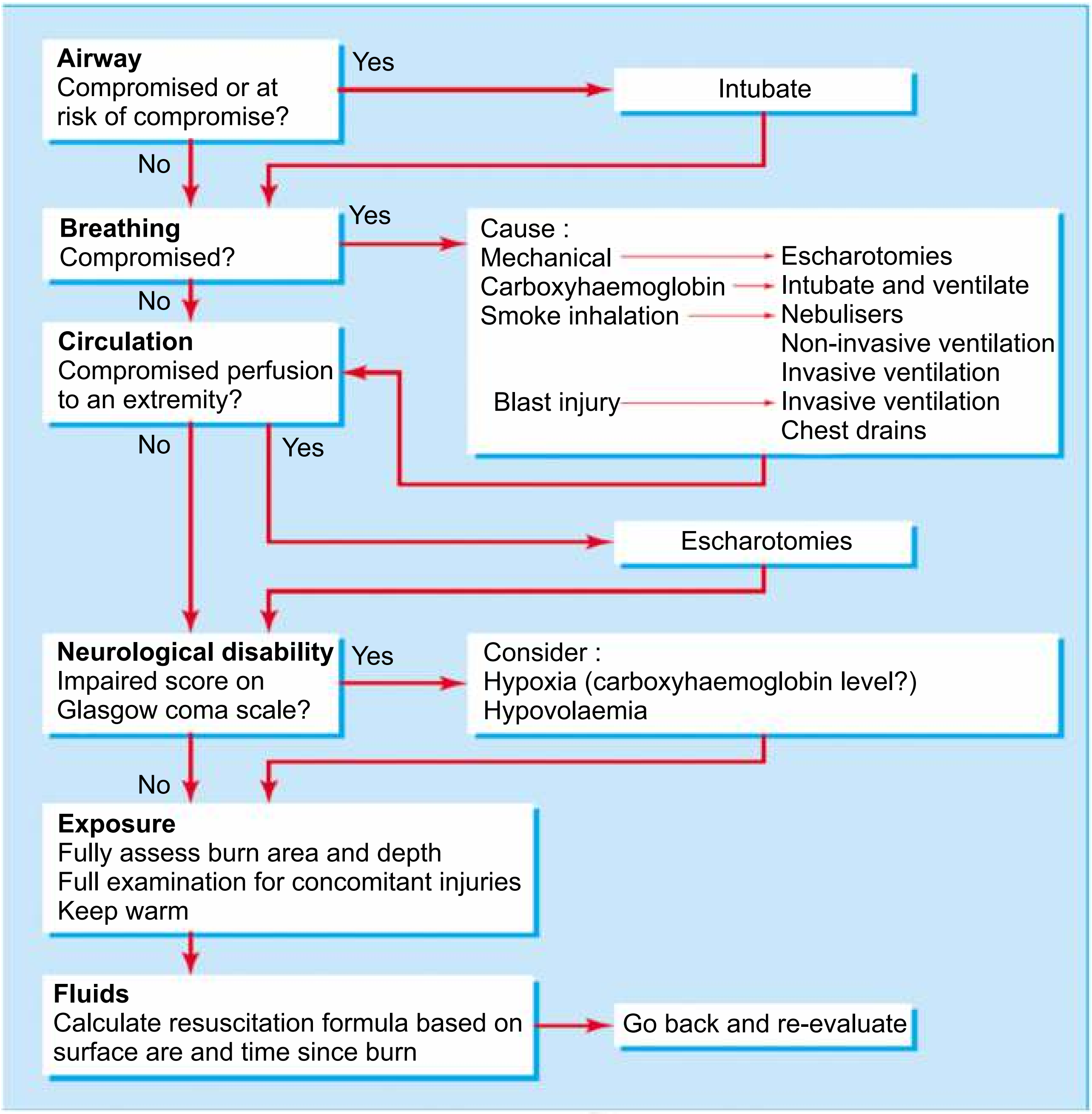


Figure 10 : Stepwise management burn patient.

E – Exposure with environmental control

F – Fluid resuscitation

- Assess burn size and depth
- Establish good intravenous access and give fluids (in children, the interosseous route can be used for fluid administration if intravenous access cannot be obtained)
- Give analgesia
- Catheterize patient or establish fluid balance monitoring
- Take baseline blood samples for investigation (full blood count; urea and electrolyte concentration; clotting screen; blood group; and save or cross-match serum)

Electrical injuries

- 12-lead electrocardiography

- Cardiac enzymes (for high tension injuries)

Inhalational injuries

- Chest X-ray
- Arterial blood gas analysis

Dressing of wound

- After completion of the primary survey, a secondary survey should assess the depth and TBSA burned, reassess, and exclude or treat associated injuries
- Arrange safe transfer to specialist burns facility

PRIMARY SURVEY and MANAGEMENT of a burn patient:

History taking :

The history of a burn injury can give valuable information about the nature and extent of the burn, the likelihood of inhalational injury, the depth of burn, and probability of other injuries. The exact mechanism of injury and any pre-hospital treatment must be established.

Primary survey :

On admission and initial evaluation, the burn victim is treated as any trauma patient and is evaluated for the "ABCDEFs" (Airway, Breathing, Circulation, Disability, Exposure &Fluid resuscitation).A modified "advanced trauma life support" primary survey is performed, with particular emphasis on assessment of the airway and breathing. The burn injury must not distract from this sequential assessment, otherwise serious associated injuries may be missed.

Table 1 : Signs of inhalational injury and its management

Signs of inhalational injury	Indications for intubation
· History of flame burns or burns in an enclosed space · Full thickness or deep dermal burns to face, neck, or upper torso · Singed nasal hair, eyebrows, and eyelashes · Carbonaceous sputum or carbon particles in oropharynx · Carboxyhemoglobin level greater than 10% in a patient who was involved in a fire	· Erythema or swelling of oropharynx on direct visualisation · Change in voice, with hoarseness or harsh cough · Stridor, tachypnoea, or dyspnoea

A—Airway with cervical spine control

An assessment must be made as to whether the airway is compromised or is at risk of compromise. The cervical spine should always be protected unless it is definitely not injured. The airway is commonly compromised in cases of inhalational injury which is described below.

Inhalational injury : Currently, inhalation injury is a more common acute cause of death from a burn injury than the surface burns themselves. The mechanisms of injury may involve carbon monoxide inhalation, thermal injury to the upper airway and digestive tract, and inhalation of the products of combustion (Figure 11).

The upper airway is at risk for obstruction because burns can result in massive oedema, especially when there are closed-space fire, burns of the head

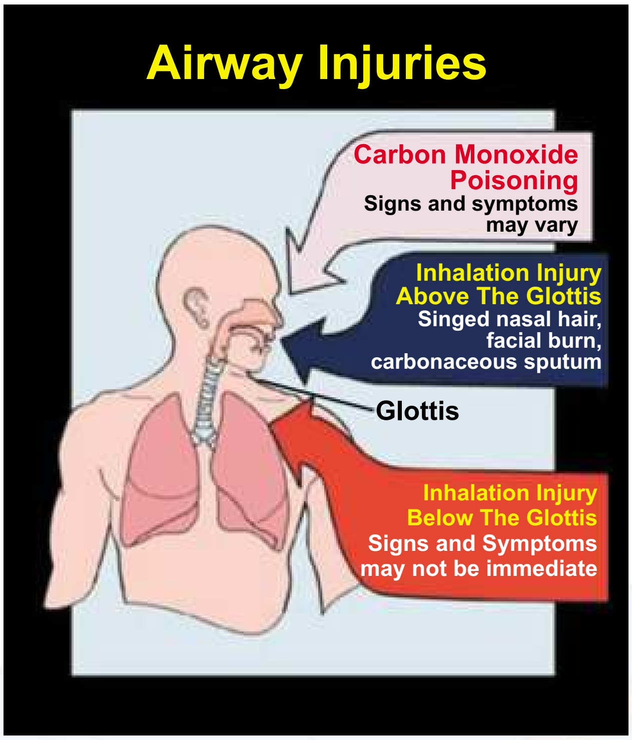


Figure 11 : Airway injuries in case of burn

and face, inhalation injury, and burns inside the mouth. This burn will become oedematous over the following hours, especially after fluid resuscitation has begun.Symptoms of inhalational injury can take 24 hours to 5 days to develop. If there is any concern about the patency of the airway then intubation is the safest policy as the signs of obstruction may initially be subtle until the patient is in crisis. Children are at more risk owing to their smaller airways.Securing the airway prior to transport is recommended (Table 1).

If inhalational injury is suspected, early intubation is necessary to prevent respiratory distress, especially if the patient is being transferred to a burn centre. The physician must maintain a high degree of suspicion for the presence of inhalational injury. If it is suspected, arterial blood gases and carboxyhemoglobin (HbCO) levels should be obtained. If HbCO levels are elevated (>10%), 100 percent oxygen must be administered.

B—Breathing

All burn patients should receive 100% oxygen through a humidified non-rebreathing mask on presentation. Breathing problems are considered to be those that affect the respiratory system below the vocal cords. There are several ways that a burn injury can compromise respiration.

Mechanical restriction of breathing— Deep dermal or full thickness circumferential burns of the chest can limit chest excursion and prevent adequate ventilation. This may require Escharotomies (Release of thick, leathery eschar from a circumferential burn to the trunk or upper and lower extremities, which can be life or limb threatening.).

Blast injury—If there has been an explosion, blast lung can complicate ventilation. Penetrating injuries can cause tension pneumothoraces, and the blast itself can cause lung contusions and alveolar trauma and lead to adult respiratory distress syndrome.

Smoke inhalation—The products of combustion, though cooled by the time they reach the lungs, act as direct irritants to the lungs, leading to bronchospasm, inflammation, and bronchorrhoea. The ciliary action of pneumocytes is impaired, exacerbating the situation. The inflammatory exudate created is not cleared, and atelectasis or pneumonia follows.

Carboxyhaemoglobin—Most devastating effect of inhalation injury in burns is Carbon Monoxide Poisoning. Carbon monoxide binds to deoxyhaemoglobin with 40 times the affinity of oxygen. It also binds to intracellular proteins, particularly the cytochrome oxidase pathway. These two effects lead to intracellular and extracellular hypoxia. The clinical features include progressive increase in respiratory effort and rate. Pulse oximetry cannot differentiate between oxyhaemoglobin and carboxyhaemoglobin, and may therefore give normal results. However, blood gas analysis will reveal metabolic acidosis and raised carboxyhaemoglobin levels but may not show hypoxia. Treatment is with 100% oxygen, which displaces carbon monoxide from bound proteins six times faster than does the atmospheric oxygen.

C—Circulation

Intravenous access - Intravenous access should be established with two large bore cannulas (16 or 18 gauge) preferably placed through unburned tissue in upper limbs. This is an opportunity to take blood for checking full blood count, urea and electrolytes, blood group, and clotting screen. Peripheral circulation must be checked. Any patient with burns over more than 20% of the body surface requires fluid resuscitation. Infusion with an isotonic crystalloid solution, preferably Lactated Ringer's Solution should be started.

Peripheral circulation must be checked. Any deep or full thickness circumferential extremity burn can act as a tourniquet, especially once oedema develops after fluid resuscitation. This may not occur until some hours after the burn. If there is any suspicion of decreased perfusion due to circumferential burn, the tissue must be released with Escharotomies. Once airway, ventilation and systemic perfusion have been established, the next priority is diagnosis and treatment of concomitant life-threatening injuries.

D—Neurological disability

All patients should be assessed for responsiveness with the Glasgow coma scale; they may be confused because of hypoxia or hypovolaemia.

E—Exposure with environment control

The whole of a patient should be examined (including the back) to get an accurate estimate of the burn area (as described above) and to check for any concomitant injuries. Burn patients, especially children, easily become hypothermic. This will lead to hypoperfusion and deepening of burn wounds. Patients should be covered and warmed as soon as possible.

F—Fluid resuscitation

The resuscitation regimen should be determined (as described above) and begun based on the estimation of the burn area. A urinary catheter is mandatory in all adults with injuries covering > 20% of total body surface area to monitor urine output. Children's urine output can be monitored with external catchment devices or by weighing nappies provided the injury is < 20% of total body area. In children the interosseous route can be used for fluid administration if intravenous access cannot be obtained, but should be replaced by intravenous lines as soon as possible.

SECONDARY SURVEY

At the end of the primary survey and the start of emergency management, a secondary survey should be performed. This is a head to toe examination to look for any concomitant injuries. This includes include physical examination, documentation, baseline blood levels and x-rays, maintenance of peripheral circulation in circumferential extremity burns, gastric tube insertion, narcotic analgesics and sedatives, wound care, and tetanus immunization.

Physical examination : In order to plan and direct patient treatment, the provider must estimate the extent and depth of the burn, assess for associated injuries, and weigh the patient.

Documentation : A flow sheet or other report that outlines the patient's treatment should be initiated when the patient is admitted to the ED. This flow sheet should accompany the patient when transferred to the burn unit.

Baseline determinations for patients with major burns : Obtain samples for a complete blood count (CBC), type and crossmatch /screen, an arterial blood gas with HbCO, serum glucose, electrolytes, and pregnancy test in all females of childbearing age. A chest x-ray should be obtained for those patients who are intubated or have a suspected smoke inhalation injury, with repeat films as necessary. Other x-rays may be indicated for appraisal of associated injuries.

Peripheral circulation in circumferential extremity burns : The goal for assessing peripheral circulation in a patient with burns is to rule out Compartment Syndrome. Compartment syndrome results from an increase in the pressure inside a compartment that interferes with perfusion to the structures within that compartment. For an extremity, perfusion to the muscle within the compartment is the main concern. Although a compartment pressure greater than systolic blood pressure is required to lose a pulse distal to the burn, a pressure of >30 mm Hg within the compartment may lead to muscle necrosis. Once the pulse is gone, it may be too late to save the muscle. Thus, clinicians must be aware of the signs of a compartment syndrome: increased pain with passive motion, tightness, numbness, and, eventually, decreased distal pulses. If there are concerns about a compartment syndrome, the compartment pressure is easily measured by inserting a needle connected to pressure tubing (arterial or central pressure monitor) into the compartment. If the pressure is >30 mm Hg, escharotomy is indicated (Figure 12).

Compartment syndromes may also present with circumferential chest and abdominal burns, leading to increased peak inspiratory pressures. Chest and abdominal escharotomies performed down the anterior axillary lines with a cross-incision at the junction of the thorax and abdomen usually relieve the problem. With aggressive fluid resuscitation, abdominal compartment syndrome may occur, so the clinicians should watch for this potential problem. In order to maintain peripheral circulation in patients with circumferential extremity burns, the clinician should:

- Remove all jewellery on the patient's extremities.

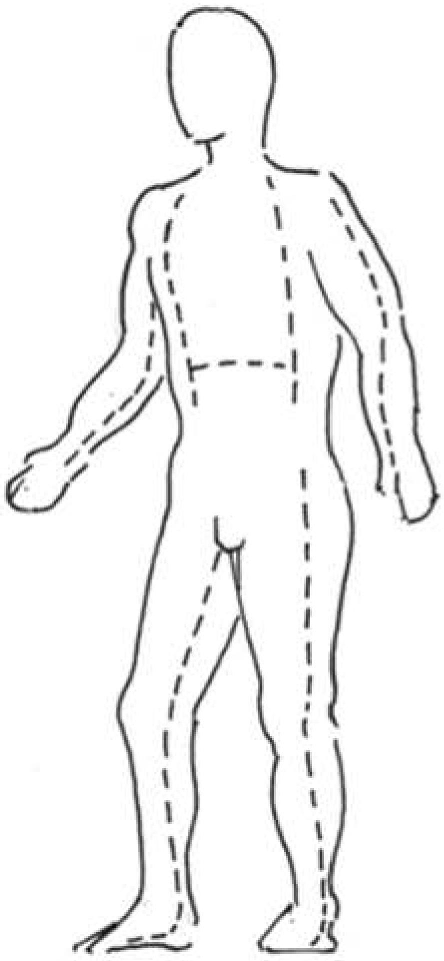


Figure 12 : The commonly used Escharotomy sites

- Assess the status of distal circulation, checking for cyanosis, impaired capillary refill, and progressive neurologic signs, such as paresthesia and deep-tissue pain. Assessment of peripheral pulses in patients with burns is best performed with a Doppler ultrasonic flowmeter.
- Relieve circulatory compromise in a circumferentially burned limb by escharotomy, always with surgical consultation. Escharotomies usually are not needed within the first 6 hours after a burn injury.
- Although fasciotomy is seldom required, it may be necessary to restore circulation for patients with associated skeletal trauma, crush injury, high-voltage electrical injury, and burns involving tissue beneath the investing fascia.

Gastric tube insertion: Prior to transfer, in order to avoid vomiting and possible aspiration, insert a gastric tube and attach it to a suction setup if the patient experiences nausea, vomiting, or abdominal distention, or if burns involve more than 20% total BSA.

Narcotics, analgesics, and sedatives: Severely burned patients may be restless and anxious from hypoxemia or hypovolemia rather than pain. Consequently, hypoxemia and inadequate fluid resuscitation should be managed before administration of narcotic analgesics or sedatives, which can mask the signs of hypoxemia and hypovolemia. Narcotic analgesics and sedatives should be administered in small, frequent doses by the intravenous route only. Remember that simply covering the wound will improve the pain.

Wound care: Partial-thickness burns are painful when air currents pass over the burned surface. Gently covering the burn with clean sheets relieves the pain and deflects air currents. Do not break blisters or apply an antiseptic agent. Any applied medication must be removed before appropriate antibacterial topical agents (Silver Sulfadiazine) can be applied. Application of cold compresses can cause hypothermia. Do not apply cold water to a patient with extensive burns (>10% total BSA).

Antibiotics: There is NO indication for prophylactic antibiotics in the early post-burn period. Antibiotics should be reserved for the treatment of infection.

Tetanus: Determination of the patient's tetanus immunization status is very important. Tetanus immune-prophylaxis should be done.

CHEMICAL INJURIES

Traditionally, chemical injuries are classified as either acid burns or alkali (base) burns. The severity of chemical injuries depends on the composition of the agent, concentration of the agent, and duration of contact with the agent. In general, alkaline burns cause more severe injury than acid burns because alkaline agents cause a liquefaction necrosis that allows the alkali to penetrate deeper, extending the area of injury. The first step in managing a chemical injury is removal of the inciting agent. Clothes, including shoes that have been contaminated should be removed. The powder, if present should first be dusted off and then irrigation can take place.

Areas of affected skin should be copiously irrigated with water immediately for at least 20 to 30 minutes up to 2 hrs. Adequate irrigation can be verified by checking the skin pH. Neutralization of the inciting agent should never be attempted because because reaction with the neutralizing agent can itself produce heat and cause further tissue damage. If ocular injury has occurred, the eyes should also be copiously irrigated. An ophthalmologist should be consulted to assist in the management of these patients.

ELECTRICAL INJURIES

Electrical injuries are potentially devastating events that result in damage to the skin as well as other tissues, including nerve, tendons, and bone. Electrical burns can take several forms, including injury from the electrical current itself, flash burns, flame burns, contact burns, or a combination thereof.Electrical burns result when a source of electrical power makes contact with a patient's body. The body can serve as a volume conductor of electrical energy, and the heat generated results in thermal injury to tissue. Different rates of heat loss from superficial and deep tissues allow for relatively normal overlying skin to coexist with deep muscle necrosis.

Patients with electrical injuries frequently need fasciotomies and should be transferred to burn centers early in their course of treatment. Immediate treatment of a patient with a significant electrical burn includes attention to the airway and breathing, establishment of an intravenous line in an uninvolved extremity, ECG monitoring, and placement of an indwelling bladder catheter. Electricity may cause cardiac arrhythmias that may require chest compressions. If there are no arrhythmias within the first few hours of injury, prolonged monitoring is not necessary. Since electricity causes forced contraction of muscles, clinicians need to examine the patient for associated skeletal and muscular damage, including the possibility of spinal injuries. Rhabdomyolysis results in myoglobin release, which can cause acute renal failure. Do not wait for laboratory confirmation before instituting therapy for myoglobinuria. If the patient's urine is dark, assume that hemochromogens are in the urine. Fluid administration should be increased to ensure a urinary output of 100 mL/hr in adults or 2 mL/ kg/hr in children <30 kg. Metabolic acidosis should be corrected by maintaining adequate perfusion.

Burn injuries that should be referred to a burn unit (BURN TRIAGE)

The American Burn Association has defined the criteria used in triaging burns to be admitted and treated in a specialized burn unit:

1. Partial- and full-thickness burns >10% TBSA in patients under 10 or over 50 years of age
2. Partial- and full-thickness burns > 20% TBSA in other age groups
3. Full-thickness burns >5% TBSA in any age group
4. Partial- and full-thickness burns involving the face, hands, feet, genitalia, perineum, or major joints
5. Electric burns, including lightning injury
6. Chemical burns with serious threat of functional or cosmetic impairment
7. Inhalation injuries
8. Any burn patient with concomitant trauma
9. Lesser burns in patients with pre-existing medical problems that could complicate management
10. Combined mechanical and thermal injury in which the burn wound poses the greater risk
11. Any case in which abuse or neglect is suspected

COLD INJURIES

Three types of cold injury are seen in trauma patients: frostnip, frostbite, and nonfreezing injury.

Frostnip : It is the mildest form of peripheral cold injury, which tends to occur in apical structures (nose, ears, hands, feet), where blood flow is most variable because of the richly innervated arteriovenous anastomoses. It is characterized by initial pain, pallor, and numbness of the affected body part. It is reversible with rewarming and does not result in tissue loss, unless the injury is repeated over many years, which causes fat pad loss or atrophy.

Frostbite: Exposure to extremes of cold (and wet) conditions can lead to cellular injury and death. Cell death and tissue necrosis occur from the formation of ice crystals within the cells and extracellular space from ice crystal formation during the period of cold exposure, whereas microvascular thrombosis is thought to occur during reperfusion when the affected limb is rewarmed. Similar to burn injury, frostbite injury is classified according to the depth of injury.

- First-degree frostbite is similar to a superficial burn injury, with tissue erythema, pain, and edema.
- Second-degree frostbite is marked by blistering and partial-thickness skin injury.
- Third-degree frostbite occurs when there is full-thickness necrosis of the skin, and
- Fourth-degree frostbite occurs when there is full-thickness skin necrosis as well as necrosis of the underlying muscle and/or bone with gangrene.

Although the affected body part is typically initially hard, cold, white, and numb, the appearance of the lesion changes frequently during the course of treatment. Again, it is important to note that determination of the full depth of tissue injury is not possible until several weeks following injury.

The first step in management of frostbite is removal of all wet clothes, gloves, socks, and shoes. Patients should then be wrapped in warm blankets. Frostbite can also be associated with hypothermia. In these cases, care must be taken to rewarm the entire body. In cases of extreme hypothermia (less than 32 ◦ C) warming can be achieved with use of warm intravenous fluids, bladder irrigation with warm solutions, placement of peritoneal catheters and chest tubes through which warm fluids can be administered, and even, if available, cardiopulmonary bypass. Frostbitten extremities should be rapidly rewarmed inwater that is 104 ◦ F (40 ◦ C). Typically, rewarming can be completed in 20 to 30 minutes. Adjunctive use of anti-inflammatory medications and anticoagulants has also been described.

Nonfreezing Injury: Nonfreezing injury is due to microvascular endothelial damage, stasis, and vascular occlusion. Trench foot or cold immersion foot (or hand) describes a non-freezing injury of the hands or feet, typically in soldiers, sailors, and fishermen, resulting from long-term exposure to wet conditions and temperatures just above freezing (1.6°C to 10°C, or 35°F to 50°F). Although the entire foot can appear black, deep-tissue destruction may not be present. Alternating arterial vasospasm andvasodilation occur, with the affected tissue first cold and numb, then progressing to hyperemia in 24 to 48 hours. With hyperemia comes intense, painful burning and dysesthesia, as well as tissue damage characterized by edema, blistering, redness, ecchymosis, and ulcerations. Complications of local infection, cellulitis, lymphangitis, and gangrene can occur. Proper attention to foot hygiene can prevent the occurrence of most such injuries. Management of this injury entails careful washing and air-drying of the feet, gentle rewarming, bed rest, and slight elevation of the extremity. Improvement occurs within 24-48 hours, while the injury completely resolves in 1-2 weeks. Early physical therapy is essential. The patient should be warned that subsequent chilling will preferentially affect the previously injured area. Key to prevention of immersion foot injury is keeping the feet dry for at least 8 h/d.

Systemic Hyperthermia: Trauma patients also are susceptible to hypothermia, and any degree of hypothermia in trauma patients can be detrimental. In trauma patients, hypothermia should be considered to be any core temperature below 36°C (96.8°F), and severe hypothermia is any core temperature below 32°C (89.6°F). Hypothermia is common in the severely injured, but further loss of core temperature can be limited with the administration of only warmed intravenous fluids and blood, judicious exposure of the patient, and maintenance of a warm environment.

CHAPTER 8 ORAL AND MAXILOFACIAL TRAUMA

The fracture of the maxillofacial bones including the mandible, maxillae, zygoma, nasal, orbital, frontal, ethmoidal, lacrimal, vomer, paired palatine bones and the sphenoid bone are treated by the maxillofacial surgeon.

Fig1: Representing Fracture of the maxillofacial bones

The mandible is largest, heaviest, strongest and the only movable bone of the facial skeleton with the incidence of injury and fracture being most common of all facial bones [61%] by virtue of its position and prominence followed by maxilla [46%], zygoma [27%] and nasal bone [19.5%] (Figure 1).

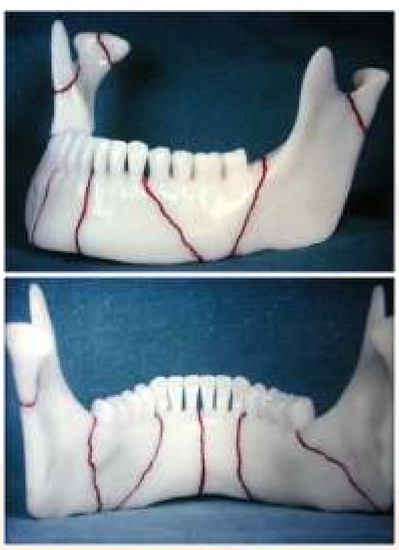


Fig 2&3: Showing the common fracture sites over the mandible

The mandibular bone can be fractured from symphysis, parasymphysis, body, angle, ramus, coronoid and the condyle which is the common site of mandibular fracture (Figure 2 & 3). Mandibular condyle commonly fractured from the indirect trauma. Bilateral fracture of the mandibular bone is also very common, but it makes the management difficult.

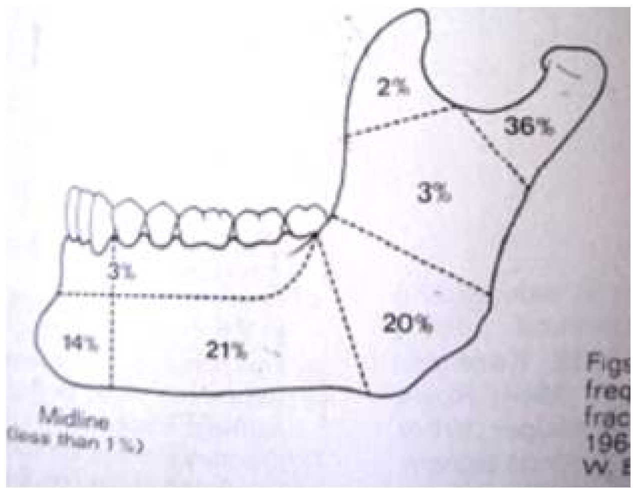


Fig 4: The percentage wise distribution of mandibular fracture

The clinical features on inspection including swelling [tumor], rubor, ecchymosis/bleeding, haematoma [sublingual], lacerations [mucosal/skin], facial asymmetry, step deformity, decreased interincisal distance, change in occlusal plane, empty sockets or fracture/loose teeth. On palpation tenderness, inter fragmentary mobility, deranged occlusion, crepitation & abnormal mandibular movements.

The Malar or the Zygomatic bone represents a strong bone on fragile supports and it is for this reason that, though the body of the bone is rarely broken, the four processes frontal, orbital, maxillary and zygomatic are the frequent sites of fracture (Figure 4-6).

Fig 5 : 3D scan showing fractured zygomatic bone

Maxillary fracture

Rene Le Fort described the classic patterns of fracture in his 1901 work. Le Fort's experiments consisted of using 32 cadavers that were either intact or decapitated. Cadaver skulls were dropped from several stories or were struck with a wooden club. He found 3 distinct fracture patterns, which he termed the lineaminorosresistentiae (Figure 7-8).

Orbit fracture occurs isolated or in association i.e blow out or blow in fracture, orbital roof or floor fracture, medial or lateral wall fracture 5 (Figure 9).

Due to its prominent position on the face the nasal bone fractured commonly, although a very little force is required to fracture the nasal bone. The clinical features including the edema, depression of the nasal bridge,epistaxis,septal dislocation or deviation, edema and ecchymosis6 (Figure 10-11).

Management of Maxillofacial fractures:

1. ABCDE : Life saving treatment first

2. Initial management : Temporary stabiliztion of the fractured bone can be achieved with the help of barrol bandage, barton bandage or a simple application of bandage from forehead to chin (Fig 12).

3. Closed reduction :Intermaxillary fixation (IMF) with the help of arch bars , IMF screws (fig 13), eyelet wiring, direct interdental wiring.

4. Open reduction and rigid internal fixation : with the help of mini plates, micro plates, reconstruction plates, lag screws, 3D plates or with bio resorbable plates. The fixation of the fracture fragment done from outer to inner surface and lower to upper fracture fragments of bone (Fig 14).

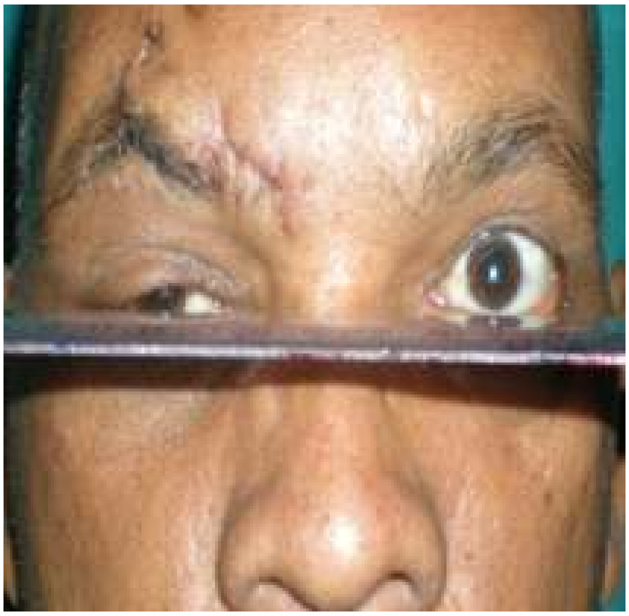


Fig 6 : Showing clinical features of zygomatic bone fracture i.e flattening of the malar prominence, subconjunctival haemoorhage, circumorbital ecchymosis, diplopia, V-in fracture of zygomatic arch, ptosis, enophthalmos, hypoglobus.

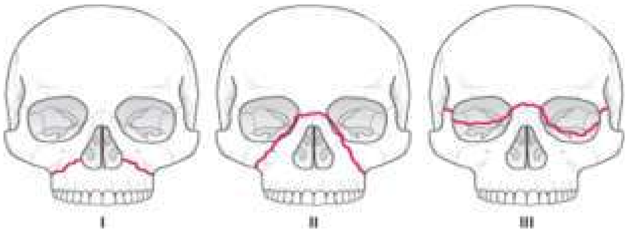


Fig 7 : Showing Le fort I,II,III fracture lines, when skull base is involved along with le fort fracture it is called as Le fort IV fracture.

Fig 8 : Showing clinical features Le fort fracture i.eguriens sign 4, dish face deformity, lengthening of the face, telecanthus, floating maxilla.

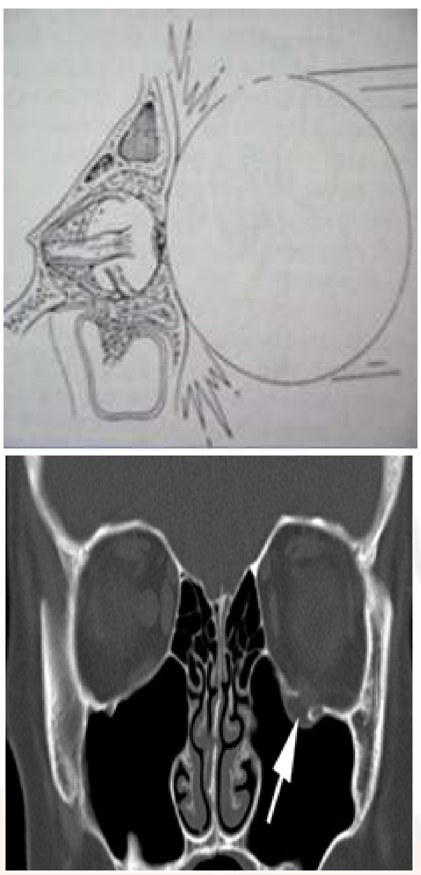


Fig 9 : Showing cause and CT scan of blow out fracture

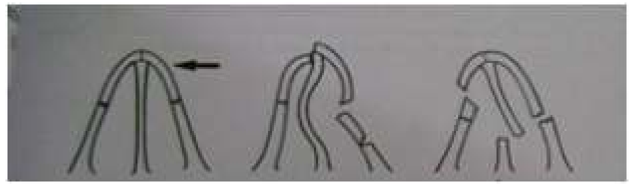


Fig 10: Nasal bone fracture due to injury from lateral aspect

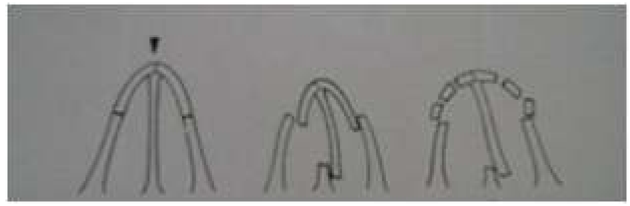


Fig 11: Nasal bone fracture due to injury from anterior aspect

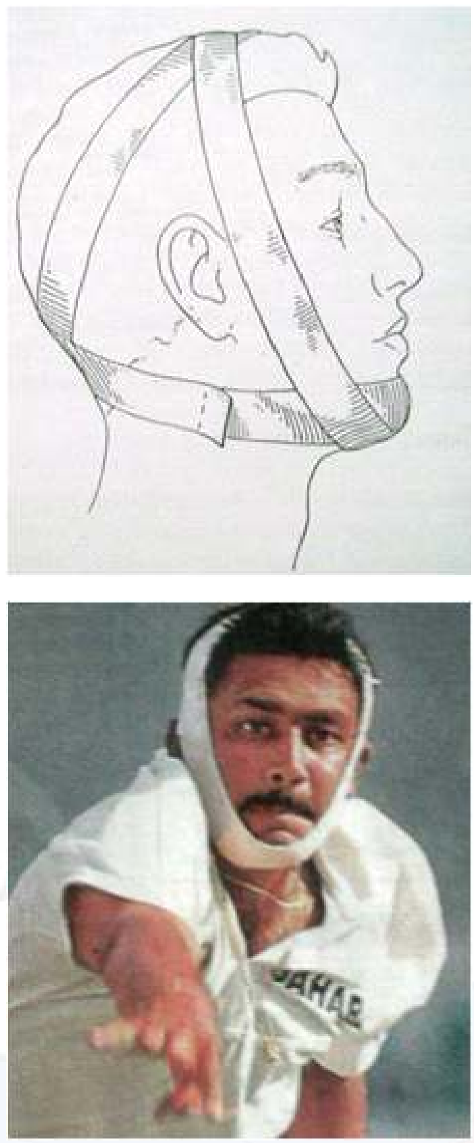


Fig 12: Showing application of bandages

Fig 13 : Representing IMF with arch bars and screws

Fig 14: Showing internal fixation of maxillofacial fractures.

CHAPTER 9 MUSCULOSKELETAL TRAUMA

The structure of the skeletal system is composed of bones, cartilages, tendons, ligaments, muscle and synovial fluid. Bones provides structural support, protection for soft tissue and leverage for mobility. Bones meet at joints and are held together by ligaments. Cartilage provides the smooth surface and padding for bones to slide or pivot against each other. The synovial fluid contained inside the ligamentous joint capsule lubricates the surface. Tendon are cord like connective tissue that joint muscle to bone, crossing joints in the cable and pulley system that effect movement. The muscle itself is encased in connective tissue compartment called fascia (Figure 1). Our primary concern is whether an injured bone or joint can still safely perform its function, or must be stabilized and protected. Musculoskeletal trauma dose not ignore the priorities of ABCDEs.

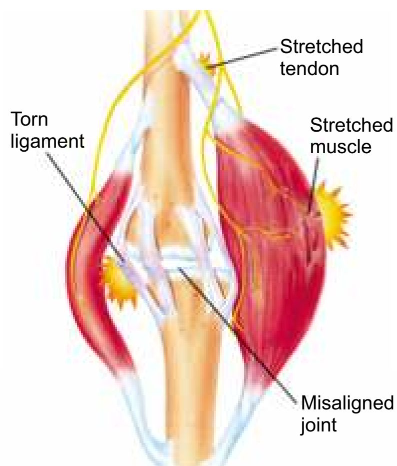


Figure 1 : Different structure of Musculo-skeleton injury in trauma

I. Primary survey and resuscitation

Assess ABCDE and treat life threatening events first. After taking care of airway with cervical spine protection (A), breathing (B)with ventilation, it becomes imperative to recognize and control hemorrhage after musculoskeletal injury.

a. **Circulation :** The circulation is the most component of ABCDE which is affected in musculoskeletal trauma. The hemorrhage from long bone fracture like femur, pelvic bone fracture may cause significant blood loss and can be fatal. In such cases proper splinting may reduce bleeding significantly by reducing movement and tamponade effect. If fracture is open, application of a sterile pressure dressing is helpful in hemorrhage control. If the fracture is consider as a cause of shock immobilization and x-ray can be used as a adjunct during primary survey.

b. **Immobilization**

The goal of immobilization is to realign the injured extremity in anatomical position as much as possible by application of inline traction to realign the extremity and keep it in place by immobilization devices. This reduces further blood loss, pain and soft tissue injury. The dislocated joint may be splinted in normal anatomic position and in case of open fracture opposing the bone may not be crucial as they may need debridement.

Steps to follow during immobilization

- Expose the patient completely and remove potentially constricting devices such as bracelets, watches, and rings etc. This has to be done fast as hypothermia has to be prevented.
- Cover any open wound with sterile dressings
- Assess for pulse, external hemorrhage, neurovascular status and perform motor and sensory examination.
- Select appropriate size and type of splint. In the case of Thomas Splint the upper cushioned ring should be placed under the buttock, adjacent to ischial tuberosity and distal end should extend beyond ankle about 15 cm.
- Immobilize one joint above and below the injury site.
- Apply padding over bony prominences
- No forced realignment of a deformed extremity

with normal pulse

- Obtain orthopedic consultation
- Document neurovascular status before and after every manipulation
- Administer appropriate tetanus prophylaxis.

Once an injury is stabilized, the most important anticipated problem becomes distal ischemia caused by compression of neurovascular bundle as swelling develops inside splints or bandages. Treatment should include medication, rest and elevation of to reduce swelling and pressure.

II. Secondary survey

Elements of the secondary survey are history and physical examination.

a. History

The history includes the mechanism of injury, predisposing factors, pre-injury status, prehospital care received, patient relatives and bystanders at the scene of the injury should be documented and included as a part of the patients medical record. The AMPLE history (allergies, medications, past history, last meal, events/environment related injury) also should include information about the patients exercise tolerance, ingestion of alcohol, other drugs and emotional problem.

b. Physical examination

The patient should be completely undressed avoiding hypothermia keeping in mind three important goals

i. Identification of life threatening events

ii. Identification of limb threatening events

iii. Systemic review to avoid any missing injury.

The dictum is look, listen and feel

LOOK:

1. Color and perfusion of the injured extremity
2. Swelling, deformity of the injured limb
3. Discoloration, anybruising
4. Patient's spontaneous extremity movement to rule out muscular and neurological injury.

FEEL

1. Palpate for tenderness, swelling, deformity, sensation. Loss of sensation may indicate peripheral nerve or spinal cord injury.
2. Palpation at the time of logrolling the patient is important to identify soft tissue injury, hematoma and gaps between spinous process etc.
3. Palpate the distal pulses in each limb

LISTEN

1. Doppler Signals : To look for signs of vascular sufficiency
2. Bruits

c. Pain control: Pain control is one of the important aspects in management of trauma patient and ways to achieve pain controls are done by

1. Appropriate immobilization
2. Use of analgesics
3. Regional nerves block, but remember to document any peripheral nerve injury before giving any regional nerve block.

MUSCULOSKELTAL TRAUMA: IMPORTANT INJURIES

I. LIFE THREATENING INJURIES

a. Crush injury

b. Major arterial injury

a. Crush injury : The crush injury of a muscle leads to direct muscle injury, muscle ischemia and cell death releasing large amount of myoglobin. The clinical features include the dark amber color urine (which is due to myoglobin), metabolic acidosis, hypocalcemia, hyperkalemia, disseminated intravascular coagulation and acute kidney injury. The treatment of choice is early and aggressive fluid therapy along with osmotic diuresis in order to maintain urine output of atleast 100ml/hour. This is done in order to reverse myoglobin induced acute kidney injury.

b. Major arterial injury : Any penetrating & blunt trauma leading to fracture, dislocation, in close proximity to artery leads to major arterial injury. This is manifested as external bleeding, feeble pulse or loss of pulse and pallor. Direct application of pressure to control bleeding along with vascular and orthopedic consultation is of prime importance.

II. LIMB THREATENING INJURIES

a. Open fracture with joint dislocation : Open fracture is communication between the bone and external environment, the damage along with bacterial contamination makes the situation prone for infection and delayed healing.

i. **Assessment :** This is based on history of the incident and physical examination of the open wound. If open wound exists close to joint it is assumed that wound is extending to joint and surgical opinion is must.

ii. **Management :** First and foremost we should try to achieve hemodynamic stability by hemorrhage control and adequate fluid resuscitation. The wound has to be immobilized. Currently, first generation cephalosporin should be given in all cases with open fractures and gram negative antibiotics should be given in cases of severe infection. Tetanus prophylaxis is a must in such cases.

b. Vascular injuries and traumatic amputation

i. Injury: History of blunt, penetrating trauma, crushing and twisting injury is there.

ii. Assessment: On examination patient has cold extremities, prolong capillary refill time and diminished peripheral pulses. They have on Doppler examination abnormal ankle brachial pressure index (ABPI).

iii. Management: First and foremost step in management is hemorrhage control along with adequate fluid resuscitation. In case of ongoing hemorrhage even after direct pressure application if bleeding doesn't stop, the use of tourniquet sometimes may be life-saving. When using a tourniquet care should be paid regarding risk of development of ischemia. If arterial injury with joint dislocation is present, a skilled clinician may attempt once to reduce joint.

iv. Care of amputated part: The amputated part should be washed thoroughly with isotonic solution and thereafter wrap it with sterile gauge which has been already soaked in aqueous penicillin (1,00,000 unit in 50 ml of R/L). The amputated part is then wrapped in a sterile moistened towel and placed in a plastic bag, and transported in insulated cooling chest with crushed ice. The amputated part should not be allowed to freeze.

c. Compartment Syndrome

It develops when pressure within a osteofascial compartment of muscle causes ischemia and subsequent necrosis. The osteo-fascial compartment comprises of artery, vein, and nerve (Figure 2). The compression of artery leads to loss of pulse, pallor and pain (which is due to accumulation of toxic products of metabolism).The compression of nerve leads to paresthesia and the compression of vein leads to swelling. These five common sign and symptoms comprises of '6 P's of compartment syndrome

- Pain (out of proportion of clinical condition)
- Pressure (One of the earliest sign is the extreme pain which is there on passive stretching too)
- Pallor
- Paresthesia
- Pulse - absent or diminished
- Palpable tenderness

It can occur in any site in which muscle is contained within a closed fascial space, However certain injuries are considered high risk such as tibial and forearm fracture ,tight dressing and casting, severe crush injury, increase capillary permeability secondary to re perfusion of ischemic muscle, burns etc.

i. **Assessment :** The key to success of acute compartment syndrome is early diagnosis; pain out of proportion to injury is the earliest recognizable sign of compartment syndrome. Other common sign and symptons are pallor, paresthesia, loss of pulse and palpable tenderness.

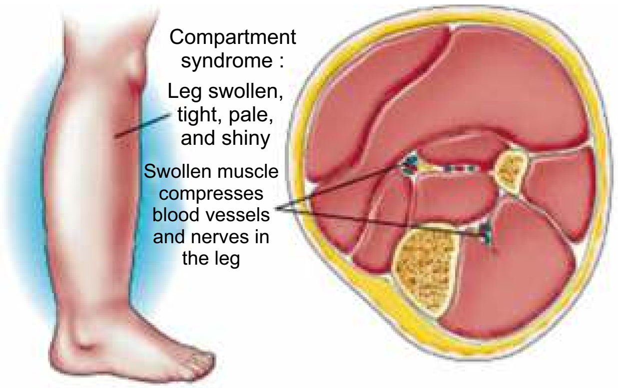


Figure 2 : Mechanism of Compartment syndrome

ii. **Diagnosis :** This is based on history of injury, physical signs with high index of suspicion. Severe hypovolemia can mask findings of acute compartment syndrome. The absence of palpable distal pulse is uncommon and late finding and should not be relied upon. The pressure measurement is indicated in all patients who have altered response to pain, unconscious or intubated patients can not complain of pain even in extreme ischemia so needs extra vigilance. Intra-compartmental pressure measurement may be helpful in diagnosis. Intra-compartmental pressure ≥30-45 mmHg is suggestive of decreased capillary blood flow.

Delta-P method: -Diastolic blood pressure–intra compartmental pressure. If it is ≤ 30mmHg, patient may have compartment syndrome

iii. **Management:-**

Remove all constrictive dressing, casts and splints applied over the affected extremity. Thereafter monitor the patient, reassess in 30-60 min and if no change occur fasciotomy should be done (Figure 3). So the definitive management of compartment syndrome is fasciotomy.

D. Neurological injury secondary to dislocation and fracture:-

Anatomical proximity of nerve to joints makes them prone to injury particularly after dislocation and fracture.

i. Assessment : Sensory function, motor function must be carried out for each significant peripheral nerve. In case of multiple injuries stabilization of the patient is first and for most priority, then one has to assess for nerve injury. The sensory & motor function should be documented properly.

Figure 3 : Plane of fasciotomy

ii. Management Immobilize the injured limb in dislocated position and ask for surgical consultation. Careful reduction may be attempted if treating doctor is competent. Reevaluate neurologic function after reduction.

CHAPTER 10 SPINAL INJURY

INTRODUCTION :

According to World Health Organization (WHO), the term 'spinal cord injury' (SCI) is defined as damage to the spinal cord from trauma (traumatic spinal cord injury i.e. TSCI) or from disease or degeneration (e.g. cancer). In this chapter, we will discuss traumatic spinal cord injury (TSCI) in details. The majority of spinal cord injuries (up to 90%) are due to traumatic causes (e.g. road traffic accidents, falls or violence). It may be associated with polytrauma or brain injury. TSCI should always be suspected in any patient with multiple traumas until proven otherwise. Approximately 2-4 % of patients with blunt trauma and 5 % of patients with brain injury have SCI.

There is no reliable estimate of global prevalence of SCI. According to estimation of WHO, globally about 250 000 to 500 000 people suffer a spinal cord injury (SCI) every year. An estimated global-incident rate is about 23 TSCI cases per million. In South-Asia its incidence is about 21 cases per million. TSCI has bimodal age of distribution. It primarily affects males aged 18–32 years in both developed (high income) and developing countries (low income). In developed countries, it affects both male and female over the age of 65 years due to an ageing population.

An accurate, properly recorded account of neurological status of a patient with SCI/trauma is most often missing. It should be recorded as soon as possible within minutes following the injury. Limiting factors for proper assessment may be altered level of consciousness, intoxication, multiple injuries, and lack of experienced health care provider. A health care provider must be aware of spinal injury, transportation and manipulation of such patients with spinal cord injuries, multiple traumas and brain injuries should be done with utmost care. Inappropriate immobilization may results into appearance of newer neurological deficit or worsening pre-existing deficit. About 3% to 25% of spinal cord injuries occur after the initial trauma, either during transportation or early in the course of management. It is important to note that prolonged immobilization is not free from danger. Along with discomfort, it may be associated with pressure ulcers. A patient with SCI should be evaluated by experts to remove him from spinal board as early as possible, preferably within two hours; otherwise he should be "logrolled" every two hours.

NEUROANATOMY AND NEUROPHYSIOLOGY:

Spinal cord starts at foramen magnum and ends at L1 in adults. Below L1, there are only nerve roots in the canal, collectively known as cauda equina, which comes out from canal from the lower side of corresponding vertebral body (Figure 1). These roots supply to various muscles (myotomes) and specific part of skin (dermatomes) through plexus and/or nerves. Each root has it localization to the corresponding spinal cord level, hence knowledge of myotomes and dermatomes is very essential for localization of level of spinal cord injury. The key dermatomes and myotomes are shown in Table 1. It is well known that spinal cord is consists of various tracts, but in trauma patients three tracts viz. corticospinal tracts, spinothalamic tracts and posterior column are clinically important. Selective

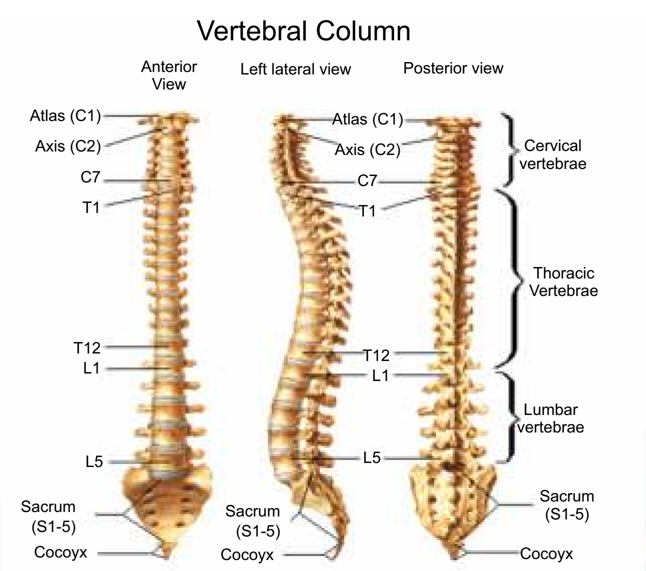


Figure 1: Anatomy of vertebral column

involvement of any of these tracts with sparing other is suggestive of incomplete cord injury.

It has to be noted that severe pain or altered level of consciousness may be the limiting factor for accurate neurological evaluation.

SPINAL CORD INJURY

Types of Spinal Cord Injury

Traumatic SCI can be classified according to

(I) Mechanism of injury,

(II) Severity & anatomical level,

(III) Neurological deficit and

(IV) Morphology

I. Mechanism of SCI

Spinal cord injury can be due to one or combination of various mechanical injuries. These injuries may be (1) Axial loading, (2) Flexion, (3) Extension, (4) Rotation, (5) Lateral bending and (6) Distraction.

II. Various sites of spinal injuries:

1. Atlanto-occipital dislocation
2. Atlas fracture
3. Atlas subluxation
4. Axis (C2) fracture
5. Fractures and dislocations of C3-C7
6. Thoracic spine fracture (T1-T10)
7. Thoracolumbar junction fracture (T11-L1)
8. Lumbar fractures
9. Penetrating injuries
10. Vascular injuries

III. Severity of SCI :

Severity of deficit depends on complete or incomplete injury to the cord (Figure1). Incomplete lesion means preservation of any sensory or motor function below the level of lesion. It includes

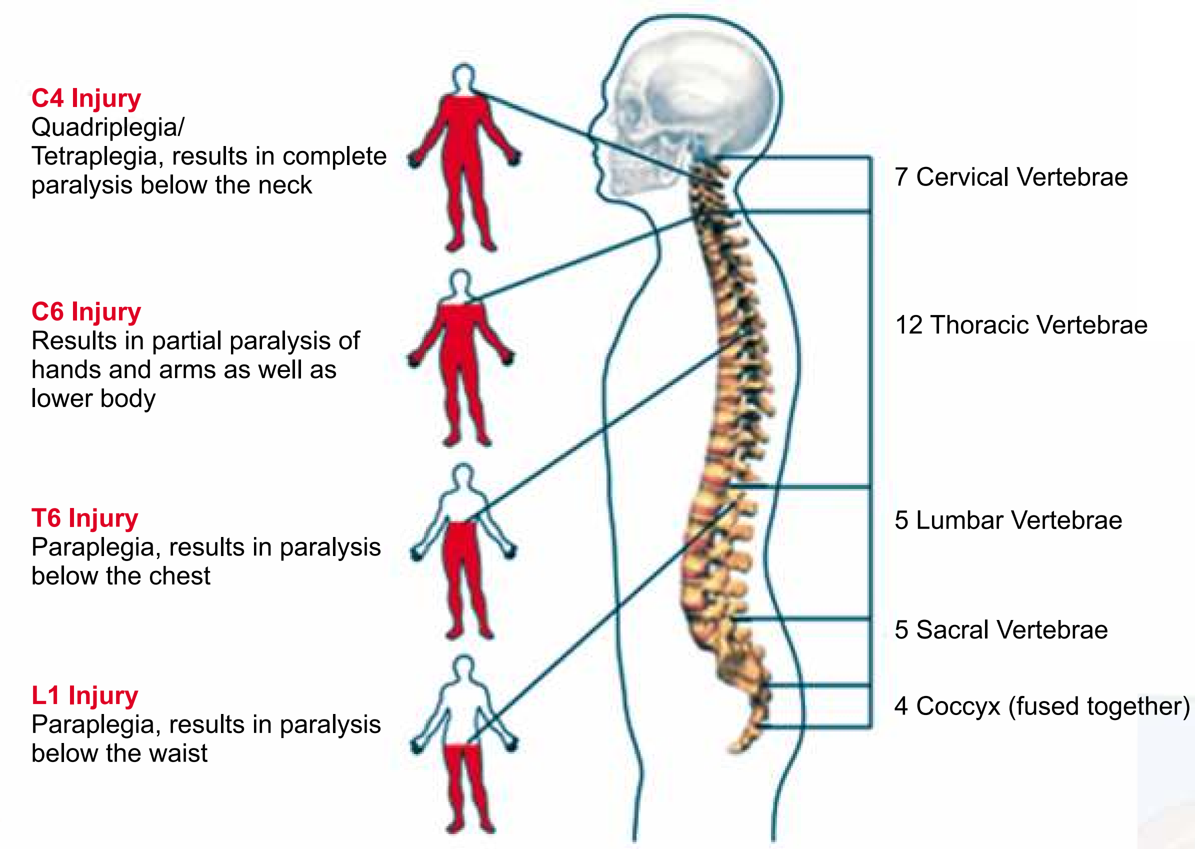


Figure 2: Level of spinal cord injury and its neurologic effects

preservation of partial or complete sensation (pain, temperature, joint position or vibration) or voluntary movement (i.e. limb movement, voluntary bladder or bowel control or sacral sparing). Reflexes may be preserved or lost in complete SCI. Injury to cervical spine leads tetraplegia/tetraparesis and lesion to thoracic spine leads to paraplegia/paraparesis.

Due to high mobility and anatomical position, cervical spine is most vulnerable to trauma in adults. However, it is less commonly involved in paediatric age groups (less than 12 years). Among children, upper cervical cord injury is more common than lower cervical cord. The cervical canal is quite wide till lower C2 vertebra, hence majority of patients with upper cervical region injury may not have neurological deficit if they are immobilized properly. However, about 1/3rd patients may die due to phrenic nerve involvement. Below C3, cervical canal is relatively narrow; hence spinal cord is liable to injury with vertebral column trauma.

Thoracic spine has different anatomical structure as it has limited mobility and support of rib cages along with relatively narrow canal. Due to these differences, most thoracic spine fractures are wedge compression without cord injury. Thoracic cord injury is seen with fracture-dislocation of spine leading to complete injury, hence paraplegia.

Lumbar vertebrae are relatively stronger, except thoraco-lumbar junction (T11 to L1). This thoraco-lumbar junction is next common site of injury after cervical region. As spinal cord terminates at L1, injury to thoraco-lumbar region commonly results in bowel/bladder abnormality or cauda equina syndrome. This region is very vulnerable to rotational movements, hence extreme care is needed during logroll or transfer of the patient.

IV. Clinical Evaluation:

Like other patients with trauma, ABC i.e. Airway maintenance & cervical spine protection; Breathing & ventilation; and Circulation and hemorrhagic control has to be followed in all patients with spinal injury. After securing ABC, disability i.e. quick neurological evaluation has to be performed. It includes patient's level of consciousness, papillary size and reaction, any lateralizing or localizing sign for example, hemiparesis, paraparesis, or cranial nerve deficit and spinal cord injury level. It is important to note that other than trauma, altered level of consciousness may be due to hypoglycaemia, alcohol, narcotics and other drugs. These causes must be explored during evaluation. (Please see Chapter on Head injury for details)

For localization of level of spinal injury, sensory and motor examination has important role as each nerve root supplies particular segment of skin (dermatome) and particular muscle (myotome). Hence knowledge of normal dermatome and myotome is prerequisite to determine the level of spinal injury. (Table 1)

i. Dermatome level: Lowest normal sensory level is considered as sensory level which can be different on other side, hence bilateral sensory examination is mandatory in all patients with suspected spinal level. Upper cervical dermatomes are variable. It should be remembered that skin over supraclavicular area and pectoralis muscle (upper chest) is supplied by C2,3,4 nerve roots followed by T2 nerve root. The remaining nerve roots i.e. C5 to T1 supplies dermatomes of upper limb. (Figure 3)

ii. Myotome : Myotome is not as simple as dermatome, as one root may supply multiple muscles and one muscle may be supplied by multiple roots (Figure 3). However, major contributory nerve root to a clinically important muscle is used for localization of spinal level (Table 1). Strength of these muscles on both sides should be evaluated on a six- point (0 through 6) scale from complete paralysis to normal strength (Table 2).

iii. Evaluation of various spinal cord tracts : The three important spinal cord tracts should be evaluated in all patients with spinal injury (Figure 4)

a. Corticospinal tract : It is situated at posterolateral segment of cord and controls ipsilateral motor strength. In conscious patients, it can be evaluated by voluntary muscle contraction and in patients with impaired consciousness, it can be evaluated by involuntary response to painful stimuli.

b. Spinothalamic tract : It is situated at anterolateral segment of cord. It carries pain and temperature sensation from contralateral side of body to thalamus. Pinprick and light touch of

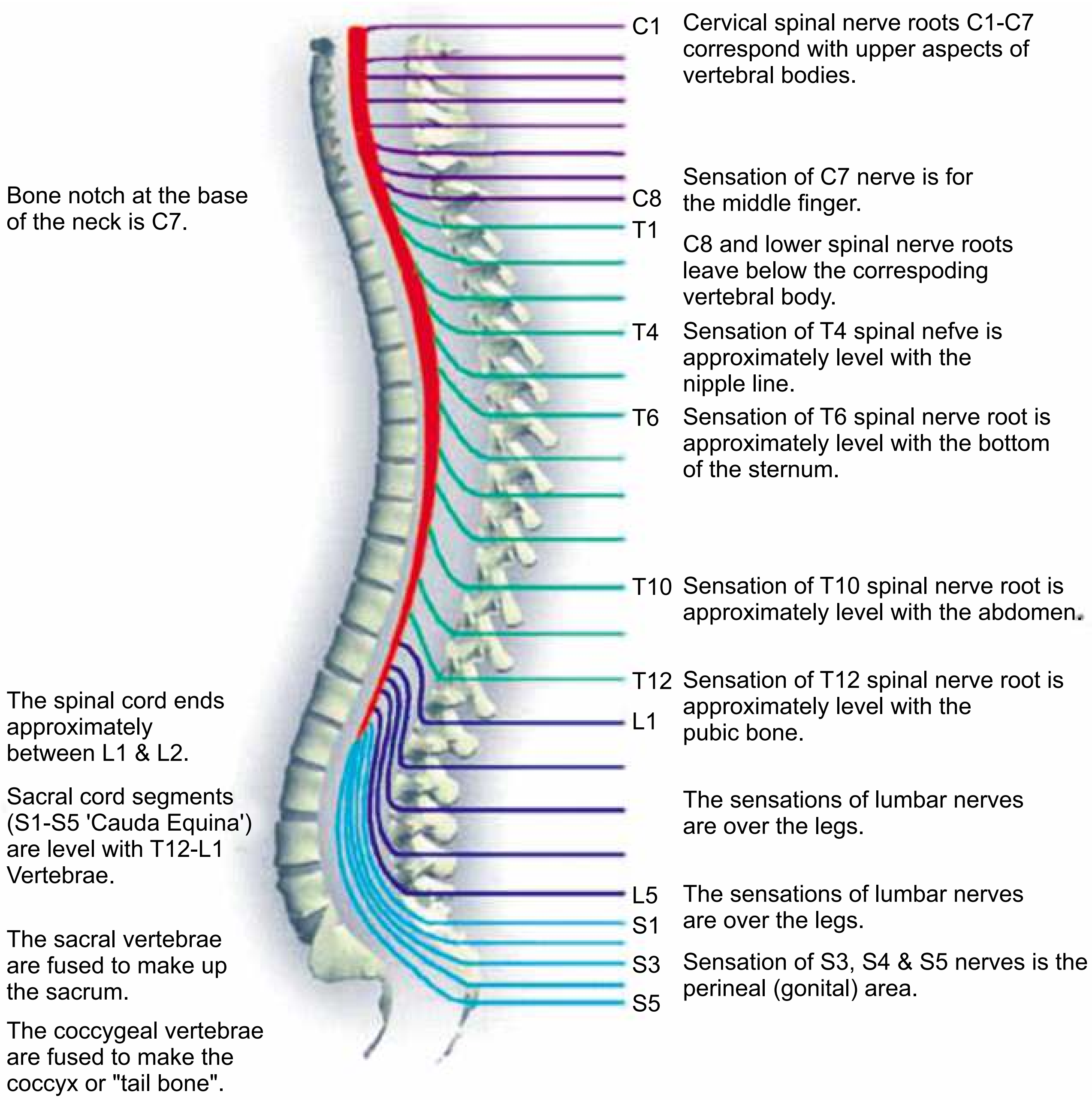


Figure 3: Key Myotomes

selected dermatome should be evaluated for localization.

c. Posterior (or dorsal) column : It is situated at posteromedial segment of spinal cord. It transmits ipsilateral position sense, and vibration sense to brain. It can be evaluated by position sense of toes and fingers or vibration sense at bony prominence by using a tuning fork.

iv Neurogenic vs Spinal shock :

Neurogenic shock result from cervical and upper thoracic spinal cord injury due to impaired descending sympathetic tract. Impaired sympathetic tone results vasodilatation followed by blood pooling and relative hypovolemia. In spite of hypotension, there is bradycardia (or no compensatory tachycardia) due to impaired

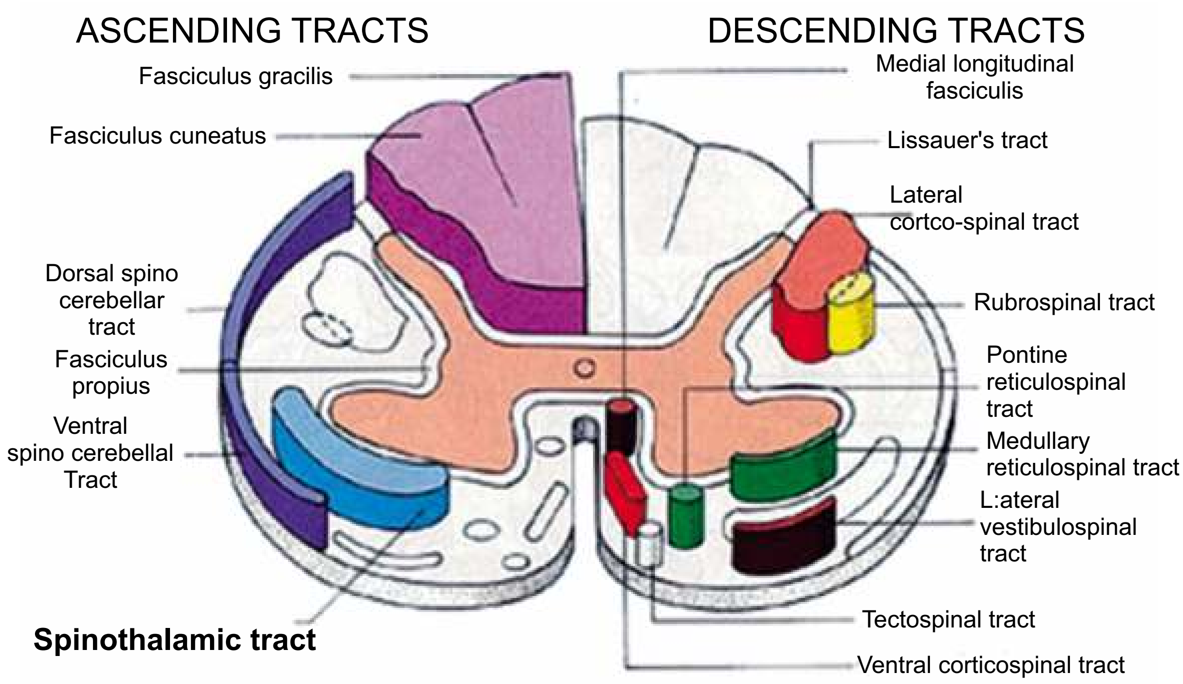


Figure 4: Various Spinal Cord Tracts

sympathetic innervations to heart. Hence a patient with upper spinal cord injury, hypotension without compensatory tachycardia (or bradycardia) is clinical clue for neurogenic shock.

Spinal shock:It is a neurologic but not a hemodynamic phenomenon. It occurs shortly after cord injury. It is of variable duration and is characterized by flaccidity and loss of reflexes.

GENERAL MANAGEMENT:

After securing ABCs, general management of acute spinal injury includes immobilization, intravenous fluids, medications and transfer to appropriate centre.

Immobilization : It is most important pre-hospital care before transportation. All patients with spinal injury should be immobilized above and below the suspected injury site in the neutral position. The spinal immobilization should be maintained spinal injury is excluded by appropriate investigation. Any deformity should not be reduced before proper evaluation and expert's opinion. If alignment of spine is painful, it may be transferred in least painful position with proper immobilization. Patients with cervical spine injury requires complete immobilization with semirigid cervical collar, along with head, entire spine and limb immobilization with backboard, tapes and straps. However, more than 2 hours immobilization may predispose them for pressure sore. In the violent, agitated patients, a short acting sedative or paralytic agent may be used after ensuring proper airway protection and ventilation. Use of these drugs requires clinical skill, experience and proper judgement.

In emergency department, patients should be removed from backboard as early as possible, preferably after spine radiograph. If radiographic evaluation is not possible for several hours, patient should be removed from board. Removal from board is a careful act and atleast 4 or more trained persons are required. During removal, patient is often "logrolled" for secondary survey to inspect and palpate spinal injury.

Four-Person Logroll : Aim of logroll is to maintain neutral anatomic alignment of unstable spine during rolling or lifting the patient. One person stands on head end of patient to control cervical spine and head. Two persons stands along the side of patient to which he has to be turned to control body and limbs. One of them manually prevents segmental movement of spine and second one prevents leg movement with respect to body. The fourth person removes board (on which patient was transferred from accident site to ED) and same time examines back. After removing board, patient is again returned to supine position. Alignment of spine must be maintained through-out the manoeuvre.

Radiographic Evaluation : A three view cervical spine series (AP, lateral, and odontoid views) is recommended for radiographic evaluation of the cervical spine in patients who are symptomatic following traumatic injury. This should be supplemented with computed tomography to further define areas that are suspicious or not well visualized on the plain cervical x-rays. However special imaging should be tailored according to site and type of injury. X-ray of whole spine should be performed to screen non contagious spinal injury.

Intravenous Fluid: A spinal injury patient with hypotension without active haemorrhage may have neurogenic shock or occult bleeding (hypovolemic shock). Neurogenic shock result from cervical and upper thoracic spinal cord injury due to impaired descending sympathetic tract. Impaired sympathetic tone results vasodilatation followed by blood pooling and relative hypovolemia. In spite of hypotension, there is bradycardia (or no compensatory tachycardia) due to impaired sympathetic innervations to heart. Hence a patient with upper spinal cord injury, hypotension without compensatory tachycardia (or bradycardia) is clinical clue for neurogenic shock. Although intravenous fluids should be administered in all patients with suspected spinal injury as early as possible, only fluid may not be able to restore blood pressure. Excess intravenous fluid may lead to fluid overload and pulmonary edema. Invasive monitoring for hydration monitoring and urinary bladder catheter for urinary output may be used if fluid status in not known.

Medications : Phenylephrine, norepinephrine or dopamine may be used for hypovolemia after moderate intravenous fluid and atropine for bradycardia. At present evidences are not sufficient to support use of steroid in patients with acute SCI. Prophylactic treatment of deep venous thrombosis to prevent thromboembolism in patients with severe motor deficits due to spinal cord injury is recommended. Low molecular weight heparin, conventional heparin or dynamic compression stocking may be used.

Definite Treatment : Definite treatment depends on type of injury at specialized centre. Early surgical decompression is safe with better results. Discussing definite treatment is beyond the scope of this chapter.

KEY POINTS:

1. Clinical finding may not be very reliable if patient has altered level of consciousness or sever pain.
2. All patients with neurological deficit or with radiographic evidence of injury should be considered as patient with unstable spinal injury.
3. An suspected cervical spine injury patient who is alert and awake, without any clinical deficit or radiographic evidence of spine injury or spinal tenderness is less likely to have spinal cord injury. He should be asked for voluntary movement. If there is no pain on movement, no need of further investigation. If he has pain on voluntary movement or mild tenderness, he should be evaluated radiographically in details to rule out spinal injury.
4. If there is doubt of injury, cervical collar should be continued.
5. Immobilization is one of the most important steps for transferring patients with suspected spinal injury.
6. Injured thoraco-lumbar spines are very vulnerable to rotational injury. Hence logrolling should be performed in these patients with extreme care.
7. About 10 % of cervical spine facture have noncontiguos vertebral column fracture. Hence whole spine screening is very important.
8. A patient on hard backboard for more than 2 hours is predisposed to pressure ulcers.
9. All radiographic images must be of good quality and must be interpreted as normal by a expert before discontinuing spinal precautions.

Table 1 Clinically Important Myotomes and Dermatomes

Spinal Root	Dermatome	Myotome
C5	Area over deltoid muscle	Deltoid
C6	Thumb	Forearm Flexor (Biceps)
C7	Middle finger	Forearm extensor (Triceps)
C8	Little finger	Finger flexors (hand grip)
T1	Inner side of forearm	Small finger abductor (Abductor digitiminimi)
T4	Nipple	-
T8	Xiphisternum	-
T10	Umbilicus	-
T12	Symphysis pubis	-
L2	Inner aspect of thigh	Hip flexor (iliopsoas)
L3,4	L3- Knee L4- Medial aspect of calf & ankle	Knee extensor (quadriceps)
L5	Web space between 1^{st}& 2^{nd} toe	Ankle & big toe dorsiflexior (Tibialis ant. & Extensor hallusislongus)
S1	Heel & lateral aspect of foot	Ankle planter flexor (gastrocnemius-soleus)
S3	Ischial tuberosity area	-
S4,5	Perianal area	

Table 2 Muscle strength grading

Score	**Strength of muscle**
0	Complete paralysis
1	Palpable or visible contractions
2	Full range of movement when gravity eliminated
3	Full range of movement against gravity
4	Full range of movement which is less than normal
5	Normal strength

CHAPTER 11 TRAUMA TRIAGE

Trauma triage is the use of trauma assessment for prioritizing of patients for treatment or transport according to their severity of injury. Primary triage is carried out at the scene of an accident and secondary triage at the casualty clearing station at the site of a major incident.

Triage is repeated prior to transport away from the scene and again at the receiving hospital. The primary survey aims to identify and immediately treat life-threatening injuries and is based on the 'ABCDE' resuscitation system:

Airway control with stabilization of the cervical spine.

Breathing

Circulation (including the control of external hemorrhage)

Disability or neurological status

Exposure or undressing of the patient while also protecting the patient from hypothermia

Priority is then given to patients most likely to deteriorate clinically and triage takes account of vital signs, prehospital clinical course, mechanism of injury and other medical conditions. Triage is a dynamic process and the patients should be reassessed frequently, the following is one example of triage sieve which is used in the UK:

A. Priority 1 (P1) or Triage 1 (T1): Immediate care needed - requires immediate life-savingintervention. The color code is **red.**

B. Priority 2 (P2) or Triage (T2): Intermediate or urgent care needed - requires significant intervention within two to four hours. The color code is **yellow.**

C. Priority 3 (P3) or Triage 3 (T3): Delayed care - needs medical treatment, but this can safely be delayed. The color code is **green.**

D. Dead is a fourth classification and is important to prevent the expenditure of limited resources on those who are beyond help. The color code is **black.**

The simplest way of triaging patients is to classify the patients arriving into the Emergency Area or Trauma Centre into five types

a) Walking

b) Talking

c) Broken

d) Bleeding

e) Dying

Walking & Talking patients would have airway, breathing &circulation intact hence are taken into green resuscitation area.

Broken patients are one with fractures; hence these patients can bleed& are taken into yellow area.

Bleeding and dying patients are on one with immediate life-threatening injuries and can die if not adequately resuscitated, hence are taken into red area.

The following is described in Figure 1

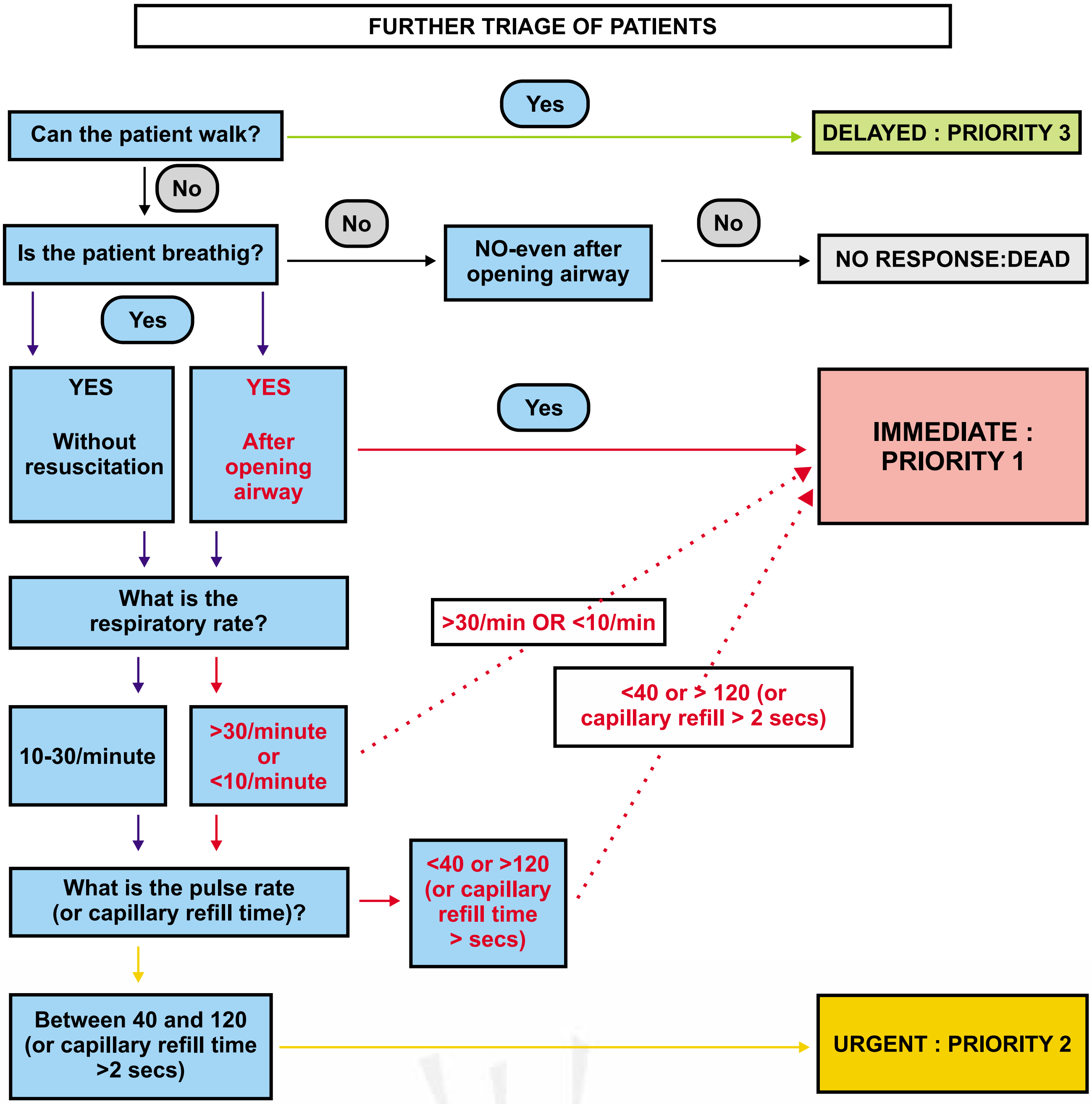
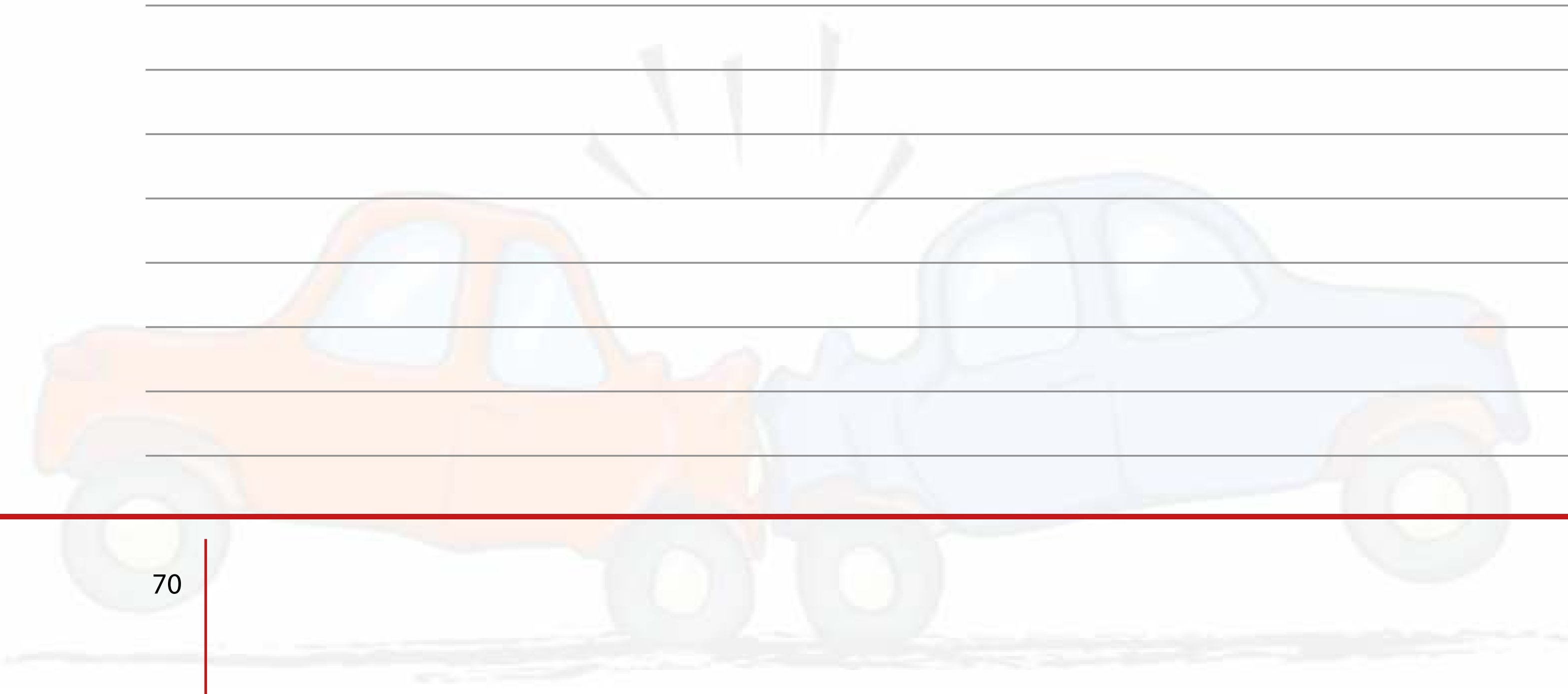


Figure 1: Triaging of patients as arriving into emergency area or trauma area.

Notes



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