ASSESSMENT AND MANAGEMENT OF TRAUMA

DIVISION OF TRAUMA AND SURGICAL CRITICAL CARE
DEPARTMENT OF SURGERY
UNIVERSITY OF SOUTHERN CALIFORNIA

D. Demetriades, M.D., Ph.D.,FACS©
Professor and Vice Chairman of Surgery
Director of Trauma and Surgical Critical Care

5th edition, 2009
To download go to link below
http://www.surgery.usc.edu/divisions/trauma/
EBook Version Created By
Chris Jack, CDR, US Navy
RN, MS, CNS, CCRN
cmjack777@gmail.com

LAC+USC TRAUMA MANAGEMENT PROTOCOLS*

TOC

*These are the protocols recommended by the Trauma Program of LAC+USC Medical Center. The protocols may be modified depending on the judgement of a senior physician. These protocols were developed jointly by the following Departments/Services: Trauma/ SICU, Emergency Medicine, Blood Bank, Obstetrics, Radiology, Orthopedics, Neurosurgery, & Urology

TOC

Trauma Protocols

INTRODUCTION

The aim of this booklet is to help residents, medical students, and nurses involved in trauma care, in the management of the injured patient, especially during the first few critical hours. Most topics in trauma are discussed, with special emphasis on common pitfalls. The clinical protocols in use in the Division of Trauma and SICU are also included. I am indebted to Aida Aguilar for preparing the manuscript and overseeing the printing.

D. Demetriades, M.D., Ph.D., FACS

Los Angeles, CA, 2009

TOC

INITIAL ASSESSMENT AND RESUSCITATION OF THE INJURED PATIENT

In severe trauma, assessment and resuscitation should be performed simultaneously. The purpose of the initial evaluation and management is to diagnose and address life-threatening problems, which can cause death or serious morbidity if not treated early. This is called Primary Survey.

PRIMARY SURVEY

The primary survey includes 5 components, which should always be followed in strict order.

- **A. Airway Maintenance with Cervical Spine Protection**
- **B. Breathing and Ventilation**
- **C. Circulation and Hemorrhage Control**
- **D. Disability/Neurological Status**
- **E. Exposure/Environmental Control**

TOC

After the 5 main components of the Primary Survey, continue with F,G,H:

- **F. Foley Catheter**
- **G. Gastric Tube**
- **H. Hertz - Trauma Ultrasound**

A. Airway

1. Clear the oropharynx of blood, mucus and foreign bodies.
2. Lift the angle of the jaw or the chin to prevent the tongue from falling back and obstructing the airway. (Don't overextend the neck; the patient might have a spinal injury!).

- Use of oropharyngeal tubes in patients with gag reflexes may induce vomiting and aspiration. Remember that oropharyngeal tubes have limited use! Perhaps their only use is in patients with orotracheal tubes, to prevent the patient from biting the endotracheal tube.

TOC

Choose the correct length oropharyngeal tube. The distance between the angle of the mouth and the earlobe is an easy way to choose the right size tube.

**If the above measures are not sufficient or if the patient is unconscious (GCS=<8), endotracheal intubation is the next step. (Size 8 for adult males, size 7 for females, or the size of the patient's small finger irrespective of age).

- Apply cricoid pressure during intubation to prevent aspiration. Keep applying the pressure until the cuff of the tube has been inflated. Make sure that the tube is in the
- Make sure that the tube is in the correct place by checking for CO2 return, listening for bilateral breath sounds and obtaining a chest x-ray.
- If endotracheal intubation is impossible (e.g. in severe facial trauma), the next step is a cricothyroidotomy. In emergencies there is no place for tracheostomy. In patients with short, fat necks, the procedure can be difficult. TOC

Cervical Spine Protection

- High index of suspicion depending on the history of the accident: (traffic accidents, falls, certain sports).
- Avoid rough manipulation of the head and neck. Use hard collars to immobilize the neck. Immobilize the whole body on a long spinal board.
- Obtain appropriate radiological evaluation. Symptomatic or unevaluable patients with suspicious mechanisms of injury should be evaluated with CT scan of the cervical spine. Radiological evaluation should be done only after the patient has been stabilized, if necessary after an emergency operation. Clearance of the cervical spine is NOT an emergency!

B. BREATHING AND VENTILATION

- Inspect for symmetrical chest movements. Auscultate for breath sounds bilaterally. Palpate the trachea for deviation and the chest wall for fractures or emphysema.

TOC

- Life-threatening problems to be identified during primary survey:

1. Flail chest: Monitor pulse oximetry and blood gases, intubate and ventilate if there is hypoxia or respiratory distress. Consider early intubation in elderly or severe multitrauma patients.
2. Open, sucking/blowing wound in the chest wall: Do not suture or pack before thoracostomy tube insertion. Danger of tension pneumothorax! A Square gauze taped on only 3 sides can be applied while preparing for chest tube insertion.
3. Tension pneumothorax: Initial decompression with needle insertion through the

2nd or 3rd intercostal space anteriorly, mid-clavicular line.

Thoracostomy tube.

C. CIRCULATION AND HEMORRHAGE CONTROL

1. Assess BP, heart rate and evidence of bleeding.
2. Control any external bleeding by direct pressure.
3. In penetrating injuries of the neck, where venous injuries are suspected, put the patient in the Trendelenberg position, (head down) to prevent air embolism.

4. If there is shock, insert one or two large intravenous lines and start fluid resuscitation.

Following trauma there are 3 groups or conditions, which can cause shock:

Hypovolemic Shock

This is the most common cause of post-traumatic Hypotension and could be due to external or internal blood loss.

- Vascular access with two or more large bore intravenous lines. Access to central veins can be achieved by means of subclavian, jugular or femoral vein catheterization. In patients with neck or arm injuries, the intravenous line should be inserted on the opposite side to avoid extravasation of the infused fluid from a proximal venous injury.
- In children younger than 6 years consider intra-osseous infusion, if a peripheral vein is not available.
- The infusion rate depends on the length and diameter of the catheter and NOT on the size of the vein.

TOC

- Give a fluid challenge of 2 liters of Ringer's Lactate (or 20 ml/kg for children). If more fluids are needed, consider blood transfusion and perhaps operation. However, if the patient has a clear indication for surgery no time should be wasted for fluid resuscitation!

There is evidence that in penetrating trauma with active bleeding some degree of mild hypotension until the bleeding is surgically controlled may be beneficial!

Blood

- Rh negative: No need for typing or cross matching. For life threatening blood loss only. Available in refrigerator in the Emergency Room and Operating Rooms.
- Typing but no cross matching. ("Type specific blood") Ready in about 10 minutes.
- Fully typed and cross-matched. Ready in about 30 minutes.
- Always use blood warmers. Hypothermia may aggravate acidosis, induce arrhythmias, shift the oxyhemoglobin dissociation curve to the left, and impair platelet function.

In severe hypovolemia use Level I rapid infusion blood warmers.

Cardiogenic Shock

This should be suspected in trauma patients with shock in the absence of blood loss. The blood pressure is low and the neck and peripheral veins are distended.

- The following conditions may be associated with cardiogenic shock: cardiac tamponade, myocardial contusion, tension pneumothorax, air embolism, and myocardial infarction. The first three will be discussed in the "chest injuries" section.
- Air Embolism may follow injuries to major veins, lungs, or the low-pressure cardiac chambers. Occasionally it may be iatrogenic, during insertion of a central venous line. Sudden deterioration of a patient in the presence of one of the above injuries should alert the doctor to the possibility of air embolism. Sometimes "sloshing" sounds may be heard over the heart. The treatment consists of positioning the patient in the Trendelenburg position,

thoracotomy and direct aspiration of the air from the heart. In lung injuries, cross-clamp the hilum to control the source of air embolism.

- Myocardial infarction should be suspected in elderly patients presenting in cardiogenic shock. ECG and Troponin level should be performed routinely

Cardiac Arrest- See: Resuscitative thoracotomy and internal cardiac massage. There is no place for external massage in trauma patients within the hospital (except in head injuries).

Neurogenic Shock

This is the result of loss of vascular tone following cervical cord or upper thoracic spinal cord injury.

D. DISABILITY (NEURO EVALUATION AND MANAGEMENT)

1. Assess level of consciousness (Glasgow Coma Scale).
2. Assess pupils (size, reactivity).

E. EXPOSURE/ENVIRONMENT CONTROL

1. Undress the patient completely for thorough examination. TOC

2. Keep the patient warm with blankets and warm IV fluids. Trauma patients become hypothermic very quickly. Severe blood loss, elderly patients and pediatric trauma patients are at high risk for hypothermia.

SECONDARY SURVEY

1. The secondary survey is done only after the primary survey (ABC's) is completed and resuscitation is initiated. Sometimes the secondary survey is performed after operation for life-threatening injuries.
2. Complete examination from head to toe (head and neck, chest, abdomen, back, rectal and vaginal examinations, and musculoskeletal).

TERTIARY SURVEY

A tertiary survey should always be performed semi-electively, according to the “Trauma Consultation” form. The purpose of this survey is to diagnose any occult or minor injuries!

TOC

EXPERT COMMENTS

1. Examination of the trauma patient:

- Often this is very difficult because of intoxication, shock or head injury.
- Undress the patient completely and always examine the back. Serious injuries may otherwise be missed. Cover the patient with warm blankets to prevent hypothermia.
- The presence of an obvious wound should not distract from another less obvious but perhaps more dangerous injury elsewhere.

2. Head Injury:

- Correct any condition, which aggravates an existing brain injury (e.g. shock or hypoxia).
- Cervical spine injury is a commonly associated problem. Apply a semi-rigid collar, keep the head and neck in a neutral position, and apply precautions during transportation, until a cervical injury has been excluded. The cervical spine clearance is not an emergency as long as protection is maintained.

- Closed head injuries alone rarely produce hypotension, except in the terminal stages or in neonates. If the patient is in shock, look for a source of bleeding, cardiogenic shock or associated cervical spine injury. Scalp lacerations can bleed profusely and may cause hypotension.

3. Fractures:

- Immobilize all severe fractures at an early stage, before moving the patient to CT scan or other investigations. This will reduce pain, decrease bleeding, reduce fat embolism, and minimize neurovascular damage.
- Fractures of the pelvis or the femur may be associated with significant blood loss.
- Early operative fixation of major fractures decreases morbidity, mortality, and hospitalization. However, in the presence of severe associated head or chest trauma, prior stabilization of the patient is advisable.

TOC

4. Common mistakes:

- Insertion of an oropharyngeal airway in the presence of brisk gag reflexes.
    - Problem: Vomiting and aspiration!
- Tracheostomy in emergency situations. Problem: It takes a few minutes even in the hands of experienced surgeons! Procedure of choice: Cricothyroidotomy.
- Cervical spine protection: Soft collars offer no protection. Hard collars offer some protection. Always apply total body immobilization with spinal board during transportation. C-spine clearance is not an emergency as long as spinal precautions are maintained.
- External cardiac massage in traumatic cardiac arrest due to blood loss or cardiac tamponade. Procedure of choice is the resuscitative thoracotomy and internal cardiac massage.
- Pack or suture open sucking/blowing wounds before thoracostomy tube insertion.

TOC

- Problem: Tension pneumothorax! If a dressing is needed, apply a square gauze taped on to skin in only 3 sides!

- Examine a severely injured patient without removing his clothes.
  - Problem: Serious injuries may be missed!
- Omit rectal or vaginal examinations, especially in pelvic fractures. (Do not perform routine vaginal exam in children).
  - Problem: Serious injuries may be missed!
- The 3 most commonly missed injuries: a) Spinal injury; b) Spinal injury; c) Spinal injury.

Never directly admit a patient with suspicious mechanism of injury (traffic injuries, falls from significant height) to an orthopedic or neurosurgical unit. It is a disaster waiting to happen! Serious injuries may be missed. The trauma surgeon should be in charge for at least the first 24 hours.

TOC

HEAD INJURIES

These may include injuries of the scalp, skull, brain, and blood vessels.

Scalp Injuries

1. Laceration of the scalp may be associated with significant bleeding. Control with deep sutures and compression dressing. Never send a patient to the radiology suite before suturing a bleeding scalp wound!
2. Scalp infections may spread intracranially via the emissary veins.

Skull Injuries TOC

1. Skull fractures are described according to shape, displacement, site and integrity of the overlying skin. Thus we have, for example, linear, stellate, comminuted, depressed, compound, and basilar fractures.
2. A fracture can be diagnosed by digital exploration of the wound, radiographically or clinically. The diagnosis of basilar fractures is often clinical:

- CSF leaking from the nose or ear.

- Periorbital ecchymosis (raccoon eyes).
- Ecchymosis behind the ear (Battle's sign).

Brain Injuries

1. Concussion: No gross pathology. Transient loss of consciousness. CT scan is normal.
2. Contusion: Bruising of the brain surface underneath a fracture or at the under-surface of the frontal and temporal lobes, due to shearing forces. Diagnosed on CT scan.
3. Laceration: Tearing of the brain substance. Diagnosed by CT scan.
4. Brain edema: This is localized in the glial cells, myelin sheaths, and intercellular spaces. It causes increased intracranial pressure, which may impair brain circulation, or result in brain herniation. It may be missed in early CT scans. Later CT scans or MRI show edema more reliably.

TOC

Brain damage is classified into:

1. Primary brain damage. It occurs at the time of injury and is irreversible (i.e. lacerations, contusions, axonal injuries of the white matter due to shearing forces).
2. Secondary brain damage. It occurs at a later stage due to tissue hypoperfusion and may be preventable and reversible. Conditions that may cause secondary brain damage:
   - Extracranial causes: shock, hypoxia, and electrolyte abnormalities. TOC
   - Intracranial causes: hematoma, brain edema, infection, and hydrocephalus.

Cerebral Perfusion Pressure (CPP)

- CPP = mean arterial pressure (MAP) - intracranial pressure (ICP).
- Normal ICP is 5-15 cmH20
- A minimum CPP of 70 mm Hg (or >50 mmHg in young children)

- Is critical in maintaining adequate brain perfusion and minimizing secondary brain damage.

Intracranial Bleeding

1. Epidural hematoma: Usually due to laceration of the middle meningial artery or venous sinuses. Commonly located in the temporal or parietal region, often with associated fractures. On CT scan it appears as a hyperdense, biconvex-shape lesion.
2. Subdural hematoma:
    a. Acute subdural: It manifests within the first few hours of injury. It is due to bleeding from injured brain tissue or from the veins, which bridge the cortex with the cavernous sinus. On CT scan it appears as a crescent-shape, hyperdense lesion.
    b. Chronic subdural: It may appear many days, weeks or months after the injury. More common in elderly patients. On CT scan it shows as a crescent-shape, hypodense lesion. TOC

3. Intracerebral hematoma: Usually beneath a cortical contusion.
4. Subarachnoid hemorrhage: It often gives symptoms and signs of Meningial irritation: headache, photophobia, neck stiffness, fever. The mental status may vary from confusion to coma. On CT scan it appears as linear, high-density areas following the sulci, often in the Sylvian fissure. The blood is usually absorbed by the CSF. It may cause late hydrocephalus because of obstruction of the CSF circulation.

A catastrophic complication in patients with intracranial hematomas is herniation of the temporal lobe through the tentorium and compression of the brain stem. Symptoms and signs:

1. Dilatation of the ipsilateral pupil, due to compression of the third nerve. In the early stages there may be transient constriction due to stimulation of the nerve.

TOC

2. Depressed level of consciousness, due to compression of the reticular formation
3. Contralateral hemiparesis, due to compression of the cerebral peduncle
4. Bradycardia
5. Elevated blood pressure
6. Irregular respiration

Initial Resuscitation TOC

The final functional outcome of head injuries depends to a considerable degree on the adequacy of the initial treatment. The ABCs (Airway with neck protection, Breathing, Circulation) always take priority.

1. Secure adequate ventilation, control external bleeding, correct hypotension, drain any hemopneumothorax. (Hypotension and hypoxia aggravate secondary brain damage and worsen the prognosis). Intubate and ventilate patients with GCS 8 or less.
2. **Closed head injuries alone rarely produce hypotension**, except in terminal stages or associated cervical spine

injuries. If there is hypotension, look for external or internal bleeding or associated cervical spinal cord injury. For fluid resuscitation in hypotensive patients consider hypertonic saline 3%, bolus 250 mls.

3. Keep the neck in hard collar and line head in neutral position until exclusion of an associated cervical spine injury, maintain total body immobilization on a spinal board during transportation.
4. Insert a nasogastric tube to prevent gastric distension and aspiration. In basilar or complicated facial fractures, choose the oral route.
5. In restless patients give adequate sedation and if necessary pharmacological paralysis and intubation.
6. Keep PCO2 at 32-35 mmHg. Too low or too high PCO2 may be harmful to the brain.

Physical Examination

1. Assess level of consciousness. Use the Glasgow Coma Scale. The minimum score is 3 and the maximum score is 15. An intubated patient has a maximum GCS 11T. A

score of 8 or less signifies severe brain damage and the prognosis is guarded.

2. Check pupils (size, reaction to light).
3. Check ears and nose for bleeding or CSF leakage.
4. Check for ecchymosis around the eyes or behind the ears (basilar fracture).
5. Check cranial nerves.
6. Exclude neck injury (neck pain, stiffness, tenderness, or paralysis are suspicious signs).
7. Limbs (strength, tone, reflexes)
8. Vital signs (blood pressure, pulse, respiration, temperature)
9. Associated injuries

TOC

Glasgow Coma Scale

Best Eye Opening (4)	Best Verbal (5)	Best Motor (6)
4 Spontaneous	5 Oriented	6 Follows Commands
3 To Voice	4 Confused	5 Localize to Pain
2 To Pain	3 Inappropriate	4 Withdraw to Pain
1 No Response	2 Incomprehensible	3 Decorticate
	1 No Response	2 Decerebrate

(back to physiologic scoring systems)

Diagnostic tests

1. Plain skull x-rays only if CT scan is not available (may show fractures, foreign bodies, air in the skull, shifting of calcified midline structures). A linear fracture increases the risk of intracranial hematoma by 400 times.
2. Cervical spine x-rays and CT scan for all unconscious patients and those with suspicious symptoms (local tenderness, neurological signs).

TOC

3. CT scan: This is the most important diagnostic tool. Indications: All patients with history of loss of consciousness, amnesia, depressed level of consciousness, headache and localizing signs should have a CT scan investigation. Subsequent CT scan may be necessary if there is deterioration of the neurological status.
4. Carotid angiogram (limited use). It might be useful in some penetrating injuries, especially with retained knife blades or bullet injuries.
5. Intracranial Pressure (ICP) monitoring: It is an essential diagnostic, monitoring, and therapeutic modality in severe head injuries. The guidelines for ICP monitoring are shown in Protocol 4. The CPP (Cerebral Perfusion Pressure) is much more important than ICP absolute values. Maintain a CPP >70 mmHg or >50 mmHg in young children.

TOC

Specific Management

1. All patients with skull fractures, history of loss of consciousness, seizures, significant headache, amnesia, depressed level of consciousness, and focal deficits should be admitted. If in doubt, e.g. when dealing with infants or drunken patients, admit.
2. Closed, uncomplicated fractures: Symptomatic management, observation for 2-3 days; no need for antibiotics.
3. Compound fractures, uncomplicated: Observation for 2-3 days, single dose of antibiotic prophylaxis, washout and closure. TOC
4. Basilar fractures: Single dose antibiotic prophylaxis. Do not pack the nose or ears to stop CSF leaking because of danger of meningitis. Put the patient in a semi-sitting position. If the CSF leak persists for more than 10 days, consider surgical intervention.
5. Depressed fractures: If it is a compound fracture, elevation may decrease the incidence of sepsis. Routine

elevation is not recommended for closed depressed fractures. Elevation does not improve the neurological outcome or risk of epilepsy.

Seizure prophylaxis in all patients with intracranial bleeding [Phenytoin loading dose 10-15 mg/Kg over 30-60 minutes, followed by 5 mg/Kg per day or Levetiracetam (Keppra) 500 mg twice a day for 7 days]. Early seizures (within 7 days) do not warrant long-term prophylaxis. Prolonged anticonvulsant prophylaxis does not prevent late epilepsy. TOC

6. A knife stuck in the skull: Do NOT remove. This should be done in the OR by a neurosurgeon, in some cases after an angiogram has been obtained.
7. Evidence of brain stem dysfunction: (deteriorating level of consciousness, fixed dilated pupil, localizing signs, bradycardia, high blood pressure): Give Mannitol if the patient is normotensive (0.5g-l g/kg over 20 minutes) or hypertonic saline 3% (250 mls over 20 minutes), lower PaCO2 to 32-35 mmHg.

8. **Elevated intracranial pressure**: The normal ICP is <15 cm H20 (<5 in young children). Treatment should be initiated if ICP >20 cm H20. High ICP is associated with poor outcome.

The indications for ICP monitoring are shown in protocol 4.

The intracranial hypertension is most severe in the first 2 to 3 days post-injury. It can be managed by a combination of the following therapeutic modalities:

General Measures

a. Correct any hypovolemia or hypoxia.
b. No tight tapes or C-collar around neck.
c. Adequate sedation and if necessary paralysis.
d. Control of seizures
e. Keep head of bed elevated (15° - 30°), provided the patient is euvolemic and has no spinal trauma.
f. Keep the body temperature normal - this reduces cerebral metabolism.

TOC

Specific Measures

a. CSF drainage through an intraventricular catheter.

b. Mannitol 0.5-1.0 g/Kg over 20 minutes (keep serum osmolality <320 m 0sm/L) provided that the patient is hemodynamically stable. Hypertonic saline (250 mls 3%) is an excellent alternative.

c. Lower pCO_2 to 32-35 mmHg by means of hyperventilation (hypocapnia causes constriction of the cerebral vessels, thus decreasing the ICP). Avoid excessive hypocapnia (PCO_2 <32), because severe vasoconstriction may result in brain hypoxia.

d. Barbiturates for persistent intracranial hypertension.

e. Always try to keep CPP > 70 mm Hg (>50 mmHg in young children).

The following therapeutic modalities are reserved for refractory intracranial hypertension: Barbiturate coma, hypothermia, hypertensive CPP treatment, and craniectomy. TOC

10. Nausea and vomiting are common in children. No prognostic significance. Treat symptomatically.
11. Restlessness: Exclude pain, a distended bladder, tight casts, and hypoxia. If none of the above is present, sedate the patient.
12. Gunshot wounds of the head: Poor survival, mortality exceeds 90%.
13. Diabetes Insipidus: Usually appears early within hours or days but it may manifest late after injury. It occurs in about 15% of severe blunt and 40% of severe penetrating trauma. Characterized by polyuria, high serum osmolality, and low urine osmolality. Treat with Desmopressin or vasopressin and fluid replacement.
14. Inappropriate ADH secretion: low serum osmolality, high urine osmolality. Treat with fluid restriction, hypertonic saline, and diuretics.
15. There is evidence that in the presence of subarachnoid hemorrhage treatment with calcium channel blockers (Nimodipine) improves survival.

16. Disseminated Intravascular Coagulopathy (DIC): It is a very common complication in severe head injuries, especially gunshot wounds. Monitor coagulation parameters very and start treating early!

NB: Urgent neurosurgical consultation is needed if there is deterioration of the level of consciousness or development of localizing signs.

- Moderate or severe head injuries undergoing operation for other associated trauma: Monitoring of ICP, close observation of pupils.
- Indications for ICP monitoring - see protocol 4.

Management of the Unconscious Patient

1. Respiratory: Endotracheal intubation or tracheostomy if prolonged intubation is anticipated. Regular suctioning of secretions. Humidified oxygen.

1. Fluids and electrolytes: Avoid over-hydration, dehydration or electrolytic disturbances, especially in the critical first few days. TOC

2. Nutrition: Consider early nasogastric or jejunal feeding. In adults about 1800 kcal and 1.5 g/Kg protein per day.
3. Bladder: Foley's catheter or condom drainage.
4. Prevent pressure sores: Special mattresses, good nutrition, and good hygiene.
5. Watch for complications such as pneumonia, UTI, meningitis, chronic subdural, hydrocephalus, meningitis, diabetes insipidus, and inappropriate ADH secretion.

Late Complications

2. Post-concussion syndrome: Headache, dizziness, poor concentration and memory. No specific therapy. Most patients improve within days to months.

3. Chronic subdural hematoma: This may present weeks or months after the injury, especially in elderly patients.

4. Subdural hygroma: Due to leakage and collection of CSF.

5. Hydrocephalus: This may follow a subarachnoid hemorrhage or intraventricular bleeding because of obstruction of the CSF circulation.

TOC

6. Late CSF leaks: It may follow a basilar fracture and may present weeks or even years after the injury.
7. Post-traumatic epilepsy: Common in bullet injuries, depressed fractures, intracranial hematomas, meningitis, and early seizures. It usually occurs within the first year. Prolonged prophylaxis does not reduce the risk of epilepsy.
8. Brain atrophy.
9. Carotid cavernous fistula: (The patient complains of headaches, "noise" in the head, proptosis of the eye, and is usually very ill)

*** Notes** TOC

1. Avoid prophylactic hyperventilation (PCO2 <35) especially in the first 24 hours, unless the patient has intractable intracranial hypertension.
2. Avoid routine prophylactic Mannitol for all severe head injuries. Mannitol should be considered only in the presence of intracranial hypertension or with neurological deterioration, and provided the patient is not hypotensive.

Hypertonic saline 3% (250 mls) is an excellent alternative in these cases.

Common Mistakes

- Closed head injuries alone do NOT usually produce hypotension, except in terminal stages or infants. Look for blood loss or associated cervical spinal cord injury!
- Minor head injuries (GCS 13-15) may be associated with significant intra-cranial lesions. All patients with GCS <15, history of loss of consciousness or amnesia should be investigated by CT scan.
- Scalp lacerations may bleed a lot! Suture before sending the patient to the radiology suite.
- Do not give seizure prophylaxis for longer than 7-10 days.

Prolonged prophylaxis does not reduce the risk of epilepsy.

- DIC, DI, and seizures are extremely common in severe trauma. Monitor closely and start treatment early! Routine seizure prophylaxis for 7-10 days.

TOC

PENETRATING INJURIES OF THE NECK

A. ANATOMICAL ZONES:

Penetrating injuries of the anterior neck are divided into 3 anatomical zones (picture): Zone 1-between the clavicle and the cricoid cartilage, zone 2-between the cricoid and the angle of the mandible, and zone 3-between the angle of the mandible and the base of the skull.

B. OPERATION OR OBSERVATION

- Criteria for emergency operation, usually without any specific investigation, include the following "hard" signs and symptoms: severe hypovolemic shock, active bleeding, an expanding or pulsatile hematoma, an absent or diminished peripheral pulse, bubbling of air through the wound, or dyspnea.
- Other "soft" signs suggestive of significant injury are pain on swallowing, small hematemesis, hoarseness, minor hemoptysis, and subcutaneous emphysema in the absence of pneumothorax. These conditions require further

investigation. The presence of an isolated nerve injury is not an indication for an emergency operation.

- If there are no hard signs of significant injury and the investigations are normal the patient is managed nonoperatively. Overall, only 15-20% of penetrating injuries of the neck require an operation.

TOC

C. INITIAL ASSESSMENT AND MANAGEMENT

1. Airway: Airway obstruction may be a problem in patients with a large neck hematoma or extensive laryngotracheal injury. Intubation, preferably with a fiberoptic scope in stable patients, or surgical airway placement in emergencies may be necessary. Pharmacological paralysis may result in loss of airway if the cords cannot be visualized. During intubation attempts the surgical team should be ready for cricothyroidotomy.
2. Bleeding: Apply external compression over the wound and put the patient in the Trendelenburg position. These simple maneuvers also prevent air embolism in venous

injuries. If the bleeding comes from a deep wound, inserting a Foley catheter and inflating the balloon with sterile water can achieve control. (See Picture).

3. Intravenous Lines: Always insert the line on the opposite from a proximal venous injury
4. Local Examination: Check for active bleeding, an expanding or pulsatile hematoma, a bruit, peripheral pulses, blood in the sputum, air bubbling through the wound, hoarseness, and subcutaneous emphysema. Exclude injury to the spinal cord, to the 7, 9, 10, 11 and 12 cranial nerves, to the brachial plexus, and to the sympathetic chain (Horner's syndrome). It is critical to perform the clinical examination according to a written protocol. TOC
5. Central Nervous System: Carotid injuries are often associated with brain ischemia and neurological signs. The neurological examination may be difficult in shocked or intoxicated patients.

6. Cardiovascular Status: Check the blood pressure in the arm opposite to the injury.
7. Associated Injuries: The presence of a bleeding wound in the neck should not distract one from looking for other dangerous injuries in the chest, abdomen, etc.

TOC

D. DIAGNOSTIC TESTS

Diagnostic investigations should be done only on reasonably stable patients.

1. Chest and neck X-rays: Look for the following radiological signs:
    a. A hemopneumothorax is a commonly associated problem (about 25% of cases).
    b. Subcutaneous emphysema: This may be due to an associated pneumothorax, injury to the trachea, larynx or esophagus, or due to air entering via the wound. Patients with subcutaneous emphysema and a wound tract with a direction toward the midline should be

assessed by means of a Gastrografin swallow and endoscopy.

c. Widened upper mediastinum: This could be the result of injury to a major mediastinal vessel. If the patient is in shock, an emergency operation is indicated. If the patient is stable, an emergency CT angiogram should be performed to exclude injury to the aorta and great vessels. TOC

2. CT scan with intravenous contrast: It is an excellent investigation in hemodynamically stable patients with gunshot wounds to the neck. It can reliably select patients who might benefit from further evaluation by angiography or esophageal studies

3. Color Flow Doppler: This has become the investigation of choice in our center. It is noninvasive, sensitive, specific, and cheap. It has some limitations in the evaluation of the internal carotid artery near the base of the skull and in proximal subclavian vessels in obese patients.

4. Angiography: There is no place for routine emergency angiography in the assessment of penetrating injuries of the neck. In our center, it has been largely replaced by color flow doppler and CT angiography. We advocate an emergency angiogram in fairly stable patients with shotgun injuries, in suspicious CT scan findings, and in stable patients with an absent or diminished peripheral pulse, or a bruit, provided the arm is not dangerously ischemic.
5. Gastrografin swallow: For suspected esophageal injuries. The patient should be awake and alert.
6. Esophagoscopy: For suspected esophageal injuries preoperatively or intraoperatively.
7. Laryngo-tracheoscopy: For suspected injuries to the larynx and trachea.

E. NONOPERATIVE MANAGEMENT

Patients selected for nonoperative management are admitted for observation, and frequent clinical reassessments. If the patient develops signs suggestive of a serious neck injury, an operation is performed. Otherwise, the patient is discharged within 24-48 hours. TOC

Common mistakes

- Sitting up a patient with venous injuries.
  - Problem: Danger of air embolism! Keep the patient in flat position!
- Insert an intravenous line on the same side of the neck injury.
  - Problem: Extravasation of infused fluids from a proximal venous injury.
- Pharmacological paralysis for endotracheal intubation in a patient with a large neck hematoma, without a surgeon been present and ready to perform a cricothyroidotomy.
  - Problem: Inability to visualize the cords and intubate may be catastrophic because patient is paralyzed and cannot breath.
- Failure to perform the clinical examination according to a written protocol.

- Problem: Important signs and symptoms may be missed! Always use our written protocol.

CHECKLIST FOR PENETRATING INJURIES OF THE NECK

FLOWCHART FOR PENETRATING INJURIES OF THE NECK

A. URGENT PRIORITIES

1. Control any active bleeding (pressure, packing, Foley's catheter).
2. If active bleeding: Trendelenburg position to prevent air embolism.
3. Secure airway.
4. I.V. fluids (no I.V. line on the side of the injury).

Depending on the findings of clinical examination further investigations such as color flow doppler, endoscopy, contrast swallow studies or angiography may be indicated.

TOC

BLUNT TRAUMA TO THE NECK

Mechanisms: Seatbelts, direct blunt trauma, hangings, overextension or over flexion injuries.

Clinical Evaluation:

- Neurological deficits might be due associated head trauma or vascular injuries

1. Laryngotracheal injury signs (dyspnea, subcutaneous emphysema, hemoptysis, hoarseness)
2. Vascular injuries: Hematoma, unexplained neurological signs, often asymptomatic.

Investigations: TOC

- CT scan for suspected laryngotracheal or spinal injuries
- CT angiogram for vascular evaluation of the carotid and vertebral arteries
- Laryngoscopy for suspected laryngotracheal injuries

Note: Vascular injuries are often asymptomatic on admission, only to thrombose and cause stroke many hours or a few days later! Liberal CT angiography evaluation should be consider in all patients with suspicious mechanism of injury, such as seatbelt mark signs, hematomas, cervical spinal or severe Laryngotracheal injuries: Small injuries can safely be observed. Major injuries require surgical repair. Carotid injuries: Major injuries to the common internal carotid or internal carotid arteries, which are accessible to surgical exposure, are managed by surgical repair. Non-accessible injuries or injuries to the vertebral arteries are best managed with anticoagulation for 3 months. Endovascular stenting might be considered in selected extra-cranial carotid injuries.

TOC

CHEST INJURIES
PRINCIPLES OF MANAGEMENT

Always start with ABCs.

During the Primary Survey, the following life-threatening conditions from the chest should be identified and treated:

1) Tension pneumothorax
2) Fail chest
3) Open, blowing chest wound
4) Massive hemothorax
5) Cardiac tamponade

During the Secondary Survey, the following injuries should be identified and treated: TOC

1) Contained rupture of the aorta
2) Perforation of the tracheobronchial tree
3) Perforation of the esophagus
4) Rupture of the diaphragm
5) Myocardial contusion
6) Pulmonary contusion

BLUNT TRAUMA

A. RIB FRACTURES

Diagnosis

1. Clinical history: Pain aggravated by breathing or coughing.
2. Anteroposterior compression of the chest elicits pain.
3. Radiological (Fractures at the costochondral junction may not be seen on the x-rays.)

Treatment

1. Mild to moderate pain: oral analgesics.
2. Severe pain: Consider epidural or patient-controlled analgesia.
3. Multiple fractures in an elderly patient: admission to SICU and epidural anesthesia.

Associated Injuries to be excluded

1. Hemopneumothorax.
2. Fractures of the first three ribs may be associated with injuries of the subclavian vessels or major bronchi.
3. Lung contusion. TOC
4. Cardiac contusions or rupture.

5. Aortic rupture.
6. Diaphragmatic rupture.
7. Fractures of the lower ribs often associated with injuries of the spleen, liver or kidney.

B. FLAIL CHEST (See illustration)

Cause

- Anterior or lateral double fractures of three or more
- Adjacent ribs.
- The flail segment moves inward during inspiration.

Investigations

1. X-rays. (See X-Ray)
2. Pulse oximetry and serial blood gases in multiple fractures. The initial blood gases may be normal!
3. Chest CT scan in severe chest trauma to assess the degree of lung contusion and evaluate for other associated injuries (i.e. aortic rupture).

Treatment

1. Continuous monitoring of SaO2 and blood gases in multiple fractures.
2. Normal SaO2 and blood gases: Analgesia (consider epidural or patient-controlled analgesia).
3. Respiratory failure or flail chest: Mechanical ventilation.
4. Low threshold for mechanical ventilation in severe multitrauma or elderly patients.

C. PNEUMOTHORAX

Definition: The presence of free air in the pleural cavity.

Symptoms and signs

1. Often asymptomatic.
2. Dyspnea, tachypnea.
3. Diminished breath sounds, hyperresonance, poorly moving hemithorax.

Investigations

Chest x-ray, preferably erect and in expiration.

TOC

Treatment

1. Small stable pneumothoraces (less than 20%) can be managed without drainage. Serial x-rays for reassessment are recommended. This approach does not apply to patients scheduled for general anesthesia or assisted ventilation or air transport because of the danger of developing a tension pneumothorax. In rare occasions, even these patients can safely be managed without a chest tube insertion, provided the patient is closely monitored.
2. Significant pneumothoraces require a chest drain. The drain is inserted through the 4th and 5th intercostal space, midaxillary line. Chest physiotherapy immediately after insertion of the drain is of paramount importance. A single-dose antibiotic prophylaxis is adequate. (See thoracotomy tube insertion.)

D. HEMOTHORAX

Definition: Free blood in the pleural cavity.

Symptoms and signs TOC

1. Often asymptomatic.

2. Dyspnea, tachypnea, hypovolemia.
3. Diminished breath sounds, dullness on percussion, poorly moving hemithorax.

Investigations

Erect chest x-ray (See example). CXR in the supine position may miss even a large hemothorax. CT scan is helpful in distinguishing a hemothorax from a lung contusion.

Treatment TOC

1. Minimal hemothorax: observation.
2. Significant hemothorax: chest drain insertion through the 4th and 5th intercostal space, midaxillary line. Use autotransfusion for all large hemothoraces. Physiotherapy and single-dose antibiotic prophylaxis is necessary after the tube insertion. (Cefazolin 2 g).
3. Life-threatening bleeding (persistent shock, blood loss >1000-1500 mls): urgent thoracotomy.
4. Residual hemothorax after thoracostomy tube insertion: Obtain CT scan and arrange thrombolytic therapy with streptokinase or urokinase. If it fails, plan thoracoscopy

and clot evacuation as soon as possible, ideally within five days.

5. Infected hemothorax – tube drainage, antibiotics, possibly thoracotomy or pigtail catheter drainage.

E. HEMOPNEUMOTHORAX

Definition: Free air and blood in the pleural cavity.

Treatment

Chest drain as described in protocol 9

F. TENSION PNEUMOTHORAX (See X-Ray)

Definition: Air under pressure in the pleural cavity due to a valve effect. Associated with life-threatening cardiorespiratory compromise due to collapse of the affected lung, compression of the normal lung and decreased venous return. TOC

Symptoms and signs

- Dramatic presentation. Panicky patient.
- Dyspnea, cyanosis, tachypnea,
- Shock, distended neck veins.
- Trachea shifted to the opposite side.

- Absent breath sounds, hyperresonance on affected side. Prominent hemithorax with no movement on respiration.

Investigations

The diagnosis is clinical. No time for x-rays!

Treatment

1. Insert a needle into the pleural cavity through the anterior 3rd or 4th intercostal space, midclavicular line or at the 5th intercostal space midaxillary line to release the tension.
2. Insert a chest tube at the usual midaxillary line.

PERSISTING ATELECTASIS AFTER CHEST DRAIN INSERTION

1. Incentive spirometry, deep breathing, coughing.
2. Consider therapeutic bronchoscopy.

SUBCUTANEOUS EMPHYSEMA

Definition: Presence of air in the subcutaneous tissues.

Possible causes:

1. Pneumothorax associated with torn pleura and intercostal muscles. TOC
2. Perforated esophagus or bronchus.

3. Air from outside.

   Its presence is an important sign but it has no clinical significance per se. Treatment should be directed towards the underlying cause

G. LUNG CONTUSION

Causes

Usually occurs after direct blunt trauma to the chest, after explosions or high velocity missiles, and in deceleration injuries.

Symptoms and signs

Depending on the severity of the contusion the patient may be asymptomatic or experience dyspnea, hemoptysis, respiratory failure.

Investigations

1. Chest x-ray (See Example). Usually fairly well localized opacification.
2. Pulse oximetry monitoring, blood gases.

TOC

3. CT scan (See Example) provides an accurate picture of the extent of lung contusion, diagnoses other associated injuries and may be helpful in distinguishing between contusion and residual hemothorax.

Treatment

1. Antibiotics (one dose Cefazolin 2 g) only if a thoracotomy tube has been inserted.
2. Oxygen by mask.
3. If respiratory failure, mechanical ventilation.

H. BLUNT CARDIAC TRAUMA **(See Illustration)**

It may vary from asymptomatic or symptomatic cardiac contusion to full cardiac rupture. Cardiac ruptures rarely reach the hospital alive.

Causes

Direct blunt trauma over the precordium, rapid deceleration accidents.

Diagnosis: High index of suspicion, cardiac failure, cardiac arrhythmia, unexplained hypotension. Often the patient is asymptomatic.

TOC

1. A FAST can diagnose tamponade due to cardiac rupture.
2. ECG: Signs of myocardial ischemia, arrhythmias, or may be normal.
3. Troponin measurements on admission and 6-8 hours later.
4. Echocardiogram (the best diagnostic modality) if ECG or
5. Troponins are abnormal.
6. Routine ECG and Troponins should be performed in all patients with a suspicious mechanism of injury.
7. Normal EKG and Troponins on admission reliably exclude any significant cardiac contusion.

Treatment

1. Observation of asymptomatic patients with EKG and Troponin levels monitoring.
2. Inotropes in cardiogenic shock.
3. Antiarrhythmics in arrhythmias.
4. Bed rest, serial ECG and Troponin levels, until they return to normal.

TOC

I. RUPTURE OF THE THORACIC AORTA (See Illustration)

A frequent cause of death in severe traffic accidents. Rare in children. Usually the result of rapid deceleration in high peed accidents or falls from heights. The rupture usually occurs distal to the left subclavian artery (93% of patients) and, less often, just above the aortic valve (areas of relative fixation) or distal thoracic aorta.

Clinical Diagnosis TOC

1. High index of suspicion. (Mechanism of injury).
2. Systolic murmur over the precordium (rare).
3. Hoarseness (compression of the recurrent laryngeal nerve), Horner's syndrome, paraplegia (rare).
4. Hypertension in the arms, hypotension in the legs.

Investigations

1. Chest x-ray: (See X-Ray) widened upper mediastinum (usually more than 8cm). Often left hemothorax. Apical cap. Deviation of the trachea or an inserted nasogastric tube to the right. Depression of left main stem bronchus.

Loss of the aortic knob. Sometimes the chest x-ray may be normal.

2. CT scan (See CT example) of the mediastinum is the investigation of choice. It may differentiate between a widened mediastinum due to a hematoma or due to other reasons (i.e., supine position, unfolded aorta), and is sensitive in identifying aortic injuries, including intimal tears. All patients with suspicious mechanism of injury should have CT evaluation of the mediastinum irrespective of chest x-ray findings. TOC
3. Aortic arch angiogram should be considered in cases with nondiagnostic CT scan, in patients undergoing angiography for other reasons (i.e. pelvic fractures, a liver injury) or when an endovascular stent/graft is considered for the treatment of an aortic rupture
4. Transesophageal Echocardiogram (TEE): For patients in SICU who cannot be moved for CT scan or aortogram.

*Note: Widened upper mediastinum: think of, a) aortic rupture, b) thoracic spinal fracture.

Treatment

1. Resuscitation as necessary. Keep a slightly low systolic pressure (about 90 mmHg) with beta blockers
2. Surgical repair or endovascular stent/graft.
3. Non-operative management for minor aortic injuries in severe multitrauma or elderly patients.

J. DIAPHRAGMATIC INJURIES

In blunt trauma the diaphragmatic rupture is usually due to severe abdominal trauma which results in a sudden, major increase of the intra-abdominal pressure. The tear is usually 7-10 cm long. Broken ribs can also cause a diaphragmatic tear. Deceleration injuries may result in avulsion of the diaphragm from its peripheral attachments. Most of the injuries involve the left diaphragm (80%). Rupture of the right diaphragm requires a much more intense force and is almost always associated with other intra-abdominal injuries. The diagnosis is discussed in the penetrating trauma section.

TOC

PENETRATING TRAUMA

Hemopneumothorax. As described in Blunt Trauma.

A. PENETRATING INJURIES OF THE HEART (see photo)

Many of the victims die before reaching hospital care. The natural selection of the survivors depends on many factors: time from injury to medical care, weapon, site and size of the cardiac injury, the presence of tamponade, and associated injuries.

Clinical Presentation

1. Restless patient. (Often mistaken as alcohol or drug intoxication!)
2. Shock, tachycardia, weak peripheral pulses
3. Signs of cardiac tamponade: Beck's triad (shock, distended neck veins, distant cardiac sounds).

   This is present in 90% of patients with tamponade. Pulsus paradoxus is present in only 10% of the cases.
4. Every penetrating injury to the chest (especially in hypotensive patients) is a cardiac injury until proven otherwise. TOC

Investigations

DO NOT waste valuable time on unnecessary procedures if the diagnosis is obvious. Investigations should be done only if the diagnosis is uncertain.

1. Trauma ultrasound performed by a surgeon or ER physician is the best investigation.
2. Chest x-ray: This should be erect and straight whenever possible. Radiological signs suggestive of cardiac injury:
   a. enlarged cardiac shadow
   b. pneumopericardium
   c. widened upper mediastinum
3. CVP measurements: If the CVP is higher than 12 cm H_2O, suspect tamponade. However, be aware that many conditions such as hemopneumothorax, restlessness, fluid overload, mechanical ventilation, and a misplaced catheter may give a raised CVP. On the other hand, a tamponade associated with severe hypovolemia may not show a raised CVP. TOC

4. ECG: This is helpful in about 1/3 of the cases with tamponade. It may show low voltage QRS complexes, elevated ST segments and inverted T waves.
5. Pericardiocentesis: This is used by very few trauma centers. We have found it very unreliable (falsely negative in up to 80%), because of clot formation in the pericardial sac. It may be of limited use in non-trauma centers in order to gain time for the definitive operation.
6. Sub-xiphoid window: Although it is used in some centers, we use it infrequently.
7. Transdiaphragmatic pericardial window: For patients with multiple or thoracoabdominal injuries undergoing a laparotomy.
8. If the patient is hemodynamically stable and there is still a high index of suspicion, obtain a formal cardiac echo by cardiology. TOC

Treatment

1. Insert one or two large-bore intravenous lines, give oxygen by mask or via endotracheal tube, and transfer to the OR

for immediate operation (Sternotomy). DO NOT waste time for resuscitation, consent, catheterization of the bladder, etc.

2. If the patient suffers a cardiac arrest or is about to arrest in the Emergency Room, intubate and perform a resuscitative thoracotomy on the stretcher. The heart is sutured, the aorta is cross-clamped, and cardiac resuscitation is carried out by means of massage, transfusion, drugs and defibrillation as required. If the heart recovers, the operation is completed in the OR. Consider internal cardiac pacing for cardiac arrest not responding to routine resuscitation.
3. Postoperative care: a) ICU monitoring in the early phase; b) ECG to assess any significant myocardial infarction; c) check clinically and with echocardiography for any intracardiac defects (i.e., ASD, VSD, etc.). These investigations should be repeated about one month later, because internal cardiac defects may manifest at a later stage. TOC

Prognosis

- Mortality for resuscitative thoracotomy in the Emergency Room:> 90%
- Injuries of the right ventricle have the best prognosis.
- Injuries of the intrapericardial aorta and the left ventricle have the worst prognosis.

B. DIAPHRAGMATIC INJURIES

Have a high index of suspicion for every penetrating injury in the left lower chest (between nipple and costal margin). Injuries to the right diaphragm rarely have any clinical significance, except for anterior injuries. In left diaphragmatic injuries, the positive intra-abdominal pressure might cause migration of abdominal viscera into the chest and formation of diaphragmatic hernia.

Incidence TOC

In about 60% of gunshot wounds and 30% of knife injuries of the left thoracoabdominal area there is a diaphragmatic injury. About 30% of all asymptomatic penetrating left thoraco-abdominal injuries are associated with diaphragmatic perforation.

Clinical Presentation

1. Often asymptomatic, especially in small penetrating injuries.
2. Blood loss in long diaphragmatic tears.
3. Cardiopulmonary distress due to massive diaphragmatic hernia.
4. Abdominal visceral obstruction or perforation. A diaphragmatic hernia may occur or become complicated within minutes, hours, weeks, or years after the injury. Stomach, colon and omentum are the most commonly herniated viscera.

Diagnosis TOC

Early diagnosis and treatment is very important because complicated diaphragmatic hernias are associated with high morbidity and mortality. High index of suspicion is the most important factor for early diagnosis. Every penetrating wound over the left lower chest should be considered as involving the diaphragm until proven otherwise.

Special Investigations

1. Chest x-ray: This may show an elevated hemidiaphragm, air fluid levels or an air-containing viscus in the chest. However, in about half the cases of diaphragmatic injuries the CXR usually shows a nonspecific hemopneumothorax, in about 40% the CXR is normal, and in only about 10% it is suspicious of diaphragmatic injury.
2. Laparoscopy: This is our standard investigation for asymptomatic patients with penetrating injuries below the nipple line and above the costal margin on the left side. Anterior injuries of the right thoracoabdominal area should also be investigated. An observation period of 6-8 hours before laparoscopy is recommended in order to exclude any intraabdominal injuries.
3. Thoracoscopy: It is rarely used during the acute stage. It might be the approach of choice in the presence of

associated significant residual hemothorax requiring evacuation.

4. If stomach is suspected to be in the chest, insert a nasogastric tube and obtain a chest x-ray.
5. Contrast meal and follow through and contrast enema for suspected diaphragmatic hernias.
6. CT scan (Example 1 / Example 2) or MRI may be helpful in diagnosing diaphragmatic hernias, but they do not detect small uncomplicated diaphragmatic perforations.

Treatment

1. If a diaphragmatic hernia is suspected, do not insert a thoracostomy tube preoperatively.
2. Surgical repair, laparoscopically or with open laparotomy.
3. Small perforations in the posterior right diaphragm do not require repair because the liver protects against herniation. However, anterior injuries should be repaired because herniation may occur.

TOC

C. ESOPHAGEAL INJURIES

High index of suspicion in posterior stab wounds near the spine and bullet injuries involving the posterior mediastinum. Mediastinal emphysema is a suspicious radiological sign. For transmediastinal gunshot wounds, a multislice CT scan may be very useful by demonstrating the bullet tract (See Example). If the tract is away from the esophagus or the aorta, no further investigations are needed. If the tract is near the esophagus, investigation by means of a water-soluble contrast (Gastrografin) swallow should be performed. A negative study should be followed by thin barium. TOC

Esophagoscopy is most useful in patients not awake enough to cooperate for a swallow study (i.e. intra-operatively or in ICU patients).

PENETRATING CHEST TRAUMA: INDICATIONS FOR EARLY THORACOTOMY

1. Severe shock (caution: cervical or high thoracic spinal cord injuries may cause hypotension!)

2. Moderate shock not responding to fluid resuscitation.
3. Signs of cardiac tamponade.
4. Profuse bleeding.
5. Absent or diminished peripheral pulses in thoracic inlet injuries. The indications and timing of operation in patients with no obvious major cardiovascular injuries are controversial. We approach these controversial situations as follows: TOC
   a. Patients with mild or moderate shock readily responding to fluid resuscitation can be observed.
   b. The amount of blood loss in the chest tube is not always a reliable index of the severity of the intrathoracic injury. The hemodynamic condition of the patient and the rate of bleeding in the chest tube should determine the need for an emergency operation. However, in blood loss more than 1000 - 1500 mls, consider a thoracotomy.

c. Persistent air leak in the chest drain is almost always self-controlled. In some patients, bronchoscopy may be advisable to exclude bronchial injury.

d. Transmediastinal bullet injuries do not always require operation. In hemodynamically stable patients perform a chest helical CT scan with thin cuts. If the bullet tract is away from the aorta or the esophagus no further investigations are performed. If the bullet tract is in proximity to these structures aortography and oresophagography are performed.

Common Mistakes

- Flail Chest: The initial blood gases may be normal. However, the patient may deteriorate very rapidly. Important to monitor with pulse oximetry and blood gases! Early intubation before CT scans in elderly patients.
- Tension pneumothorax: The diagnosis should be clinical. Delays for radiological confirmation may prove catastrophic! TOC

- Widened upper mediastinum following a traffic accident or a fall: In addition to aortic rupture, think of thoracic spinal injury!
- Many patients with rupture of the thoracic aorta may have a normal mediastinum! Perform routine CT scan evaluation in all patients with suspicious mechanism of injury (traffic accidents, falls from heights).
- Sucking or blowing chest wound: Do not pack and do not suture before chest drain insertion! It may cause tension pneumothorax! Tape a square gauze over the wound on only 3 sides. TOC
- Many diaphragmatic injuries may be completely asymptomatic and the chest films may be normal or non-diagnostic. For left thoracoabdominal or anterior right thoracoabdominal injuries, routine laparoscopy should be performed irrespective of clinical or radiological findings.
- Cardiac tamponade: The patient is often very restless and the inexperienced physician might mistaken it for alcohol or drug intoxication!

- A moderate size hemothorax might be missed on a supine chest x-ray!

TOC

ABDOMINAL TRAUMA

There are significant differences in the assessment, investigations, and treatment between blunt and penetrating abdominal trauma.

A. BLUNT TRAUMA

Intra-abdominal injuries may occur by four mechanisms:

1. Crushing of an organ against the spine, pelvis or the abdominal wall.
2. Deceleration forces.
3. Sudden increase of the intraluminal pressure and bursting of a hollow viscus.
4. Injury by broken lower ribs.

Clinical Examination

- Clinical examination remains the most important diagnostic tool. Associated abdominal wall contusion, fractures of the lower ribs or the pelvis, or associated head and chest injuries may make clinical assessment difficult.

- Rigidity and severe or increasing tenderness are signs of peritonitis.
- Pain referred to the left shoulder (Kehr's sign) is suggestive of splenic injury. Similarly, pain referred to the right shoulder is suggestive of hepatic injury. Often, these signs can be elicited by placing the patient in the Trendelenburg position.
- Seat-belt marks are associated with a high incidence of intra-abdominal injuries (about 20%).

Investigations TOC

If the patient clearly needs a laparotomy, undue delay for unnecessary investigations is unwarranted.

1. It is our standard protocol to evaluate all trauma patients admitted through the resuscitation room by means of ultrasound. The equipment is readily available and the

investigation is performed by ER physicians and trauma surgeons.

2. Plain x-rays: Chest x-ray is part of the abdominal evaluation because thoracic trauma is a commonly associated problem. X-rays of the spine, pelvis, and ribs are obtained as indicated. Routine pelvis x-rays in an alert asymptomatic patient are not indicated. Important radiological findings include: fractures, free intraperitoneal gas, retroperitoneal gas, an elevated diaphragm, a hollow viscus in the chest, soft tissue shadows, scoliosis, and loss of the psoas shadow.
3. Abdominal CT scan: CT scan is the most valuable investigation in the evaluation of abdominal trauma. It provides reliable information on solid organ injuries, free fluid in the peritoneal cavity, and pelvic or spinal fractures. It might also show signs suggestive of hollow viscus injury (free air, unexplained free intraperitoneal fluid, bowel wall thickening, mesenteric stranding). It has a poor sensitivity for uncomplicated small diaphragmatic injuries.

4. Microscopic analysis for hematuria: It should be done on all patients with blunt abdominal trauma.
5. Serum amylase: All patients with epigastric trauma should have a serum amylase determination to exclude pancreatic trauma. However, it must be borne in mind that only about 70% of cases with blunt pancreatic trauma have raised serum amylase. Also, some patients with elevated amylase values do not have pancreatic injury. Serial amylase levels are more valuable than the initial value.
6. Diagnostic peritoneal aspirate (DPA): It is often used in multi-trauma patients who are hemodynamically unstable and have a negative or questionable FAST exam and the source of hypotension is not obvious. At our center we almost never perform Diagnostic Peritoneal Lavage (DPL). TOC

[Technique of DPA and DPL (Closed Approach): see protocol 13

B. PENETRATING ABDOMINAL INJURIES

A distinction should be made between high-velocity and low-velocity injuries. This is necessary because the severity of the injury, the treatment, and the prognosis are different in the two groups.

High-Velocity Injuries TOC

High-velocity missiles cause extensive tissue damage (page 77). These patients almost always require a laparotomy.

Low-Velocity Injuries

These are usually due to “civilian” violence (stab wounds, most handguns). Their management remains controversial. There are three schools of thought:

1. Routine exploration of every injury, which could have penetrated the peritoneum, irrespective of clinical signs: The biggest disadvantage is the unacceptably high incidence of unnecessary operations (up to 50% in stab wounds and 25% in gunshot wounds to the anterior abdomen). We do not advocate this policy.

2. Operation on every case with proven peritoneal penetration: Local exploration of the wound or sonograms through the stab wound have been used to check the integrity of the peritoneum. However, peritoneal penetration does not necessarily mean intra-abdominal injury. Up to 30% of the patients with stab wounds and proven peritoneal violation have no significant abdominal injury. We do not advocate this policy.
3. Selective non-operative management: This is our recommended policy for both stab wounds and gunshot wounds. The patient is operated on only if there is clinical evidence of peritonitis or severe bleeding. If the abdomen is soft with no guarding, tenderness (except near the wound), or rebound tenderness, the patient is observed.
   - This policy should not be used in unconscious patients or patients with spinal cord injury where clinical examination of the abdomen is difficult. Similarly, if the patient is to receive general anesthesia for another

problem (e.g., chest, neck trauma, fractures, etc.), it is advisable to explore the abdomen as well.

- With the policy of selective nonoperative management, about 50% of knife injuries to the anterior abdomen, about 85% of knife injuries to the back and about 25% of gunshot wounds to the abdomen can safely be managed non-operatively

C. INVESTIGATIONS FOR PENETRATING TRAUMA

Very few investigations are needed in the assessment of penetrating trauma. They should be performed only on fairly stable patients where the abdominal physical examination is equivocal.

1. Plain chest and abdominal x-rays (for gunshot wounds) are the most useful investigations. Look for associated hemopneumothorax, diaphragm abnormalities, fractures, missiles.
2. Urinalysis for hematuria. TOC
3. Diagnostic laparoscopy is the most useful procedure for suspected diaphragmatic injury. In our center, this is a

routine investigation for all asymptomatic left or anterior right thoracoabdominal injuries.

4. CT scan with intravenous contrast for patients selected for nonoperative management.
5. Sigmoidoscopy should be done for pelvic gunshot wounds with suspected rectal injuries, especially if blood is found on rectal examination.

D. GENERAL MANAGEMENT

1. Patients with signs of peritonitis or hemodynamic instability should be operated on immediately. Preoperative antibiotics should be administered to all patients. Depending on the operative findings, the antibiotics can be modified or stopped postoperatively. Our protocol dictates a 24-hour prophylaxis irrespective of operative findings. Ampicillin / sulbactam (3 g) is our preference in this center.
2. Patients selected for nonoperative management are given intravenous fluid therapy and nasogastric suction. Frequent recordings of blood pressure, pulse, and

temperature are done. The same doctor reassesses the abdomen regularly, preferably. It is of critical importance that careful documentation, with date and time, is recorded in the chart. In addition:

- Serial Hb and WBC (every 6 to 12 hours).
- No routine prophylactic antibiotics or analgesia are given because they may mask important symptoms and signs.
- If the patient develops signs of peritonitis (tenderness, tachycardia, fever, persistent leucocytosis), an operation is performed; otherwise he is discharged within 24-48 hours.

TOC

SPLENIC INJURIES

Clinical Diagnosis

Signs of hypovolemia (often the patient is hemodynamically stable), left upper abdominal pain radiating to the left shoulder (Kehr's sign).

Special Investigations

1. Chest x-ray: possibly fractures of the left lower ribs, elevated hemidiaphragm, medial displacement of the stomach, downward displacement of the splenic flexure, enlarged splenic outline.
2. Trauma ultrasound (FAST)
3. Positive diagnostic peritoneal aspirate (DPA).
4. Elevated WBC.
5. CT scan with intravenous contrast is the most useful investigation. Besides the anatomical diagnosis of the splenic injury it may show evidence of active bleeding or false aneurysm ("blushing").

TOC

Treatment

- Most children (about 90%) and many adults (about 60%) can safely be managed nonoperatively provided they are hemodynamically stable and there are no signs of an acute abdomen.
- Serial CT investigations are important in the follow-up of non-operatively treated patients with severe splenic injuries (grade 3 or worse). Picture of grade 5 spleen injury

Special Post Splenectomy Problems

1. Overwhelming post splenectomy infection: Usually due to encapsulated organisms (pneumococcus, meningococcus, hemophilus). This complication is more common in children. It is a common practice to give pneumococcal vaccine. In addition to the vaccine, in children and immune-suppressed adults, some physicians give prophylactic penicillin for two or more years. We do not support this practice. Advise to seek medical care with the first sign of infection. TOC

2. Increase in the platelet count: This might pose a problem if the platelet count is more than 1 million/mm3 or if the patient is predisposed to thrombosis (i.e., previous DVT). In these cases, some form of prophylaxis (i.e., Aspirin) may be indicated.
3. Local Complications: Subdiaphragmatic collections, basal atelectasis or pneumonia, left pleural infusion, pancreatitis, pancreatic fistulas, gastric dilation, gastric greater curvature necrosis, splenic vein thrombosis.

B. LIVER INJURIES

Clinical Features

Pain in the right upper abdomen sometimes radiating to the right shoulder, hypovolemia, often-associated fractures of lower ribs.

Special Investigations

1. Trauma ultrasound (FAST) may show free intraperitoneal fluid (often in the hepatorenal space)
2. Chest x-ray: Possibly fractured right lower ribs, elevated hemidiaphragm. TOC

3. Diagnostic Peritoneal Aspirate (DPA) in hemodynamically unstable multi-trauma patients
4. CT scan with intravenous contrast is the most valuable investigation in hemodynamically stable patients.

Treatment

- Liver injuries with no signs of peritonitis or hemodynamic instability may be managed non-operatively. Serial CT scans should be performed in patients with severe liver injuries.
- Angiographic evaluation with possible embolization may be useful in the appropriate cases.
- Significant injuries with hemodynamic instability or peritonitis need operative intervention.

Complications

1. Hemobilia (blood in the biliary system): This may present with pain, jaundice, hematemesis, or unexplained anemia. Some cases resolve spontaneously. Persistent cases may require angiographic embolization.

2. Abscess formation (subdiaphragmatic, subhepatic, intrahepatic).
3. Intrahepatic false aneurysms or arteriovenous fistulas. Angiographic embolization is the management of choice.
4. Bilomas, biliary fistulas.
5. Liver parenchyma necrosis with persistent fever.

TOC

C. RENAL INJURIES

Clinical Presentation

1. A contusion or penetrating wound over the loin.
2. Pain in the loin.
3. Gross or microscopic hematuria.
4. Bruit or murmur due to traumatic aneurysm or arteriovenous fistula.

Investigations

1. CT scan with contrast is the best investigation. It provides reliable information on the extent and severity of the renal injury. (CT #1, CT#2, CT#3)

2. Angiogram: This is indicated if a kidney does not take up contrast during CT evaluation, if there is evidence of false aneurysm or arteriovenous fistula on CT scan, or if there is persistent gross hematuria.

Treatment

1. Most renal injuries can be safely managed non-operatively. Important to follow-up for bruits or hypertension.
2. Surgical intervention is indicated in patients with peritonitis or hemodynamic instability.
3. Early (4-6 hours) diagnosis of renal artery thrombosis: Consider endovascular stenting or observation. In late diagnosis the treatment of choice is observation. Monitor for complications such as abscess or hypertension.

TOC

D. BLADDER INJURIES

Often associated with pelvic fractures or blunt abdominal trauma with a full bladder. Rupture may occur intraperitoneally or extraperitoneally.

Clinical Presentation

1. Suprapubic pain.
2. Hematuria.
3. Inability to pass urine.
4. Abdominal distension.
5. Urine extravasation in the scrotum.

Special Investigations

1. The serum urea is usually elevated.
2. Cystogram (the bladder should be filled and oblique x-rays should always be obtained). If an abdominal CT scan is performed, a CT cystogram may replace the standard cystogram.

Treatment

1. All intraperitoneal ruptures should be repaired surgically.
2. Small extraperitoneal ruptures may be managed nonoperatively with transurethral catheter drainage for about 10 days.

TOC

E. URETHRAL INJURIES

Almost exclusively in males. Usually associated with pelvic fractures; less often with falls resulting in straddle injuries.

Clinical Presentation

1. Blood at the urethral meatus.
2. Inability to pass urine.
3. High "Floating" prostate on rectal examination.
4. Urine extravasation in the scrotum.

Note: Do not insert Foley catheter before urethrogram if any of the above is present.

Special Investigations

Urethrogram

Treatment

In suspected urethral injuries avoid transurethral catheterization. If catheterization is attempted, it should be performed by the most experienced person. Conservative management. A suprapubic or transurethral catheter is inserted and kept in place for about two weeks. Endoscopic alignment and catheterization should be considered soon after admission.

TOC

F. PANCREATIC INJURIES

Blunt or penetrating trauma. Blunt injuries often pose diagnostic problems. Often associated with duodenal injuries.

Clinical Presentation

1. History of abdominal trauma.
2. Epigastric pain, often very mild.
3. Acute pancreatitis.
4. Sometimes-late presentation with pancreatitis or a pseudocyst.
5. Obvious peritonitis.

Special Investigations

1. Serum amylase (elevated in about 70% of blunt trauma and 30% of penetrating pancreatic trauma).
2. CT scan with oral and intravenous contrast may be helpful, especially in blunt trauma. An early CT scan may be falsely normal. If necessary repeat CT in 6-10 hours.

3. MRCP for evaluation of the pancreatic duct.
4. ERCP for evaluation of the pancreatic duct.

Treatment

1. Minor injuries as shown on CT scan may be managed nonoperatively. Watch for pseudocyst formation.
2. Injuries with major ductal leaks require surgery.

G. COLONIC INJURIES

Usually due to penetrating trauma. Less often in blunt trauma.

Clinical Presentation

Signs of acute abdomen. The diagnosis is made intraoperatively.

Treatment TOC

1. Start preoperative antibiotics (Ampicillin/ Sulbactam).
2. Surgical intervention: Various methods of operative management can be used: primary repair with or without a proximal colostomy, exteriorization of the wound as a colostomy, colonic resection with primary anastomosis or colostomy. It is our practice to perform primary repair in

all cases except in the presence of severe colon edema or questionable blood supply.

TOC

H. RECTAL INJURIES

Usually due to penetrating trauma. Less frequently associated with pelvic fractures or foreign bodies.

Clinical Presentation

Extraperitoneal perforations may give minimal abdominal symptoms. On rectal examination, the perforation might be felt. Blood on glove.

Investigations

1. Sigmoidoscopy
2. Gastrografin enema

Treatment

- Early repair with or without colostomy.

TOC

Common Mistakes in Managing Abd. Trauma

- A negative DPL does not exclude significant intra-abdominal injuries. In diaphragmatic, retroperitoneal or hollow viscus perforations it is often falsely negative.
- Diaphragmatic injuries may be asymptomatic and the chest x-ray is usually non-diagnostic! Routine laparoscopy for all asymptomatic patients with penetrating injuries to the left or anterior right thoracoabdominal areas.
- Blunt pancreaticoduodenal injuries often do not give early peritoneal signs. Serial serum amylase levels and white cell count, and repeat CT scan with oral and intravenous contrast should be considered in suspected cases.
- Hollow viscus perforation in the blunt unevaluable trauma patient may be missed. Look for occult CT scan findings (unexplained free fluid, small amounts of free gas, bowel wall thickening, mesenteric stranding) , unexplained leucocytosis, deteriorating base deficit, and failure to

improve clinically. Always review the CT scan with an experienced radiologist.

TOC

PERIPHERAL VASCULAR INJURIES

ETIOLOGY

Penetrating injuries, fractures, dislocations, and direct blunt trauma.

Clinical Signs

- Hard signs: severe active bleeding, anemia, shock, large Expanding hematoma, pulsatile hematoma, bruit, absent or diminished peripheral pulse. These patients need an operation.
- Soft signs: small stable hematoma, minor bleeding, and proximity injuries. These patients need further evaluation.
- The presence of peripheral pulse does not exclude proximal arterial injury. In many arterial injuries the peripheral pulse is present. However, when all other clinical signs are included, clinical examination is very

accurate in diagnosing or highly suspecting significant vascular injuries.

- Knee dislocation (especially posterior) is a high-risk injury. Incidence of popliteal artery injury: about 30%

Investigations TOC

1. Doppler pressures: An ankle-brachial index (ABI) in lower extremity injuries or brachio-brachial index for upper extremities <0.9 is suspicious of arterial injury and is an indication for further investigation (i.e. CFDor angiography). In minor injuries (small intimal tears or false aneurysm) the ABI may be normal.
2. Color Flow Doppler (CFD): It is the investigation of choice at our trauma center. Recommended for all proximity injuries in the neck and the extremities. The combination of a good clinical examination and CFD diagnoses or highly suspects practically all vascular injuries.
3. Arteriogram: The indications for emergency angiograms are controversial. Some centers perform angiograms in all injuries near major vessels. We rely very much on clinical

signs, CFD, and ABI pressures. Our indications for emergency angiography are: a bruit or murmur in a stable patient, shotgun injuries, most vascular injuries due to blunt trauma and inconclusive CFD studies. In selected cases intra-operative on-table single exposure angiography may be useful.

Technique of Single exposure Arteriogram

Usually done in the operating room, before or during operation. 20 ml of contrast is introduced into the proximal limb artery using an 18G intravenous cannula. The contrast is injected as fast as possible. The x-ray is taken just before the syringe is empty.

Complications of Vascular Injuries

Unrecognized vascular injuries may lead to late thrombosis, aneurysm, A/V fistula.

Treatment TOC

Significant injuries require repair. Some radiologically detected, clinically occult injuries, may be managed nonoperatively. Selected cases can be managed by angiographic stenting or embolization.

Common Mistakes

- The presence of peripheral pulse does not exclude significant vascular injury. Always compare with the normal side (palpation and Doppler pressures).
- A single exposure angiogram may miss arterial injuries.
- Always suspect an arterial injury in posterior dislocation of the knee.
- In the presence of severe extremity ischemia due to trauma do not delay the operation in order to get a formal angiogram. The patient may lose his limb as a result of the delay of the operation! If necessary, perform an "on-table" angio in the operating room.

TOC

PELVIC FRACTURES

Commonly Associated Injuries

- The overall incidence of associated intraabdominal injuries is about 15%. This increases to 30% in severe pelvic fractures.
- Severe bleeding in the pelvic fracture is common.
- Bladder and urethral injuries are common.

Investigations

1. Always do a rectal examination!
2. Look for signs of bladder or urethral injuries
3. Urinalysis for hematuria.
4. Cystogram (or CT cystogram) or urethrogram as indicated.
5. CT scan of the abdomen and pelvis.

Management TOC

The following measures may help reduce the hemorrhage from the fracture site:

1. Pelvic binder for significant pubic diastasis.
2. External pelvic fixation in the appropriate cases (rare).

3. Angiography and embolization of the bleeders. Angiography should be done early in all severe pelvic fractures. DO NOT wait until major blood loss has occurred! Radiological findings associated with a high incidence of severe bleeding: a) disruption of the sacroiliac joint; b) diastasis of the pubic symphysis >2.5 cm; In the presence of any of these radiological findings an early angiography should be considered. Lower threshold for angio in severe multitrauma, elderly patients or in the presence of major comorbid conditions.
4. Consider laparotomy with ligation of both internal iliac arteries and pelvic packing.

Common Mistakes TOC

- Omission of rectal examination. Serious
- Injuries may be missed!
- Delay angiography and embolization. Major blood loss and coagulation problems may occur.
- Plain films often underestimate the severity of pelvic fractures! Liberal use of CT scan is recommended.

SPINAL INJURIES

Causes

- Spinal fractures, dislocations, penetrating injuries. About 90% of all spinal injuries due to blunt trauma are located at C5-C6, T11-L1, T4-T6.
- Falls from height (>15 feet) are associated with a very high incidence of spinal injuries. About 25% of victims ≥15 years old have a spinal injury. The older the patient, the higher the risk of spinal fracture.

Diagnosis TOC

1. The diagnosis is often delayed, especially in the presence of associated severe head injury, multiple injuries, or intoxication. When n doubt, protect the potentially injured spine. Always think of spinal injuries after falls, traffic accidents, and penetrating injuries near the spine. Palpate the spinal processes for tenderness and swelling. Examine for paralysis or weakness (corticospinal tracts), sensation to pinprick (spinothalamic tracts), deep sensation (posterior columns), and reflexes.

2. In describing a cord injury, record the level of damage using myotomes and dermatomes (useful sensory levels: nipples T4, xiphoid T6, umbilicus T10, pubis T12. Useful myotomes: shoulder abduction C5, elbow flexion C5-C6, elbow extension C7, finger flexion C8, hip flexion L1-L2, knee extension L3-L4, knee flexion L4-L5-S1, toe flexion S1-S2, anal sphincter S2-S3-S4.
3. The spinal cord ends at L1-L2. Spinal injury below this level damages the roots of the cauda equina.
4. Serious intra-abdominal injuries may be masked in the presence of spinal cord injuries. TOC
5. Spinal shock: No reflexes or voluntary activity distal to the level of injury. This appears immediately after injury and is transient. Once some reflex activity has returned and there is no distal sensation or voluntary motor control, the cord lesion is considered as complete and without any significant chances of functional recovery. The sacral reflexes (anal and bulbocavernosus reflexes)

are the first to recover from spinal shock, usually within 24 hours.

6. Neurogenic shock: Hypotension due to loss of sympathetic tone following cervical or upper thoracic spine injuries. In high cervical cord injuries the hypotension is associated with bradycardia.

INCOMPLETE SPINAL CORD INJURIES

1. Anterior cord syndrome: Loss of power, loss of pain/temperature sensation, and preservation of proprioception.
2. Posterior cord syndrome: Loss of proprioception, preservation of power and pain/ temperature sensation.
3. Brown-Sequard syndrome (usually after penetrating wounds): Ipsilateral spastic paralysis and loss of proprioception below the level of the injury, and contra-lateral loss of pain and temperature sensation below the level of the lesion. TOC
4. Central cord syndrome: Involves the cervical spinal cord usually in elderly patients. Due to hyperflexion or

hyperextension injury. Weakness or paralysis of all four extremities, more severe in upper extremities.

SPECIFIC FRACTURES OF THE CERVICAL SPINE

1. Fractures of the atlas: The most common type is the extension-compression fracture of the posterior arch. It is a stable fracture. Treatment with hard collar.
2. Jefferson's fracture: Vertical compression and bursting of the lateral masses of the atlas by the condyles of the occiput. It is an unstable fracture.
3. Fracture of odontoid process. Instability and non-union are common, depending on the level of the fracture. Operative fusion may be necessary in fractures near the base of the dens..
4. Hangman's fracture: Hyperextension injury with fracture and dislocation of C2-C3. Traction for about six weeks.
5. Dislocation of C7-T1: Often operative reduction is necessary. TOC

THORACOLUMBAR INJURIES

Most stable fractures are managed conservatively with bed rest and a brace for 8-12 weeks. Operative fusion may be necessary in unstable injuries with incomplete cord lesion.

INVESTIGATIONS TOC

1. Plain x-rays: An adequate C-spine film should include C1 and T1. Special views with the mouth open shows the dens. Swimmer's view shows the lower cervical vertebra. Soft tissue thickness of more than 5 mm in front of C3 or more than 2/3 of the thickness of the spinal body is suggestive of significant injury to the anterior structures a widened upper mediastinum may be the result of a thoracic spine fracture. CT scan or MRI has replaced most special views.
2. CT scan: It's a very useful investigation and should be performed on all patients with significant
3. C-spine pain or neurological deficits, irrespective of plain film findings. Also, unevaluable multi trauma patients with suspicious mechanism of injury (i.e. high speed

traffic accidents, falls from heights) should have a CT scan with reconstruction series.

4. MRI scan in suspicious cases with a normal CT scan. The best modality for the diagnosis of central cord syndrome.
5. The combination of C-spine x-rays and CT scan reliably diagnoses or highly suspects all significant spinal injuries.
6. In patients with suspicious mechanisms of injury undergoing CT scan of the chest and abdomen, request lateral thoracolumbar spine scannogram.
7. The pediatric spine has many radiological differences from the adult spine. (See Pediatric Trauma Chapter).

GENERAL MANAGEMENT TOC

1. Correct any existing hypotension or hypoxia in order to prevent or diminish secondary cord damage.
2. Cervical spinal cord injuries are often associated with hypotension due to absent sympathetic tone distal to the injury (neurogenic shock). Elevation of the foot of the bed, IV fluids or vasopressor drugs may be required.

3. High doses of steroids may be given (only in blunt trauma) within eight hours of the injury. (Methyl-prednisolone, a bolus of 30 mgr/Kg followed by 5.4 mg/Kg per hour for 23 hours if given within 3 hours or for 48 hours if given with 3 to 8 hours post-injury). This is a controversial issue and many surgeons do not practice this protocol. No steroids in penetrating trauma.
4. In quadriplegia there is a risk of respiratory failure. Early mechanical ventilation is essential.
5. Reduce and immobilize any existing dislocation. This is usually achieved with proper positioning of the patient and traction. TOC
6. Paralytic ileus is common after spinal cord injury. Nasogastric tube is necessary.
7. In penetrating injuries antibiotics may be useful.
8. Drain bladder by means of a Foley catheter. Later, intermittent catheterization is preferable because it decreases the risk of infection and promotes bladder training.

9. Prevent pressure sores. Regular turning, special mattresses, good nutrition and good hygiene
10. DVT prophylaxis (leg compression devices, subcutaneous heparin, caval filter).
11. Spasticity may occur after the initial period of spinal shock. Treat with physiotherapy and if necessary with drugs: Baclofen (acts at spinal level) or Dantrolene sodium (acts at muscle level). Get Physiotherapy and Occupational Therapy involved soon after resuscitation.
12. Late follow-up with kidney ultrasound for obstructive uropathy.
13. Hypertension due to sympathetic hyperactivity below the cord lesion (autonomic dysreflexia).

This might be precipitated by a full bladder or other intra-abdominal conditions. Remove the causative factor, and if necessary, administer nitroglycerides.

PROGNOSIS TOC

1. Complete cord transection: Bad prognosis, no effective treatment.

2. Partial transection: Most patients improve. In penetrating injuries (especially knife wounds) many patients recover completely.

Common Mistakes TOC

- A widened upper mediastinum: Besides aortic rupture think of spinal injury as well!
- All patients with significant spinal tenderness should have a CT scan, even with normal X-rays!

Similarly, a complete C-spine CT scan (C1 -T1) should be performed in all unevaluable, multi-trauma patients with a suspicious mechanism of injury. If you forget this recommendation, it will be a matter of time before you have a disaster!

- Quadriplegics may give a false picture of respiratory stability on admission. Rapid deterioration with acute respiratory failure may occur a few hours after admission! Consider early endotracheal intubation.
- The spinal board used for spinal protection is very uncomfortable. It should be removed as soon as the

patient completes the radiological investigations and is transported to the operating room or ICU.

TOC

MAXILLOFACIAL INJURIES

Airway

- Airway obstruction due to hematoma or edema is the most common cause of death in isolated facial injuries. Clear any clots from the oropharynx, remove any secretions, broken teeth, etc. In severe cases consider endotracheal intubation or surgical airway.
- Missing teeth: chest x-ray to exclude aspiration.

Hemorrhage

Profuse nasal bleeding is managed by anterior and posterior nasal packing. Posterior packing can be achieved by inserting a size 8 Foley's catheter through the nostril into the oropharynx, and inflating the balloon with 5-10 ml of saline. The balloon is then impacted in the posterior nasal vault by gentle traction. Anterior packing is then carried out using conventional hemostatic material (i.e. nasal tampons, etc.).

Packs should not be left in place for more than 24-48 hours because of the danger of infection and meningitis. Persistent bleeding can be managed by angiographic embolization.

Associated Injuries: In GSW's of the face there is a high incidence of associated brain and spinal cord injuries.

SECONDARY PROBLEMS TOC

Identify and treat other non life-threatening injuries such as:

- Fractures of facial bones: The diagnosis is clinical and radiological. Special facial views or CT scan may be necessary. Fractures of the mandible or maxilla are often contaminated because they usually communicate with the oral cavity. These patients should have tetanus prophylaxis, antibiotics and antiseptic mouthwashes.
- Parotid duct injury: Early recognition and repair is important to avoid later complications such as sialoceles or salivary fistulas. Catheterization of the duct from inside the mouth will identify any injuries.

- Facial nerve injury: There is no need for emergency repair. However, it should be repaired as soon as possible.
- Eyes: Check vision, pupils, eye movements, diplopia, hyphema, direct trauma.
  - Hyphema: The presence of blood in the anterior chamber. The patient requires strict bed rest for at least five days because of the danger of recurrent bleeding. TOC
  - Penetrating injuries of the eye: Repair if the damage is correctable or enucleation in severe injuries. This should be done within two weeks of the injury to prevent autoimmune damage to the other eye (sympathetic ophthalmia)
  - Double vision after trauma may be due to:
    - Orbital fractures
    - Orbital hematoma
    - Injury to the extra-ocular muscles
    - Injury to the 3, 4, 6 cranial nerve

- Asymmetry of the pupils after trauma may be due to:
    1. Direct trauma to the eye
    2. Third cranial nerve injury
    3. Horner's syndrome
    4. Local drugs

Soft tissue wounds: Avoid extensive debridement. Facial wounds heal well and sepsis is rare.

Most lacerations can be sutured up to 24 hours after injury.

Common Mistakes

1. Underestimating the danger of airway obstruction. The patient may deteriorate very rapidly. Consider early intubation or surgical airway!

TOC

NERVE INJURIES

TYPES OF INJURIES

Neuropraxia

Functional paralysis of the nerve but no obvious anatomical injury. The prognosis is excellent. Usually due to blunt trauma or proximity shock wave injuries in gunshot wounds.

Axonotmesis

Division of the nerve fibers (axons), intact neural sheath. Usually due to blunt trauma. Regeneration of the nerve fibers will occur. The prognosis is good.

Neurotmesis

Complete or partial division of the neural sheath and nerve fibers. Needs surgical repair. Radial nerve repair has excellent prognosis, medial nerve good and ulnar nerve the worst prognosis.

TOC

COMMON CRANIAL NERVE INJURIES

2. **Third nerve injury (Oculomotor)**: This will result in ptosis of the upper eyelid, proptosis, mydriasis, loss of accommodation, diplopia and external strabismus.
3. **Facial Nerve Injury (CN VII)**: In central palsy there is contralateral spastic paralysis of the muscles of the lower face. The muscles of the forehead and eyelid remain intact. In lower palsy there is ipsilateral flaccid paralysis of the muscles of the forehead, eye, and mouth. Characteristically, the eye cannot be closed and whistling is impossible. Eg. Left facial nerve injury, Left facial nerve paralysis
4. **Accessory Nerve Injury (CN XI)**: Paralysis of the sternomastoid and trapezius muscles. Drooping of the shoulder, inability to abduct the arm above the horizontal level. (Left Hypoglossal nerve Injury (CN XII))

TOC

COMMON PERIPHERAL NERVE INJURIES

Radial Nerve

1. Proximal Injury:
   a. Motor signs: Inability to extend the forearm, wrist and fingers. Characteristic wrist drop.
   b. Sensory Loss: Anesthesia over the dorsum of thumb and first interosseous space.
2. Distal Injury: No motor problems. Area of anesthesia over the base of the thumb, dorsally.

Median Nerve TOC

1. Proximal Injury:
   a. Motor: The patient cannot make a fist. Inability to flex the index and middle fingers, while the ring and small fingers can be flexed (by the part of the flexor profundus digitorum which is innervated by the ulnar nerve). This is the "benediction" or "Pope"s" hand. Loss of abduction, flexion and a position of the thumb.

2. Distal Injury

a. Sensory: Anesthesia over the radial 3½ fingers.

Ulnar Nerve

1. Proximal Injury:
   a. Motor: Inability to abduct and adduct the fingers. If the patient tries to grip a card between the thumb and finger, this is only possible by flexing the terminal phalanx of the thumb (Froment's sign). The small finger is in abduction andslight flexion.
   b. Sensory: Anesthesia over the ulnar 1½ fingers.
2. Distal Injury: Roughly the same problems as in proximal injuries, except that the flexor carpi ulnaris and part of the flexor profundus digitorum retain their innervation.

Circumflex or Axillary Nerve

Paralysis of the deltoid muscle results in inability to abduct the arm. TOC

Musculocutaneous Nerve

Inability to flex the forearm.

Sciatic Nerve

1. Motor: Foot drop, weakness of the knee flexion.

2. Sensory: Complete sensory loss below the knee, except a narrow strip along the inner surface of the leg and foot, which gets innervation from the long saphenous nerve.

Lateral Popliteal Nerve

a. Motor: Paralysis of the extensor and peroneal groups of muscles, resulting in foot drop.

b. Sensory: Anesthesia of the lateral leg, lower two-thirds.

Medial Popliteal Nerve

1. Motor: Paralysis of the calf muscles.

2. Sensory: Anesthesia of the sole.

Femoral Nerve TOC

1. Motor: Paralysis of the quadriceps and inability to extend the knee.

2. Sensory: Anesthesia over a strip along the inner surface of the leg and foot.

SYMPATHETIC CHAIN INJURIES

Horner's syndrome: Damage to the stellate ganglion. Clinically, it presents with enophthalmos, ptosis, miosis, anhydrosis.

TOC

SOFT TISSUE INJURIES

A. EXTENSIVE BLUNT SOFT TISSUE TRAUMA

Pathophysiology and complications similar to those seen in the crush syndrome. (Example 1 / Example 2)

Systemic Complications

1. Hypovolemic shock. (Due to extravasation of blood and fluid into the tissues.)
2. Renal failure. (The result of myoglobinuria. Myoglobin damages the tubular epithelium.)
3. Metabolic changes: High potassium, low calcium (deposition of calcium in the injured tissues), high phosphorus, high uric acid, high CPK.

4. Hematological changes: DIC (disseminated intravascular coagulopathy) due to release of tissue thromboplastin from the injured tissues.

Local Complications

1. Sepsis of open wounds.
2. Infection of hematomas or damaged tissue.
3. Compartment syndrome (See example).
4. Necrotizing fasciitis.

Investigations, Monitoring

1. CBC, platelets, urea and electrolytes, Ca, P, CPK.
2. Urinalysis for hematuria, myoglobinuria, pH.
3. CVP measurements in appropriate cases
4. Bladder catheterization, hourly urine output.

Treatment TOC

a. Renal failure can be prevented by early and aggressive treatment. Give intravenous fluids to maintain the urine output at about 100 ml/hour for the first 24 hours. The urine pH should be neutral or slightly alkaline. If necessary, give intravenous $NaHCO_3$. A low pH predisposes to renal failure. Mannitol administration might be helpful.

b. Tetanus toxoid as indicated.

c. Correct any existing hyperkalemia. The combination of hyperkalemia (even mild) and hypocalcemia is cardiotoxic.

d. Fasciotomy if compartment syndrome develops

B. INCISING WOUNDS

Primary Repair: Indicated for fresh clean wounds.

Technique

1. Local or general anesthesia. TOC

2. Irrigation with normal saline or sterile water. No antiseptic agents in the wound.

3. Digital exploration of the wound for any foreign bodies (e.g. glass, stones, etc).

4. Surgical debridement in the appropriate cases (excision of ragged or ischemic tissues).

5. Suture in layers to obliterate any dead spaces.

6. Consider immobilization and elevation in certain injuries (i.e. hands).
7. Tetanus prophylaxis.
8. Antibiotics.

Delayed Primary Repair

This is used whenever there is suspicion of contamination or necrotic tissue. Closure before granulation tissue formation (less than four days).

Secondary Repair

This is reserved for obviously contaminated or infected wounds. Closure after granulation tissue formation (more than four to five days). Often requires a graft. TOC

HUMAN AND ANIMAL BITES

BACTERIOLOGY

The mammalian mouth contains more than 200 bacterial species. Staphylococcus and streptococcus are the most common causes of infection. In dogs, pasteurella multocida is often a cause of infection. This organism is sensitive to penicillin, tetracycline and cephalosporins. It is resistant to erythromycin and aminoglycosides. Human bites can transmit hepatitis, AIDS, syphilis, actinomycosis and tuberculosis. Dog bites can transmit rabies, brucellosis, blastomycosis.

PROGNOSIS

Human bites are not worse than animal bites, as is generally believed. Bites on the hands are the worst because of the high incidence of sepsis. Loss of fingers or stiff joints are not uncommon complications.

TREATMENT TOC

1. Most bites can safely be managed on an outpatient basis. Exceptions: a) infected bites, b) joint penetration, c) tendon sheath penetration.
2. Most bites can safely be sutured primarily. Exceptions: a) septic bites, b) hands, c) puncture bites.
3. Antibiotic prophylaxis. Various antibiotics may be used: Ampicillin + Cloxacillin or Tetracycline or Cephalosporin. Erythromycin or aminoglycosides are not good choices in dog bites for the reasons mentioned above.
4. Tetanus prophylaxis if indicated.

5. Rabies prophylaxis if indicated.
6. Immobilization and elevation for bites on the hand.

RABIES PROPHYLAXIS

1. Bite by a known healthy domestic animal: no need for rabies prophylaxis.
2. Bite by a stray animal available for observation: Observe for ten days. If any signs suggestive of rabies develop, the animal should be destroyed and the brain examined. If the tests are positive, rabies prophylaxis is indicated.
3. Bite by a stray animal not available for observation: If the attack was unprovoked, give rabies prophylaxis.
4. Bite by a wild feral carnivore: Rabies prophylaxis unless the animal is caught and shown to be free of the disease.

COMMON MISTAKES

- Give erythromycin or aminoglycosides in animal bites. These antibiotics do not cover pasteurella multocida!
- Not suturing extensive lacerations. They can safely be sutured primarily!

TOC

EXTREMITY COMPARTMENT SYNDROME

Definition: Increased pressure within a muscle compartment (usually above 25-30 cm H2O) resulting in reduction in the capillary perfusion below a level necessary for tissue viability.

- Normal compartment pressures: <10 cm H20.

Etiology TOC

Fractures, hematomata, contusions, vascular injuries, burns, tight dressings or casts, massive fluid resuscitation.

Sites

Most commonly in lower legs. Less often in forearms, thighs, arms, buttocks, in this order.

Clinical Findings (6 P's)

1. Pain
2. Pressure (swollen, tense compartment).
3. Paresthesia.
4. Paralysis.
5. Pink color (not pale, except in advanced stages!).
6. Pulse (usually palpable, except in advanced stages!).

Differential Diagnosis

1. Nerve injury.

2. Vascular injury.

Investigations

- Intra compartmental pressures in doubtful cases.
- Fasciotomy is recommended if the pressure is >30 cm H_2O, or if there is strong clinical suspicion of compartment syndrome.

Treatment TOC

1. Treat the cause (i.e. remove tight casts, repair arterial injuries, etc.)
2. Mannitol may be helpful, and there is evidence that in some cases it may avoid fasciotomy. (1g/Kg over 20 min)
3. Fasciotomy and **decompression.**

LEG COMPARTMENT SYNDROME

Anatomy

There are four compartments:

1. **Anterior**
2. **Lateral**
3. **Superficial posterior**
4. **Deep posterior**

The anterior compartment is the most commonly involved, followed in this order by the lateral, the deep posterior and the superficial posterior.

Fasciotomy

- The standard method is with two incisions for 4-compartment fasciotomies.
- The first incision is about 20 cm in length and is done halfway between the tibial crest and the fibula. The skin edges are undermined proximally and distally for wider exposure of the fascia. For decompression of the anterior compartment, the fascia is incised in the direction of the big toe distally and the patella proximally. The lateral compartment is relieved by dividing the fascia towards the head of the fibula proximally and the lateral malleolus distally. TOC
- A second skin incision 20-25 cm in length is performed about 2 cm posterior to the posterior tibial margin. The skin edges are undermined. The superficial and deep

fascias are divided as far as possible proximally, and towards the medial malleolus distally

- A 4-compartment fasciotomy may be performed through a single long incision between the tibia and the fibula. This approach is performed in the presence of tibial fractures because it avoids converting a closed fracture into an open one. TOC

THIGH COMPARTMENT SYNDROME

Anatomy

There are 3 muscle compartments: Anterior, posterior and lateral. Thigh compartment syndromes are not common and they usually involve the anterior or posterior compartments.

Decompression

Incision over lateral thigh. With adequate skin undermining and retraction, both the anterior and posterior compartments can be decompressed. It is very unusual that the medial compartment needs decompression.

FOREARM COMPARTMENT SYNDROME

Anatomy

There are 2 major muscle compartments: Anterior (volar), and posterior (dorsal), and one mini-compartment, the mobile wad.

Decompression

The anterior compartment is decompressed through a long incision from above the antecubital fossa to the mid-palm. Carpal tunnel decompression should be done. The dorsal compartment is decompressed through a short incision over the back of the forearm.

TOC

ARM COMPARTMENT SYNDROME

Anatomy

There are 2 muscle compartments: Anterior and posterior.

Decompression

Both compartments can be decompressed through a lateral incision.

Common Mistakes

- In the early compartment syndrome the pulse is usually present and the color of the skin is pink. Absence of pulse and pale skin are late signs!
- Ignore persistent extremity pain not responding to usual analgesia! Check for compartment syndrome.
- Cover with dressing the toes or fingers of a severely injured extremity, especially if the patient is pharmacologically sedated and/or paralyzed! Ischemic problems may be missed!
- Excluding compartment syndrome in suspicious cases on clinical examination alone. It can be misleading! In suspected cases measure the pressures!
- Technical errors in measuring the compartment pressures! Measurements should be performed in ALL compartments (i.e. 4 measurements in lower leg)

TOC

ABDOMINAL COMPARTMENT SYNDROME

Definition

Increase of the intra-abdominal pressure, usually above 25-30 mmHg. These results in respiratory compromise (poor oxygenation, increased peak inspiratory pressure in ventilated patients), decreased urine output, hypovolemia, tachycardia, decreased gut perfusion, probably increased bacterial translocation.

Causes

Usually due to damage control operations (i.e. packing for severe liver injuries), severe bowel edema secondary to prolonged hypotension, massive fluid resuscitation, or hypothermia.

Diagnosis TOC

Tense abdomen, tachycardia, in severe cases hypotension, increase peak inspiratory pressure, CO_2 retention, decreased urine output.

Investigations

Measurement of intra-abdominal pressures by bladder pressure measurements with a Foley catheter, (normal pressures <10 cm H20)

Treatment (see picture)

Release of the intra-abdominal pressure by opening the abdomen. Usually indicated for pressures >30-35 cm H2O. Closure is achieved with a plastic bag or other prosthetic material. Abdominal wall closure is attempted later after any packs are removed from the abdomen and the bowel edema is significantly reduced.

Prevention

In high-risk patients the intra-abdominal pressures should be monitored very closely. TOC

MISSILE AND BLAST INJURIES

Penetrating injuries are divided into those inflicted by low velocity missiles (<340 m/sec), i.e. knives and handguns, and those inflicted by high velocity missiles (>340 m/sec), i.e. rifles, bomb explosions. This distinction is important because the severity of the injury, the management, and the prognosis are different in the two groups.

MECHANISMS OF BULLET INJURIES

1. Low velocity injuries: The tissue damage is by direct laceration and crushing. Only tissues that have come into direct contact with the missile are damaged. The damage is obvious and nothing is hidden.
2. High Velocity Injuries: The tissue damage is caused by 3 mechanisms:
   a. Laceration and crushing, as in low velocity missiles
      - Types of bullets vary. See examples-
        - Hollow point bullet
        - Black Talon bullet
        - Scored bullet
        - Bullet fragments
   b. Shock waves: The missile compresses the tissue in front of it and this Thus, it can cause damage away from the permanent wound tract. Solid tissues (i.e., liver, spleen, muscle) are very susceptible to shock wave injuries. TOC
   c. Temporary cavitation: A large transient cavity is created around the missile tract. Bone may be

shattered and blood vessels may be damaged without being hit directly. The negative pressure within this cavity sucks in debris and bacteria. Solid organs are more susceptible to injury. Skin and lung tissue are more resistant.

Note: The severity of tissue damage is determined by the velocity of the bullet, the amount of energy released into the tissues, and the degree of fragmentation and deformation. Bullets with soft, hollow, scored or non-jacketed tips cause more damage because they deform or fragment.

Treatment of High Velocity Injuries

- Conservative debridement of skin, subcutaneous tissues, and muscle.
- Exclude vascular injuries even if the vessels are away from the missile tract.
- In limb injuries, a fasciotomy is usually necessary.
- Lung injuries do not require routine thoracotomy. These injuries are managed like any other penetrating chest injury. TOC

BOMB BLASTS

1. The bomb fragments at close range behave like high velocity missiles and cause damage by direct laceration and crushing, shock waves, and temporary cavitation. In addition to that the blast wave can cause major injuries. At greater distances they behave as low velocity missiles.
2. Blast wave: Compressed air, in the form of a sphere, expands rapidly. The pressure near the explosive charge is extremely high and might cause dismemberment. Immediately after the positive pressure phase there is a negative pressure or suction component and subsequently a dynamic pressure due to the expanding gases which displace an equal volume of air. This air travels at very high velocity.
   - Blast injuries in water are more severe than in air.
   - Gas-containing organs are susceptible to blast wave injuries: TOC
   - Ears: Rupture of tympanic membrane, ossicle dislocation, inner ear damage.

- Lungs: Hemorrhages, pulmonary contusion, destruction of alveoli, air embolism.
- Gastrointestinal tract: Rupture of hollow viscera, hemorrhages.

SHOTGUN INJURIES

1. Less than 6 meters: behave like high velocity injuries. Extensive tissue damage. (See example 1 & example 2)
2. Less than 2 meters: the entire charge penetrates the body.
3. More than 6 meters: low velocity injuries.
4. Sawn-off shotguns are more likely to produce low-velocity injuries even in close distances.

Treatment TOC

- Penetration of skin and subcutaneous fat: no need for removal of pellets. Tetanus prophylaxis.
- Penetration of fascia: Exclude neurovascular injuries, otherwise as above. Liberal use of angiography in shotgun injuries of the extremities.

- Massive tissue destruction: Debridement, repair vascular injuries, leave the wound open, consider fasciotomy, antibiotics, tetanus prophylaxis.

Common Mistakes

- High velocity injuries: There may be significant injuries to adjacent structures (i.e. vessels, solid organs).
- Bomb blasts: There may be significant internal injuries with no obvious external damage!

TOC

SPECIAL BURNS

ESOPHAGEAL BURNS

Acids cause a coagulation necrosis and the biggest damage occurs in the stomach. Alkali causes a liquefaction necrosis and the esophagus suffers the most extensive damage.

Treatment TOC

- Do not use stomach washout or emetics because of danger of perforation. Antidotes are contraindicated.
- Intravenous fluids. Nothing orally before the extent of the damage has been established. In severe damage, start parenteral nutrition.
- Early (within 12 hours) flexible esophagoscopy to assess the extent of the damage.
- In severe burns, give a broad-spectrum antibiotic and an antifungal agent for about ten days.
- In severe burns, steroids for about three weeks (initially hydrocortisone 200 mgr 6-hourly and later oral prednisone 1 mg/Kg daily). This practice is controversial.

- Contrast studies of the esophagus and the stomach are performed about ten days after admission to assess the degree of damage.
- Contrast studies should be repeated about one month after the injury to check for strictures.

BATTERY INGESTION

All batteries contain potassium hydroxide. If an ingested battery leaks, there is danger of caustic injuries. Mercury batteries may cause poisoning if they leak.

Management

Observe carefully. If after 24 hours the battery is still in the stomach, then consider endoscopic or surgical removal. Similarly, if there is radiological evidence of leak, consider operation.

TOC

Pediatric Trauma [TOC]

Special Physiologic Considerations

1. Pediatric Vital Signs

	Pulse Rate	Blood Pressure	Respiratory Rate
Infant	160	80	40
Preschool	120	90	30
Adolescent	100	100	20

2. Children suffer hypothermia faster than adults (proportionately larger body surface).
3. Children have a pliable skeleton. They may suffer major internal injuries without fracture.
4. Estimating weight: 2 x age (years) + 8 = weight in kg.

*Children frequently need to be fully restrained to protect c-spine.

Note: Use Broselow Pediatric Emergency Tape to estimate weight, fluid and medication administration. Use our color-coded packs and pediatric trauma forms to help you with normal vital signs, size of instruments and doses of common medications.

INITIAL EVALUATION AND RESUSCITATION

Always ATLS principles: Primary Survey (A B C D E), Secondary Survey. TOC

1. **Airway:**
   - Infants are nose breathers. Keep nares clear, use orogastric tube rather than nasogastric tube.

- Use orotracheal intubation, avoid nasotracheal intubation.
- Use uncuffed endotracheal tube (avoid subglottic edema and injury) below the age of 8 years.
- ET tube size: The child's small finger or use the charts on the trauma forms.
- The epiglottis is large and floppy and the cords are higher and more anterior. Intubation is easier with a straight laryngoscope blade.
- Cricothyroidotomy should be avoided in children <6 years.

2. **Rapid Sequence Intubation:**
   - Preoxygenate with 100% oxygen.
   - Premedicate with:
     - Lidocaine TOC
     - Atropine
   - Paralyze: succinylcholine.
   - Orotracheal intubation.
   - Always check the position of the tube with a chest x-ray. High incidence of right-stem intubation (about 17% of emergency intubations).

3. Cervical Spine: TOC

- Radiological interpretation is difficult:
- Normally there is increased anterior displacement C2-C3 (pseudosubluxation). Less frequently there is a pseudosubluxation of C3 -C4. This pseudosubluxation may be found up to the age of 16 years.
- Loss of Lordosis in the C-Spine
- Normally there is increased space between C1 and dens. It might be mistaken for subluxation.
- Normal wedging of an intervertebral space or the body of C3 may be mistaken for spinal trauma.
- Normal translucencies of the dens may be mistaken for fracture.
- In children there is a high incidence of spinal cord injuries without radiological abnormalities. (SCIWORA)

4. **Fluid Resuscitation:**

- Venous Access:
  - Avoid femoral vein
  - Attempt a peripheral IV line first.

- In difficult venous access use intraosseous infusion (ages <6 years).
- As a last resort attempt femoral vein or major neck vein catheterization.

- Clinical shock usually appears after loss of more than 25% of blood volume.
- Initial bolus fluid: Warm crystalloid 20 ml/kg. Repeat if not adequate response. After first or second bolus give blood 10 ml/kg.

5. **Head Trauma:**
   - Children generally recover from head trauma better than adults. TOC
   - Children tolerate expanding intracranial lesions better than adults because of fontanel's and suture lines.
   - Epidural hematomas are more common than in adults.
   - Infants may develop hypovolemic hypotension from blood loss in the subgaleal or epidural space.
   - Vomiting and seizures are common in children.

- The Glasgow Coma Scale is applicable to pediatric trauma. For children <4 years, the verbal score is modified as follows: TOC

	Verbal Score
Appropriate words, social smile, fixes and follows	5
Cries, but consolable	4
Persistently irritable	3
Restless, agitated	2
None	1

6. Chest Trauma:

- Children suffer rib fractures less often than adults. When present, they indicate severe trauma.
- Pulmonary contusions are more common in children than in adults. Aortic rupture is rare!

7. Abdominal Trauma:

- Evaluate as in adults.
- Nonoperative management of splenic or liver injuries is more successful in children than adults.
- Liberal insertion of nasogastric tube. Very young children swallow a lot of air and develop gastric distention. This

might interfere with respiratory function and abdominal evaluation.

Common Mistakes

- False sense of security because of "hemodynamic stability"; children may lose significant amount of blood and still maintain a "normal" pressure by vasoconstriction.
- Severe gastric dilatation due to swallowing of air may cause respiratory difficulties or complicate the abdominal examination. Insert a nasogastric tube in the appropriate cases.
- Failure to administer Atropine during rapid sequence intubation. Risk of severe bradycardia!
- Check the correct position of the endotracheal tube. High incidence of right stem intubation

TOC

GERIATRIC TRAUMA

GENERAL PROBLEMS

1. Higher mortality and morbidity, longer hospital stay and more disability than younger patients with similar injuries.
2. Mechanism of injury is often a fall or motor traffic accident. Exclude myocardial infarction, TIA, seizures, stroke or hypoglycemia causing the fall or automobile accident. TOC
3. Consequences of Aging:
   a. Greater tendency toward more severe and multiple fractures.
   b. Decreased immune and wound healing due to multiple factors, often malnutrition.
   c. Decreased ability of the heart to respond to endogenous or exogenous signals to increase cardiac output.
   d. Decreased pulmonary compliance, vital capacity, P02 and increased residual capacity.

e. Loss of kidney mass, decreased creatinine clearance and concentrating ability. Less kidney tolerance to hypotension and nephrotoxic drugs.
f. Cerebral atrophy. Subdural hematoma may manifest late. TOC
g. Associated medical problems and often-on medications.
h. Limited physiological reserves. Rapid deterioration.
i. Check for advance directives regarding medical care.
j. Age >70 years combined with major decelerations mechanisms (traffic injuries, falls from height) or penetrating trauma are in themselves criteria for Trauma Team Activation.

SPECIAL PROBLEMS

1. Airway: Remember dentures!
2. Breathing: Flail chest may not show easily because of cage rigidity. Pain control is critical in multiple rib fractures (epidural anesthesia strongly recommended). Consider liberal early intubation and mechanical ventilation.

3. Circulation:
    - Blood pressure and pulse may not be reliable hemodynamic parameters (heart disease, cardiac drugs).
    - Chronic use of diuretics results in intravascular depletion. Blood loss is not tolerated well.
    - Limited oxygen carrying reserves. Transfuse early.
    - Early placement of pulmonary artery catheter.
4. Disability:
    - Epidural hematomas are rare.
    - Subdural hematomas are 3-4 times more common than in young victims.
    - Rehabilitation is more difficult.
5. Exposure:
    - Hypothermia occurs faster and is more difficult to correct.

TOC

Common Mistakes

- Underestimate the risks in relatively moderate trauma. Intensive monitoring is critical. Liberal criteria for admission to ICU. TOC
- Relatively innocent rib fractures can lead to pneumonia and/or respiratory failure. Close monitoring (SaO2, blood gases), and epidural anesthesia.
- Subdural hematomas may manifest clinically much later than younger patients. Consider liberal head CT scanning.
- Failure to perform early endotracheal intubation in the emergency room in patients with severe trauma and "normal" respiratory function. Elderly patients often decompensate rapidly in the radiology suite. Early intubation avoids this potentially dangerous complication.
- Failure to obtain a detailed medical history from the patient or the family. Ask specifically for beta blockers, other cardiac or anti-hypertensive medication, anticoagulants, aspirin. These medications may complicate

the clinical presentation and the risk of bleeding, especially intracranially!

- Underestimate the significance of even "minor" head injuries. There is a high incidence of intracranial bleeding. Liberal use of CT scans evaluation.

TOC

TRAUMA IN PREGNANCY

SPECIAL PROBLEMS

1. Blood volume increases by 40-50% in third term. The injured victim may lose up to 1/3 of her volume without significant hemodynamic changes.
2. Compression of the inferior vena cava by the enlarged uterus impairs venous return. Left lateral position or tilting of the spinal board prevents this problem.
3. Injuries to the lower extremities bleed more than usual
4. Risk of placenta abruptio. Consider the diagnosis in all pregnant patients with vaginal bleeding or lower abdominal pain.

5. Risk of isoimmunization. All Rh negative victims should receive immunoglobulin (Rhogam).
6. Risk of amniotic fluid embolization.
7. High fetal mortality, even in moderate maternal trauma (Mortality in major trauma with hypovolemic shock is >80%). TOC
8. Risk of perioperative aspiration is higher than usual (hypotonic gastrointestinal tract due to progesterone).

INVESTIGATIONS

1. All female trauma patients in the reproductive years should have a pregnancy test done.

2. Indicated radiography or CT scans should NOT be deferred because of pregnancy. Abdominal shielding whenever is possible. Unnecessary irradiation should be avoided because of the risk of fetal harm, especially during the first 16 weeks of pregnancy

3. If a DPA is indicated (rarely), the supra umbilical semi-open technique should be used.

4. Ultrasound of the uterus and fetus should be done routinely.

5. Immediate consultation with Obstetrics/Gynecology.

6. Fetal heart monitoring in advance pregnancy with viable fetus (>24 weeks).

TREATMENT

1. Routine oxygen supplementation.
2. In advanced pregnancy place patient in the left lateral position. If on a spinal board, tilt it to the left by inserting sandbag or rolled towels underneath.
3. Aggressive IV fluid resuscitation from the very early stages.
4. Administer Rhogam to all Rh negative patients. (50 microg in the first trimester, 300 micrograms during the second and third trimester).
5. Perimortem C-section in maternal cardiac arrest or imminent arrest and gestation >26 weeks. (See protocol 16)

TOC

COMMON MISTAKES

- Underestimate blood loss because of early "stable" vital signs. In advanced pregnancy blood loss up to 1500 ml may not manifest with hypotension.
- Delay necessary x-rays or CT scans because of the pregnancy.
- Underestimate the risk of fetal loss in fairly moderate maternal injury.
- Trying to save the fetus at the expense of the mother! The best treatment for the fetus is resuscitation of the mother!

TOC

RESUSCITATIVE PROCEDURES

RESUSCITATIVE THORACOTOMY

Indications TOC

- Cardiac arrest or imminent cardiac arrest following penetrating injuries of the chest, abdomen, neck or extremities.
- Its role in blunt or head trauma is controversial.
- Most valuable in penetrating chest, neck or extremity injuries with vital signs present on arrival.

Technique **(See Incision Site)**

- The procedure is performed with the patient on the stretcher. The left arm is abducted at 90 degrees and a left anterolateral thoracotomy through the fifth intercostal space, just below the nipple, is performed while other members of the trauma team insert an endotracheal tube and at least two intravenous lines.
- The pericardium is opened in front of the phrenic nerve. Any major bleeding is controlled, the aorta is cross-clamped

above the diaphragm, and the heart is massaged. For massive lung injuries, cross-clamp the hilum.

- Transfusions, drugs (e.g., epinephrine, $NaHCO_3$), and internal defibrillation (10-50 joules) are given as indicated. If air embolism is suspected, aspiration of the heart is performed.
- If the heart recovers, the operation is completed in the operating room.
- For persistent cardiac arrest internal pacing should be considered.

BACK TO PROTOCOLS

TOC

CRICOTHYROIDOTOMY

Indication

Airway obstruction where immediate relief is required, or inability to intubate a hypoxic patient.

Technique

- The thyroid cartilage is immobilized between the thumb and the index finger.
- The trachea is entered via a transverse incision in the cricothyroid space (4 fingers above suprasternal notch).
- Only the skin and a membrane have to be cut.
- The upper part of the tracheal wound is grasped with a tissue forceps or a tracheostomy hook and pulled cephaladly and forward. In this immobilized position the insertion of the tube becomes much easier. The tube should be one size smaller than in orotracheal intubation.
- The procedure can be difficult in fat, short necks.

BACK TO PROTOCOLS TOC

SUBCLAVIAN VEIN CATHETERIZATION

Technique

- The patient is put in the Trendelenburg position for better filling of the vein and prevention of air embolism. The arm is abducted about 30 degrees.
- A 12-gauge needle with a 14-G cannula mounted on a syringe is inserted under the midpoint of the clavicle and directed towards the suprasternal notch. When the vein is entered, a “give” is felt and blood is aspirated. The syringe is disconnected and a 16-gauge catheter is inserted over a guide-wire into the vein through the needle and secured to the skin with a suture
- Ideally, x-ray before use to exclude pneumothorax and check the position of the catheter.

BACK TO PROTOCOLS

TOC

INTERNAL JUGULAR VEIN CATHETERIZATION

Technique

The patient is put in the Trendelenburg position for the reasons mentioned above. A 14-gauge needle mounted on a syringe is inserted under and behind the sternomastoid, 1-2 cm below its midpoint, and directed towards the sternoclavicular junction. When the jugular vein is entered and blood aspirated, a 16-gauge catheter is inserted over a guide-wire through the needle and connected to an infusion set. The catheter is secured to the skin with a suture

Thoracostomy Tube: See protocol 9

BACK TO PROTOCOLS

TOC

SCORING SYSTEMS IN TRAUMA

The purpose of these systems is to estimate objectively the severity of trauma in a patient or group of patients. There are physiological scoring systems that measure the degree of physiological derangement, and anatomical systems that measure the degree of anatomical damage.

PHYSIOLOGICAL SCORING SYSTEMS

1. Glasgow Coma Scale
2. Revised Trauma Score (RTS): This measures the degree of physiological derangement on the basis of coded measurements of systolic blood pressure, respiratory rate, and Glasgow Coma Scale.

The coded value is multiplied by a weighting factor and the sum of the three values gives the RTS. To learn more or perform a RTS calculation, click the link (Trauma.org)

BACK TO PROTOCOLS

TOC

ANATOMICAL SCORING SYSTEMS

Abbreviated Injury Scale (AIS): Scores from 1 (minor) to 6 (fatal).

Injury Severity Scale (ISS): The body is divided into six areas:

1. Head and neck
2. Face
3. Chest
4. Abdomen and pelvic contents
5. Bony pelvis and limbs
6. Body surface

The AIS for each body area is estimated using the AIS booklet. The ISS is determined by adding together the squares of the three highest AIS scores from the above-described body areas. The maximum ISS is 75 (52+52+52), which is fatal. A patient with AIS of 6 in one body area is automatically given an ISS of 75. An ISS higher than 15 is considered severe trauma.

To perform a calculation click the link [(ISS Calculation)]

TRISS METHODOLOGY

TRISS combines the RTS, the ISS, the age of the patient, and the mechanism of trauma (blunt or penetrating), and gives an estimate of the probability of survival. It is best done by feeding the above information into specially designed computer programs. Its role and value have been challenged and we believe that it has limited or no role in trauma Quality Improvement. See Trauma.org for further information

BACK TO PROTOCOLS

TOC

1. TRAUMA ALERT PROTOCOLS

TRAUMA TEAM ACTIVATION ("Trauma Code")

PATIENT SELECTION: The Trauma Team will be activated for any patient meeting Los Angeles County DHS criteria for transport to a trauma center that additionally have any of the following criteria:

a. BP <90 mmHg
b. HR>120
c. RR <10>29
d. Unresponsive to pain*
e. Age >70 years (excluding ground level falls
f. Gunshot wounds to the chest or abdomen
g. Stab wounds anterior chest

(*Excludes unresponsive patients with isolated head trauma and otherwise normal vital signs)

Pediatric trauma patients (under eight years of age) whose vital signs meet the above criteria will be immediately presented to the DEM Attending physician or two-star senior resident and decision to activate the team will be made on a case by case basis. TOC

Additionally, the Trauma Team may be activated by the DEM Attending Physician or Senior Resident for any trauma patient in route to LAC+USC who in their opinion might benefit by the presence of the surgical members of the team on arrival, for any critical patient arriving without notification or for any trauma patient critically deteriorating while in the DEM.

ACTIVATION: TOC

The Simultaneous Activation System will be activated by the base station receiving notification of the impending arrival of a patient meeting selection criteria; or by DEM staff for any patient not meeting criteria but for whom the Trauma Team is being requested. Upon activation of their beepers to indicate a Trauma Code, all members of the team will proceed immediately to Resuscitation Room. If the Trauma Team is occupied in the operating room they will notify the Trauma Observation Unit to immediately contact the non-trauma in-house general surgical team to respond. Time of activation of the team will be recorded in a log kept for that purpose and times of arrival will be recorded on the Trauma flow sheet.

MEDICAL DIRECTION:

The Trauma Team Leader will be the Trauma Surgery Attending Physician or, if not immediately available, the Emergency Medicine Attending Physician.

TEAM OPERATIONS: TOC

As the patient arrives in Resuscitation Room, the transport litter will be brought to the Resuscitator's side of the gurney and the Trauma Team and paramedics will transfer the patient to the gurney on the Resuscitator's count of three.

While the Nurse Assistant is removing the patient's clothing and obtaining vital signs, the Resuscitator, under the direction of the Team Leader, begins the primary survey, directing the Airway Manager and the Procedure Resident as necessary to establish an airway and adequate IV access and to place thoracotomy tubes if indicated. The Senior Trauma Resident confirms the primary survey and proceeds with the secondary survey either after the above are completed or, in unstable patients, while those resuscitative measures are underway.

PROGRESSION:

The Senior Trauma Surgery Resident will confer with the Team Leader and the Resuscitator in developing a definitive evaluation plan. Diagnostic peritoneal aspirate, cricothyroidotomy and resuscitative thoracotomy should be performed by the trauma surgeon. Central lines, thoracostomy tubes and endotracheal intubation will be performed by the emergency medicine resident under the team leader direction. TOC

If the patient is not in need of admission to the Trauma Surgery Service, he may be cleared by the Senior Trauma Surgery Resident and appropriate disposition arranged by the DEM staff. If the patient does warrant Trauma Surgery Service admission but also warrants additional consultation by other specialists, such consultation may be carried out in the DEM or in the Trauma Observation Unit as agreed upon by the Team

Leader, the Senior Trauma Resident and the DEM senior resident or attending.

In the event that multiple critically injured patients arrive or are in the DEM simultaneously, the team leader will direct additional consultation by other specialists, such consultation may be carried out in the DEM or in Trauma Observation Unit, as agreed upon by the Team Leader, the Senior Trauma Surgery Resident and the Resuscitator.

In the event that multiple critically injured patients arrive or are in the DEM simultaneously, the team leader will direct additional DEM, Trauma Surgery, and Nursing Staff to form subteams as needed. The Trauma Surgery team may request assistance from the in-house non-Trauma Surgery Team including their attending and/or call in additional Trauma Residents or attending. TOC

TEAM ASSIGNMENTS:

- Team Leader (TL) - initially positioned at the foot of the gurney, has ultimate responsibility and authority for all management. Ideally allows senior residents to initiate resuscitation, evaluation and interventions but redirects or overrides any orders as necessary. Directly supervises and assists in major emergency interventions, e.g., E.D. thoracotomy, cricothyroidotomy, as well as invasive diagnostics, e.g., peritoneal aspirate.

- Senior Trauma Surgery Resident (STR) (PGIV or PGV Trauma Surgery resident) - initially positioned on the patient's right side, confirms primary survey and performs secondary survey as soon as resuscitative procedures are under way. In consultation with Team Leader, determines need for immediate surgical intervention or immediate transfer to the Operating Room. If patient is stabilizing in conjunction with Resuscitator, develops plan for further evaluation, consultation and disposition.

- Resuscitator (R) (PG IV DEM resident) - initially positioned on the patient's right side near the head of the gurney, under supervision of Team Leader, performs an initial assessment (A-E) and on the basis of that assessment:
    - Direct the management of the airway
    - Ensures C-spine precautions if indicated

- Airway Manager (AM) (PG IV or PG III DEM resident) - initially positioned at the head of the gurney, follows Resuscitator's directions regarding necessary airway management, If directed, performs endotracheal intubation with or without rapid sequence paralysis as indicated. Confirms tube placement and ventilates patient until relieved by R.T.

- Procedure Resident 1 (PREM) (PG III PG II DEM Resident) - initially positioned on the patient's left side, follows directions regarding placement of central venous lines and/or thoracostomy tubes. TOC

- Procedure Resident 2 (PRS) (PG III PG II Trauma Surgery Resident) - initially positioned on the patient's right side, follows directions for additional or simultaneous procedures; subsequently assists Senior Trauma Surgery Resident in patient evaluation. TOC

- Primary Nurse (RN1 (DEM nurse) - initially positioned on the patient's left side, assists in undressing the patient, obtains vital signs, assesses the status of IVs started in the field and reports above to Recording Nurse. Obtains or assists in obtaining blood samples and placing them in proper collections tubes. As directed, places or assists in placing nasogastric tubes and urinary catheters. Connects and monitors function of pleurovac systems for thoracostomy tubes. Other functions as directed.

- Recording Nurse (RN2) (DEM nurse) - initially positioned at the C-Booth counter, calls for X-Ray Technician on ring down phone, records all vital signs, procedures, medications, etc. on appropriate sheets. Prepares, labels and sends laboratory specimens; spins hematocrit and performs other bedside diagnostic tests as directed. Notes time of arrival of Trauma Surgery Team attending and/or Senior Trauma Resident (PG V or IV) and other surgical consultants (Ortho.)

- X-Ray Technician (XR) (MAR X-Ray Tech) - initially positioned back from Trauma Team, stands by with portable X-Ray machine until directed by Resuscitator, Senior Trauma Surgery Resident or Team Leader to obtain films; routinely brings cassettes for cervical spine, chest and pelvis films. TOC

EMERGENT TRAUMA CONSULTATION

Trauma patients meeting the following criteria will be considered emergent, and a PG IV or PG V Trauma Resident should be present in the resuscitation area within 5 minutes. An emergent trauma consultation should be sought as soon as notification of their status is received from the field or upon arrival in the DEM if they arrive without notice. It is absolutely essential that the time of response and the seniority of the resident is recorded!

Emergent Criteria:

1. GGS <12 (excluding clearly isolated head trauma). In isolated head injuries with GCS<12 or localizing signs the neurosurgeon should be notified immediately
2. Initial hematocrit <30 or dropping >5%
3. Previously stable vital signs deteriorating to the levels noted above
4. Initial chest tube output of >300 cc of blood or persistent significant output
5. Clinical evidence of flail chest
6. Perceived indication for emergent diagnostic peritoneal aspirate TOC
7. Clinical evidence or suspicion of cardiac injury or pericardial tamponade
8. Vascular injuries resulting in impaired circulation to an extremity or significant hemorrhage

9. At the discretion of the senior DEM physician
10. Penetrating injuries of the head (activate neurosurgery team) TOC

(Note: If BP<90, P>120, RR <10 >29, unresponsive to pain, gunshot wounds to the chest or abdomen, stab wounds of the anterior abdomen and age >70 years, the whole Trauma Team should be activated via the beeper system (Trauma Code).

URGENT TRAUMA RESPONSE CRITERIA

Trauma patients not meeting Emergent criteria but meeting the following criteria will be considered Urgent, and the PG IV or PG V surgical resident of the Trauma Team will proceed to the DEM within 30 minutes of notification:

1. Clinical evidence or suspicion of penetrating abdominal injury
2. Pneumothorax with persistent air leak
3. Evidence of gastrointestinal bleeding secondary to trauma
4. Penetrating injury in proximity to major vessel
5. Two or more proximal long bone fractures

6. Pelvic ring fractures with displacement
7. Gross hematuria
8. Paralysis of a limb TOC
9. At the discretion of the senior DEM physician

SURGICAL SPECIALTY CONSULTANTS

Upon request of the senior members of the Trauma Team and at whatever point deemed appropriate, additional consultation will be provided by the following services in the time frames indicated:

Neurosurgery (immediate - in house)
Orthopedics (immediate - in house)
Obstetrics [for emergency C-section] (immediate - in house)
Head and Neck Surgery/Otolaryngology (30 minutes)
Ophthalmology (30 minutes)
Urology (30 minutes)
Burn Surgery (30 minutes)

NON-SURGICAL CONSULTANTS

The following services will also ensure emergency consultation in the time frames indicated and may be called at the discretion of the senior members of the Trauma Team:

Anesthesia (immediate - in house)

Pediatrics (immediate - in house)

Cardiology, other medical specialties (30 minutes)

Radiological Support

Upon initial notification of the impending or actual arrival of a patient meeting Emergent Response criteria, Emergency Department Radiology will be notified via the dedicated phone, and a radiology technician and portable x-ray unit placed on standby in the Resuscitation Room.

CT Scan TOC

As soon as it is determined that a trauma patient requires CT scanning, the Radiology Department will be contacted and patient priorities re-evaluated. Patients will not normally be sent to CT scan until they have been stabilized. TTA patients are escorted to the radiology suite by the trauma residents. Non-TTA patients are escorted by DEM residents.

Operating Rooms

As soon as a determination is made by the senior Trauma Surgeon that a patient needs to be taken directly to the Operating Room, the OR will be so notified and prepared.

TRAUMA PATIENTS NOT MEETING EMERGENT OR URGENT CRITERIA TOC

Patients meeting Trauma Center Field Triage Criteria but not meeting Emergent or Urgent criteria as defined in this document, as well as any other trauma patients presenting to or being transferred to LAC+USC, will be managed by EMD staff with Trauma Surgery and/or other surgical consultation as deemed appropriate. Patients fully stabilized but still requiring admission to the Trauma Surgery Service will normally receive expeditious consultation prior to their admission.

Patients being admitted to the Surgical Trauma Service may be consulted in the DEM by other services as deemed appropriate by the EMD or surgical staff. This is particularly desirable in cases where emergent surgery by other surgical specialists is likely. Less emergent consultations can and should be deferred to the Trauma Observation Unit.

At the discretion of the EMD staff, assessment by the Trauma Surgery Service or other surgical specialty consultants may be requested for patients being admitted to services other than the Surgical Trauma Service prior to admission to those services. TOC

Disposition of Trauma Patients from the DEM

Once it becomes obvious that a trauma patient warrants admission to the Surgical Trauma Service or to any other surgical specialty service, that patient's admission should be expedited and additional studies that will not alter their disposition deferred to the admitting areas. Patients requiring CT scans, angiography or other studies that will not influence their disposition should be physically transported to the service to which they are to be admitted, and have studies performed from those services as inpatients. Only when their ultimate disposition is not clear and the results of those studies are necessary to make such a determination should patients have such studies done from and be returned to the EMD.

BACK TO PROTOCOLS

TOC

2. BLOOD TRANSFUSIONS IN TRAUMA

Blood administration in the Emergency Room:

a. O-negative (or if unavailable, O-positive) red blood cells (RBC) are stored in the Resuscitation Room Blood Bank Refrigerator, usually 6-8 units.

b. O-negative blood should be transfused only if the patient is in need of immediate transfusion. If O-negative blood is not available, the refrigerator may be stocked with O-positive blood. Care must be taken when giving O-positive blood to women of childbearing potential.

c. Type-specific blood should be used if blood is not required for 15 minutes, and fully crossmatched blood should be used if an hour delay is safe.

d. All policies regarding identification of patients' specimens (double-checking of specimen labels and papers against identa-band) must be rigidly followed despite the pressure of time. TOC

e. All trauma patients will receive duplicate identa-bands: one wrist and one ankle. If an identa-band must be removed, reattach it to another extremity.

f. In order to avoid hypothermia, transfused blood must always go through the Level I rapid infusion blood warmer. Similarly, warm ambient temperatures and reflective covers should be used on the patients.

g. All patients with suspected significant hemothoraces should be included in the auto-transfusion protocol and the special collection bags should be attached to the thoracostomy tube drainage system.

Blood administration in the operating rooms and post-anesthesia recovery rooms should follow the Operating Rooms/Post-Anesthetic Recovery Policy "Administration of Blood and Blood Products". Briefly: TOC

a. The operating room also maintains a satellite Blood Bank refrigerator stocked with O-negative (or, if unavailable, O-positive) blood. Indications for the use of this blood are the same as noted for EMD use; that is, it should only be used if type-specific or fully crossmatched blood is not available and transfusion must be given immediately.

b. Indications for uncrossmatched type-specific blood are the same as noted for the EMD.
c. Warmed and fully humidified anesthetic gas should be used.
d. All patients are placed on a warming blanket on the OR table.
e. The operating room environment should be kept warm, above 80oF
f. Maintain reflective blanket coverage of skin as much as possible.
g. Warm saline for irrigation (10 liters) should be immediately available in the OR.
h. Strict compliance with blood unit/recipient identification procedures must always be maintained.
i. Bair Hugger Technology should be instituted in the OR and PAR when available. TOC

j. Patients who receive massive transfusions should be managed according to the protocol below:

Blood Transfusion Flowchart

BACK TO PROTOCOLS

TOC

Rapid Uncontrolled Hemorrhagic Shock

- **HEMORRHAGE CONTROL** (surgical / endovascular)
- **SEND LABS** (type and cross,
- aPTT, INR, platelet count)
- **AUTOTRANSFUSE** (shed pleural blood)
- **CONTROL HYPOTHERMA**
- (Warm fluids & vent gases, remove wet clothing, dry patient, Bair Hugger)

1. Start with O RBC transfusion
Opening ER or OR fridge containing 8 units of O RBC notifies blood bank so patient identity and units taken can be documented
2. Switch to type specific or crossmatched blood as soon as it is available

Component Therapy Triggers

EMPIRIC
1. > 6 units of RBC
2. History of Coumadin

- 6 U type compatible pre thawed plasma
- 1 U pheresis platelets

TARGETED
Abnormal aPTT / INR
Platelets < $50x10^9$/L
Fibrinogen < 100mg/dL

Diffuse Nonsurgical Bleeding

- Recombinant Factor VIIa
- 100 mcg/kg
- Up to 3 additional doses as required

rFVIIa Dosing Guide

***Wt.* (Kg)**	***Vials* (1.2mg)**
13-19	1
20-32	2
33-45	3
46-59	4
60-72	5
73-85	6
86-99	7
>100	8

TOC

3. INDICATIONS AND TIMING OF CT OF THE HEAD

Isolated head injury

-History of loss of consciousness
-Amnesia
-Severe headache
-GCS <15
-Localizing signs
-CSF leaks
-Penetrating skull injuries

CT scan

Multi-trauma requiring non-neurosurgical operation

Hemodynamically stable

-GCS $\leq$12
-Localizing signs

CT scan before operation

-GCS $\geq$ 13
-LOC
-Severe headache

CT may precede operation

(depending on type of injury, OR availability, etc.)

Hemodynamically unstable

Operation

CT scan

4. HEAD INJURIES: ICP MONITORING GUIDELINES

Guidelines For ICP Monitoring

1. GCS =< 8 with abnormal CT scan.
2. GCS =< 8 with normal CT scan, if 2 or more of the following: a) age >40, b) BP<90, posturing.
3. GCS 9-12 with abnormal CT scan if the patient will undergo a prolonged operation for other extra-cranial injuries.

Back to Head Trauma Chapter

BACK TO PROTOCOLS

TOC

5. CLINICAL EVALUATION OF "BRAIN DEATH"

Definition: Death due to neurologic failure ("brain death") is defined as the state in which there is no neurologic function of the brain and brain stem, and that this state is irreversible.

Criteria: All of the following must be true:

- NORMOTHERMIA (CORE TEMPERATURE > 95 F)
- ABSENCE OF PHARMACOLOGIC EFFECT (NEGATIVE TOXICOLOGY)(barbiturate level < 5. Other levels [if present] must be individually evaluated to determine if they are contributory to decreased neurologic function. Trace levels do not absolutely rule out the ability to determine brain death) TOC
- ELECTROLYTES (ranges for normal neurological function)
  - Sodium 125 – 160
  - Potassium 3 – 7
  - Magnesium 1 – 4
  - Phosphorus 1 – 8
  - Glucose 50 – 400
- ABSENCE OF NEUROLOGIC FUNCTION OF THE BRAIN OR BRAIN STEM. IN PARTICULAR:

- NEGATIVE CORNEAL REFLEX
- ABSENT PUPILLARY REFLEXES
- ABSENT OCULOCEPHALIC REFLEX (negative "doll's eyes")
- ABSENCE OF RESPONSE TO COLD CALORIC STIMULATION (direct instillation of 60 cc iced solution into each ear canal fails to cause ocular motion)
- NO SPONTANEOUS RESPIRATIONS (in the presence of sufficient arterial paCO2 to stimulate respiration, usually paCO2 > 60mm/Hg(*See apnea test)

Procedure: Two licensed physicians shall perform the neurologic examination independently. Each physician shall document findings in the patient record, and at least one of the physicians shall be a member of the attending staff of the LAC+USC Medical Center, and one physician shall be approved by Chief of Neurosurgery or Neurology for brain death declaration. TOC

NOTE: This protocol refers to the clinical determination of "brain death." Alternative methods such as brain perfusion studies (almost always used in children below 12 years of age) may be used in cases where the clinical evaluation is impractical; however, the clinical determination alone is sufficient to determine death based upon neurologic function.

Spinal reflexes: may be present, but do not change the status of the patient if brain stem function is absent.

TOC

*Apnea test

1. Patient should have ventilator adjusted resulting in normal pH and $PaCO_2$, with 100% saturation.
2. Preoxygenate for 5-10 minutes with 100% FiO_2.
3. Disconnect patient from ventilator and place a catheter down the length of the endotracheal tube. The catheter should be connected to 100% O_2 at 12-15 liters/minute.
4. Observe the patient for approximate 10 minutes for respiratory effort.
5. The test is stopped when the ABG PCO_2>60mm Hg and rises 20mm Hg above base line.
6. The test should be terminated early and the patient placed back on the ventilator if spontaneous respiration is noted, the O_2% Sat<90, and/or the patient becomes hemodynamically unstable.

BACK TO PROTOCOLS

TOC

MANAGEMENT OF THE POTENTIAL ORGAN DONOR PATIENT

TOC

Pt. Evaluated in ER

AVOID HYPOXIA & HYPOTENSION

1. Labs obtained: ABG /serum lactate /CBC/ PT/PTT/lytes
2. Transfuse to maintain Hct > 30
3. Bolus 1 liter NS
4. Control active bleeding
5. Maintain MAP > 70 with fluid
6. Place large trauma central line
7. CT scan
8. Protect the patient from hypothermia

Patient's (mean arterial pressure)MAP > 70

YES

- Continue to fluid resuscitate as needed, and correct lab abnormalities.
- Points of resuscitation should include normalization of base deficit/lactate**,** CVP and/or PAOP 8-15, and minimal use of pressors. (dopamine<5.)
- **Rules of 100's:** SBP>100mm Hg, UOP > 100, PaO_2 > 100.
- Maintenance fluid: Early NS or LR; then adjust as indicated.

NO

1. Continue to fluid resuscitate with 5% albumin and NS (Continue with this protocol until MAP > 70 with dopamine<5)
2. Double the dose of dopamine q5 minutes to maintain MAP > 70
3. Once dopamine is at 20 g/kg/min, if MAP < 70, start epinephrine drip.
4. Double epinephrine drip q5 minutes and bolus over 20 minutes, 1 liter NS with 100cc of 25% albumin.
5. ARE CVP and/or PAOP (wedge) > 17?
   NO: Continue to bolus with above NS/albumin solution.
   YES: Does the patient have clinical symptoms and laboratory values suggestive of DI (diabetes insipidus)?
   UOP > 600 cc/hour and serum sodium > 150?
   NO: Consider starting norepinephrine if CI > 4
   YES: Start vasopressin at 1-8 units/hour, and replace UOP over 200cc with 1/2 NS cc for cc every hour.

(Norepinephrine and vasopressin should not be used if SVRI > 1100, or CI<3)

Continued on next page.

All patients require q4 hour ABG's, serum lytes, serum lactate, and cardiac output if available (even after declaration of brain death). Avoid hypernatremia (see DI below): If serum Na> 145 change from NS to LR. Do not use more than 3 liters albumin per day. TOC

Common Problems:

- DIC: If a patient has clinical signs of DIC, transfuse immediately with 4-6 units of FFP. Delaying transfusion while waiting for lab results with uncontrolled hemorrhage is not indicated. Maintain Hct > 30 with pRBC.
- DI: If patient is normotensive, serum sodium > 148 and UOP > 600cc/hr, give 1-2 micrograms of DDAVP IVP (q 2-8 hours as needed) and replace UOP cc for cc with 1/2 NS q hour for UOP > 200 (example: for UOP of 1000cc replace with 800cc of 1/2 NS). If patient's serum sodium > 148 and UOP > 300cc/hr, replace UOP cc for cc with 1/2 NS q hour for UOP > 200cc. If patient is hypotensive, then use above protocol. **Continued on next page.**

- Tachycardia and hypertension: This commonly occurs prior to complete herniation. The effect of treatment is not clearly defined, but any agents used should have a very short half-life.
- Neurogenic pulmonary edema: This may occur and decreases the PO2; increase ventilator support as needed. With severe problems of oxygenation, use the percussinator ventilator.
- Hypokalemia and/or hyperglycemia: Use sliding scales as needed.
- Hypothyroid: Many patients have a T-3/T-4 abnormality and require additional thyroxin. Start patients on thyroxin protocol (attached: T-4 Donor Protocol) once declared brain-dead or when they fail to have spontaneous respirations via an apnea test.

1. Cardiac arrest: Follow ACLS code guidelines.

BACK TO PROTOCOLS

TOC

T-4 DONOR PROTOCOL

Pretreatment:

1. Hydrate donor to a minimum central venous pressure >7 cm Hov or PAWP 12-15 mmHg.
2. Transfuse with pRBC to obtain and maintain Hemoglobin>10 and/or Hematocrit>30
3. Correct electrolyte abnormalities

Indications: TOC

Donor is requiring a combined vasopressor need greater than 15 mcg (all vasopressors combined including dopamine) to maintain a systolic pressure of 100 mmHg after the pre-treatment is completed.

T-4 Protocol:

- Administer IV boluses of the following in rapid succession:

  1 Amp of 50% Dextrose
  2 Gms of Solumedrol
  20 units regular insulin
  20 mcg Thyroxin (T-4)

- Start a drip of 200 mcg T-4 in 500cc Normal Saline (.4mcg/cc). Administer at 25cc (10mcg) per hour initially. Reduce levels of other pressors as much as possible and then adjust T-4 as necessary to maintain desired pressure.
  Continued on next page

1. Donors > 100 lbs give above dose
2. Donors 50-75 lbs give 13cc = 5-2 mcg/hr
3. Donors 75-100 lbs give 19cc = 7-6 mcg/hr

3. After 30 to 60 minutes the donor will usually become tachycardic with an increase in temperature and blood pressure.

4. Monitor K+ (serum potassium) levels carefully. Serum potassium levels usually decrease and require aggressive replacement.

NEVER discuss organ donation with the family, but call Organ Procurement Agency as soon as possible. Use attached guidelines for Brain Death Evaluation.

Abbreviations:

MAP=mean arterial pressure
CVP=central venous pressure
Lytes= serum electrolytes
PAOP= pulmonary artery occlusion pressure ("wedge pressure")
UOP=urinary output
PaO2=PaO2 of arterial blood gas
Na=serum sodium
NS=normal saline
LR=lactated ringers
NS/albumin= 1 liter of normal saline combined with 100cc of 25% albumin (used initially when hypotension follows brain herniation as a intravascular volume expander)
SVRI=systemic vascular resistance index
CI=cardiac index
ED=emergency department
One Legacy=regional organ procurement agency
ACLS=advance cardiac life support
ATLS=advanced trauma life support

TOC

MANAGEMENT OF THE SPINAL TRAUMA PATIENT

SPINAL CORD INJURY PRECAUTIONS

General Points

- High index of suspicion for the diagnosis of spinal cord injuries.
- Strict spinal cord precautions / protection measures must be maintained until these injuries can be excluded clinically or radiologically
- Many patients with a spinal fracture at one level will have a second injury at a higher or lower level. For this reason, if one spinal fracture is found, full radiographic evaluation of the spine is warranted
- If a patient is too unstable for complete evaluation of the spine, the patient should be placed in full spinal precautions until diagnostic evaluation of the spine can be safely performed

TOC

Guidelines for Evaluation for C-Spine Injury

Evaluable Patient TOC

- If the patient is evaluable the C-spine can be cleared clinically (Patient must be alert, non-intoxicated, without distracting injury, and without neurologic abnormality). If these criteria are me perform clinical evaluation of the spine, as follows:

1. Ask the patient about any pain in the cervical spine. If he/she reports pain, stop, immobilize and obtain a CT scan from occiput to T1
2. In the absence of neck pain, loosen the collar and palpate the entire midline bony cervical spine looking for tenderness or bony step off while maintaining manual neck stabilization. If tender, replace collar and obtain a CT scan from occiput to T1.
3. If no pain press down on top of skull (axial loading)
4. If the patient is symptomatic and the CT proves normal, obtain MRI

Continued on next page.

Unevaluable Patient

- If the patient is unevaluable (head injury, obtunded, intoxication, distracting injury):
- Obtain a CT scan from occiput to T1
- If the CT scan is normal by neuroradiologist, there is no neurological deficit, and the patient remains unevaluable, clear cervical spine (if suspicion for injury is low). Obtain MRI of cervical spine (if suspicion is high and the patient can be transported safely to MRI)

MANAGEMENT OF DIAGNOSED SPINAL CORD INJURY

1. Spine Surgery service notification
2. Steroid therapy
   a. NOT indicated in penetrating trauma
   b. Its role in blunt trauma is controversial; decision is by trauma or neurosurgery attending or fellow TOC
   c. If started within 3 hours of injury: Methylprednisolone 30 mg/kg bolus over one hour, followed by continuous infusion 5.4 mg/kg/h for 23 hours

Continued on next page

d. If started 3 – 8 hours after injury: Methylprednisolone 30 mg/kg bolus over one hour, followed by continuous infusion 5.4 mg/kg/h for 47 hours

e. After 8 hours – No steroid therapy

BACK TO PROTOCOLS

TOC

8. PENETRATING INJURIES OF THE NECK

TOC

A. Cause of injury: ☐ bullet ☐ knife ☐ other

B. Site of injury:

	Wound tract:
☐ anterior neck triangle (anterior to SMS muscle)	☐ towards midline
☐ posterior neck triangle (posterior to SMS muscle)	☐ towards clavicle
☐ Lower zone (between clavicles and cricoid)	☐ away from midline or clavicle
☐ middle zone (between cricoid and angle of mandible)	☐ can't assess
☐ upper zone (between angle of mandible and base of skull)	

C. Vascular structures

1. Active bleeding: ☐ none, ☐ minor, ☐ moderate, ☐ severe
2. Hypovolemia: ☐ BP>100, ☐ BP 60-90, ☐ BP<60
3. Hematoma: ☐ none, ☐ small ☐ moderate ☐ large ☐ expanding ☐ pulsatile
4. Peripheral pulses (compare with contralateral):
   - Distal carotid: ☐ normal, ☐ diminished, ☐ absent
   - Superficial temporal: ☐ normal, ☐ diminished, ☐ absent (use portable doppler)
   - Brachial or radial: ☐ normal, ☐ diminished, ☐ absent
5. Doppler pressures: Right arm: ☐ Left arm: ☐ (wrist/brachial index)
6. Bruit: ☐ No, ☐ Yes, (If so where__________)

D. Larynx/trachea, esophagus

1. Hemoptysis (ask patient to cough and spit on paper): ☐ yes, ☐ no
2. Air bubbling through wound (ask patient to cough): ☐ yes, ☐ no
3. Subcutaneous emphysema: ☐ none, ☐ minor, ☐ moderate, ☐ severe
4. Hoarseness: ☐ yes, ☐ no

5. Pain on swallowing sputum: ☐ yes, ☐ no
6. Hematemesis: ☐ yes, ☐ no

E. Nervous system

1. GCS: ☐ eye response, ☐ verbal response, ☐ motor response TOTAL GCS____
2. Localizing signs:

Pupils: ☐ normal, ☐ anisocoria

Limbs: ☐ normal, ☐ hemiparesis, ☐ hemiplegia,

☐ monoparesis, ☐ monoplegia, ☐ quadriplegia

Cranial nerves:

Facial n: ☐ normal, ☐ abnormal

Glossopharyngeal n: (check midline portion of soft palate) ☐ normal, ☐ abnormal

Recurrent laryngeal n (hoarseness, effective cough): ☐ normal, ☐ abnormal

Accessory n (lift the shoulder): ☐ normal, ☐ abnormal

Hypoglossal n (check midline position of tongue): ☐ normal, ☐ abnormal

Spinal cord: ☐ normal, ☐ hemiparesis, ☐ hemiplegia ☐ monoparesis,

☐ monoplegia, ☐ quadriplegia ☐ Brown-Sequard

Horner's syndrome (myosis, ptosis): ☐ yes, ☐ no

Brachial plexus:

Median n (fist): ☐ normal, ☐ abnormal

Radial n (wrist extension): ☐ normal, ☐ abnormal

Ulnar n (abduction/adduction of fingers): ☐ normal, ☐ abnormal

Musculocutaneous n (flexion of forearm): ☐ normal, ☐ abnormal

Axillary n (abduction of arm): ☐ normal, ☐ abnormal

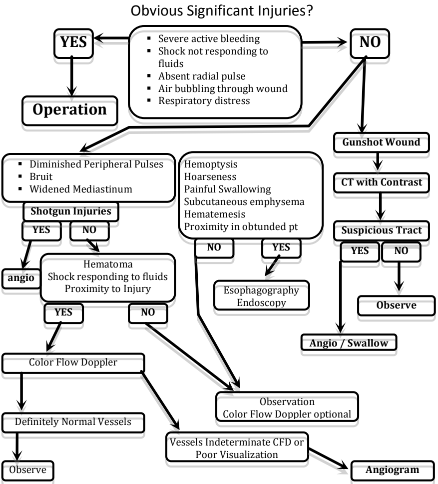
Flowchart NECK CHAPTER

BACK TO PROTOCOLS

TOC

Algorithm for Evaluation of Penetrating Neck Injuries

Clinical Exam according to protocol



BACK TO PROTOCOLS NECK CHAPTERS TOC

9. THORACOSTOMY TUBE INSERTION AND FURTHER MANAGEMENT

CHEST INJURIES CHAPTER

1. Open Technique
2. Strict antiseptic precautions (scrub, gown, mask, gloves).
3. Local anesthesia (Lidocaine 1%).
4. Site of Insertion: Mid-axillary line, always above the level of Nipples at 4th intercostal space (Below this level there is danger of diaphragmatic injury). Small incision, about 1.5 cm. (Please avoid long incisions!)
5. Digital exploration for intrapleural adhesions, in the appropriate cases (i.e. previous chest trauma or intrathoracic sepsis). Routine digital exploration is unnecessary.
6. Catheter size 36 in adult males, 32-36 in adult females, and in children 10-28 depending on age.
7. Insert the drain into the chest directing it towards the apex and posteriorly, 8-10 cm.. No need for subcutaneous tunnel. Make sure that all the drain holes are in the pleural cavity. Connect to underwater drainage system

(Pleurovac). Fix tube on skin. Nylon 2/0 vertical mattress suture for closing the incision during tube removal.

8. Instruct the patient to cough vigorously while sitting up, lying on his/her back and lying on his/her sides. IMPORTANT for early re-expansion of the lung and drainage of the free blood before clotting occurs.
9. Antibiotic prophylaxis: A single dose in the emergency room (Cefazolin 2g). No need for further prophylaxis. If possible give antibiotic before tube insertion.
10. Remove drain as soon as air or blood leaks stop.
11. Chest physiotherapy in the ward.
12. Remove drain with the patient in deep inspiration or deep expiration and Valsaava.
13. Chest X-ray after removal.

Note:

Please use the auto-transfusion device available in the emergency room in all patients with suspected large hemothorax! **BACK TO PROTOCOLS** **TOC**

Percutaneous Dilational Technique

1. Strict antiseptic precautions (scrub, gown, mask, gloves).
2. Site of insertion: Mid-axillary line, always above the level of nipples at 4th intercostal space).
3. Local anesthesia (Lidocaine 1%). Insert needle (close to upper border of the rib) attached to a syringe with sterile water. The entry into the pleural cavity is confirmed by aspiration of air bubbles.
4. Detach syringe and insert the guidewire through the needle. Remove the needle while keeping the guidewire in place.
5. Make a small incision (slightly bigger that the diameter of the chest tube)
6. Insert the dilator over guidewire
7. Remove dilator and insert the chest tube (8-10 cm) over the guidewire.
8. Remove the guidewire, connect to the collection system and secure the tube on the skin

Protocols **TOC**

10. EMERGENCY ROOM THORACOTOMY (ERT)

1. Prepare for ERT for the appropriate patients as soon as you hear from the paramedics. Open the thoracotomy tray, organize the instruments.
2. In traumatic cardiac arrest there is NO place for external cardiac massage, except in head injuries. The procedure of choice is a resuscitative thoracotomy.
3. Technique:
    a. Immediate endotracheal intubation in patients with no prehospital intubation.
    b. Supine position with the left arm abducted 30 degrees.
    c. Left anterolateral thoracotomy, 4th - 5th intercostal space below the nipple in males or below the breast crease in females.
    d. Control any active bleeding by compression, clamping or suturing.
    e. Open the pericardium longitudinally (to avoid phrenic nerve injury), suture any cardiac wound, and start direct cardiac massage. TOC

f. Cross-clamp the aorta above the diaphragm.

g. Defibrillate (10-50 joules), administer Epinephrine, Vasopressin, Atropine as indicated.

h. In persistent cardiac arrest or severe arrhythmia or appearance of air bubbles in coronary vessels, in associated lung or venous or atrial injuries aspirate the heart for air embolism.

i. If the heart recovers, transfer the patient to OR.

4. Absolute Indications for ERT

a. Cardiac arrest during pre-hospital transport or arrest/imminent arrest after admission to Emergency Room for penetrating injuries of the chest, neck or extremities.

b. Isolated blunt trauma to the chest.

5. Relative Indications for ERT

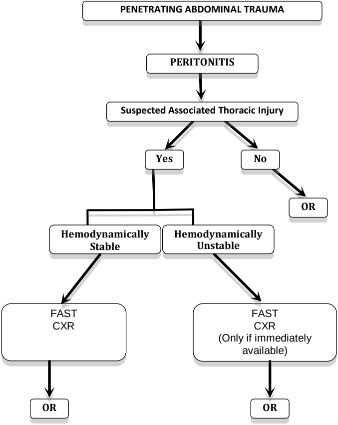
a. Cardiac arrest during pre-hospital transport or arrest/imminent arrest after admission to Emergency Room, for penetrating or blunt injuries of the abdomen.

6. Absolute Contraindications for ERT:

a. Cardiac arrest due to head trauma.

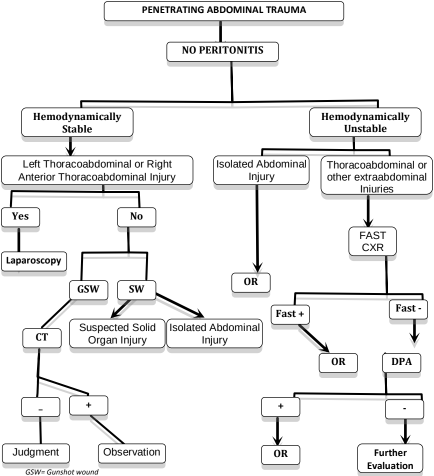
b. Cardiac arrest due to multiple blunt trauma.

11a. ALGORITHIM FOR TRIAGE OF PATIENTS WITH PENETRATING ABDOMINAL TRAUMA IN THE PRESENCE OF PERITONEAL SIGNS Protocols TOC



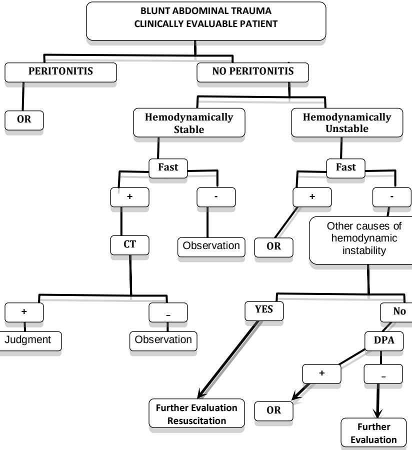
FAST= Focused Abdominal Sonogrophy for Trauma
CXR= Chest X-Ray
OR= Operating Room

11b. ALGORITHM FOR THE TRIAGE OF PTS WITH PENETRATING ABDOMINAL TRAUMA, IN THE ABSENCE OF PERITONITIS Protocols TOC

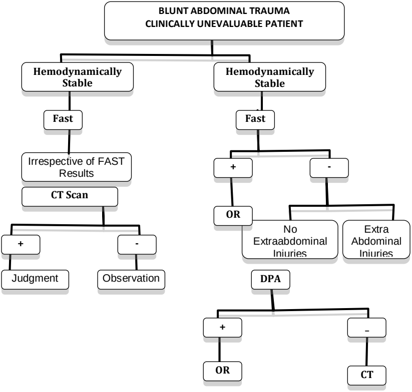


GSW= Gunshot wound
SW= Stab Wound
FAST= Focused Abdominal Sonogrophy for Trauma
CXR= Chest X-Ray
OR= Operating Room
**Judgement: Operation, angiography or other studies observation according to CT Findings*

12a. ALGORITHM FOR THE TRIAGE OF PTS WITH BLUNT ABDOMINAL TRAUMA, IN CLINICALLY EVALUABLE PATIENTS Protocols TOC



FAST= Focused Abdominal Sonogrophy for Trauma
CXR= Chest X-Ray
OR= Operating Room
**Judgement: Operation, angiography or other studies observation according to CT Findings*



BACK TO PROTOCOLS

TOC

13a. DIAGNOSTIC PERITONEAL ASPIRATE (DPA)

Indications: Blunt or sometimes penetrating multitrauma with unexplained hypotension, where the FAST exam is not diagnostic.

Technique

1. The bladder is catheterized.
2. Under local anesthesia, a 0.5 cm incision is made just below the umbilicus.
3. The needle is inserted into the peritoneal cavity and a guide-wire is placed through the needle aiming towards the pelvis. The needle is removed and the plastic catheter is fed into the peritoneal cavity over the guide-wire. Aspirate with a syringe. If blood is aspirated, the procedure is considered positive and it is terminated. If no gross blood is aspirated the reason for hypotension is not intraperitoneal bleeding and the procedure is terminated

BACK TO PROTOCOLS

TOC

BACK TO ABDOMINAL TRAUMA

13b. DIAGNOSTIC PERITONEAL LAVAGE (DPL)

We rarely perform full DPL for evaluation for acute intraperitoneal bleeding.

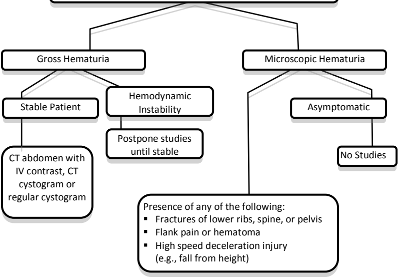
Technique of DPL

1. If after the insertion of the catheter as for DPA no gross blood is recovered, proceed to next step.
2. One liter of warm Ringers Lactate (in children 10ml/kg) is inserting the guide-wire or the catheter, or if the infused fluid is not running fast,convert to open technique.
3. The patient is shaken from side to side a few times, and the fluid is siphoned back into the empty container, which has been lowered to below the level of the patient.
4. A specimen of the fluid is examined macroscopically, microscopically and biochemically.
5. The lavage is considered positive if any of the following is present; bile or intestinal contents; frank blood aspirated via a syringe from the lavage catheter prior to running in the lavage fluid; after infusion of the fluid, more than 100,000 red cells/mm3 or >500 white cells or elevated amylase.
6. The presence of significant paralytic ileus, previous laparotomy or previous peritonitis are relative contravindications to closed DPL. In these situations, the catheter should be inserted under direct vision. In advanced pregnancy the catheter is inserted under direct vision, always above the level of the uterus.
7. A lavage result positive for blood is not in itself an absolute indication for laparotomy. (Small liver or splenic lacerations may give a positive lavage, but they do not require surgical repair).

BACK TO PROTOCOLS

TOC

14. HEMATURIA AFTER BLUNT TRAUMA



BACK TO PROTOCOLS

TOC

15. MANAGEMENT OF PELVIC FRACTURE

1. The management of pelvic fractures depends on the hemodynamic condition of the patient and the stability of the fracture.
2. For every major pelvic fracture, the patient should have intra-abdominal injury excluded by clinical examination, trauma ultrasound, Diagnostic Peritoneal Aspirate or CT scan.
3. Grossly unstable patients with free fluid in the abdomen (FAST, DPA, CT scan) require emergency laparotomy.
4. Patients with pubic symphysis diastasis or ilio-sacral disruption should have a pelvic binder applied.
5. CT evaluation should be performed on all patients with suspected severe pelvic fracture. Plain X-rays usually underestimate the severity and type of fracture.
6. Angiography should be performed very early in patients with major pelvic fractures. Do NOT wait until the patient bleeds massively, requires many transfusions or develops DIC. Radiological signs which are associated with a high incidence of bleeding from the pelvis include pubic diastasis >2.5 cm, disruption of the sacroiliac joint or fracture of the superior and inferior pubic rami bilaterally (butterfly fracture). The presence of any of these radiological findings is an indication for early angiographic evaluation.

BACK TO PROTOCOLS

TOC

16. MANAGEMENT OF TRAUMA IN PREGNANCY

1. Trauma patients in advanced pregnancy should be transported in the left lateral decubitus position to avoid the "supine hypotensive syndrome". If spinal immobilization is indicated, the backboard can be tilted to the left by inserting rolled towels under the right side of the board.
2. All pregnant trauma patients should receive supplemental oxygen because of increased maternal O2 consumption, decreased maternal vital capacity, and high sensitivity of the fetus to maternal hypoxia.
3. All but the most minor pregnant trauma patients (e.g. isolated extremity injury, lacerations, etc.) should have at least one peripheral IV and a fluid bolus administered since expanded vascular volume may obscure the extent of blood loss. TOC
4. All female trauma patients in the reproductive years should have a bedside urinary pregnancy test performed.

5. Appropriate radiographs should be obtained with abdominal shielding whenever possible in all females of reproductive years. Indicated x-rays should not be deferred because of pregnancy.
6. Estimation of gestational age is critical to decision-making in pregnant trauma patients. The gestational age should be estimated by date of last menstrual period, previous or current ultrasound examination, and fundal height.
7. Ultrasound examination of the uterus and fetus should be performed by Obstetrics and Gynecology in the Emergency Department on all pregnant trauma patients.
8. All Rh-negative pregnant females should receive Rhogam to prevent isoimmunization. In the first trimester the dose is 50 µg; in the second and third trimesters full dose Rhogam (300 µg) is routinely administered. A Kleihauer-Betke test may be performed to detect fetomaternal hemorrhage, quantitate fetal blood loss and determine the need for further Rhogam. TOC

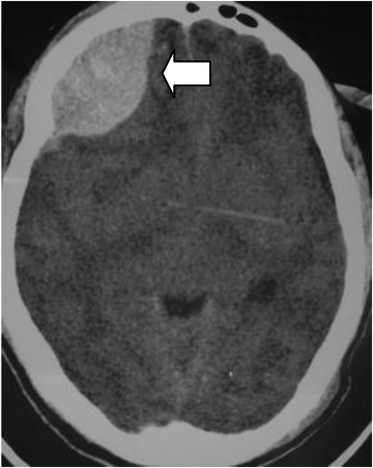
9. Immediate consultation with Obstetrics/Gynecology is indicated for pregnant patients. Fetal monitoring in advanced pregnancy with a viable fetus. Both Ob/Gyn and Pediatrics (Neonatal Resuscitation team) must be notified immediately for fetal distress if delivery is considered imminent, or if a perimortem C-section is contemplated or performed.
10. Perimortem C-section should be undertaken by the OB/Gyn consult, the senior surgeon, or the most senior emergency physician present, providing there are signs of fetal life, maternal demise is imminent, and gestational age is estimated at > 24 weeks.
11. Cardiotocographic monitoring should be performed for at least 8 hours by OB/GYN nurse in all pregnancies with a viable fetus. Longer monitoring may be needed in some cases.

BACK TO PROTOCOLS

TOC

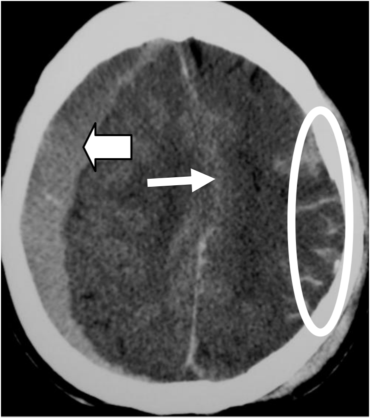
Raccoon eyes (fracture base of the skull)

BACK



Epidural Hematoma

BACK



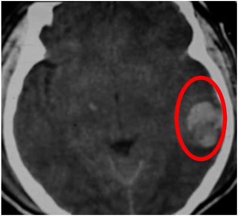
Subdural with midline shift
& Subarachnoid Hemorrhage

BACK

Chronic Subdural

BACK

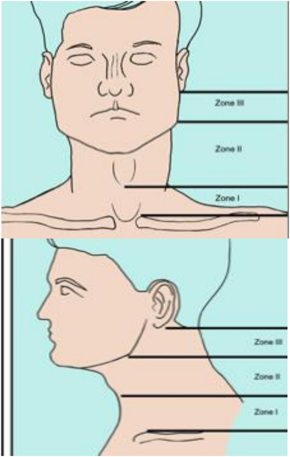
GSW head, hematoma, intraventricular bleeding



BACK

Intracerebral Hemorrhage

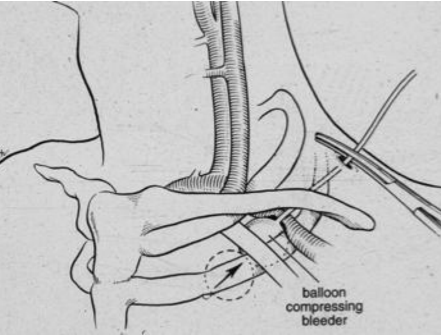
ANITOMICAL ZONES OF THE NECK



BACK

Fiberoptic Intubation in Neck Hematoma

BACK



Balloon tamponade of neck bleeding

BACK

Seatbelt mark on neck with a carotid artery intimal tear

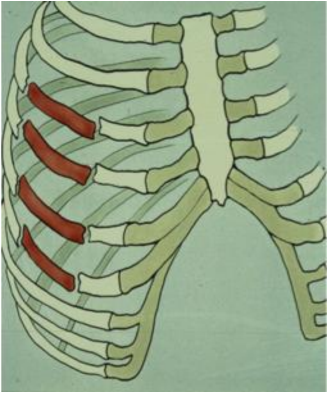
BACK

Internal carotid aneurysm, successful stenting

BACK

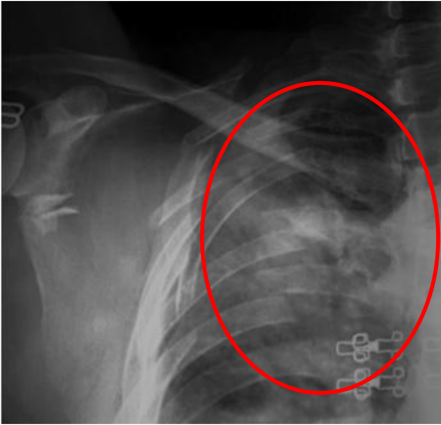
Asymptomatic seatbelt mark.
Angio shows injury to the common carotid artery

BACK



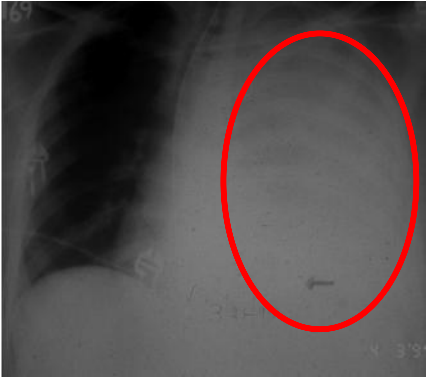
Flail Chest

BACK



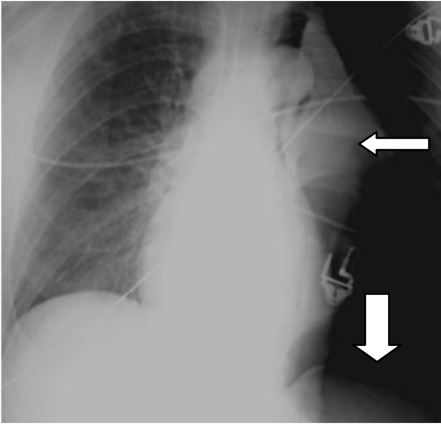
Flail Chest

BACK



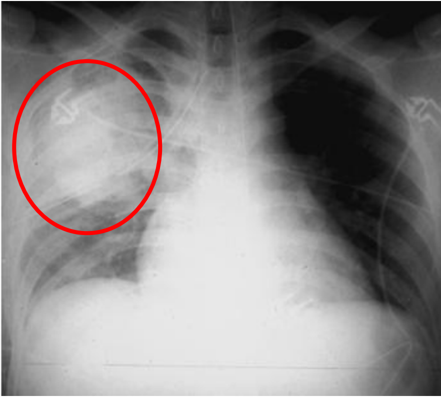
Massive left hemothorax

BACK



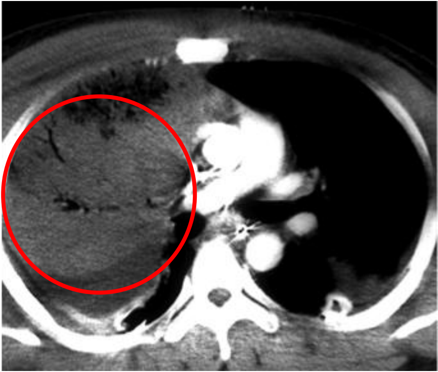
Tension pneumothorax

BACK



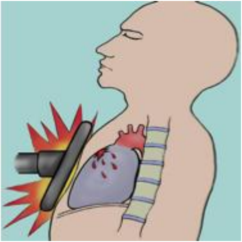
Lung contusion

BACK



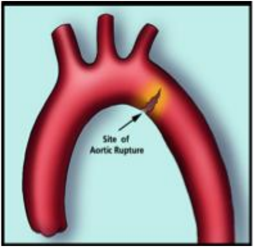
CT scan: Right lung contusion

BACK



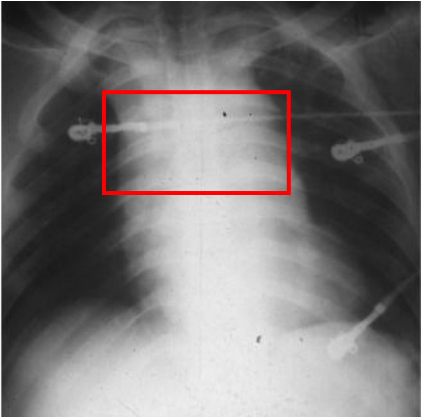
Mechanism of blunt cardiac trauma

BACK



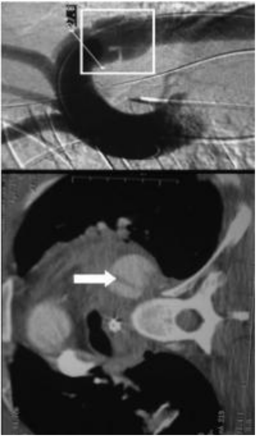
Site of aortic rupture, distal to the left subclavian artery

BACK



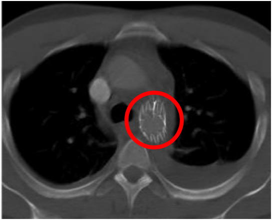
Widened mediastinum due to aortic rupture

BACK



Aortic Rupture: CT Scan & Aortogram

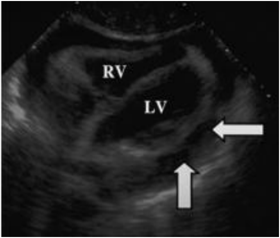
BACK



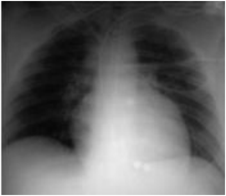
Stent/graft management of the aortic

Aortic Stent / Graft

BACK

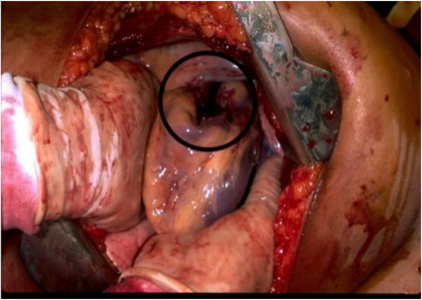


Trauma ultrasound: Cardiac tamponade



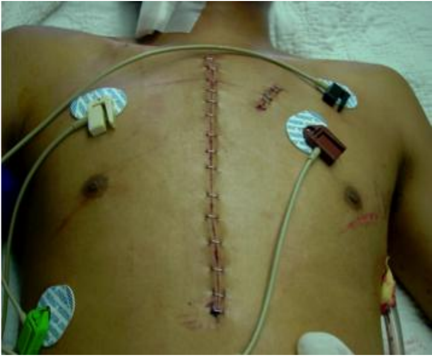
Cardiac tamponade: Enlarged cardiac shadow

BACK



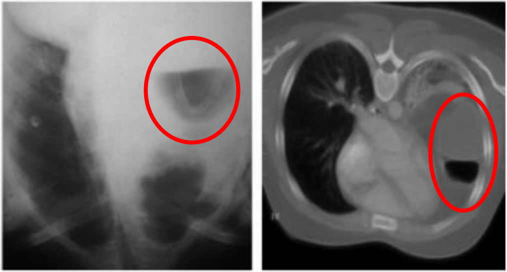
GSW of the heart

BACK



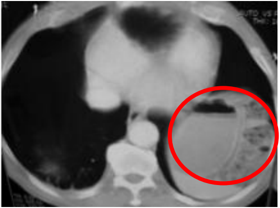
Median sternotomy for repair of cardiac injury

BACK



Diaphragmatic hernia with gastric herniation (NG tube in chest) (left). CT with stomach in chest (right)

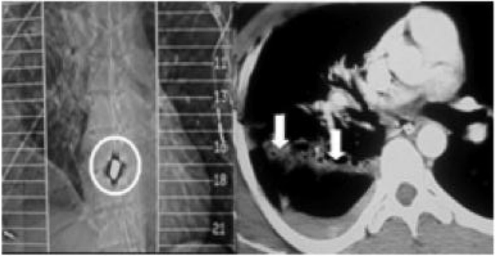
BACK



Diaphragmatic hernia with stomach and colon in the chest

Laparoscopy with omental herniation through diaphragmatic injury

BACK



GSW mediastinum. CT scan shows a bullet tract away from the aorta and esophagus

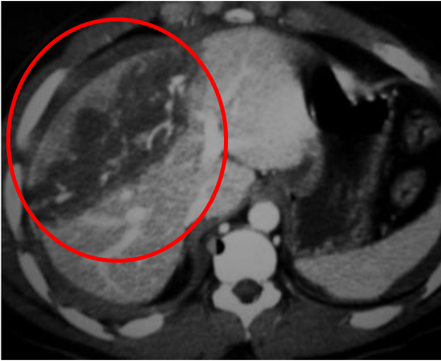
BACK

Abdominal seat-belt mark

BACK

CT scan shows edematous bowel wall

BACK

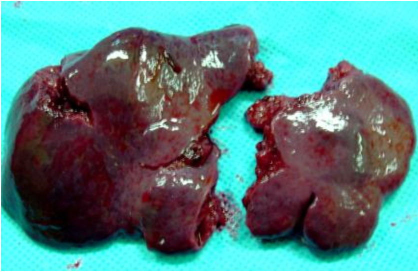


CT scan: GSW of the liver

BACK

Rupture spleen with “blush”

BACK

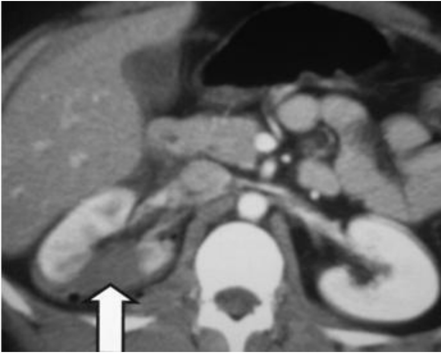


Grade 5 splenic injury

BACK

CT Scan: grade IV liver

[BACK](#)

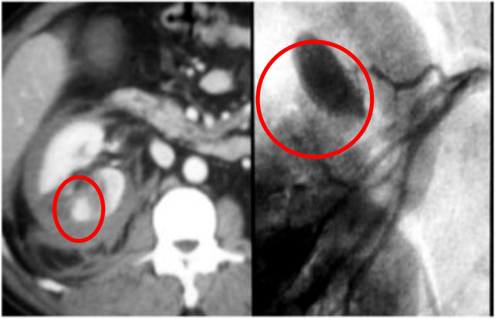


CT scan: GSW kidney

BACK

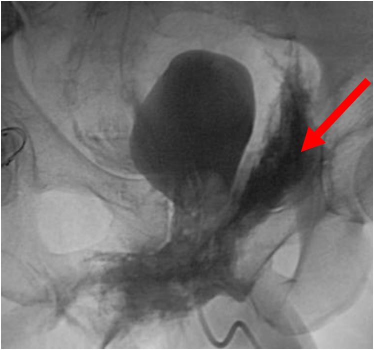
CT scan shows no contrast uptake by the left kidney due to renal artery thrombosis

BACK



CT scan and angio show
a false renal aneurysm

BACK

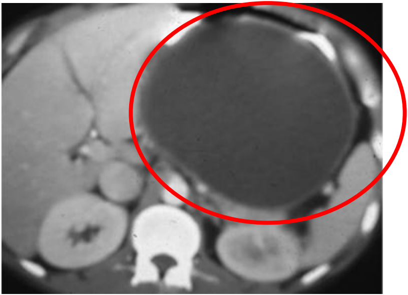


Cystogram: Rupture bladder

BACK

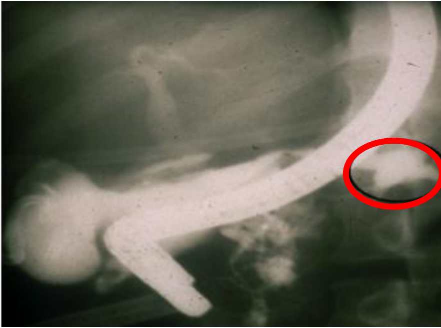
Urethrogram: Rupture posterior urethra

BACK



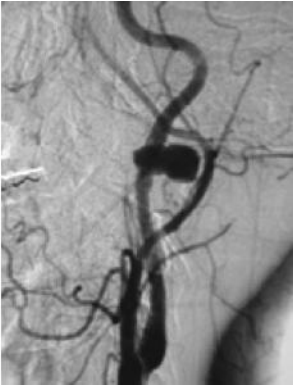
CT Scan: traumatic pancreatic pseudocyst

BACK



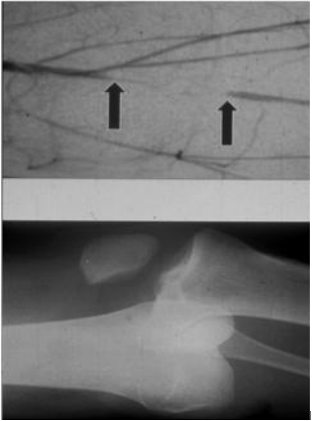
ERCP shows pancreatic duct injury

BACK



GSW neck: false aneurysm internal carotid artery

BACK

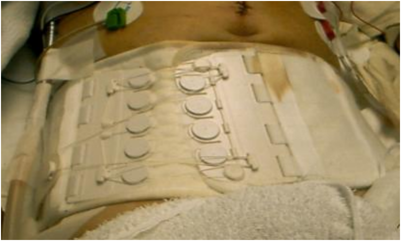


Dislocation of the knee with popliteal artery injury

BACK

Pubic symphysis diastasis is often associated with severe bleeding

BACK

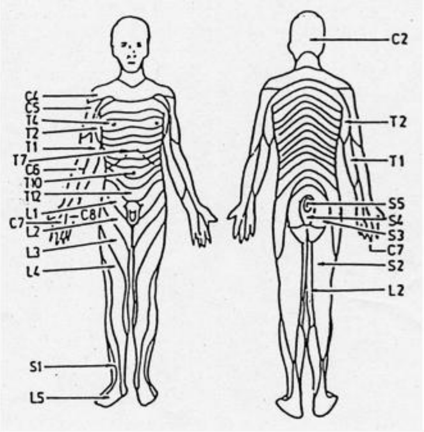


Pelvic binder for pubic symphysis

BACK

Angiographic embolization of pelvic bleeders

BACK



Spinal Cord: Sensory levels

BACK

Subluxation C4-C5

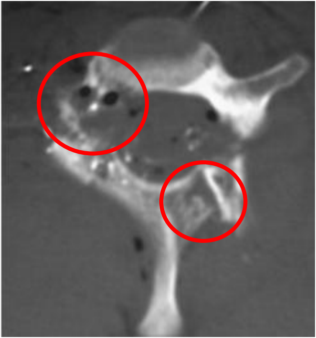
BACK

MRI: Fracture and dislocation of the thoracic spine

BACK

Lumbar spine

BACK



CT scan:GSW cervical spine

BACK

MRI: Fracture and dislocation of the thoracic spine

BACK

GSW face: Cricothyrodotomy for imminent airway obstruction

BACK

Maxillofacial trauma: missing tooth in upper airway

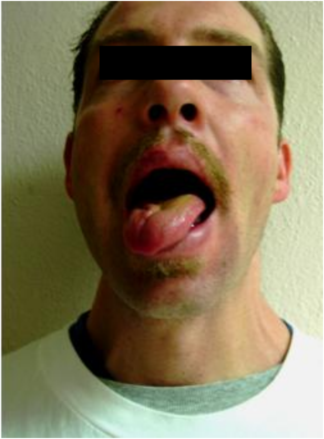
BACK

Left Facial nerve injury

BACK

Left Facial nerve paralysis

BACK



Left Hypoglossal nerve injury

BACK

Radial nerve palsy: Wrist drop

BACK

Ulnar nerve injury:
Note the abduction and slight flexion of the small finger

BACK

Extensive soft tissue trauma:
High incidence of myoglobinemia

BACK

Extensive soft tissue trauma with myoglobinuria and renal failure

BACK

Infected human bite

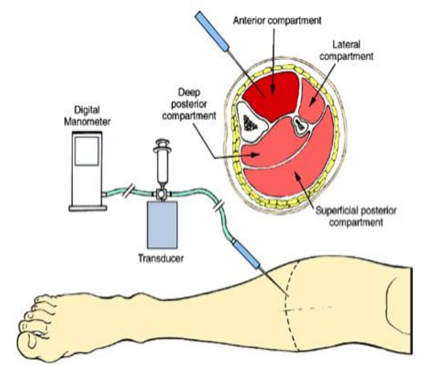
BACK

Neglected right leg compartment syndrome with severe ischemia

BACK

Neglected left arm compartment syndrome with severe ischemia

BACK

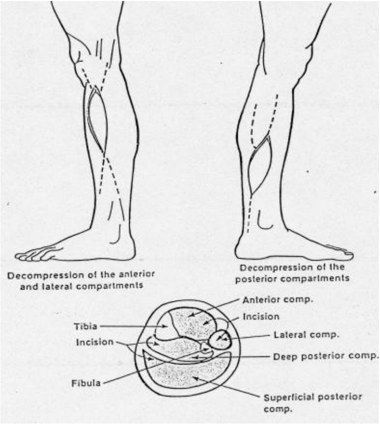


Lower leg compartments and pressure measurements

[BACK](#)

Compartment pressure measurements

BACK



Lower leg compartments and fasciotomies

BACK

Fasciotomy 1st Incision

BACK

Fasciotomy 2nd Incision

[BACK](#)

Fasciotomy, flexor compartment of the left forearm

BACK

Thigh Compartment Fasciotomy

BACK

Abdominal compartment syndrome, treated with an open abdomen

BACK

Low-velocity gunshot wounds

BACK

High-velocity gunshot wound

BACK

Hollow-point bullet

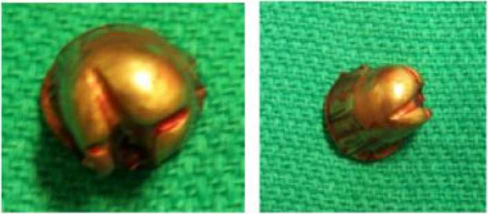
BACK

Black talon bullet

BACK

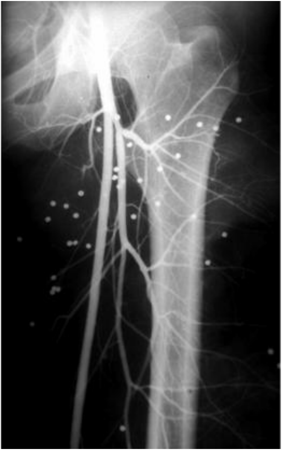
Fragmentation of bullet

BACK



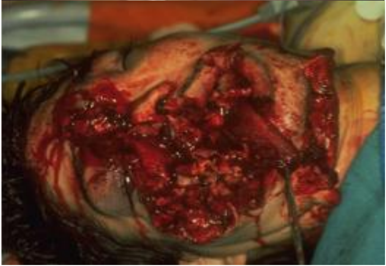
Scoring of the bullet promotes fragmentation

BACK



Shotgun injuries: angiographic evaluation is indicated

BACK



BACK

BACK

Broselow tape and color-coded packs for pediatric patients

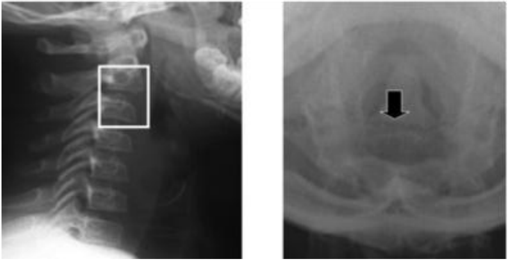
BACK

Right stem intubation with left lung collapse

BACK

Loss of lordosis is normal in the pediatric C-spine

BACK



Pseudosubluxation C2-3 (left). Pseudofracture of the dens (right)

BACK

Intraosseous fluid infusion

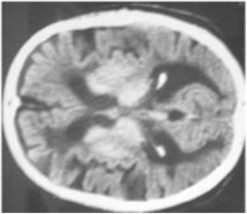
BACK

Gastric dilatation is common in children

BACK

Total body immobilization for spinal protection

[BACK](#)



BACK

Compression of the IVC in advanced pregnancy

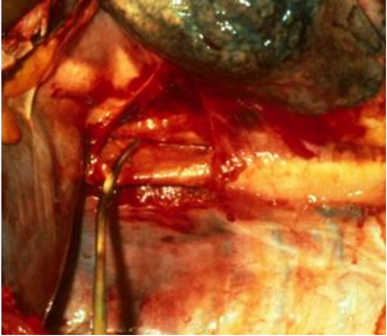
BACK

Perimortem C- section with viable fetus

BACK

Incision for ER thoracotomy

BACK BACK TO PROTOCOL



Aortic cross-clamping

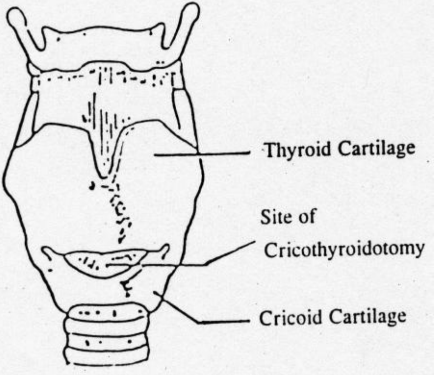
BACK

BACK TO PROTOCOL

Cardiac defibrillation during ER thoracotomy

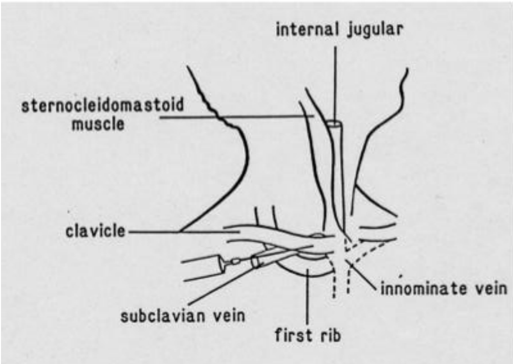
BACK

BACK TO PROTOCOL



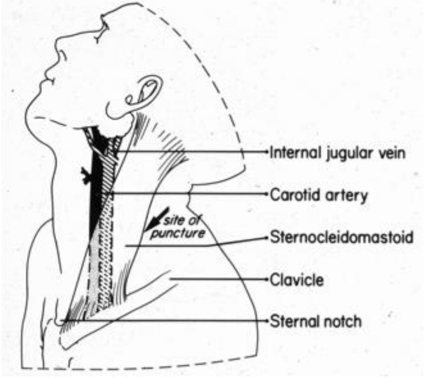
Site of Cricothyrodotomy

BACK



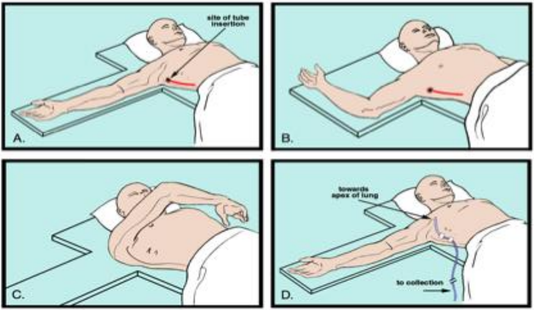
Site of insertion of subclavian vein catheter

BACK



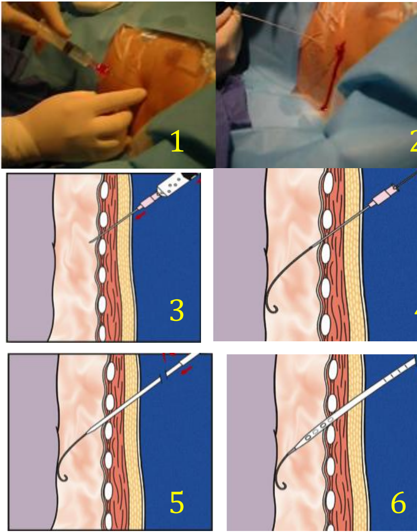
Site of insertion of internal jugular vein catheter

BACK

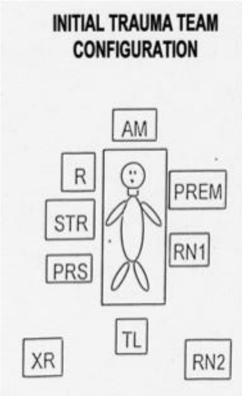


Chest tube insertion: Abduction of the arm , midaxillary line, above the level of the nipple (A or B). Adduction of the arm (C) is a bad position. Insert tube 8-10 cm, aim towards the apex and posteriorly

BACK



BACK



TL - TEAM LEADER

STR - SENIOR TRAUMA RESIDENT

R - RESUSCITATOR

AM - AIRWAY MANAGEMENT

PREM - PROCEDURE RESIDENT 1

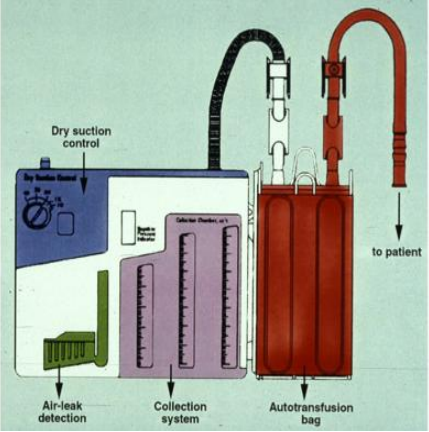
PRS - PROCEDURE RESIDENT 2

RN1 - NURSE ASSISTANT

RN2 - RECORDING NURSE

XR - XRAY TECHNICIAN

BACK

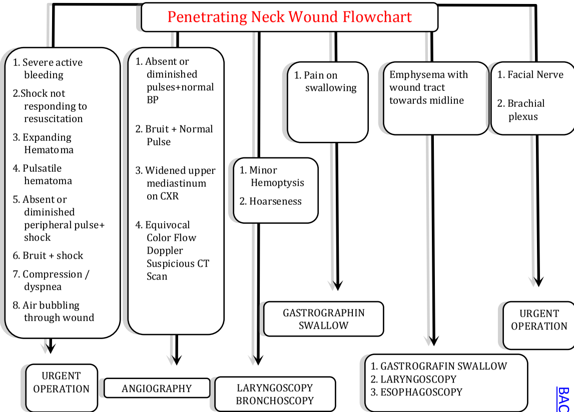


Thoracostomy collection

BACK

Positive DPA

BACK TO PROTOCOL


Penetrating Neck Wound Flowchart
1. Severe active bleeding
2.Shock not responding to resuscitation
3. Expanding Hematoma
4. Pulsatile hematoma
5. Absent or diminished peripheral pulse+ shock
6. Bruit + shock
7. Compression / dyspnea
8. Air bubbling through wound
URGENT OPERATION
1. Absent or diminished pulses+normal BP
2. Bruit + Normal Pulse
3. Widened upper mediastinum on CXR
4. Equivocal Color Flow Doppler Suspicious CT Scan
ANGIOGRAPHY
1. Minor Hemoptysis
2. Hoarseness
LARYNGOSCOPY BRONCHOSCOPY
1. Pain on swallowing
GASTROGRAPHIN SWALLOW
Emphysema with wound tract towards midline
1. GASTROGRAFIN SWALLOW
2. LARYNGOSCOPY
3. ESOPHAGOSCOPY
1. Facial Nerve
2. Brachial plexus
URGENT OPERATION

BACK