Stanford Trauma Service Housestaff Manual

Table of Contents

Goals and Objectives of Stanford Trauma Surgical Rotation

PGY IV Resident By completion of the rotation the resident will be 1) ATLS certified and 2) proficient in the use of diagnostic ultrasound of the abdomen for trauma. The Resident should be skilled at the evaluation, triage and treatment of multiple injured trauma patient. The details of specific organ injuries and their management will be well understood by the Resident at the end of their rotation. The Resident will perform operations on the injured patient. The Resident will increase their knowledge base by independent readings and interactions on daily hospital rounds. Twice a month the Trauma Resident will be responsible for presenting a case at the combined Trauma/ER conference. In addition, the Resident will present a case each Monday morning at the Trauma/ICU conference. It is expected that the Trauma Chief Resident will learn to manage the complex trauma patient and deal effectively with multiple consultants, specifically emergency room physicians, neurosurgeons and orthopedists.

PGY I Resident The PGY I residents rotating on the Trauma service should be ATLS certified prior to initiating their rotation on the Trauma service. They will respond to all Trauma alerts and will be introduced into the process of evaluation, triage and treatment of the multiple injured patient. They will do this under the guidance of the PGY IV Resident and the Trauma Surgery Attending. They should be fully versed and capable of performing both the primary and secondary surveys on injured patients and developing a treatment plan for those patients. In addition, the first year Resident will be involved primarily in the management of Trauma patients on the surgical ward. They will be supervised by the Trauma Chief Resident and Attending. Trauma intern will be given the opportunity to be introduced to technical skills as they relate to trauma such as arterial line placement, central line placement, chest tube placement, diagnostic peritoneal lavage and placement of immobilizing splints.

Stanford Trauma Service

Housestaff Manual

TRAUMA

Trauma is the medical term for injury. Major trauma represents life- or limb-threatening severe injury. Energy transmission is the etiologic agent of trauma. Unlike other agents, such as bacteria or viruses, energy transmission occurs in an instant and the injuries are complete. From the time of injury, physiologic compensatory mechanisms attempt to maintain homeostasis.

In trauma care, time is at a premium. Care is directed at stabilizing identified injuries and returning the body to homeostasis**.** A multi disciplinary team approach is essential in the care of the major trauma victim. Each patient is considered to have multiple injuries until proven otherwise. Early surgical consultation and evaluation is essential for all major trauma patients with multi-system or abdominal trauma.

I. Pathophysiology

Energy transmission may cause damage to bones, vessels, and organs, including fractures, lacerations, contusions, and disruption of whole organ systems. Hypovolemia is the major cause of shock in most major trauma victims, although spinal and septic shock may intervene.

A. Specific compensatory mechanisms are invoked in an attempt to maintain cardiac output and cellular profusion.

1. **Activation of the sympathetic nervous system** causes increased venous and arterial tone, bronchodilitation, tachycardia, tachypnea, capillary shunting, and diaphoresis.
2. **Heart rate** may increase. Cardiac output is equal to stroke volume times heart rate. As stroke volume falls, heart rate may increase.
3. **Respiratory rate** increases**.** With inspiration, negative intrathoracic pressure is generated. This thoracic pumping action brings blood to the chest and pre-loads the right ventricle to maintain cardiac output.
4. **The urinary output decreases**. Anti-diuretic hormone and aldosterone are excreted to retain vascular fluid. A decreased glomerulofiltration rate contributes to this response.
5. **A decreased pulse pressure** reflects a falling cardiac output (systolic) and increased vasoconstriction (diastolic). Normal pulse pressure is 35 to 40 mm of mercury.
6. **Capillary shunting** and trans-capillary refill may cause cool, pale skin and dry mouth, respectively. Capillary refill may be delayed.
7. **Altered mental status and aviation** may result from decreased perfusion to the brain or may be a direct result of head trauma.

II. Blunt Versus Penetrating Trauma

A. Penetrating trauma results from a focal application of energy. Gunshot wounds, knife wounds, and punctures are the most common examples of penetrating trauma. Single or multiple-organ injuries can occur depending on the path and depth of penetration. Low-velocity wounds such as knives and punctures from falls and assaults differ from high-velocity impacts such as gunshot wounds. The latter transmits shock waves, which cause stretching and tearing to tissue of the body. Bullets may also fragment and ricochet creating multiple paths.
Victims of violent crime should have consideration for the preservation of evidence during the course of care as long as it does not impede prompt evaluation and treatment.

B. Blunt Trauma results when kinetic energy is absorbed either focally or diffusely. Falls from a height, motor vehicle impacts, and assaults are the most common mechanisms of blunt injury. Multi-system injury is common. Thorough repetitive evaluations are often necessary to identify all the injuries sustained.

Ill. General Approach to Trauma Patient

See Appendix A – Trauma Alert Decision Guide

A systematic approach is necessary to identify and prioritize injuries and rapidly stabilize the patient. The American College of Surgeons advocates a four-phased approach to evaluating the trauma patient, which is delineated in the Advanced Trauma Life Support® (ATLS) guidelines. This approach to trauma care is divided into:

1. Primary survey focused on airway, breathing and circulation
2. Resuscitative phase
3. Secondary survey with head to toe examination
4. Definitive care phase

1. Primary Survey

The primary survey follows the pneumonic **ABCDE**:

A. **Airway** patency has the biggest priority. The most common cause of airway obstruction is altered level of consciousness, allowing the tongue or other matter to block the posterior pharynx. In trauma, other causes are:

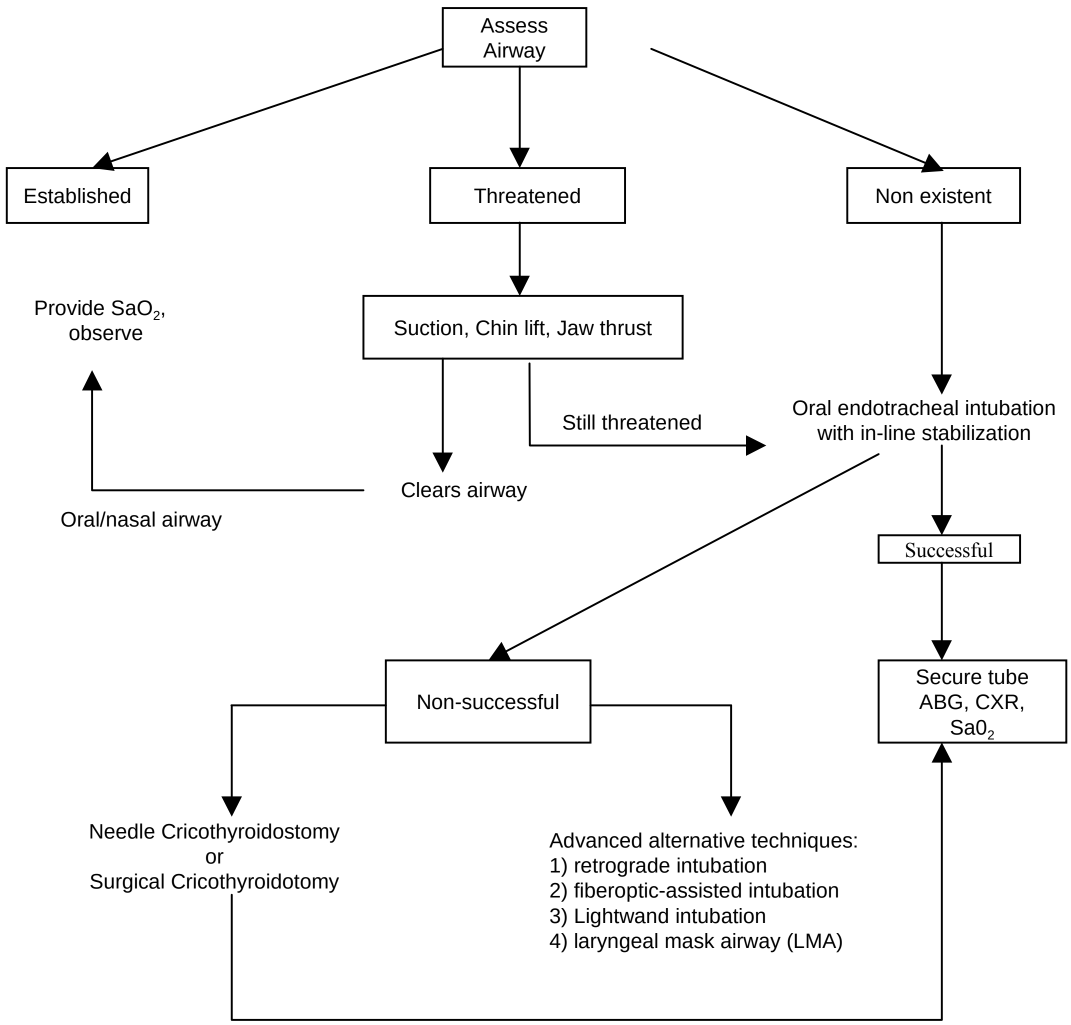
1. Massive swelling
2. Foreign bodies
3. Blood and secretions
4. Loss of bony support for soft tissue

Clearing the airway may be as simple as suctioning of blood and debris or inserting a nasopharyngeal or oropharyngeal tube to lift the tongue out of the posterior pharynx. However since cervical injury may be of concern in these patients, extension of the neck is contraindicated. Cervical spine immobilization is mandatory until clearance occurs.

A nasaopharyngeal tube may be inserted in nares of a patient who is conscious or has a gag reflex. An oroparyngeal airway may be placed in-patients without a gag reflex. In either instance, the appropriate size airway may be approximated by determining the distance from the aperture to the angle of the jaw.

If facial trauma, massive bleeding, or swelling precludes a secure airway, intubation is indicated. Orotracheal intubation is preferred in almost all situations. Patients with major facial trauma or laryngeal trauma require surgical airways. Patients with laryngeal trauma may present with cough, dysphonia, hoarseness, stridor, hematemesis, hemoptysis and dysphagia.

Airway Management



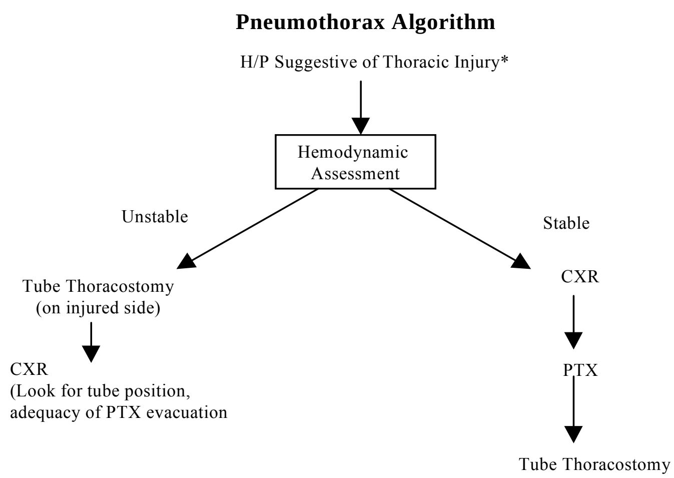
Definition: SaO_2 = Arterial saturation by continuous pulse oximetry

Caution: 1) Always consider unstable cervical spine.
2) Avoid nasal tubes when in setting of craniofacial injuries.

Fig. 1 – Airway Management Algorithm

B. **<u>B</u>reathing** is the mechanics of ventilation. Consider breathing as everything below the larynx. Breathing is contingent upon the integrity of three factors:

1. **Neural supply** - phrenic nerve and brainstem. Consider head injury, neck trauma, and spinal injury.
2. **The bony chest** - Consider the ribs, chest wall, costochondral junctions, and diaphragm. Flail segments and open wounds in the chest wall negate efforts to generate negative intrathoracic pressure. As wound size increases, air will preferentially flow through an opening in the chest wall rather than through the trachea. The diaphragm acts as a movable floor of the chest cavity. Disruption of the diaphragm can severely affect ventilation. Herniation of abdominal contents into the thoracic cavity requires surgical intervention.
3. **Chest contents** - Consider pulmonary injury and loss of integrity of the pleural space. Air or blood in the pleural space causes pneumothorax and hemothorax respectively. Evacuation of the pleural space with a chest tube is necessary to stabilize patients with respiratory compromise. Pulmonary contusions require oxygenation and often need positive pressure ventilation.



Definitions: SOB = shortness of breath
JVD = jugular venous distension
CXR = Chest X-ray
PTX = pneumothorax

*Penetrating wound, SOB, respiratory distress, chest wall crepitance / tenderness decreased breath sounds, tracheal deviation, JVD

Fig. 2 Pneumothorax Algorithm

C. To access **<u>C</u>irculation** in the primary survey, palpation of pulses provides immediate information to the patient's circulatory status. Radial and carotid pulses should be palpated. Pulses are palpable at the following approximate systolic blood pressure (mmHg): carotid-60, femoral-70, brachial-80, radial-90. Consider. pressures less than 90 mmHg as evidence of shock.

Pulse should be noted. Pulses greater than 120 per minute represent approximately a 30% hemorrhage and a greater than 140 heart rate represents approximately 40% or more of blood volume, In these cases, the capillary refill time generally exceeds two seconds.
Obvious bleeding should be controlled with direct pressure. Avoid ligatures in the uncontrolled setting as nerves frequently run with arteries and may be injured. Scalp hemorrhage can be initially controlled with Raney clips – do not just “wrap”. Large amounts of blood loss can be “hidden” under gauze turbans & even beneath the patient and on the floor.

D. Assessing **<u>D</u>isability** requires continuous assessment of the neurologic status and is essential to identifying central nervous system injury. Prehospital care provider assessments can help one determine the patient's neurologic trend. The Glasgow coma scale is often used to score a patient's neurologic response. See (Table IA & B.) The Glascow coma scale is a component of the Revised trauma score, which uses three physiologic parameters to quantitate injury severity. (See Table 1C.)

A simple, readily repeatable scoring system describes the patient's level of consciousness as:

A - Alert
V - Verbal; responsive to verbal stimulus
P - Pain; responsive to painful stimuli
U - Unresponsive to painful stimuli. Note pupils for equality and reactivity to light.

E. **<u>E</u>xpose** the patient completely to evaluate him/her for injury. The only way to diagnose the injury is to look and feel for it. Do not forget the patient's back. Then cover the patient to prevent heat loss.

Table 1A - Glasgow Coma Scale

	Response	**Score**
Eyes Opening:	Opens Eyes Spontaneously	**4**
	Opens Eyes to Command	**3**
	Opens Eyes to Pain	**2**
	None	**1**
Best Verbal Response:	Spontaneous and appropriate	**5**
	Confused	**4**
	Inappropriate words	**3**
	Incomprehensible sounds	**2**
	None	**1**
Best Motor: Response	Obeys Commands	**6**
	Localizes Pain	**5**
	Withdraws from Pain	**4**
	Abnormal Flexion (decorticate posturing)	**3**
	Abnormal Extension (decerebrate posturing)	**2**
	No Response	**1**

Table 1B - Modified Glasgow Coma Scale for Infants and Children

	Child	Infant
Eye opening	Spontaneous	Spontaneous
	To verbal stimuli	To verbal stimuli
	To pain only	To pain only
	No response	No response
Verbal response	Oriented, appropriate	Coos and babbles
	Confused	Irritable cries
	Inappropriate words	Cries to pain
	Incomprehensible words or nonspecific sounds	Moans to pain
	No response	No response
Motor response*	Obeys commands	Moves spontaneously and purposefully
	Localizes painful stimulus	Withdraws to touch
	Withdraws in response to pain	Withdraws in response to pain
	Flexion in response to pain	Decorticate posturing (abnormal Flexion) in response to pain
	Extension in response to pain	Decerebrate posturing (abnormal Extension) in response to pain
	No response	No response

***If the patient is intubated, unconscious, or preverbal, the most important part of this scale is motor response. This section should be carefully evaluated.

Modified from Davis RJ, et al. Head and spinal cord injury. In: Rogers MC, ed. Textbook of Pediatric Intensive Care. Baltimore, MD: William Wilkins; 1987. James H, Anas N, Perkin RM. Brain Insults in Infants and Children. New York, NY: Grune & Stratton; 1985. Morray JP, et al, Nursing Care of the Critically Ill Child, 2nd ed. St. Louis, MO: Mosby Year Book, 1992.

Table 1C Revised Trauma Score

Glasgow Coma Scale	**Systolic Blood Pressure**	**Respiratory Rate**		**Coded Value**
13 - 15	>89	10 – 29	=	4
9 – 12	76 – 89	7 – 29	=	3
6 – 8	50 – 75	6 – 9	=	2
4 – 5	1 – 49	1 – 5	=	1
3	0	0	=	0

2. **Resuscitative Phase**
After the primary survey, direct efforts toward resuscitation of the patient. If adequate personnel are available, this phase may be on-going during the primary survey. The pneumonic for the resuscitative phase is AEIOU.

A. The **Airway** should be re-evaluated. Definitive care with intubation will be necessary if conditions warrant. Patients with head trauma requiring hyperventilation and protection of the airway from aspiration may need intubation at this point

E. **ECG monitoring** identifies changes in heart rate as well as signs of cardiac irritability and perfusion. These changes may occur despite normalization of the blood pressure.

I. Intravenous access is accomplished by the use of two large bore peripheral lVs. Resistance to flow is a function of length and is inversely proportional to the radius by the fourth power. Large bore tubing is necessary to overcome this resistance and provide high flow. Peripheral catheters are short and over the needle. Central lines are usually longer and may have smaller internal diameters. For these reasons, central lines are usually reserved for monitoring purposes and should be placed on an elective basis to avoid complications. When peripheral access is unobtainable, large bore cutdowns and femoral lines with large bore catheters are preferable to internal jugular lines. Arterial lines should be placed on all hemodynamically unstable patients. Any IV placed in the field, or in less than sterile manner in the ED, is to be replaced on the admitting unit.

Crystalloid solution is usually given as Ringers lactate. Two liters are administered by rapid bolus infusion during the resuscitative phase. Patients who are only temporarily stabilized may have on-going bleeding that needs operative intervention. Patients in whom no response is noted may be in need of blood replacement and immediate operative intervention.

O. Oxygen is given to all trauma patients to maintain hemoglobin saturation. Oxygen content is a function of saturation and percent hemoglobin. Hemoglobin is assumed to be failing in trauma patients until proven otherwise. The measurement of transcutaneous oxygen saturation is standard in trauma resuscitation.

U. Urinary and nasogastric tubes are placed as both therapeutic and diagnostic adjuncts. A urinary catheter should be passed only after evaluation of the perineum for signs of injury (scrotal/labial hematoma, meatal blood) and a rectal exam is done in males to assure that prostate is in proper position. Urine flow should be at least 40 ml/hour. A drop in urine output may signify inadequate perfusion. Urine should be dip tested, and if positive for blood, evaluated for the presence of myoglobin and/or red blood cells. Nasogastric tubes will decompress the stomach and allow inspection of the gastric aspirate for gross blood. Placing an NG tube prior to chest x-ray may enhance the interpretation of the film (see chest injury, below), however, the chest x-ray is the first film to be done and NG placement can compromise C-spine stabilization in the awake, uncooperative patient. The tube should be placed through the mouth in intubated patients with facial fractures.

3. Secondary Survey

The secondary survey of the patient proceeds in a head-to-toe manner to identify all possible injuries. The **definitive treatment** plan is formulated based upon the injuries identified and there relative priorities. As a rule, injuries identified as needing rapid surgical intervention take priority over prolonged detailed evaluation unless failure to diagnose a suspected injury would jeopardize a patient during the period of anesthesia.

Table 2 - Secondary Survey

Item to Assess	Establishes / Identifies	Assess	Finding	Confirm By
Abdomen/ Flank	▪ Abdominal wall injury ▪ Intraperitoneal injury ▪ Retroperitoneal injury	▪ Visual inspection ▪ Palpation ▪ Auscultation ▪ Determine path of penetration	▪ Abdominal wall pain/tenderness ▪ Peritoneal irritation ▪ Visceral injury ▪ Retroperitoneal organ injury	▪ DPL/ultrasound ▪ CT scan ▪ Celiotomy ▪ Contrast GI x-ray studies ▪ Angiography

Pelvis	▪ GU tract injuries
	▪ Pelvic fracture(s)
		▪ Palpate symptoms pubis for widening
		▪ Palpate bony pelvis for tenderness
		▪ Determine pelvic stability only once
		▪ Inspect perineum
		▪ Rectal/vaginal exam
			▪ GU tract injury (hematuria)
			▪ Pelvic fracture
			▪ Rectal, vaginal, perineal injury
				▪ Pelvic x-ray
				▪ GU contrast studies
				  ▪ Urethrogram
				  ▪ Cystogram
				  ▪ IVP
				  ▪ Contrast-enhanced CT

Spinal cord	▪ Cranial injury ▪ Cord injury ▪ Peripheral nerve(s) injury	▪ Motor response ▪ Pain response	▪ Unilateral cranial mass effect ▪ Quadriplegia ▪ Paraplegia ▪ Nerve root injury	▪ Plain spine x-rays ▪ MRI
Vertebral column	▪ Column injury ▪ Vertebral instability ▪ Nerve injury	▪ Verbal response to pain, lateralizing signs ▪ Palpate for tenderness ▪ Deformity	▪ Fracture vs dislocation	▪ Plain x-rays ▪ CT scan
Extremities	▪ Soft-tissue injury ▪ Bony deformities ▪ Joint abnormalities ▪ Neurovascular deficits	▪ Visual inspection ▪ Palpation	▪ Swelling, bruising, pallor ▪ Malalignment ▪ Pain, tenderness, crepitus ▪ Absence/diminished pulses ▪ Tense muscular compartments ▪ Neurologic deficits	▪ Specific x-rays ▪ Doppler examination ▪ Compartment pressures ▪ Angiography
Level of Consciousness	▪ Severity of head injury	▪ GCS Score	▪ ⌠8; severe injury ▪ 9-12; moderate head injury ▪ 13-15; minor head injury	▪ CT scan ▪ Repeat without paralyzing agents
Pupils	▪ Type of head injury ▪ Presence of eye injury	▪ Size ▪ Shape ▪ Reactivity	▪ Mass effect ▪ Diffuse axonal injury ▪ Ophthalmic injury	▪ CT scan
Head	▪ Scalp injury ▪ Skull injury	▪ Inspect for lacerations and skull fractures ▪ Palpable defects	▪ Scalp laceration ▪ Depressed skull fracture ▪ Basilar skull fracture	▪ CT scan
Maxillofacial	▪ Soft-tissue injury ▪ Bone injury ▪ Nerve injury ▪ Teeth/mouth injury	▪ Visual deformity ▪ Malocclusion ▪ Palpation for crepitus	▪ Facial fracture ▪ Soft-tissue injury bones	▪ Facial bone x-ray ▪ CT scan of facial bones
Neck	▪ Laryngeal injury ▪ C-spine injury ▪ Vascular injury ▪ Esophageal injury ▪ Neurologic deficit	▪ Visual inspection ▪ Palpation ▪ Auscultation	▪ Laryngeal deformity ▪ Subq emphysema ▪ Hematoma ▪ Bruit ▪ Platysmal penetration ▪ Pain, tenderness of c-spine	▪ C-spine x-ray ▪ Angiography/duplex exam ▪ Esophagoscopy ▪ Laryngoscopy
Thorax	▪ Thoracic wall injury ▪ Subq emphysema ▪ Pneumo/hemothorax ▪ Bronchial injury ▪ Pulmonary contusion ▪ Thoracic aortic disruption	▪ Visual inspection ▪ Palpation ▪ Auscultation	▪ Bruising, deformity, or paradoxical motion ▪ Chest wall tenderness, crepitus ▪ Diminished breath sounds ▪ Muffled heart tones ▪ Mediastinal crepitus ▪ Severe back pain	▪ Chest x-ray ▪ CT scan ▪ Angiography ▪ Bronchoscopy ▪ Tube thoracostomy ▪ Pericardiocentesis ▪ TE ultrasound

A. Head Injury

Head injury is the leading cause of trauma deaths. lntracranial injury may cause increased intracranial pressure, resulting in decreased cerebral perfusion, herniation, and death. The injured brain is extremely sensitive to hypoxia, hypercarbia, hypoglycemia, and hypotension. Early neurosurgical involvement in operative lesions is essential. The cervical spine is assumed to be injured until proven otherwise and cervical immobilization maintained until cleared.

1. **Evaluation**. Altered mental status may be the result of intoxication (drug/alcohol), insufficient perfusion, or intracranial injury. Disability should be continually evaluated with the Glasgow Coma Score or AVPU method. Signs of trauma to the head are usually present with intracranial injury since direct impact to the head is most common. However, be aware that significant brain injury such as shear effect can occur from forceful head movement without direct contact. Battle's sign (hematoma at the mastoid area), hemotympanum, raccoon's eyes (bilateral black eyes), and CSF leak from the nose or auditory meatus are synonymous with basilar skull fracture. Focal neurologic deficits indicate surgical lesion. Posturing may occur from diffuse axonal injury or increased intracranial pressure (ICP). Bradycardia and hypertension (Cushing's sign) can occur in response to elevated ICP.

2. **Radiographic evaluation** is best accomplished with CT. Non- contrast CT studies in trauma patients will identify most acute bleeding and are excellent for evaluating bone and sinuses. Plain skull films are of little value.

3. **Treatment** is directed to minimizing intracranial pressure and evacuating focal surgical lesions. Subdural, epidural, and intracerebral hematomas require immediate neurosurgical evaluation. Possible signs of increased ICP are dilated pupils, HTN with bradycardia and focal neurologic deficits. The approach to reducing intracranial pressure should be discussed with the admitting physician when possible to assure a continuum of care. Treatment of suspected increased intracranial pressure include:
   a. lntubation and hyperventilation should occur only after a complete baseline neurological exam is done. Hypocarbia decreases cerebral blood flow and decreases brain edema. PCO2 should be maintained at 28-30 torr. Too low a PCO2 can cause ischemia to occur. Hyperventilation should only be used in patients with suspected elevated ICP. Prophylatic hyperventilation is no longer used.
   b. Mannitol can be administered at a dose of I gm/kg to cause diuresis and decrease brain edema. Care must be taken to not cause hypovolemia in the traumatized patient.
   c. Monitor fluid administration. Overhydration contributes to brain edema. Once hypotension is treated, reduce intravenous fluids to maintenance levels or two-thirds maintenance levels if the patient is hemodynamically stable.
   d. An intracranial pressure monitor may be placed by a neurosurgeon and is generally indicated for a GCS ⌠ 8. This is especially important if the patient is comatose or is receiving sufficient sedatives/narcotics/paralytics to hamper proper assessment of LOC. Cerebral perfusion pressure (CPP) can be calculated as CPP = Mean arterial pressure (MAP) - ICP. CPP should be ∫ 70. Avoidance of hypotension is crucial in head injured patients.

B. Vertebral and Spinal Cord Injuries

Vertebral and Spinal Cord Injuries can lead to lifelong disability. Early detection and evaluation are mandatory to minimize additional injury. Blunt trauma patients and patients with penetrating wounds that track near the spinal columns are at risk for vertebral and spinal injury. In these patients, spinal column injury should be suspected and immobilization maintained until physical or radiographic examination dictates otherwise. Prehospital history regarding mechanism of injury and patient condition may give clues to underlying injury. CT scanning is valuable evaluation of the relationship between vertebral injury and the spinal cord. Obtain neurosurgical or orthopedic consultation as soon as an injury is strongly suspected.

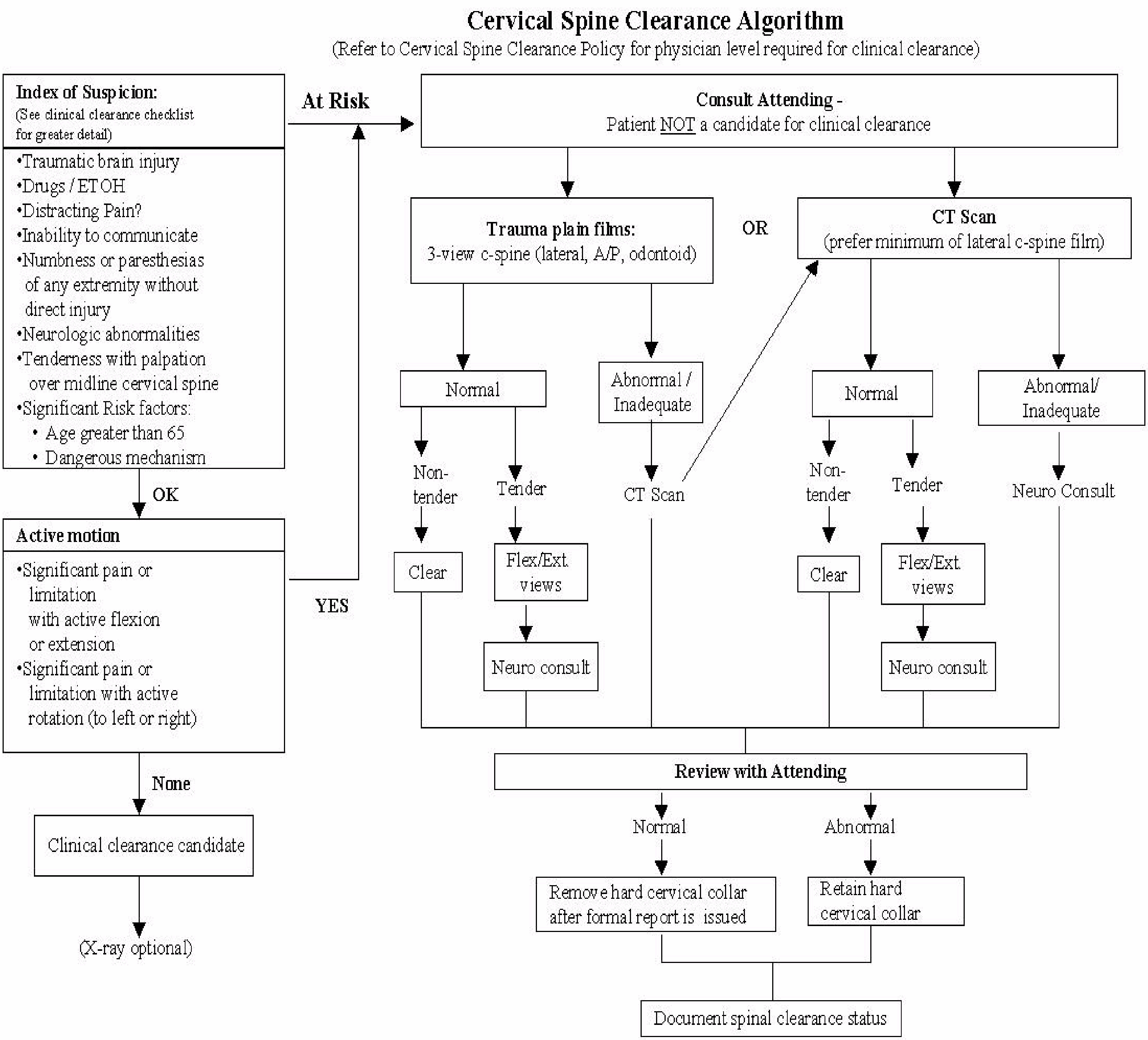
1. **Physical findings** suggestive of vertebral fracture are pain, swelling, crepitance, or deformity found upon palpation of the vertebral. Ecchymosis or deformity may be visible. Sensation, motor, and proprioception must all be tested. Diaphragmatic breathing, priapism, flaccid areflexia, loss of sensation, and paresis are indicative of spinal injury.

2. **Cervical spine injury** usually is associated with falls, motor vehicle impacts, and diving. Immobilization consists of an appropriately sized cervical collar, lateral supports, a spinal back board and immobilization of the head and chest. Awake, alert patients with no physical findings or cervical pain to palpation are candidates for clinical clearance. (C-spine Clearance documents, see Fig.3, and Appendix B.) In all cases, a complete neurologic examination should be done and documented. Patients with altered level of consciousness, severe multiple trauma, abnormal neurologic exam, and those with other vertebral fractures require radiographic evaluation of all seven cervical vertebrae. At a minimum, lateral, odontoid, and anterior-posterior radiographs are required. Additional views or CT scanning may be required for evaluation of suspicious lesions. Patients with real or suspected injury should be maintained in cervical immobilization until cleared. Other injuries may take priority over radiographic clearance. CT and MRI compatible cervical tongs are available in ED.

3. An algorithm for steroid use in spinal cord injury is found in Appendix C.

4. See Thoracic – Lumbar spine protocol - Appendix D.

Fig. 3 C Spine Algorithm



5. **Thoracic spine injuries** are often associated with motorcycle and bicycle impacts where the patient has been thrown forward and landed on the base of the neck. lnterscapular pain is common. Compression fractures are likely, but burst fractures may cause complete disruption and complete spinal injuries. Radiographic examination should be done on suspected injuries with the patient on a spinal backboard. Thoracic spine films are mandatory in patients with significant mechanism and altered mental status.

6. **Lumbar fractures** are also associated with motor vehicle impacts and falls. A vertebral body distraction fracture (Chance fracture) is associated with seat belt marks across the soft abdomen. Lumbar fractures can cause impingement upon the cauda equina and resultant neurologic findings.

7. **Spinal cord injury** demands special attention. Neurosurgical consultation should be sought. Care should be taken to minimize movement of unstable injuries and avoid further injury to the spinal cord. High cervical injuries demand attention to patient ventilatory status. Examination of the patient can determine whether a spinal injury is complete or incomplete. Incomplete injuries have sparing of some sensory or motor function and are associated with improved recovery - although definite diagnosis (complete vs. incomplete) may take time due to initial swelling. Therefore, a thorough neurologic exam is essential. Sacral sparing, anal wink, and bulbocavernosus reflexes should be noted and motor function of all four extremities clearly documented.

   Once a spinal injury is identified, high dose methylprednisolone therapy (30mg/kg bolus followed by an infusion of 5.4 mg/kglhours for the next 24 hours) is associated with improved prognosis. Therapy in penetrating cord injury and with length of time since injury is controversial, Neurosurgery consultation is imperative.

8. **Spinal shock** can occur with spinal injuries above the T6 cord segment. Spinal shock represents a loss of sympathetic tone. Physical findings include bradycardia, warm and dry skin from vasodilation, and hypotension. Blood pressure in the 80-90 mmHg range is acceptable and the impulse to increase the heart rate or give massive fluids should be resisted. Concurrent known or potential abdominal or vascular injuries can complicate fluid management decisions. Use of vasopressors for sustained hypotension not attributable to other sources can be used in these patients (Dopamine 5 mcg / kg / min.).

C. Chest Injury

Chest injury can cause respiratory distress or massive hemorrhage. Approximately 90% of chest injuries can be managed without thoracotomy. (See Appendix C and Fig. 4). Non-operative management or simple chest tube placement is definitive treatment in 90% of chest injuries. Patients with blunt chest injury usually have associated extrathoracic injuries. The major initial working diagnostic/treatment categories of chest trauma are:

1. **Chest wall crepitance** suggests **rib fracture** and the potential for pneumothorax. Tenderness may be elicited by direct or remote palpation. If no pneumothorax is noted on initial chest radiograph, observation with repeat radiograph in 4-6 hours is appropriate. Simple rib fractures can be treated with analgesia or intercostal nerve block in difficult cases. Older patients with rib fractures may require admission and pulmonary toilet until ventilation is unrestricted by pain. Epidural analgesia is effective for many patients with multiple rib fractures to maximize respiration and minimize atelectasis. Patients requiring positive pressure ventilation should have tube thoracostomy to prevent development of tension pneumothorax. For nonintubated patients with rib fractures going to OR for general anesthesia the anesthesiologist must be careful to assess for airway pressure changes as evidence of a developing tension pneumothorax (PTX).

2. **Pneumothorax, hemothorax, and hemopneumothorax** are secondary to entry of air, blood, or both into the pleural space. Collapse of the lung is related to the loss of pleural space. Physical findings include decreased movement of the involved hemithorax and decreased breath sounds. Percussion elicits resonant sounds for pneumothorax and dull sounds for hemothorax. Small pneumo/hemo-thoraces can be managed with serial observations. Pneumothorax can be treated with 28-30F chest tube in anterior 4th ICS, mid-axillary line. Most hemothoraces or combined PTX/HTX require large bore (36-40F) chest tube insertion in the mid-axillary line at 4th-5th ICS. If more than a liter of blood is returned or the subsequent output is more than 200 ml./hour, thoracotomy is indicated. Massive hemothorax may tamponade itself and sudden vascular collapse will occur with insertion of a chest tube. These patients need aggressive volume resuscitation and urgent thoracotomy. Particulate matter aspirated by a chest tube and large air leaks are suspicious for esophageal rupture and need surgical exploration.

   Tension pneumothorax occurs when positive pressure builds up within the pleural space causing shift of the mediastinum, decrease in venous return and hemodynamic compromise. Physical findings are tracheal shift to the opposite side, jugular venous distention, respiratory distress, absence of breath sounds on the affected side, and a tympanic percussion note. Immediate needle decompression of the affected chest is mandatory. A chest tube must be placed to prevent reoccurrence.

3. **Widened mediastinum** occurs with high energy deceleration and carries the suspicion **of central great vessel and traumatic aortic and transection.** Physical findings and symptoms suggestive of traumatic aortic disruption are swelling at the base of the neck, bruits, pulse and pressure differentials between arms, dysphagia, and chest pain, especially radiating to the back or shoulder blades. Blood from thoracic spine injuries may cause a widened mediastinum on AP chest films. Blood distribution changes in the supine position, therefore, an erect film is preferred. A mediastinal shadow of greater that 6 cm at the T4 level is considered wide. Table 3 shows the five common radiographic findings of aortic arch disruption. CT angiogram is the initial diagnostic test. Arch aortogram may still be required in certain circumstances and should be discussed with cardiothoracic surgery. Treatment may be either operative or endovascular stenting. However, intraperitoneal bleeding, pelvic fracture bleeding and neurosurgical evaluation / intervention take precedence as aortic injuries are not often acutely life-threatening.

Table 3 - Radiographic Signs of Potential Aortic Arch Disruption

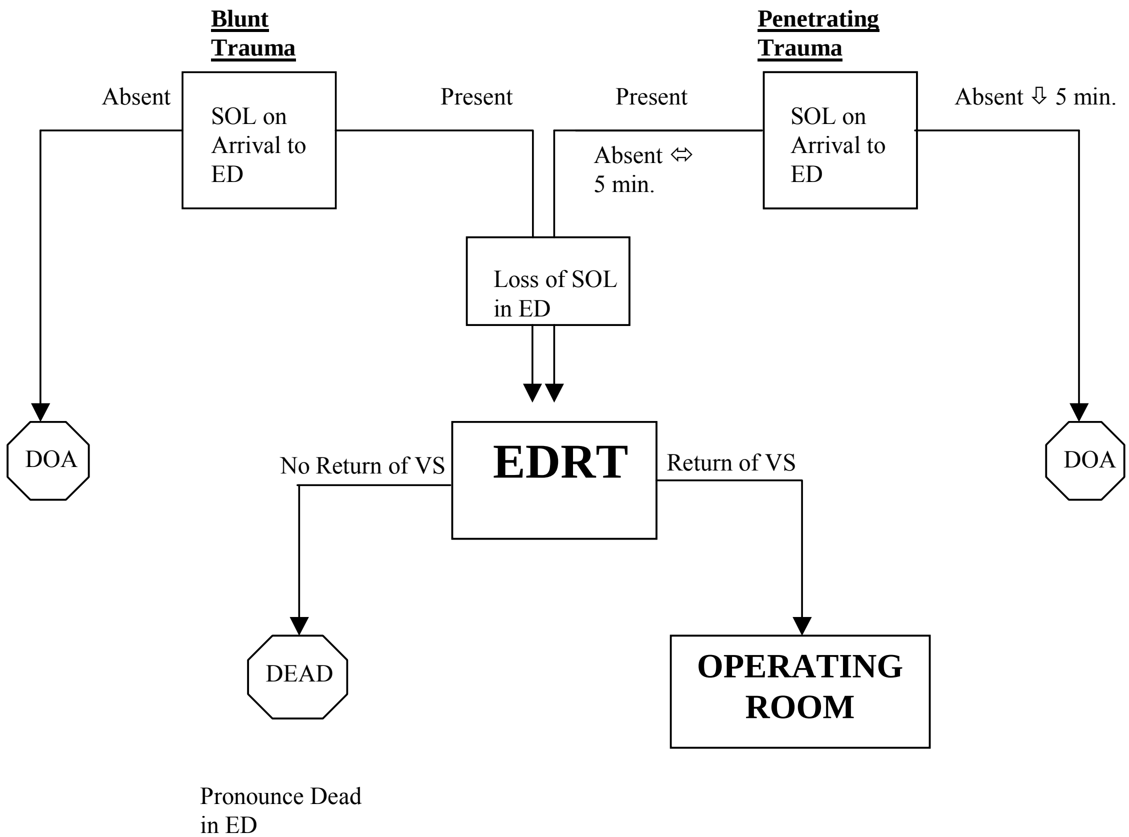
♦ Loss of aortic knob
♦ Left plural cap
♦ Trachial deviation to right
♦ Depressed left main stem bronchus
♦ Deviation of nasogastric tube to right (2 mm to right of spinous process of T4)

ED Thoracotomy Algorithm

**Guidelines for Emergency Department
Resuscitative Thoracotomy**

Adult & Peds

MECHANISM OF INJURY



<u>Abbreviations</u>

SOL = Signs of Life
- supraventricular rhythm with or without palpable pulse
- agonal respirations
- pupillary reaction

VS = Vital Signs
- palpable pulse
- measurable blood pressure
- spontaneous respirations

ED = Emergency Department

EDRT = ED Resuscitative Thoracotomy (open chest)

OR = Operating Room

DOA = Dead on Arrival

Emergency Medicine / Trauma 5/92, revised 11/93, 4/97

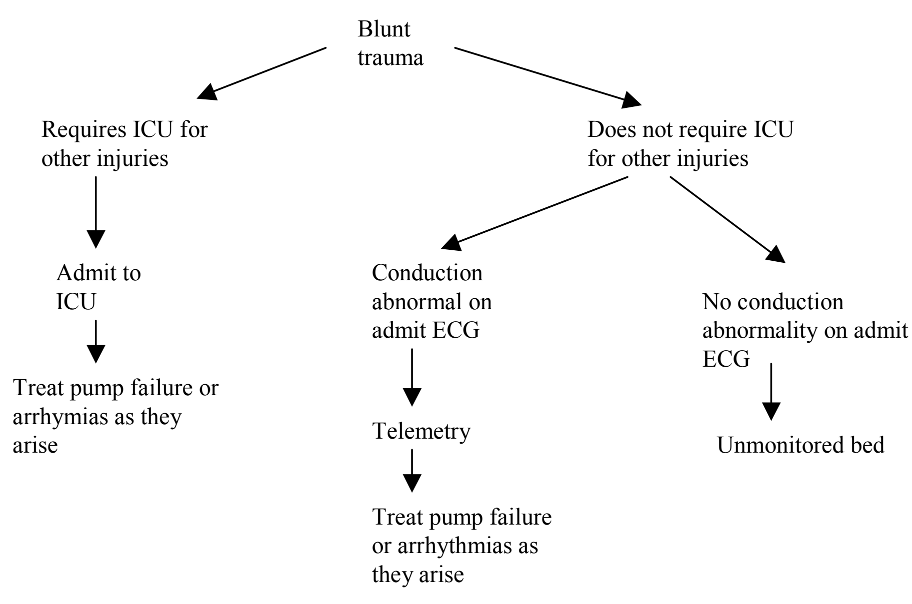
Fig. 4 – ED Thoracotomy Algorithm

4. **Multiple rib fractures and flail chest** segment may compromise ventilation (Refer to Breathing, section B, point 2). Diagnosis of free floating flail segment is clinical, demonstrating a paradoxical movement to the rest of the chest. Initial treatment is supportive. lntubation (internal splinting) is required for proven hypoxia or fatigue. Associated pulmonary injury often mandates intubation, tube thoracostomy and pain management. ICU admission is strongly urged, especially for elderly patients with rib fracture(s).

5. **Pulmonary contusion** is identified as a hazy opacity or infiltrate on chest radiograph, usually segmental or lobar in distribution. This represents alveoli containing blood and is usually self limiting/correcting over time. Patients showing respiratory distress or hypoxia require intubation and positive pressure ventilation. Extrapleural hemorrhage from central, rib, or supraclavicular vessels may mimic the radiographic findings. Chest CT scan and angiography can distinguish these from pulmonary contusion. Chest CT scan often shows pleural laceration associated with pulmonary contusion.

6. **Cardiac contusion** is an overused diagnosis for patients with chest wall pain and is clinically important only in those patients with dysrhythmias, ectopy, or cardiac dysfunction during the initial phases of their evaluation. **CPK, CPK-MB fraction, troponin, nuclear scans, and echocardiography do not correlate with autopsy studies.** Multi-system trauma and head injuries cause cardiac dysrythmias, ectopy, and serum enzyme elevations unrelated to direct cardiac trauma. We use the algorithm shown in Fig. 5. Patients with dysrythmias should be monitored and treated accordingly. A Swan-Ganz catheter may be useful in optimizing fluid and inotropic support for true cardiac contusions.

Cardiac Contusion Algorithm



Algorithm for triage and treatment of patients with blunt trauma and suspected blunt trauma cardiac injury. (Note. Redrawn from "Suspected Myocardial Contusion: Triage and Indications for Monitoring by D.H. Wisner, W.H. Reed, and R.S. Riddick, 1990, *Annals of Surgery*, 212 (1), pp. 82 - 86).

Fig. 5 – Cardiac Contusion Algorithm

7. **Cardiac tamponade** may be due to blunt or penetrating trauma, Prognosis is much better for penetrating trauma since the site of bleeding is usually focal. Cardiac tamponade depresses preload and causes hemodynamic compromise secondary to inadequate cardiac filling. Physical findings are hypotension, tachycardia, pulsus paradoxus, distended jugular veins, and muffled heart sounds. A rise in central venous pressures may aid diagnosis and rule out hypovolemia. The diagnosis is made by ultrasound finding of pericardial fluid (Fig. 6). Intravenous infusion of crystalloid may improve cardiac output while preparing the patient for pericardiocentesis. Subxiphoid pericardiocentesis may be life-saving but is temporizing and urgent thoracotomy is indicated. Large hemorrhage into the pericardial sac will overwhelm its thrombolytic system, resulting in clotted blood that cannot be aspirated.

8. **Gun shot wounds to chest.** Except for mediastinal traverse, most lateral gun shot wounds to the chest may be managed by chest tube placement and monitoring the rate of blood loss from the tube. The majority will not require thoracotomy. Antibiotics, cefotetan 1 gm IV, should be given in the emergency department.

   Mediastinal Traverse with Penetrating Foreign Body: If a gun shot wound is on one side of chest and another wound or foreign body is on the other side of the chest, a presumption of mediastinal crossing or penetration is made, and mandates adjunctive diagnostic studies. Initial evaluation should be with FAST to assess for pericardial fluid. If the patient is hemodynamically stable, then spiral CT of the chest with CT angiography is the primary diagnostic study. **Evidence preservation should be considered with victims of violent crime.**

Fig. 6 - Pericardial Fluid by Ultrasound After Blunt Torso Trauma

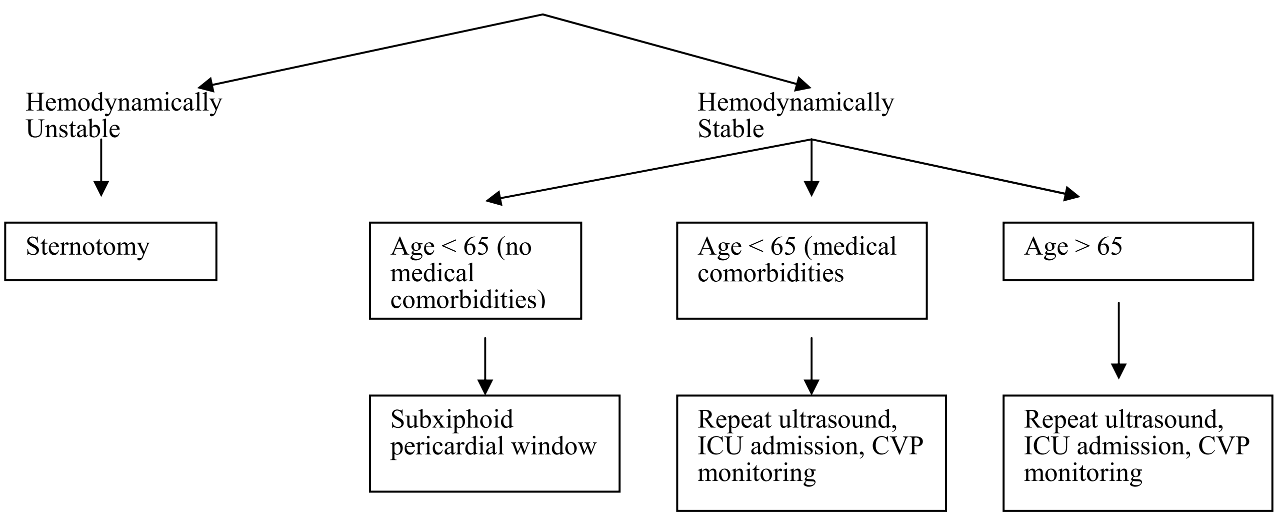


Fig. 6 Working protocol in patients with “incidental” pericardial effusion after blunt thoracoabdominal trauma.

D. Abdominal Injuries

Death from abdominal hemorrhage is a common cause of preventable death in trauma patients. In the emergency department, initial evaluation and treatment is not geared towards identification of a specific abdominal injury, but to determine whether a surgical intraabdominal injury exists. Patients who are unstable need rapid resuscitation and a chest and pelvic radiograph. If these are negative, the active bleeding is assumed to be in the abdomen and should be confirmed with ultrasound. Patients that stabilize with initial resuscitation are candidates for further evaluation and possible non-operative management. In the multiply injured patient, the ability to assess the abdomen by manual and visual examination is often limited. CT scan, Ultrasound and peritoneal lavage offer adjuncts to this evaluation.

1. **CT scan** is preferred only in stable patients because of the accuracy and specificity, allowing selective non-operative management of stable patients with solid organ injuries. CT scan of the abdomen can be done sequential to CT of the head if non-operative lesions. Indications for abdominal/pelvic CT scans are listed in Table 4. Intravenous contrast should be given to visualize renal function. Presence of free fluid on CT scan without evidence of solid organ injury suggests perforation of hollow viscus and is generally an indication for laparotomy. A physician and nurse must accompany the patient while in CT.

Table 4 - Indications for abdominal/pelvic CT scans

1. Equivocal abdominal examination
2. Blunt trauma patient with closed head injury
3. Blunt trauma patient with spinal cord injury
4. Gross hematuria
5. Pelvic fractures, with or without suspected bleeding
6. Patient requiring serial examinations, but will be lost to physical examination for prolonged period (i.e., orthopedic procedures, general anesthesia, etc.)
7. Patient with dulled or altered sensorium due to toxic, metabolic, or psychiatric event

*CT Scans are contraindicated in unstable patients

2. **F.A.S.T. Ultrasound** is used to evaluate for intra-abdominal blood loss and may indicate the need for operative control of hemorrhage. This should be the primary diagnostic test in unstable patients. Any positive FAST result must be immediately reported to the Trauma Attending by the Trauma Resident.

3. **Peritoneal lavage** is used when FAST is inadequate or equivocal. This occurs most commonly in patients with pelvic fracture. Gross blood aspirated upon catheter insertion is indication for immediate laparotomy.

4. **Plain films of the abdomen** add little information, in blunt trauma, but are very useful to identify bullet tracks in gunshot wounds.

5. **Physical findings** associated with intra-abdominal injury include guarding, peritoneal signs, diffuse and focal tenderness, and nausea. Abdominal wall contusion and fractures of the lower ribs often make it difficult to evaluate the abdomen by palpation. Bowel sounds are unreliable. Lower rib fractures are associated with a spleen or liver injury 10-20% of the time. Seat belt marks across the soft abdomen are associated with intestinal injury, especially at the proximal jejunum and terminal ileum and mesenteric tears. Direct blunt trauma usually causes rupture or tear of the solid organs. Rectal examination should be done and checked for blood.

6. **Retroperitoneal bleeding** may come from bleeding of the aorta, vena cava, kidneys and ureters, pancreas, pelvic fractures, and retroperitoneal portions of large and small intestine. Physical findings may be minimal. FAST and peritoneal lavage may be negative. CT scan will identify significant retroperitoneal bleeding. Flank pain and contusion are often late findings.

7. **Stab wounds.** Stab wounds differ from gunshot wounds in that stab wounds usually are low velocity and can be managed selectively. The evaluation is geared to early identification of either systemic symptoms of hemorrhage or potential for peritonitis. **Evidence preservation should be considered with victims of violent crime**. Stabs are stratified by loci:

a. Anterior abdominal are anterior to the anterior axillary line, below the costal margin, and above the inguinal ligament. In the absence of hypotension, peritonitis, obvious evisceration, or intraabdominal fluid on ultrasound, most of these patients can be managed expectantly with serial physical examination.

b. Flank stabs are between the anterior and posterior axillary lines, and the lower ribs to iliac crests. Because of the retroperitoneal attachments of the ascending and descending colon, and duodenum, triple contrast CT scan (IV, oral and rectal) is indicated.

c. Back stabs are posterior to the posterior axillary lines, If there is no anterior abdominal tenderness, and in presence of bowel sounds, back stabs are managed selectively, with non-operative management initially. In the absence of peritonitis, or external bleeding, back stabs should be admitted for observation, unless they are clearly seen to be superficial slashes. High lumbar and low thoracic right paravertebral stabs have potential for posterior duodenal or hepatic injury. CT scan can reveal these injuries, but they are easily missed. Admission for observation is advised.

d. Lower chest stabs below the nipples in any locus, anterior, lateral, or posterior carry potential for intra-thoracic and intra-abdominal injury. Because of the potential for transdiaphragmatic traverse, this area remains a diagnostic dilemma. Small diaphragm wounds may not bleed significantly, and may not have caused significant subdiaphragmatic injury. The pressure gradient between intra-abdominal and pleural space may cause diaphragm wound enlargement and herniation of stomach, omentum, or spleen. Thoracoscopy may be useful to visualize the diaphragm.

e. Peristernal potential mediastinal wounds are in the vicinity of the cardiac silhouette and the base of the neck in the suprasternal notch. Examine for clinical signs of cardiac tamponade. Liberal use of central venous pressure monitoring and ultrasonography is encouraged to diagnose cardiac tamponade early. Chest and parasternal stabs without initial evidence of hemopneumothorax or tamponade should be observed a minimum of six hours and a chest radiograph repeated to detect occult or developing pneumothorax

8. **Gun shot wounds to abdomen** are associated with high energy transmission and have a very high incidence of serious injury. Compared to stab wounds there is less room for selectivity and stratification in these higher energy injuries. Grazing wounds occur, but most gun shot wounds have a high potential for intra-abdominal penetration to cause hemorrhage and perforation. Most gun shot wounds to the abdomen should be explored at laparotomy. Preservation of evidence should be considered with victims of violent crime. Antibiotics, cefotetan or cefoxitin, 1-2gms IV should be started in the emergency department.

E. Peripheral Vascular Injury

Peripheral vascular injury usually occurs from penetrating mechanism, but fracture-dislocation of tibia-fibula, distal femur, or midshaft of humerus has potential for concomitant arterial vascular injury to popliteal trifurcation, superficial common femoral, and radial artery respectively. A distal pulse is present in up to 10% of transected major arteries due to collateral flow or "transmission of pulse across clot. Pallor, pulselessness, paresthesias, paralysis, pain (ischemic), poikilothermia are the six classic P's of peripheral vascular arterial injury. Except for paresthesias these are all considered "hard signs", and if an extremity is cadaveric, exploration of the most likely injured vascular structure is indicated without benefit of arteriography. Other indications for immediate surgical exploration are continued brisk external hemorrhage with rapidly expanding hematoma. A machinery bruit is an indication for operation, with or without arteriography depending upon location of bruit.

Without signs of rapid hemorrhage, or cadaveric extremity, the presence of any of the above mentioned "hard signs", arteriography is useful to identify the site of the lesion. Selective management of "minimal angiographic findings" is now practiced. If there are no "hard signs" and the injury is only in proximity to a major vascular structure, an angiogram is not needed urgently, but requires serial observation.

Vascular Injury to Extremities in Trauma

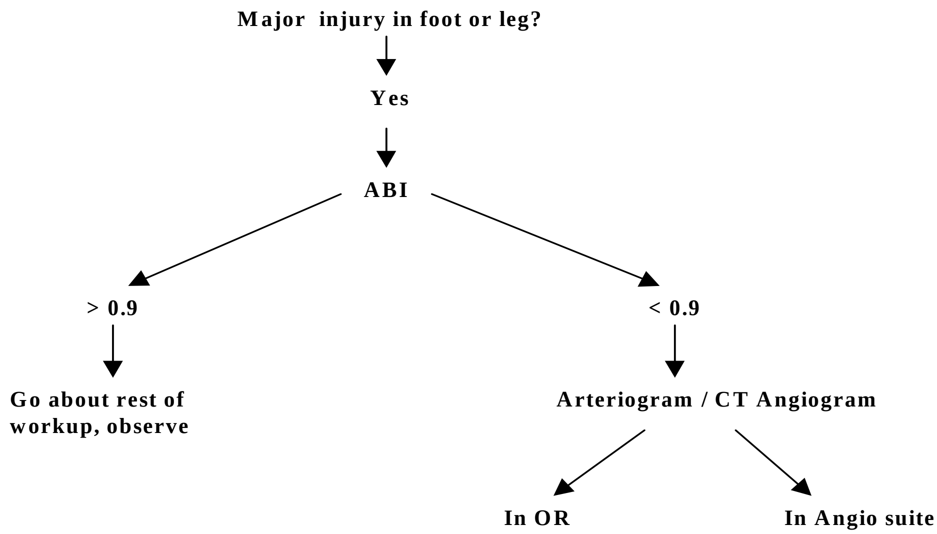


Fig. 7 – Vascular Injury

F. Extremity Injuries

Extremity injuries are rarely life-threatening, but are a leading cause of long term disability and surgical intervention for these patients. Initial treatment should consist of control of hemorrhage, evaluation of function and neurovascular status and splinting. Direct pressure may decrease or stop obvious hemorrhage.

1. **Physical findings** include obvious deformity, crepitance, loss of normal contours, shortening, rotation, angulation, and loss or decreased function beyond a wound. Injury to tendons can cause inability to extend or flex specific anatomy. Neurovascular status can be evaluated by palpation of pulses, noting perfusion, color, and temperature, and testing for motor and sensation.

2. **Wounds** may be an obvious source of bleeding or cause an expanding hematoma. Distal neurovascular status and tendon function should be assessed. Wounds should be cleaned with copious irrigation and explored for foreign bodies prior to repair. Wounds in the vicinity of a fracture suggest an open fracture. Administer tetanus prophylaxis as indicated

3. **Radiographic evaluation** of potential fractures should be used liberally. Failure to locate a fracture results in delayed treatment and potential to worsen the injury. Radiographs should include the joint above and below the fracture site. (See Table 5.)

4. **Fractures** should be aligned as best as possible and splinted to minimize further injury to neurovascular structures and decrease pain. Neurovascular status should be reassessed after splinting. In many instances, simply realigning the extremity will improve vascular status. Open fractures should be cultured and antibiotics given. Orthopedic consultation is mandatory.

5. **Dislocations and fracture-dislocations** should be relocated as soon as possible. Radiographs are essential to determine dislocation from fracture- dislocation. Both are associated with mal-alignment and may cause neurovascular injury and ischemic necrosis to overlying skin.

6. **Femur fractures** are associated with neurovascular compromise and may cause severe bleeding. Physical findings include external rotation and shortening of the lower leg, firm expanding hematoma of the thigh, and thigh or hip pain. These fractures should be placed in a traction device and pulled out to length. Doing so may relieve thigh spasm, decrease bleeding at the fracture site, and improve neurovascular status.

G. Renal / Genitourinary Injury

Gross hematuria and blood at the urethral meatus are the two hallmarks of significant renal / genitourniary injury. Microscopic hematuria is ubiquitous-in blunt trauma, and carries little clinical significance in the absence of flank pain.

1. **A urethral tear** is suspected if there is blood at the urethral meatus. Urethral tears are much more common in males, and quite rare in females. A urethrogram must be performed before insertion of a urinary catheter is attempted. If the urethrogram is normal, then a urinary catheter is passed and 400 ml of contrast instilled into the urinary bladder. The catheter is clamped and a cystogram is performed to determine **bladder extravasation.** At times it is difficult to distinguish free intra-peritoneal bladder perforation from extra-peritoneal extravasation of contrast. CT scan of the abdomen/pelvis with the catheter clamped is useful in this circumstance.

2. **Foley Placement in Males**
   To avoid a foley catheter balloon being blown up within the prostatic urethra, be certain to place the foley and not blow up the balloon until urine is seen actually flowing out of the foley catheter. It is best to insert the foley all the way to the hob in male patients, then once the urine flows, to pull it back gently.

3. **Gross hematuria** returned on insertion of a urinary catheter, when no urethral meatal blood had been present, mandates an abdominal /pelvic CT scan with clamped catheter. Intravenous contrast will help evaluate kidney perfusion, ureteral integrity and that there is no extravasation from the urinary bladder. Renal arteriography, complete intravenous pyelogram (IVP), and single image IVP to evaluate gross hematuria have been supplanted by combined intravenous contrast abdominal/pelvic CT scan for the evaluation of genitourinary trauma. Occasionally, for urgent laparotomy a single image IVP (50mL renal contrast intravenously followed by plain film KUB done at 2 minutes) done in the emergency room or OR may give assurance that two perfused kidneys are present. Dilutional effect from rapid fluid resuscitation can limit the image quality of IVP, therefore dosing may vary.

H. Pelvic Injury

Pelvic trauma must be viewed as an indicator of major trauma and is likely to be associated with associated systems injuries. The osseous structures of the pelvis are in close proximity to vascular, neurological, hollow-visceral, urogenital, and pelvic organs therefore injuries to these structures are common. Urgent management decisions are aimed at identifying and treating life-threatening injuries. These decisions are based on the patient's vital parameters, physical examination and an initial AP pelvis x-ray. The physical examination of a patient with a pelvic fracture includes identifying deformity, wounds, swelling, and ecchymosis. Manual determination of stability by AP and lateral compression should be performed, avoid repeated examinations. All patients should have a digital rectal examination to evaluate the position of the prostate and identify penetrating bony fragments. Injuries to the anterior pelvic ring in woman necessitate a vaginal manual examination. In the situation of hemodynamic instability and mechanical instability of the pelvic ring immediate resuscitation procedures are initiated according to a treatment algorithm. The primary goal is to determine the source of hemorrhage and control it. Preliminary stabilization of the pelvis may control the hemorrhage. Persistent hemodynamic instability is treated with surgical hemostasis or angiographic embolization.

Open pelvic fractures or deep perineal lacerations may need diverting colostomy. Rectal contrast can augment CT evaluation of suspected left colon injuries. For pelvic fractures suspected of significant on-going extra-peritoneal hemorrhage, early external fixator placement by orthopedic service may stop or slow hemorrhage. If fixator is not effective angiographic embolization is indicated for diagnosis and therapy. Call early for angiography team.

Pelvic Trauma

Instability of the pelvic ring combined with hemodynamic instability

Emergency algorithm for pelvic injuries

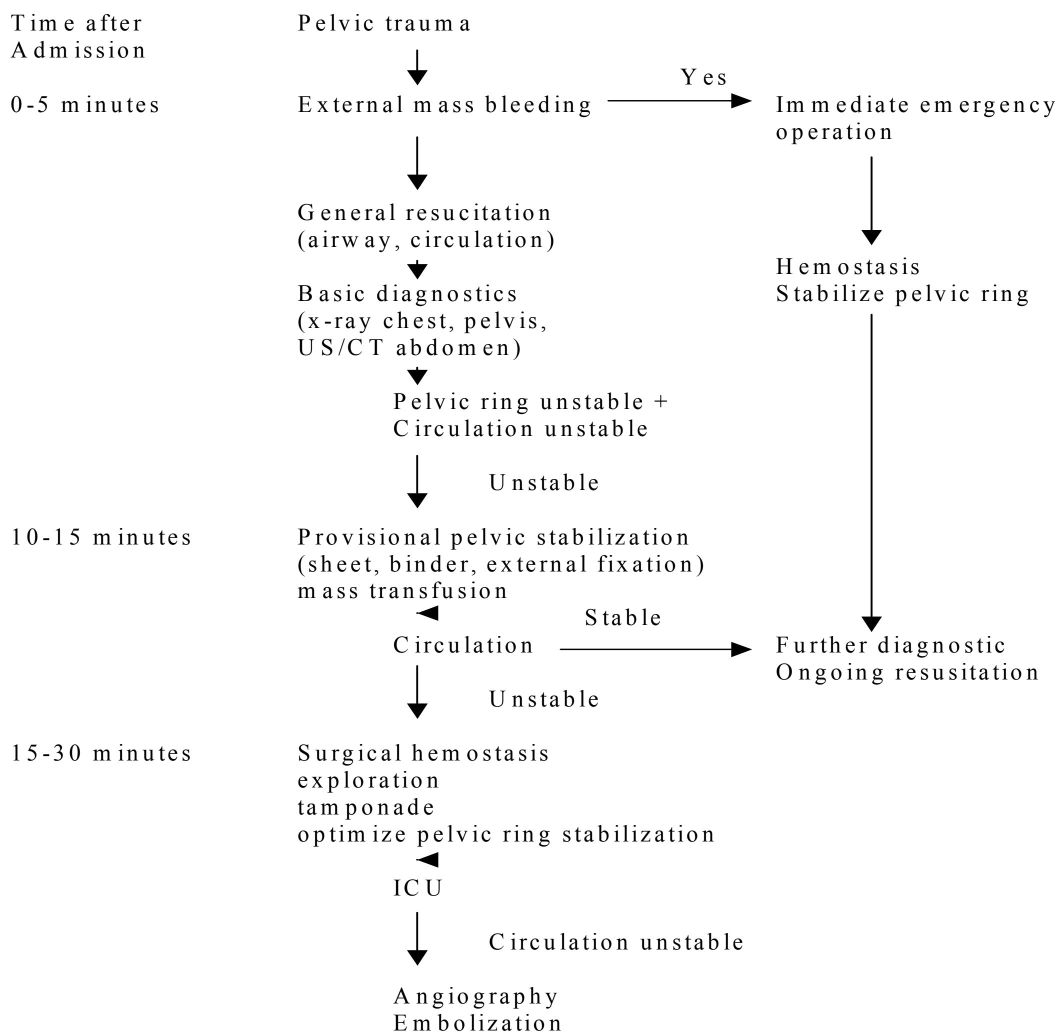


Fig. 8 – Pelvic Trauma

Radiographic Evaluation of Suspected Fractures	
Shoulder	AP, Axillary, Y Scapula
Humerus	AP, Lateral
Elbow	AP, Lateral
Radius / Ulna	AP, Lateral
Wrist	AP, Lateral
Hand	AP, Lateral, Oblique
Spine	AP, Lateral CTLS spine
	C-spine (separate C-spine policy)
Pelvis	AP, + fracture → 45° Oblique views, 40° Caudad and Cephalad views

Table 5 – Radiographic Evaluation of Suspected Fractures

I. Perineal Wounds and Suspected Rectal Traverse Wounds

The extraperitoneal rectum is encased in the deep pelvis and pelvic floor musculature and is not easily evaluated for penetrating or blunt injury. The potential for devastating deep perineal muscle infections, both abscess and synergistic fasciitis warrants a liberal use of diverting colostomy. In stable patients, anoscopy and sigmoidoscopy may determine the presence of a rectal injury, but may be equivocal or impractical to perform in face of proximity bleeding, unstable pelvis or long bone fractures. If anoscopy/sigmoidoscopy reveals blood or clot, the presumption of a rectal tear is made and diverting colostomy with presacral drainage is indicated. If rectal penetration is highly suspected but not definitively proven, high index of suspicion is an indication for fecal diversion/ presacral drainage

J. Blood Component Therapy

Blood component therapy in the emergency department is based upon patient requirement. For the initial resuscitation of the trauma patient, type 0 negative ("universal donor") packed red blood cells are used for patients who remain hypotensive, with signs of poor perfusion (i. e. decreased mental status, oliguria, cool skin with > 3 seconds capillary refill) despite at least two liters of warm crystalloid infusion. In general, packed RBCs are given with the supposition that definitive operative therapy is available within the hour. It is counterproductive to aggressively transfuse packed RBCs with crystalloid simply to transiently increase intravascular volume and systolic pressure, which may increase rate of hemorrhage and precipitate rapid vascular collapse with lethal arrhythmia. Considerable judgment must be exercised in balancing the need for transfusion and the need and availability of immediate operative therapy. When 0 negative is unavailable, type O positive blood may be given, but females should be given Rh prophylaxis. Type specific and, when possible, cross matched RBCs should be given to augment hemoglobin content of stable patients. Platelets and fresh frozen plasma are not indicated prophylactically. Fresh frozen plasma should be dictated by coagulation studies. Rapid crystalloid and colloid infusions must be warmed using the Level I fluid warmer.

The Transfusion Department has blood buckets with "O" packed cells immediately available (3 – 5 minutes) for any department at SHC & LPCH (ED, OR, ICU, etc.)

K. Medications

1. **Pain control** is contraindicated in patients with severe shock and significant closed head injuries. Lucid patients with milder injuries who have been examined and resuscitated need adequate analgesia. Small, serial doses of intravenous morphine sulfate, 2-4 mg, may be used in monitored patients. Agitation is often due to hypoxia and/or pain, and should be treated by ensuring adequate oxygenation and providing compassionate analgesia. Chemical restraint with muscle paralysis, though often needed to accomplish intubation, should not be used as first line treatment of agitation. There should be a primary need for intubation. Muscle relaxants should only be used to facilitate intubation, rather than a decision made to use muscle relaxants for agitation control, and

therefore a secondary need for intubation. It is recognized that sustained chemical control may be required to facilitate essential diagnostic studies such as CT of the head.

After the ED, pain control for fractures and soft tissue injury may be controlled with IV, or PO morphine sulfate, PO meds, or ketorolac (Toradol) 60 mg. IM. Use of Toradol in the presence of concurrent injury that might hemorrhage (e.g. pelvic fracture, liver or spleen contusion or laceration, etc.) is controversial due to the effect on platelets. Elevation of an injured extremity minimizes the throbbing associated with vascular congestion and swelling and also facilitates surgical repair.
There is no indication for epidural analgesia in the emergency department, though temporary peripheral nerve blocks may be helpful to facilitate procedures and wound repair.

2. **Antibiotics** used in the emergency department for penetrating abdominal or chest trauma include 2 gms of cefotetan or cefoxitin. Pre-op'doses given intravenously are useful in starting treatment and preventing post-operative abscesses. For blunt abdominal trauma suspected of perforated viscus the same regimen is used. For large soft tissue destructive injuries, initial use of 2 million units aqueous penicillin intravenously is a safe initial regimen and should be followed by copious irrigation in the operating room with the jet lavage device. Subsequent choice of antibiotic should await Gram stain and culture result.

   Tetanus prophylaxis should be done on open fractures and tetanus prone wounds.
   Thiamine 100mg IM should be given to reduce the risk for Wernicke's encephalopathy to any patient with a history of recent or chronic alcohol/drug use or behavior or odors indicative of substance abuse. All patients with ALOC or GCS<15 should be considered at physician discretion.

L. Pediatric Trauma: Special Considerations

In general, pediatric trauma care is delivered systematically, using the same guidelines established by the ACS for adult patients. There are however, a few features of the pediatric trauma patient that are worthy of special mention. The pediatric patient has anatomic and physiologic differences that warrant further evaluation by the pediatric trauma team.

1. Vital Signs

Children's normal vital signs vary according to age. The following table is a useful guide to age adjusted vital signs:

Age (Years)	Heart rate (per min)	BP (mm Hg)	Resp
0-1	120	80/40	40
1-5	100	100/60	30
5-10	80	120/80	20

Table 6 – Peds vital signs

2. Temperature Regulation

Because of their large surface to mass ratio and a blunted shivering response, children (especially infants) are particularly prone to rapid heat loss and hypothermia. Before the patient arrives, the trauma room should be maximally heated. Body temperature should be measured on arrival, and warming measures (e.g. Bair Hugger) should be started immediately, if necessary. Patient exposure should be limited to that needed for assessment and treatment. Reversing hypothermia and maintaining body temperature are key priorities in resuscitation and stabilization.

3. Airway

Compared with adults, children have short, anteriorly placed airways, and are more prone to esophageal or right mainstem intubation by inexperienced personnel. Endotracheal intubation is accomplished using uncuffed tubes. General guides to the correct sized endotracheal tube are the size of the child's fifth fingernail or nares, or the tube size predicted by the formula: 16 + age in years / 4.

4. Venous Access

Intravenous resuscitation is accomplished through large catheters placed in the antecubital veins. Alternate sites of venous access are the long saphenous vein at the ankle or in the groin (cutdown), or percutaneous central access, either through the internal jugular or subclavian veins. In a profoundly shocky baby, the only achievable access for resuscitation may be via a 16g intraosseous needle placed in the tibia just below the tibial tuberosity.

5. Resuscitative Fluids

Bolus crystalloid fluids (either LR or NS) should be given in volumes of 20 cc per kg and titrated to a desired hemodynamic response. If after 2 crystalloid boluses, the patient remains hemodynamically unstable, consideration should be given to transfusion of blood (10 mL / kg).

6. Evaluation and Management of Blunt Abdominal Trauma

The vast majority of blunt liver and spleen injuries in children are managed non-operatively. Because hemoperitoneum alone, is NOT an indication for laparotomy following blunt abdominal injuries in children, peritoneal lavage is seldom utilized. Abdominal CT scan (with IV and PO contrast) is the diagnostic test of choice in the evaluation of blunt abdominal trauma in children. If a liver or spleen injury is identified, a decision to treat conservatively is based exclusively on hemodynamic stability, absence of signs of other intrabdonimble injuries, or ongoing requirements for blood transfusion less than half a blood volume (40 cc/kg).

M. Burns

The American Burn Association criteria is used to determine the need for a burn patient to be transferred to a burn center. The injury history and time of contact with the burn source is extremely valuable in evaluating for additional injury and further treatment.

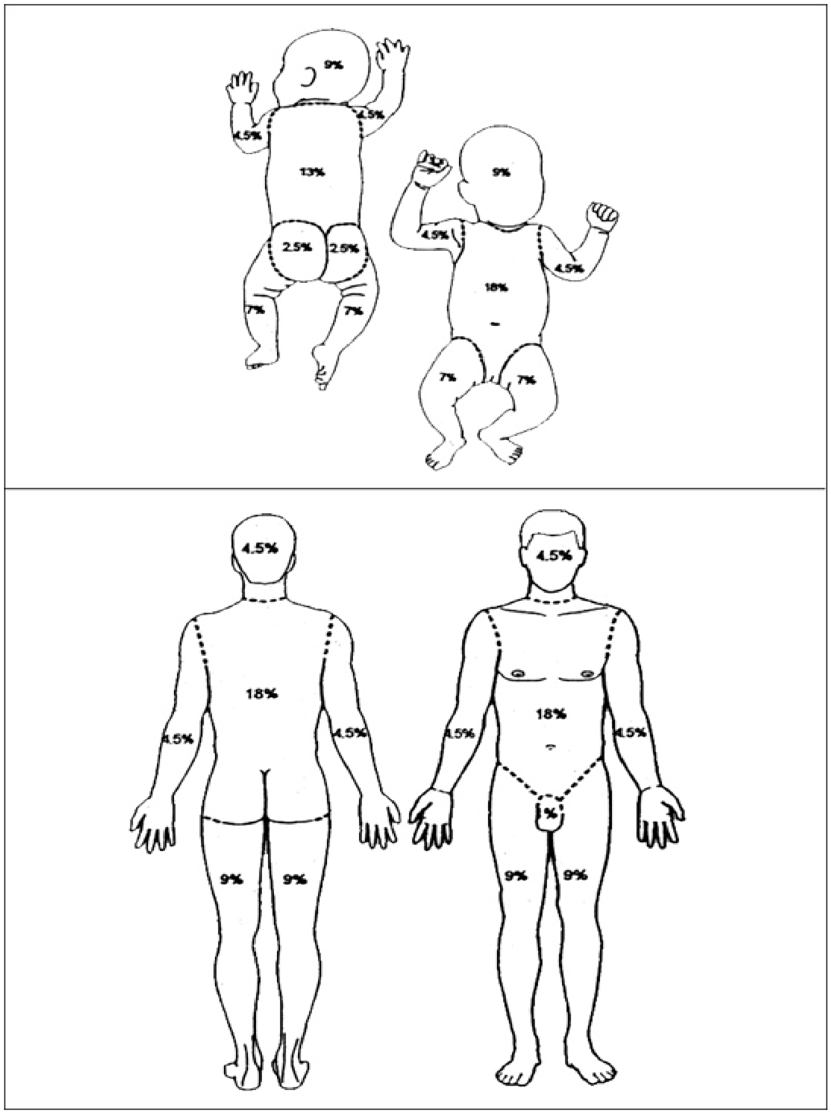
The American burn Association has identified the following types of burn injuries that usually require referral to a burn center:

- Partial-thickness and full-thickness burns greater than 10% of the total body surface area (BSA) in patients under 10 years or over 50 years of age
- Partial-thickness and full-thickness burns greater than 20% BSA in other age groups
- Partial-thickness and full-thickness burns involving the face, eyes, ears, hands, feet, genitalia, or perineum or those that involve skin overlying major joints
  1. Full-thickness burns greater than 5% BSA in any age group
  2. Significant electrical burns including lightning injury (significant volumes of tissue beneath the surface may be injured and result in acute renal failure and other complications.)
  3. Significant chemical burns
  4. Inhalation injury
  5. Burn injury in patients with preexisting illness that could complicate management, prolong recovery, or affect mortality
  6. Any burn patient in whom concomitant trauma poses an increased risk of morbidity or mortality may be treated initially in a trauma center until stable before transfer to a burn center
  7. Children with burns seen in hospitals without qualified personnel or equipment for their care should be transferred to a burn center with these capabilities.

The **"Rule of Nines"** is used in the hospital management of severe burns to determine fluid replacement. It also is useful asa practical guide for the evaluation of severe burns. The adult body is generally divided into surface areas of 9% each and/or fractions or multiples of 9%.

Fig. 9 - Rule of Nines

(Graphics used with permission from LifeART Collections Images, Copyright © 1989-1997 by TechPool Studios, Cleveland, OH)



N. Unique and Special Patient Population Considerations:

Some factors should lower the threshold for a trauma evaluation. Patients over the age of fifty-five (55) have an increased risk due to co-morbid health factors. Children under the age of 14 have subtle anatomic and physiologic differences that require additional evaluation by a pediatric specialist.

1. **Suspected pediatric Child Abuse (Non-Accidental Trauma, NAT)**
   Additional evaluation by the pediatric surgeon is required as well as contact with the social worker on call when a pediatric patient is suspected of having been a victim of NAT.
2. **Suspected Domestic Violence and/or Sexual Assault**
   A trauma patient that is suspected of being a victim of sexual assault is required to be reported to law enforcement.
   A patient that may have been involved in a domestic violence situation, is reported to law enforcement if any injuries are present and is reported to social services for further consultation and referrals.
3. **Trauma in Pregnancy**
   A fetal heart rate should be obtained at the time of initial evaluation.
   All pregnant patients are evaluated by the trauma team. If the gestational age is =/> 20 weeks, they are also evaluated by the OB resident prior to disposition.
   If maternal injuries are deemed medically clear and admission is not needed, she will be discharged from the ED and sent to L&D for fetal cardiotocographic monitoring by the OB service.
   If maternal injuries require admission, the OB service will admit for further cardiotocographic fetal monitoring with the trauma service consulting.
   (See Article Appendix F)

4. **Victims of Violent crime**
   Any suspicion of violent crime is to be reported to law enforcement.
   Consideration of the possibility of evidence preservation during the course of patient care will assist in the recovery of evidence after the critical event.
   Security and Nursing staff can facilitate evidence collection and preservation.

5. **Death**
   The death of a trauma patient is a coroner's case.
   An autopsy finding report form (Autopsy Information Form--See Appendix H) should be filled out to include suspected injuries and therapy given. Additional copies are kept in the Trauma Service office, ICU, OR, and ED. Brain death criteria and donor request requirements are attached in Appendix I.

Appendix A Trauma Alert Decision Guidelines

Appendix B Clinical C-Spine Clearance Guideline

Clinical C-spine Clearance Guideline pg. 2

Clinical C-spine Clearance Guideline pg. 3

Clinical C-spine Clearance Guideline pg. 4

Clinical C-spine Clearance Guideline pg. 5

Appendix C Methylprednisolone Protocol for Acute Spinal Cord Injury

Appendix D Thoracic and Lumbar Spine Clearance

STANFORD HOSPITAL AND CLINICS
TRAUMA SERVICES

THORACIC AND LUMBAR SPINE CLEARANCE

PURPOSE

The diagnosis of an unstable spinal injury and its subsequent management can be difficult, and a missed spine injury can have devastating long-term consequences. Spinal column injury must therefore be presumed until it is excluded. The trauma policy regarding thoracic and lumbar spine (T/L-spine) clearance was developed to provide an appropriate course of action for evaluation of the potentially unstable spine.

IMPLEMENTATION

A. Careful evaluation for risk for having thoracic and/or lumbar spine injuries must be completed. The following types of patients should be carefully evaluated.

1. Patients who fall greater than 15 feet
2. Patients in motor vehicle collisions with high-speed deceleration, ejection, or other high-speed mechanism
3. Patients who complain of pain and/or tenderness in the thoracic and/or lumbar spinal area
4. Patients with concomitant cervical spine injury or any other spinal column or cord injury
5. Patients with known history of chronic spinal column disease
6. Any comatose patients
7. Patients with neurological deficits referable to the thoracic or lumbar/sacral spinal cord or nerve roots

B. The T/L spine can be <u>clinically</u> cleared (without obtaining radiographs) by the following individuals:

1. Trauma or ED Attending
2. **Neurosurgery or Orthopedic Attending**
3. Surgery R4 or higher or EM R3
4. Neurosurgery R3 or higher or Ortho R4 Chief Resident

C. Radiographic exam and clearance is done when clinical clearance is not indicated.

1. **Trauma plain films and CT scans:**
   a. If the patient is alert, awake, not intoxicated, neurologically normal, has no midline back pain or tenderness, and the history and physical do not suggest back injury-
      - The physician makes the determination, documents the exam findings in the medical record, and removes the patient from the long spine board after laterally log rolling the patient under strict spine precaution and palpating the spinous processes of each of the spine levels.
      - A comprehensive exam including rectal exam for any patients with potential thoracolumbar spine injury.

b. If the patient is alert, awake, and complains of back pain
   - Obtain plain films (anteroposterior and lateral views) of the thoracic and lumbar spine
   - Axial CT images at 3mm intervals should be obtained for any suspicious areas identified on the plain films.

c. If the patient has neurological deficits referable to a spine injury
   - Obtain plain films and CT images as described above
   - Obtain a MRI of the thoracic and/or lumbar spine if necessary
   - Obtain a spine surgery consultation

d. If the patient has altered mental status and return of normal mental status is not anticipated for a period of time, e.g., severe traumatic or hypoxic brain injury
   - Obtain plain films and CT images as described above in #2.

e. PEDIATRIC: Need a careful evaluation of risk. Nonverbal or preverbal pediatric patients are at special risk because they can't report back reliably or it is difficult to elicit report of back pain.

f. The patient is to remain on the logroll precautions until clinical clearance is complete or thoracolumbar imaging is negative. The backboard should be removed as soon as possible.

g. Should any abnormality be identified, appropriate consultation with neurosurgery/spine surgery will be obtained.

Awaiting final VP approval (due 6/04)

Appendix E Guidelines for ED Resuscitative Thoracotomy

Emergency Department Resuscitative Thoracotomy (EDRT) is an aggressive procedure to save a dying patient. The decision to perform this procedure should be guided by appropriate indications, prognostic factors, potential for survival, and the cost-benefit analysis.

Prognostic factors that have been identified in the literature include: mechanism and site of injury, presence of vital signs or signs of life at the scene and in the ED, total field time, and the expertise of the person performing the procedure. [1-11]

MECHANISM OF INJURY

Patients sustaining cardiac arrest subsequent to blunt trauma have an extremely poor prognosis, () – 2%). [1,9,10,11] In a recent study by Kavolius, et al., only one blunt-injured patient out of 57 who arrived in the ED without vital signs survived after EDRT. This patient suffered severe anoxic brain injury.[11]

Patients sustaining penetrating trauma have a statistically better chance of survival after EDRT compared with cardiac arrest victims from blunt trauma. Among patients with penetrating trauma, those with stab wounds have a better survival rate than those suffering cardiac arrest from gun shot wounds. Two studies have shown that isolated stab wounds to the heart have the best prognosis following EDRT, (survival rates of 22% and 37%).[2,3] The better survival rate seen with stab wounds is because cardiac arrest often results from pericardial tamponade, which can be rapidly reversed by EDRT.

DEFINING SIGNS OF LIFE AND VITAL SIGNS

Signs of life will be considered present when a trauma patient has one of the following: Supraventricular electrical cardiac activity with or without a palpable pulse, agonal respirations, pupillary reaction.[6]

Vital signs will be defined as either a palpable pulse, measurable blood pressure, or presence of spontaneous respirations.

PRE HOSPITAL FIELD TIME

Patients who initially have signs of life or vital signs in the field and subsequently develop cardiac arrest following penetrating trauma have a poor prognosis if transport time to definitive care is longer that 5 – 10 minutes.[8] Closed chest CPR is not effective in trauma patients and permanent brain injury occurs after 5 minutes without perfusion unless the patient is profoundly hypothermic.[1] EDRT should therefore not be performed on normothermic trauma patients who have been without signs of life for longer than 5 minutes before arrival in the Emergency Department.

Because cardiac arrest from blunt trauma has uniformly resulted in poor prognosis, EDRT should not be initiated unless the patient has signs of life on arrival or just prior to arrival in the ED.

EMERGENCY DEPARTMENT RESUSCITATIVE THORACOTOMY ALGORITHM

Institution of the algorithm should lead to standardization of indications for EDRT. It will also increase the cost of effectiveness of EDRT, and decrease unnecessary risks to health care providers without sacrificing the number of neurologically intact survivors.

1. Boyd M, Vincent VW: emergency Room Resuscitative Thoracotomy. When is it indicated? Journal of Trauma. 33: 714, 1992.
2. Vig D, Simoni E, smith RF, et al.: Resuscitative thoracotomy for patient with traumatic injury. Surgery 94; 554, 1983.
3. Rohman M, Ivatury RR, Steichen FM, et al: Emergency Room thoracotomy for penetrating cardiac injuries. J Trauma 23: 570, 1983.
4. Harnar TS, Oreskovich MR, Copass MK, et al: Role of emergency thoracotomy in the resuscitation of moribund trauma victims. AM J Surg 142: 96, 1981.
5. Felician DV, Mattax KL: Indications, technique, and pitfalls of emergency center thoracotomy. Surg Rounds (Dec) 4: 32, 1981
6. Brautigan MW, Tietz G: Emergency thoracotomy in an urban community hospital: initial cardiac rhythm as a new predictor of survival. AM J Emerg Med 3: 311, 1985.
7. Baker CC, Thomas AN, Trunkey DD: The role of emergency room thoracotomy in trauma. J Trauma 20: 848, 1986.
8. Clevenger FW, Yarbrough DR, Reines HD: “Resuscitative Thoracotomy”, The effect of field time on outcome. J Trauma 28: 1, 1988.
9. Ordog GJ: Emergency department thoracotomy in traumatic cardiac arrest. J Emerg Med 5: 217, 1987.
10. Shimaza S, Shatney CH: Outcomes of trauma patients with no vital signs on hospital admission. J Trauma 22: 213, 1983
11. Kavolius J, Golocovsky M, Champion HR: Predictors of outcome in patients who have sustained trauma and who undergo emergency thoracotomy. Arch Surg 128: 1158, 1993.

Appendix F Predictors of Outcome in Trauma During Pregnancy
Pg. 1

Predictors of Outcome during Pregnancy Pg. 2

Predictors of Outcome during Pregnancy Pg. 3

Predictors of Outcome during Pregnancy Pg. 4

Predictors of Outcome during Pregnancy Pg. 5

Predictors of Outcome during Pregnancy Pg. 6

Predictors of Outcome during Pregnancy Pg. 7

Predictors of Outcome during Pregnancy Pg. 8

Appendix G Autopsy Information Form

Appendix H   Referral Process of All Deaths

Appendix I Brain Death Protocol

Appendix J Brain Death SHC Administrative Manual