Airway/Maxillofacial/ Penetrating Neck/Thoracic/ Abdominal Trauma

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AIRWAY/MAXILLOFACIAL/PENETRATING NECK/THORACIC/ABDOMINAL TRAUMA

AIRWAY MANAGEMENT IN TRAUMA

I. INITIAL MANAGEMENT

A. Assess the airway: Common indications for advanced airway management in trauma

1. Cardiopulmonary arrest
2. Advanced hemorrhagic shock
3. Severe head injury
4. Significant airway burn
5. Penetrating face or neck wounds
6. Flail chest
7. Pulmonary contusion

B. Open the airway

1. Head Tilt & Chin lift vs Jaw thrust (C-spine Injury)

II. MAINTAINING THE AIRWAY

A. Oral adjunct

1. Indications: Unconscious patient
2. Contraindications: Awake patient
3. Size: Front teeth to angle of mandible
4. Technique of insertion: 180° then rotate (adults only) or use tongue depressor

B. Nasal adjunct

1. Indications
   a. Awake patient
   b. Intact gag reflex
2. Contraindications
   a. Coagulopathy
   b. Midface trauma
3. Size: Tip of nose to ear lobe. Same diameter as opening of nares
4. Technique of insertion
   a. Lubrication
   b. Direct posteriorly along floor nasal cavity into nasopharynx
III. NASOTRACHEAL INTUBATION

A. Advantages: Better tolerated
   1. Patient can’t bite tube
   2. Can be done in awake patient

B. Disadvantages
   1. Requires awake patient
   2. Sinusitis/otitis
   3. Blind insertion

C. Contraindications
   1. Apneic patient
   2. Pediatric patient
   3. Midface trauma
   4. Skull fracture
   5. Coagulopathy

D. Technique
   1. Local anesthesia
   2. Lubrication
   3. Gently insert one size smaller tube posteriorly into nasopharynx
   4. Listen for exhalation
   5. Advance tube during inhalation
   6. Confirm placement
      a. Inability to vocalize
      b. End tidal CO2
      c. Air movement through tube
      d. Thoracic breath sounds
      e. Chest X-ray

E. Complications
   1. Airway trauma
   2. Malposition

IV. OROTRACHEAL INTUBATION: TECHNIQUE OF CHOICE

A. Advantages
   1. Apneic patient
   2. Fewer infectious complications
B. Disadvantages

1. Patient discomfort

C. Laryngoscope selection

1. Miller blade
   a. Lifts epiglottis
   b. Harder to move tongue
   c. Harder to pass tube
2. Mac blade
   a. Lifts tongue
   b. Easier to move tongue
   c. Harder visualize

D. Technique

1. Sellick maneuver: “Cricoid pressure”
   a. To minimize aspiration
   b. Start when induction agent given
   c. Release after ETT placement confirmed and cuff inflated.
2. Patient positioning
   a. “Sniffing” if possible
   b. C-spine immobilization, not traction
3. Confirm placement:
   a. See tube pass through cords
   b. ETCO2 after 6 Bag Breaths
   c. Auscultation
   d. Condensation
   e. Chest X-ray

E. Complication

1. Malposition
   a. Right main stem intubations
   b. Esophageal intubations
2. Airway trauma
   a. Edema
   b. Hemorrhage

V. RAPID SEQUENCE INTUBATION IN TRAUMA

A. Induction agents

1. Etomidate (0.3mg/kg)
   a. Little effect on hemodynamics
   b. Lowers seizure threshold in patients with focal seizures
   c. Briefly suppresses cortisol production
2. Thiopental (3mg/kg)
a. Short acting barbiturate  
b. Cardiovascular depressant  
c. Lowers intracranial pressure  

3. Ketamine (2 mg/kg)  
a. Minimal cardiovascular effect  
b. Increases ICP & IOP  
c. Give with atropine to minimize secretions  
d. Give with Versed in adults to block emergence reactions  

B. Paralytic  

1. Succinylcholine (1.0-1.5mg/kg adults, 1.5-2.0mg/kg peds)  
a. Rapid onset and short duration  
c. Give with atropine in children to block excessive bradycardia  
2. Rocuronium (0.6-1.2mg/kg):  
a. Non-depolarizing  
b. Newer reversing agents in development  

C. Reduce intracranial pressure  

1. Lidocaine  
2. Defasciculating agent (1/10 RSI dose)  
3. Fentanyl  

<table>
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<tr>
<th>Special Situations</th>
<th>Low BP</th>
<th>Head Injury</th>
<th>Peds</th>
<th>Neck Trauma</th>
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</thead>
</table>
| Drugs              | Etomidate 20mg  
Sux 100mg       | Lido 100mg  
Pavulon 1mg  
Thiopental 200mg  
Sux 100mg | Give atropine with sux | Local Anesthesia and Sedation |
| Other              | Always Cspine Works for everyone | Especially Cspine | Age/4 + 4 = ET tube size | Foptics Best IF Plan Ahead |

VI. SURGICAL CRICOTHYROTOMY  

A. Indications  

1. Inability to intubate orally  
a. Glottic edema  
b. Laryngospasm
c. Severe oropharyngeal hemorrhage/secretions  
2. Adult patients

B. Contraindications

1. Laryngeal pathology  
2. Pediatric patient (<8 y/age)  
3. Tracheal transaction w/ retraction

C. Technique

1. Anatomic considerations  
   a. Cricothyroid membrane between thyroid and cricoid cartilages  
   b. Procedure:  
      i. Skin preparation  
      ii. Transverse incision 1-2cm  
      iii. Longitudinal ONLY if laryngeal pathology or significant edema  
      iv. Tracheal hook to stabilize thyroid cartilage  
      v. Dilation with hemostat or dilator  
      vi. Insert tube  
      vii. #4 or smaller Shiley  
      viii. 6.0 or smaller ETT  
      ix. Secure tube  
      x. Connect to ventilator/Ambu bag  
     xi. Confirm placement

D. Complications

1. Malposition  
   a. Soft tissues  
   b. Esophagus  
2. Bleeding  
   a. Incision too lateral  
   b. Anterior jugular veins  
   c. Thyroid vessels  
3. Wound infection  
4. Laryngeal injury  
   a. Fracture from oversized tube  
   b. Subglottic stenosis  
   c. Voice changes

VII. NEEDLE CRICOTHYROTOMY

A. Indications

1. Same as surgical cricothyrotomy
2. Pediatric patient (<8 years old)

B. Relative contraindications

1. Same as surgical cricothyrotomy
2. Adult patient

C. Technique

1. Skin preparation
2. 14 gauge over-needle catheter attached to 5ml syringe
3. Advance at 45° angle caudally until air is aspirated
4. Insert catheter while removing needle
5. Connect to oxygen source
   a. 3.0 ETT adapter and Ambu bag/ventilator
   b. Direct connection of high-flow oxygen tubing with Y connector or in-line side port
   c. Cycle ventilation (Inspiration 1 second: Expiration 4 seconds)
6. Confirm placement
7. Secure catheter without kinking
8. Convert to formal tracheostomy ASAP

VIII. OTHER AIRWAY TECHNIQUES

A. Laryngeal mask airway

1. Indications: Failed intubation and difficult to bag.
2. Pros: Easy to insert and buys time.

B. Fiberoptic intubation

1. Indications: Patients with maxillofacial and penetrating neck trauma, limited neck mobility or mouth opening, or prior history of difficult intubation.
3. Cons: Only if you got time to call anesthesia and have suctioned out all the blood and secretions.

C. Combitube

1. Indications: Not pretty, but it will get the job done.
2. Pros: Easy to insert and buys time.
3. Cons: Does not protect the airway. Vomiting may cause esophageal rupture.
D. Retrograde intubation

1. Indications: Severe orofacial trauma with airway distortion.
2. Pros: Another option of last resort in the “can’t intubate/can’t ventilate” failed airway nightmare, doesn’t require neck movement.
3. Cons: Contraindicated in coagulopathy, with an expanding hematoma, or inability to open mouth. Requires the right kit and experience.

IX. INHALATION INJURIES

A. Types of inhalation injury

1. Supraglottic injuries
   a. Thermal
   b. Upper airway edema
   c. Rapid onset
2. Infraglottic injury
   a. Chemical
   b. Tracheobronchiolitis
   c. Delayed presentation
3. Toxic gas poisoning
   a. Lack of tissue oxygenation

B. Indication for airway management

1. Historical
   a. Closed space
   b. Respiratory distress/arrest
2. Clinical
   a. Facial burns/singing
   b. Soot in nose/mouth
   c. Carbonaceous sputum
   d. Oropharyngeal edema
   e. Voice changes
   f. Stridor
   g. Rales/wheezing

C. Additional considerations

1. Carbon Monoxide
   a. Incomplete combustion of fossil fuels
   b. Pulse ox not helpful.
   c. “Cherry red” blood
   d. Levels on ABG or VBG:
      i. 0-15% - asymptomatic
      ii. 15-50% - progressive dysfunction
iii. >50% - lethal
2. Cyanide toxicity.
   a. Plastics and solvents.
   b. Metabolic acidosis with high lactate with normal PaO2.
   c. Poor man’s test = Increased venous O2 saturation.
   d. If suspected with CO poisoning, then treat with only IV sodium thiosulfate from kit or hydroxycovalmin.

D. Management

1. 100% oxygen
2. Early intubation
3. Bronchoscopy
4. Antidote specific as indicated

MAXILLOFACIAL TRAUMA

I. GENERAL PRINCIPLES

A. Rarely the direct cause of death. Other injuries take precedence. Exceptions:

   1. Distal carotid artery injury

B. Definitive treatment days later

   1. Tetanus & antibiotic prophylaxis
   2. Soft tissue swelling resolved
   3. Definitive CT imaging done
   4. Restore normal occlusion, then cosmetics

C. Force differential

   1. Weakest bones: nasal, zygoma, and angle of mandible
   2. Strongest bones: supraorbital rim, mandibular symphysis

II. INITIAL MANAGEMENT

A. Airway obstruction

   1. Aspiration of blood, saliva, teeth, vomit, etc.
   2. Inability to protrude tongue. Pull tongue with towel clip or suture.
   3. Edema of soft palate
   4. Maintain C-Spine precautions

B. Hemorrhage control
1. When other causes excluded
2. Local pressure
3. Sterile packing
4. Avoid blind clamping

III. DIAGNOSIS

A. History & physical
   1. Mechanism (consider abuse)
   2. Malocclusion
   3. Facial paresthesias
   4. Visual Symptoms
      a. Monocular diplopia – lens dislocation
      b. Binocular diplopia – extraocular muscle or nerve

B. Imaging
   1. Plain X-rays: Water’s Views screen in low risk patients
   2. CT scan: Definitive diagnosis and surgical planning

IV. MIDFACE FRACTURES

A. General principles
   1. Occur in any and all combination
   2. Initial treatment supportive
   3. Definitive repair days later

B. Zygomatic arch
   1. Isolated fractures uncommon
   2. Signs & symptoms
      a. Facial dimpling/depression
      b. Point tenderness
      c. Inability to open mouth

C. Tripod fractures: Zygomatic-maxillary complex (ZMC) fracture
   1. General principles
      a. Fractures occur at articulations with frontal bone, temporal bone, and maxilla
      b. Often cause entrapment
   2. Signs & symptoms
      a. Cheek or periorbital edema
      b. Facial flattening
      c. Circumorbital and subconjunctival ecchymosis
      d. Anesthesia of cheek, upper lip, teeth and gums
e. Step deformity and tenderness
f. Diplopia
g. Limitation of mandibular movement
h. Overlying emphysema
i. Intraoral ecchymosis of upper buccal sulcus

D. Orbit

1. Components
   a. Ethmoid, frontal, lacrimal, maxillary, sphenoid, zygomatic bones

2. General principles
   a. May be part of ZMC fracture
   b. Less commonly isolated “blowout” (floor/medial wall)
   c. Direct entrapment of EOM is rare. More commonly related to swelling.
   d. Orbital soft tissue may protrude into maxillary sinus

3. Signs & symptoms
   a. Inferior globe displacement
   b. Diplopia
   c. Infraorbital nerve hypoaesthesia
   d. Globe injury: corneal abrasion, scleral tears, etc.
   e. Evaluate orbit and retinal function (Marcus Gunn pupil and acuity)

E. Maxillary

1. LeFort I = Horizontal Maxillary Fracture. Above palate and below zygomatic process
   a. Motion of hard palate but not nose
   b. Many not displaced
   c. Subcutaneous air = sinus fracture

2. LeFort II = Pyramidal Fracture. Vertical fractures Extends through maxillary sinuses and infra-orbital rims bilaterally, across nasal bridge
   a. Motion of hard palate and nose but not eyes
   b. Entire midface swollen
   c. Bilateral subconjunctival hemorrhage
   d. Blood in nares, rhinorhea or otorhea

3. LeFort III = Craniofacial dysjunction. Through frontozygomatic sutures, across orbits through base of nose and ethmoid region.
   a. Lateral rim of orbit separated
   b. Motion of entire face but not head
   c. “Dishface” deformity
   d. Occlusion of posterior molars only
   e. CSF rhinorrhea
F. Nasal

1. Most common facial fracture  
2. Most displaced laterally or posteriorly  
3. Signs & symptoms  
   a. Crepitus  
   b. Hypermobility  
   c. Edema  
   d. Tenderness  
   e. Deformity  
   f. Minor epistaxis  
4. Diagnosis: Clinical. X-rays not necessary.  
5. Treatment  
   a. Control epistaxis  
   b. Treat septal hematoma  
      i. Benzocaine/Afrin or Cocaine  
      ii. I&D at inferior border  
      iii. Pack  
   c. Ice & analgesia  
6. Reevaluate in 1 week by PMD or plastic surgeon

V. MANDIBLE FRACTURES

A. Anatomic locations: Commonly two fractures similar to pelvic ring  

1. Condyle – 30%  
2. Angle/Ramus – 30%  
3. Body – 30%  

B. Symptoms  

1. Malocclusion  
2. Pain  
3. Signs  
4. Crepitance over fracture  
5. Decreased ROM
6. Swelling, ecchymosis and deformation
7. Deviation on opening
8. Mental nerve anesthesia
9. Inability to snap tongue blade

C. Extraoral examination

1. Palpate entire mandible
2. Numbness of lower lip

D. Intraoral examination

1. Note movement on mouth opening
2. Check for break in mucosa
3. Check for malocclusion
4. Loose teeth
5. Bloody secretions
6. Sublingual hematoma: consider airway protection

E. Radiographs

1. Panorex – Still BEST
2. CT mandible: preferred today by many oral surgeons

F. Condyle fractures

1. Jaw deviates toward fracture on maximal opening
2. If bilateral – no contact of incisors on occlusion

G. Angle/body fractures

1. Bilateral angle fractures causes bucket handle defect resulting in loss of anterior tongue support and risk of airway obstruction.

H. Symphysis fractures

1. Unusual because of thick bone
   a. Displaced lower incisors
   b. Disrupted arch continuity
   c. Segments easily moved on bimanual exam
   d. Potential for blunt carotid injury

I. Alveolar fractures

1. Anterior or incisor area most common
2. Preserve teeth
3. Most stabilized with wires or arch bars
J. Treatment

1. Remove nonviable teeth
2. Tetanus prophylaxis
3. Antibiotics for open fractures
4. Reduced by wiring upper and lower teeth in occlusion
5. Open fixation for edentulous or posterior segments

VI. AURICULAR INJURIES

A. Hematoma

1. Blood collects between perichondrium (blood supply) and cartilage (avascular). May occur after blunt or shear force without laceration.
2. Aspiration alone often leads to recurrence.
3. Incise along curvature of pinna no greater than 1 cm, evacuate, then irrigate.
4. Hold pressure for 5 minutes then antibiotic ointment, packing, and pressure dressing for 48 hours.
5. DC with PO antibiotics and recheck in 24 hours.

B. Laceration

1. Prevent skin and cartilage loss.
3. For large gaping wounds, close cartilage with 6.0 Nylon with small knots.
4. Hold pressure for 5 minutes, then antibiotic ointment and non-adherent gauze over wound. Apply pressure dressing for 48 hours.
5. DC with PO antibiotics and recheck in 24 hours.
6. Refer patients with significant amount of avulsed skin to plastic surgeons for a flap closure.

PENETRATING NECK TRAUMA

I. GENERAL PRINCIPLES

A. Multiple injuries common

1. Vascular
2. Respiratory
3. Neurologic
4. Aerodigestive (esophagus and oropharynx)
5. Skeletal
B. Anatomic boundaries

1. Zone I = “Thoracic Outlet”
   a. Superior to sternal notch
   b. Inferior to cricoid cartilage
   c. Subclavian and carotid vessels, trachea, esophagus

2. Zone II
   a. Superior to cricoid cartilage
   b. Inferior to angle of mandible
   c. Ability to obtain proximal and distal vascular control
   d. Carotid arteries, larynx & trachea, esophagus

3. Zone III
   a. Superior to angle of mandible
   b. Inferior to base of skull
   c. Distal carotids, oropharynx

4. Posterior neck
   a. Posterior to sternocleidomastoid
   b. Superior to thoracic vertebrae
   c. Inferior to base of skull
   d. Vertebral arteries, spinal cord, vertebrae

5. Layers:
   a. Platysma: Wounds that violate the platysma require aggressive evaluation.
   b. Deep cervical fascia:
      i. Prevents external bleeding.
      ii. Hematoma may lead to extrinsic compression of nearby structures.
      iii. May lead to spread of infection to mediastinum.
II. INITIAL MANAGEMENT

A. Primary Survey

1. Airway: Indications for definitive airway
   a. Acute respiratory distress
   b. Airway compromise from blood or secretions
   c. Expanding hematoma
   d. Massive subcutaneous emphysema
   e. Tracheal shift
   f. Impending respiratory arrest
   g. AMS

2. Breathing
   a. R/O associated pulmonary injury

3. Circulation
   a. Hemorrhage – external, contained, or internal
   b. Control with direct pressure or packing
   c. Avoid blind clamping and valsalva

B. Secondary Survey

1. Physical examination
   a. Check for platysma violation
   b. **Do not probe** wounds
   c. Check for “Hard Signs” of neck injury
   d. Strangulation often results in petechiae and subconjunctival hemorrhage

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<tr>
<th>Tract</th>
<th>Hard Signs</th>
<th>Soft Signs</th>
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<tr>
<td>Vascular</td>
<td>Hypotension in ED</td>
<td>Hypotension in field</td>
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<tr>
<td></td>
<td>Active arterial bleeding</td>
<td>History of arterial bleeding</td>
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<tr>
<td></td>
<td>Diminished carotid pulse</td>
<td>Tracheal deviation</td>
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<td></td>
<td>Expanding hematoma</td>
<td>Large hematoma</td>
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<td></td>
<td>Trill or bruit</td>
<td>Apical capping on Chest XR</td>
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<td>Laryngeotracheal</td>
<td>Air or bubbling in wounds</td>
<td>Subcutaneous emphysema</td>
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<td></td>
<td>Hemoptysis</td>
<td>Stridor, hoarseness</td>
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<td>Esophageal</td>
<td>Hematemesis</td>
<td>Dysphagia</td>
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<tr>
<td>Neurologic</td>
<td>Lateralizing signs</td>
<td>Vocal cord paralysis</td>
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<td></td>
<td></td>
<td>Seventh cranial nerve palsy</td>
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<td></td>
<td></td>
<td>Unexplained bradycardia</td>
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</table>
2. Plain radiographs  
   a. Retained foreign body  
   b. Retropharyngeal/ subQ air  
   c. Bony/ cartilaginous injury  
   d. Intrathoracic injury  
3. CT of the neck  
   a. Delineates path of bullet/knife and proximity to underlying structures  
   b. Sensitivity approaching other studies across zones.  
4. Esophageal studies: Requires both esophagoscopy followed by esophagram to reliably exclude injury.

III. MANDATORY VERSUS SELECTIVE EXPLORATION OF ZONE II NECK INJURIES

A. Mandatory exploration

1. Pre WWII – Expectant management with high mortality  
2. WWII and Korean – Decreased mortality with mandatory exploration  
3. Indications for emergent operative exploration  
   a. External hemorrhage  
   b. Expanding hematoma  
   c. Unstable  
   d. Obvious aerodigestive injury

B. Selective management

1. Indications for selective management  
   a. Absence of above findings  
   b. Stable patient  
   c. Institutional capabilities  
2. Pros  
   a. Accuracy nearly equivalent to exploration  
   b. Fewer negative explorations  
   c. Shorter hospital stay  
3. Cons  
   a. No missed injuries with mandatory exploration  
   b. May delay definitive operation  
   c. Requires 24 hour support
### Summary of Work Up by Zone

<table>
<thead>
<tr>
<th>Zone I</th>
<th>Zone II</th>
<th>Zone III</th>
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</table>
| Angio of Arch and Great Vessels  
Consider esophagoscopy and esophagram  
Bronchoscopy with signs or symptoms of LT injury | Angiography of carotids and vertebrais  
Esophagoscopy and esophagram  
Bronchoscopy with signs or symptoms of LT injury | Examination of Oropharynx  
Angiography of carotids |

### THORACIC TRAUMA

I. **GENERAL PRINCIPLES:**

A. Second leading cause of traumatic death behind traumatic brain injury.

1. Death on scene: Cardiac and great vessel injury
2. Mortality w/in the “Golden Hour” (target of primary survey)
   a. Airway obstruction
   b. Tension pneumothorax
   c. Massive hemothorax
   d. Open pneumothorax
   e. Flail chest
   f. Cardiac tamponade

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<th><strong>Emergent Life Threats</strong></th>
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<tr>
<td><strong>Dx</strong></td>
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<tr>
<td>Airway Obstruction</td>
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</table>
| Tension PTX               | JVD  
Tracheal Deviation  
Absent Breath Sounds  
Hyperresonant          | Needle                                |
| Massive HTX               | Diminished Breath Sounds  
Dullness to percussion    | Chest Tube then OR               |
| Open PTX                  | Sucking Chest Wound  
Three sided tape Chest tube |                                  |
| Flail Chest               | Paradoxical Chest Wall Motion  
Positive Pressure Ventilation |                                  |
| Cardiac Tamponade         | JVD  
Hypotension  
Muffled Heart Sounds    | IVF’s  
Needle  
OR                       |
B. Indications for airway management

1. Airway protection
2. Oxygenation
3. Ventilation
4. Planned Procedures

C. Central venous access

1. If central line needed above the waist (pelvic fracture), then place line on side of injury to avoid dropping remaining uninjured lung.
2. With possible injury to vasculature, especially the SVC, place IV or central line below the waist.

II. CHEST WALL INJURIES

A. Rib fractures

1. Significance of this injury is not fracture itself but associated injuries (e.g., PTX, HTX)
   a. Fractures of ribs 1st and 2nd require high force and often associated with other injuries.
   b. 4th – 9th most commonly involved
   c. Fracture of 6th – 12th associated with intra-abdominal injury
2. Upright CXR
   a. Does not demonstrate fracture in up to 50%.
   b. Useful for evaluating possible intrathoracic or mediastinal injury.
3. Rib film indications:
   a. Suspected fracture # 1-3 or # 9-12
   b. Multiple fractures
   c. Elderly patient
   d. Pulmonary disease
4. Management:
   a. Simple fractures – oral analgesics and pulmonary toilet
   b. Multiple fractures - Admit elderly, cardiopulmonary comorbidities, or inability to clear secretions despite pain control

B. Sternal fractures

1. Usually secondary to blunt anterior chest trauma (restrained passenger in MVC)
2. Isolated sternal fractures typically benign
3. Complications
   a. Cardiac 1.5 – 6%
   b. Spinal fractures < 10%
c. Rib fractures 21%
d. No association between sternal fracture and aortic rupture.

4. Workup
a. CXR: Lateral views best for making diagnosis
b. CT: Best for evaluating for suspected secondary mediastinal injuries.
c. EKG: At 0 and 6 hours to evaluate for blunt cardiac injury.

5. Management and disposition: Same as rib fracture.

C. Flail chest

1. Three or more adjacent ribs are fractured at two or more sites with paradoxical movement of the chest wall segment
   a. Pre-hospital intubation and positive pressure ventilation splints the chest wall hindering the clinical diagnosis.
   b. Pulmonary contusion is the major cause of respiratory insufficiency.
2. Workup
   a. CXR: Multiple rib fractures usually identified.
   b. CT: More accurate than CXR when evaluating for the presence and extent of pulmonary contusion and associated injury.
3. Management:
   a. Pulmonary physiotherapy, effective analgesia, and selective use of endotracheal intubation
   b. NIPPV may avoid the need for intubation.
   c. Judicious fluid administration.

III. PULMONARY INJURIES

A. Pulmonary contusion

1. Found in more than 50% of patients with major blunt thoracic trauma
3. Trauma results in injury to the lung parenchyma. Overzealous fluid resuscitation leads to alveolar edema and hemorrhage.
4. Clinical findings include dyspnea, tachypnea, cyanosis, tachycardia, dry to wet rales, and hypotension.
5. CXR: Unilateral areas of patchy consolidation beneath the site of injury. Often delayed up to 6 hours.
6. Management: Same as for flail chest.
   a. Greater than 25% contusion often requires mechanical ventilation.

B. Pneumothorax

1. Most common injury after penetrating chest trauma. Typically
accompanied by hemothorax.

2. Types:
   a. Simple: No communication with the atmosphere and no mediastinal shift.
   b. Open pneumothorax: Chest wall defect greater than 2/3 tracheal diameter producing “sucking chest wound”
   c. Tension pneumothorax: Progressive accumulation of air within the pleural space causes shift of the mediastinum and compression of the contra-lateral lung and great vessels.

3. Shortness of breath and chest pain are the most common presenting complaints. But the signs and symptoms often do not correlate with the degree of pneumothorax.

4. CXR: Obtain an expiratory if a suspected PTX is not visualized on the initial inspiratory film.

5. Management:
   a. Severe dyspnea, hypotension, tracheal deviation and JVD = tension pneumothorax
      i. Long 14 gauge needle in midclavicular line just over rib.
      ii. Coverts tension to open PTX. Follow with chest tube.
   b. Indications for closed-tube thoracostomy:
      i. Traumatic pneumothorax
      ii. Moderate-to-large pneumothorax
      iii. Respiratory symptoms regardless of the size
      iv. Increasing size
      v. Patient requires general anesthesia
      vi. Associated hemothorax
      vii. Bilateral pneumothorax regardless of size
   c. Occult PTX seen only on CT do not require immediate tube thoracostomy unless patient requires mechanical ventilation.
   d. If no pneumothorax on initial film and patient asymptomatic, may be safe to discharge if 3 hour repeat film remains negative.

C. Hemothorax

1. Accumulation of blood in the pleural space after blunt or penetrating chest trauma. Sources in order of frequency and least to most volume of bleeding:
   a. Lung parenchyma
   b. Intercostal artery
   c. Great vessel injury

2. Massive hemothorax = >1500ml of blood in adult patients.

3. Imaging
   a. CXR
      i. 200 to 300 ml of fluid will result in blunting of the costophrenic angles on upright CXR.
      ii. Supine films may have only a hazy appearance to lung base with up to 1000ml of fluid.
b. FAST: Detects 50 ml of blood.

4. Management
   a. 36-40F tube thoracostomy
   b. Indications for OR thoracotomy
      i. Initial thoracostomy tube drainage is > 20 ml/kg of blood or 1500 ml.
      ii. Increasing hemothorax seen on chest X-ray studies
      iii. Patient remains hypotensive despite adequate blood replacement and other sites of blood loss have been ruled out
      iv. Patient decompensates after initial response to resuscitation.

D. Tracheobronchial injury

1. Sudden deceleration with shearing of more mobile distal segments from fixed proximal segments.
2. Most occur within 2cm of carina
3. Symptoms
   a. Hemothysis, dyspnea, subcutaneous emphysema, Hamman’s crunch, and sternal tenderness.
   b. Up to 10% are asymptomatic.
4. Workup
   a. CXR: Findings include large PTX, pneumomediastinum, deep cervical emphysema or rounded appearing endotracheal balloon.
   b. Bronchoscopy: Perform when injury suspected.
5. Management:
   a. Gentle intubation over a bronchoscope (to limit injury progression)
   b. Operative repair

IV. CARDIOVASCULAR INJURIES

A. Blunt cardiac injury: Spectrum of disease from myocardial concussion to myocardial; rupture.

1. Myocardial concussion (Commotio Cordis) - blow to chest during repolarization resulting in life-threatening dysrhythmia
   a. Classic case is young baseball player hit in chest by pitch.

B. Myocardial contusion

1. Most common and least serious complication
3. Results from a direct blow or compression between the sternum and vertebrae.
4. Most commonly affects anterior right ventricle, anterior
interventricular septum, and anterior-apical left ventricle.
5. Clinical findings may not be present. Suspect in any patient with moderate to severe upper abdomen or chest trauma.
6. Workup
   a. EKG: Findings include tachycardia out of proportion to blood loss, arrhythmias especially PVC’s and atrial fibrillation, and conduction defects.
   b. Cardiac enzymes: Repeatedly proven to be ineffective and costly. Exception being patient with chest pain who crashed care driving to hospital.
   c. Echocardiography: For patients with dysrhythmias or cardiac dysfunction.
7. Management:
   a. Admit patients with new EKG abnormalities for 24 hours. Provide close follow up at DC for eval of possible complications including post traumatic pericarditis, VSD, valve defect and ventricular aneurysms.
   b. Patients with normal initial EKGs may be discharged after 4 hours of monitoring.

<table>
<thead>
<tr>
<th>Urgent Life Threats: Consider during the Secondary Survey</th>
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<tbody>
<tr>
<td>Dx</td>
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<tr>
<td>Rib and Sternum Fx</td>
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<td>PTX</td>
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<td>Pulmonary Contusion</td>
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<tr>
<td>Blunt Cardiac Injury</td>
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<tr>
<td>Traumatic Aortic Injury</td>
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<tr>
<td>CT Screen Angio if Equivocal</td>
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<tr>
<td>Diaphragm Injury</td>
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</table>

C. Acute pericardial tamponade

1. Less than 25% of penetrating cardiac injuries survive to reach the hospital.
2. Most common with isolated stab wound to the RV
3. Rarely seen with blunt trauma
4. Clinical exam
   a. Tachycardia and hypotension
   b. Beck’s triad of hypotension, distended neck veins, muffled
heart tones occurs immediately before death

5. Workup
   a. CXR and EKG: Rarely helpful. Electrical alternans has been reported as a highly specific marker of pericardial tamponade only in medical effusions.
   b. Ultrasound: Sensitive for the detection of pericardial fluid and tamponade (diastolic collapse of the right ventricle).

6. Management:
   a. Aggressive IVF resuscitation to increase filling pressures in right atrium.
   b. Pericardiocentesis: Temporizing measure for patients in shock when immediate OR not an option. High incidence of false positives and negatives.
   c. Thoracotomy for patients in extremis despite IVFs with suspected cardiac injury.

D. Blunt Aortic Injury (BAI)

1. 80% dies at scene. 50% of survivors will die within 24 hours.
2. Suspect in patients with sudden deceleration or high-speed side impact injuries
3. 90% of BAI occurs in the descending aorta at the isthmus between the left subclavian artery and the ligamentum arteriosum.
4. Most patients are asymptomatic
5. Workup
   a. CXR findings (Up to 1/3 normal initially)
      i. Widened mediastinum. Most sensitive sign, subjective impression of two experienced physicians.
      ii. Obscured aortic knob
      iii. Displacement of left mainstem bronchus downward/right upwards.
      iv. Displaced nasogastric tube
      v. Widened paratracheal stripe
      vi. Widened right paraspinal interface
      vii. Apical cap
   b. CT: New generation helical CT scans nearly 100% sensitive for detecting BAI. (normal -> workup done)
   c. Transesophageal echocardiography (TEE): Alternative to CT in unstable patient. Identifies intimal flap and periaortic hematoma.
   d. Aortography: Still the gold standard.
6. Management:
   a. Maintain BP between 100-120 mmHg systolic
   b. Operative repair
V. ESOPHAGEAL INJURIES

A. High mortality secondary to spillage of contents into the mediastinum with secondary infection (mortality is 5-25% if repaired within 12 hours. 25-66% if treated after 24 hours)

B. Most common causes of esophageal perforation:
   1. Iatrogenic
   2. Foreign bodies
   3. Caustic burns
   4. Blunt or penetrating trauma
   5. Spontaneous rupture (Boerhaave’s syndrome)

C. Clinical findings
   1. Most reliable symptom of an esophageal injury is pleuritic pain exacerbated by swallowing or neck flexion.
   2. Mediastinal air surrounding the heart may produce the systolic crunching sound known as Hamman’s sign.

D. Workup:
   1. CXR
      a. Mediastinal air with or without subcutaneous emphysema
      b. Left-side pleural effusion
      c. Pneumothorax
      d. Widened mediastinum
   2. Scope and Swallow: Requires esophagoscopy followed by contrast studies to reliably exclude injury.

E. Management
   1. NPO
   2. Broad-spectrum antibiotic therapy (covering oral flora)
   3. Volume replacement
   4. Emergency surgical consultation

VI. DIAPHRAGMATIC INJURIES

A. More common from penetrating trauma.

B. Right sided and small penetrating injuries more difficult to diagnose.

C. Suspect in any patient with intra-thoracic injury resulting from apparent penetrating abdominal trauma.
1. Workup
   a. CXR: Most commonly an indistinct left hemidiaphragm and focal atelectasis in the left lower lobe. Occasionally viscera or a nasogastric tube above the diaphragm in the left hemithorax.
   b. CT scan and Upper GI may help diagnose but inadequate to definitively rule out
   c. Consider DPL with penetrating thoracoabdominal trauma, counts > 10K necessitate OR evaluation

D. Management: Injuries not diagnosed initially may become clinically evident months to years later. Herniation leads to complications such as visceral incarceration, obstruction, and ischemia.

ABDOMINAL TRAUMA

I. GENERAL PRINCIPLES:
   A. Most common cause of non-intentional death and disability in the United States is the MVC followed by falls.

1. Blunt injuries
   a. Mortality greater in blunt injuries due to difficulty in diagnosis.
   b. Direct transmission of energy in crushing or compression mechanisms results in diffuse pattern of injury
   c. Falls more likely to result in hollow viscus injuries resulting from movement of more mobile organs around fixed attachments such as the mesentery, ligament of Treitz and mobile small bowel at fixed right colon.
   d. Retroperitoneal injury commonly results from falls with vertical force transmitted up the axial skeleton or from high speed horizontal deceleration injury.

2. Penetrating injuries:
   a. Gunshot wounds:
      i. Direct injury in path of missile.
      ii. Secondary injury from bone or bullet fragments and along blast cavity.
   b. Stab wounds
      i. Injury confined to path of object. Depth and angle often impossible to predict from history and physical exam.
      ii. If local wound exploration by surgeon clearly demonstrates no peritoneal violation, treat like any other similar wound.

II. SOLID ORGAN INJURY
   A. Morbidity and mortality due to blood loss. Most common presenting
signs are tachycardia and hypotension with abdominal tenderness progressing to rigidity

1. Suspect in any patient with injury to the lower ribs, abdomen or pelvis.
2. Younger patients, pregnant or intoxicated patients, and those with distracting injury / head trauma may present with minimal initial symptoms.
3. The spleen is the organ most often injured organ in blunt trauma.
4. Serial physical exams (Kehr’s sign - pain referred to the shoulder due to intraperitoneal blood)

III. HOLLOW VISCUS INJURIES

A. Most commonly from penetrating injury to small bowel but may occur with deceleration injuries.

1. Symptoms secondary to blood loss and/or perforation with contamination and infection.
2. May have minimal initial symptoms
3. Peritonitis can take up to 8 hours to develop

IV. RETROPERITONEAL INJURY

A. Duodenal injuries

1. Hematoma secondary to crush injuries.
2. Very slow to develop as contained initially in retroperitoneum
3. Symptoms usually vague including abdominal pain, nausea/vomiting, and fever

B. Pancreatic injuries

1. Classic mechanism is secondary to blunt forces from a handlebar or steering wheel
2. Leakage of enzymes causes autodigestion, superinfection, and abscess.

V. WORK UP:

A. Laboratory:

1. Initial hematocrit reflects baseline. Serial determinations more helpful.
2. Neither serum amylase nor lipase is useful when obtained routinely.
   a. Normal levels do not exclude a major pancreatic injury in adult patients.
b. Frequently utilized in pediatric patients due to less reliable exam and reluctance to CT

B. Radiographs:

1. CXR: Check for free air and herniated contents
2. AP Pelvis: Pelvic fractures often associated with abdominal injury
3. KUB
   a. Blunt: Routine use not cost effective
   b. Penetrating: Mark the wounds and connect the dots to help estimate path of bullet

<table>
<thead>
<tr>
<th></th>
<th>DPL</th>
<th>FAST</th>
<th>CT</th>
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</thead>
<tbody>
<tr>
<td>Pros</td>
<td>Most sensitive</td>
<td>Sensitive</td>
<td>Sensitive and SPECIFIC</td>
</tr>
<tr>
<td></td>
<td>Unstable patients</td>
<td>Noninvasive</td>
<td>Evaluates retroperitoneum</td>
</tr>
<tr>
<td></td>
<td>“Easy” to perform</td>
<td>Evaluates chest and abdomen</td>
<td>Identifies non operative injury</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rapid and repeatable</td>
<td></td>
</tr>
<tr>
<td>Cons</td>
<td>Too sensitive</td>
<td>Operator and patient</td>
<td>Cost, radiation,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dependent</td>
<td>time and dye</td>
</tr>
</tbody>
</table>

C. DPL: Replaced by FAST and CT today as per ACEP Clinical Policy in references

1. Pros: Sensitive, relatively fast, readily available and low complication rate
2. Cons: Not helpful in retroperitoneal injuries, lack of specificity, potential for iatrogenic injury, and overly sensitive. Non-therapeutic laparotomy rate of up to 30%.
3. Indications
   a. Blunt trauma indications:
      i. Too unstable for CT.
      ii. Unexplained hypotension with +/- physical exam.
   b. Penetrating trauma indications
      i. Uncertain whether exploratory laparotomy needed.
      ii. Stab wounds
      iii. Confirming negative physical exams in patients with lower chest wounds.
4. Contraindications:
   a. Patient should be in OR
   b. Relatives: Advanced hepatic failure, coagulopathies, prior abdominal surgeries, and pregnancy.
5. Counts:
   a. Aspiration of 10mL of gross blood is positive (should really make you wonder why you thought you had to tap him anyways)
b. Blunt abdominal trauma and anterior abdominal stab wounds:
   > 100,000 RBCs

c. Everything else: > 10,000 RBCs (tangential GSW, thoracoabdominal wound, back and flank wound and penetrating pelvic wound)

d. Less helpful: WBC > 500, bile or vegetable

D. FAST: Accurate Screening Tool - Sensitive but not specific.

1. Recommended in place of DPL by ACEP Clinical Policy

2. Pros:
   a. Rapid, repeatable, noninvasive, and free from contrast or radiation
   b. Very helpful in patients with relative contraindications to DPL
   c. Screens for intra-abdominal, pleural and pericardial fluid.

3. Cons:
   a. Nonspecific and operator dependent
   b. No definitive evaluation of retroperitoneum
   c. Difficult in obese, post burrito, and ascites

NORMAL RUQ VIEW                RUQ VIEW WITH FREE FLUID
                             IN MORRISON’ S POUCH

NORMAL SUBX VIEW              SUBX VIEW WITH FREE FLUID
E. CT:

1. Pros:
   a. Greater specificity
   b. Localizes injury and evaluates retroperitoneum
   c. Identifies non-operative injuries
   d. Noninvasive.
2. Cons:
   a. Expensive
   b. Radiation and contrast exposure
   c. Time consuming
   d. Outside of resus bay

### Work Up by Zones in Penetrating Trauma

<table>
<thead>
<tr>
<th>Zone</th>
<th>Definition</th>
<th>Workup</th>
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<tbody>
<tr>
<td>Anterior Box</td>
<td>Sternal notch to costal margin</td>
<td>Echo</td>
</tr>
<tr>
<td></td>
<td>Between nipples</td>
<td></td>
</tr>
<tr>
<td>Posterior Cardiac Box</td>
<td>Between scapula</td>
<td>GSW: Arch Angio, Eso w/up, +/- Bronch</td>
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<td>SW: If abnl mediastinum on CXR then above</td>
</tr>
<tr>
<td>Thoracoabdominal</td>
<td>Below nipples and scapula to inferior costal margins</td>
<td>CXR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DPL</td>
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<tr>
<td></td>
<td></td>
<td>CT</td>
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</tbody>
</table>
### Anterior Abdomen

- Costal margins to inguinal ligaments
- Between midaxillary lines

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<thead>
<tr>
<th>CT</th>
<th>DPL</th>
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### Back and Flank

- Between scapula and iliac crest
- Posterior to midaxillary lines

<table>
<thead>
<tr>
<th>Triple contrast CT</th>
<th>DPL</th>
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**VI. PELVIC FRACTURE WORK UP BY MECHANISM**

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Workup</th>
</tr>
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<tbody>
<tr>
<td>Blunt (Significant Fractures)</td>
<td>Retrograde urethrogram before foley (especially with blood at meatus, scrotal hematoma or high riding prostate) then cystogram.</td>
</tr>
<tr>
<td>Penetrating</td>
<td>Outlet Tracts: Cystogram, proctoscopy, and vaginal speculum exam.</td>
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</tbody>
</table>
## VII. INDICATIONS FOR LAPAROTOMY

<table>
<thead>
<tr>
<th>Blunt</th>
<th>Penetrating</th>
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<tbody>
<tr>
<td>Definitely</td>
<td>Shock</td>
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<tr>
<td>Anterior abdominal injury with hypotension</td>
<td>Transabdominal GSW</td>
</tr>
<tr>
<td>Abdominal wall disruption</td>
<td>Injury to abdomen, back or flanks with hypotension</td>
</tr>
<tr>
<td>Peritonitis or Free Air</td>
<td>Evisceration or retained implement</td>
</tr>
<tr>
<td>CT injury (Pancreatic transection or duodenal rupture)</td>
<td>Abdominal tenderness</td>
</tr>
<tr>
<td>Gross blood per NG or rectal</td>
<td>Gross blood per NG or rectal</td>
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<tr>
<td></td>
<td>Positive DPL</td>
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<tr>
<td></td>
<td>CT injury (Ureter or pancreas)</td>
</tr>
<tr>
<td>Maybe</td>
<td>Positive local wound exploration</td>
</tr>
<tr>
<td>Positive DPL or FAST in stable patient</td>
<td></td>
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<tr>
<td>Solid organ injury in stable patient</td>
<td></td>
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<tr>
<td>Hemoperitoneum without clear source</td>
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</table>
AIRWAY/MAXILLOFACIAL/PENETRATING NECK/THORACIC/ABDOMINAL TRAUMA

PEARLS

Airway Management in Trauma

1. Trauma Airway Management = ACBCs. Always assume cervical spine injury.

2. Nasal trumpets if awake, oral airways only if unconscious.

3. Nasotracheal intubation only if breathing spontaneously and no facial trauma.

4. 20mg of Etomidate and 100mg of Sux will intubate anyone. But 100mg of Lidocaine, 1mg of Pavulon, 200mg thiopental and 100mg of Sux better in head injury patient.

5. Horizontal Surgical Cricothyrotomy if you have a cricothyroid membrane. Vertical incision if landmarks grossly distorted. Needle Cric if less than < 8 years old.


7. Singed face and hair or soot in airway = supraglottic injury. Intubate now.

8. Infraglottic injury more subtle but can be just as deadly!

Maxillofacial Trauma

1. Always look for more than one fracture site when dealing with ring structures such as the pelvis, ankle and mandible.

2. Rule out globe injury with any orbital fracture.

3. LeFort fractures may result in retropharyngeal hematoma and airway obstruction.

4. Sublingual or buccal ecchymosis is pathognomonic for a mandibular fracture.

5. Recognize and drain septal and auricular hematomas on presentation to avoid significant deformity later.
Penetrating Neck Trauma

1. Early intubation always leads to easier intubation, especially in cases of expanding hematomas.

2. Always consider injury to all tracts; airway, vascular, GI and neurologic systems.

3. Selective Management is indicated in stable Zone II injuries without hard signs of injury when diagnostic modalities and surgical expertise is readily available.

4. Esophagram and esophagoscopy necessary to reliably exclude Zone I and Zone II esophageal injury and prevent life-threatening mediastinitis.

Thoracic Trauma

1. Emergent life threats to recognize and treat during the primary survey include; airway obstruction, tension pneumothorax, massive hemothrorax, open pneumothorax, flail chest and cardiac tamponade.

2. Tension Pneumothorax is a clinical diagnosis: JVD, tracheal deviation away from side of injury, and no breath sounds on affected side.

3. Cardiac Tamponade: JVD, diminished heart sounds, and hypotension.

4. Right Main Stem Intubation: JVD, tracheal deviation to left, normal resonance, breath sounds on right but diminished on left.

5. Underlying pulmonary contusion the real problem in flail chest. Intubate early and don’t overhydrate!

6. Labored breathing, hemoptysis, subcutaneous emphysema, tension PTX, persistent air leak from chest tube = tracheobronchial injury. Confirm with bronchoscopy.

7. Pneumomediastinum results from esophageal perforation, bronchial injury, and interstitial pulmonary emphysema extending to the mediastinum.

8. Troponins not helpful in blunt cardiac injury. Admit people with abnormal EKG’s. Get Echo if unstable.
9. Traumatic Aortic Injury surviving to reach the ED are held together by the adventitia but will rupture within 24 hours if not detected. Get the CTA to screen and control the BP!


11. Rare and likely fatal air embolism occurs after combined pulmonary and vascular injury especially with concurrent positive pressure ventilation. Displace air from right ventricle outflow tract by placing head and left side down. Use echo for diagnosis and guidance for removal.

Abdominal Trauma


2. Handlebars to epigastrium: Pancreatic or duodenal injury.


4. FAST: Bedside repeatable screening test for stable and unstable patients.

5. CT: Greater specificity than DPL or FAST. Sensitivity approaching DPL without high negative lap rate. Evaluates solid organs, retroperitoneum and pelvis.
REFERENCES


