Anesthesia for Trauma

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OVERVIEW

• “It’s not the speed which kills, it’s the sudden stop”
Epidemiology of Trauma

- ~8% worldwide death rate
- Leading cause of death in Americans from 1-45 years of age
- MVC's leading cause of death
- Blunt > penetrating
- Often drug abusers, acutely intoxicated, HIV and Hepatitis carriers
Epidemiology of Trauma

• “Golden Hour”
  - First hour after injury
  - 50% of patients die within the first seconds to minutes \(\rightarrow\) extent of injuries
  - 30% of patients die in next few hours \(\rightarrow\) major hemorrhage
  - Rest may die in weeks \(\rightarrow\) sepsis, MOSF
Pre-hospital Care

- ABC’S
  - Initial assessment and BLS in trauma
  - GO TEAM: role of CRNA’s at Maryland Shock Trauma Center

- Resuscitation
- Reduction of fractures
- Extrication of trapped victims
- Amputation
- Uncooperative patients
Initial Management Plan

- Airway maintenance with cervical spine protection
- Breathing: ventilation and oxygenation
- Circulation with hemorrhage control
- Disability
- Exposure
Initial Assessment

Primary Survey:

- AIRWAY
  - ALWAYS ASSUME A CERVICAL SPINE INJURY EXISTS UNTIL PROVEN OTHERWISE
  - Provide MANUAL IN-LINE NECK STABILIZATION
  - Jaw-thrust maneuver
Initial Assessment

• Airway cont’d:
  - Cervical spine evaluation
    • Cross table lateral and swimmer’s view Xray
    • Need to see all seven cervical vertebrae
    • Only negative CT scan R/O injury
Initial Assessment

• Cervical spine cont’d:
  - Functional assessment of cervical level
    • C5  Biceps   Abduct shoulder,  Flex elbow
    • C6  Wrist extensors  Cock wrist
    • C7  Triceps  Extend elbow
    • C8  Finger flexors Grasp finger in palm
    • T1  Finger abductors  Spread fingers
Initial Assessment

ALWAYS ASSUME FULL STOMACH PRECAUTIONS ➔ RAPID SEQUENCE INTUBATION

• Indications for intubation:
  - Airway obstruction
  - PaO2 < 80 mmHg or SpO2 < 90% with O2
  - Shock with SBP < 90 mmHg
  - Severe head injury or unconscious (GCS <9)
  - Anticipated surgery with multisystem injury
  - Combativeness
Initial Assessment

• Rapid sequence intubation (or modified)
  - Preox
    • Use slow inspiratory flow rates (1-1.5 sec inspiratory time)
    • Avoid stomach distention → gastric inflation occurs when inspiratory pressure exceeds EOP (~15-18 cm H2O)
  - “Pent, Sux, Tube”
  - May have to decrease amount of sedative drugs and give appropriate dose of RSI muscle relaxants
    • Succinylcholine: 1-2 mg/kg
    • Zemuron: 1.2 mg/kg
    • Vecuronium: .2 mg/kg
Initial Assessment

• Airway cont’d:
  - Remove front of C-collar and maintain in-line stabilization
  - Cricoid pressure (Sellick’s maneuver) after Pent given
    • 10 # pressure required to seal esophagus
  - MAC vs. Miller debate
Initial Assessment

- Awake intubation: local, topical superior laryngeal nerve blocks
- Awake fiberoptic: may be too bloody
- Awake cricothyrotomy/tracheostomy
- Gum elastic bougie/LMA
- Know your difficult airway algorithm!
Initial Assessment

- BREATHING
  - Always verify correct position of ETT, even if arrive intubated !!
  - 100 % O2
  - May have Combitube in; change to ETT
  - Nasal intubation: watch with basilar skull fractures
Initial Assessment

• Circulation
  - Control hemorrhage first!
  - Crystalloids vs. colloids vs. blood products?
  - Alot or alittle?
  - Early or later?
Secondary survey

• After primary survey complete, attempt to complete a head-to-toe assessment
• Ask pertinent questions if patient able to answer
  - Allergies, PMH//PSH, meds, ETOH/drug use, weight, last meal
Trauma/preop assessment

- Cardiac: S/S shock, EKG changes
- Respiratory: Breath sounds, crepitus, respiratory patterns/distress, CXR
- Neurologic: GCS, LOC; assume C-spine injury until ruled out → Lateral C-spine Xray, palpate neck
- Renal: monitor urine output, amount and color
Trauma/preop assessment

- Gastrointestinal: FULL STOMACH!!!!
  - Gastric emptying slows or stops at time of trauma
- Endocrine: release of stress hormones (catecholamines and glucose)
- Hematologic: hypovolemic shock; coagulopathies
Laboratory/diagnostic tests

- CBC, electrolytes, urinalysis, PT/PTT, lactate, baseline ABG (as condition permits); T&C for at least 4 units
- CXR, lateral C-spine, CT/MRI
- 12 lead EKG
- FAST: focused abdominal sonography for trauma
- DPL: diagnostic peritoneal lavage
Anesthetic management of trauma patient

- Preop: Sedation rarely necessary
  - Versed in small doses (.5-1 mg IV)
  - Bicitra 30 cc preop
Induction
- Standard monitors
- Preoxygenation
- Basic airway and difficult airway adjuncts
- RSI with cricoid pressure
- Invasive monitors as indicated
Induction agents

- Thiopental 3-4 mg/kg; reduce doses in unstable patients; most commonly used in trauma
- Ketamine 0.5-1 mg/kg; useful for burn and hypovolemic patients; avoid with head injured
- Etomidate 0.1-0.3 mg/kg; reduce doses with hypovolemia; ?myoclonus effects
- Propofol 1-2 mg/kg in stable patients; reduce doses in hypovolemia
Muscle relaxants

- Succinylcholine: 1-2 mg/kg; useful for RSI/emergency; contraindicated in burns, spinal cord injury and crush injuries > 24-48 hours after injury
  - May give nondepolarizing dose prior to Sux to inhibit fasciculations (esp. with SCI)
Muscle relaxants

• Nondepolarizers
  - Vecuronium .28 mg/kg (250-300 mcg/kg) high dose; onset in 80 secs; duration 75-90 min; good cardiovascular stability without histamine release
  - Rocuronium 1.2 mg/kg high dose; onset 45-60 secs; duration 67 minutes
Maintenance

- O2/air/Forane mixture
- Avoid N2O if any question of pneumothorax, pneumocephalus, pneumomediastinum, bowel injury
- Fentanyl 1-10 mcg/kg/hr
- Monitor fluids and administer carefully
- Prepare to give blood products if necessary
Hypothermia

• Common with traumatic injuries and related procedures
• Warm all IV fluids
  - Level 1: warms IVF and blood to 42°C and delivers at 75-30,000 ml/hr
  - Rapid infusion system (RIS): warms to 42°C and can deliver products as bolus and various rates, up to 3000ml/min; cell saver can be attached to system

• Forced air warming systems
• Heat moisture exchangers
Emergence

• Normal extubation criteria

Instructed with coagulopathies should remain hemodynamically unstable, unstable, elderly, those who have received massive fluid and blood resuscitation, severe burns, and those with rib and long bone fractures, those who remain hemodynamically unstable, unstable, elderly with normal extubation criteria.
Postop

• Monitored and labs followed closely
  – Correct acid-base imbalances and electrolyte disturbances
• Long-acting opioids
• Epidural infusions
• Intercostal blocks
• Complications:
  – Hypothermia, atelectasis, V/Q mismatch, coagulopathy
Mechanism of injury

- Blunt trauma: caused by high-velocity or low-velocity impact from generally dull objects
- Penetrating trauma: result of sharp objects piercing through tissue, such as stab wounds produced by knives or bullet wounds produced by gunfire
- Impalement injuries: combination of blunt and penetrating trauma
- Falls: vertical high-velocity injuries
- Burns: thermal, electrical or chemical
Mechanism of injury cont'd

- Biological, chemical or nuclear warfare consequences of nature
- Environmental injuries: poisonous poisons, insects, snakes, animals or consequences of nature
- Airway burns and smoke inhalation
Blunt trauma

- Result of direct impact, deceleration, continuous pressure, shearing, and rotary forces
- Associated with injuries from high-speed collisions and falls from heights
- Motor vehicle crashes (MVC) are classified as head on, rear impact, side impact, rotational impact, and rollover
- Injuries commonly much more severe than penetrating
Penetrating trauma

- Often requires surgical intervention
- Damage depends on 3 factors:
  - Type of wounding instrument
  - Velocity of instrument at time of impact
  - Type of tissue that instrument passes through (organs, vessels, nervous tissue, muscle, fat, bone)
Thoracic injuries

- Blunt or penetrating trauma
- Most ominous sign: hypoxia from tension pneumothorax, hemothorax, flail chest, hypovolemia, cardiac tamponade
- Chest wall trauma can result in above
### Pneumothorax

- **Accumulation of air between parietal and visceral pleura**
- **Results in severe V/Q mismatch and hypoxia**

**S/S:**
- Chest wall hyperresonant to percussion
- Breath sounds decreased or absent unilaterally
- Subcutaneous emphysema
- CXR confirms

**Treatment:**
- Needle decompression second intercostal space midclavicular line
- Chest tube 4th or 5th ICS, midaxillary line
Hemothorax

- Can be caused from bleeding of heart and great vessels
- Fluid load before chest tube placement
- Differentiated from pneumothorax by dullness to percussion with absent breath sounds
Tension pneumothorax

- Develops from air entering pleural cavity through a one way valve in lung or chest wall
- With each inspiration, more air becomes trapped in thorax, increasing intrapleural pressure
- Eventually the ipsilateral lung collapses and the mediastinum and trachea shift to contralateral side
Tension pneumothorax cont’d

- **S/S**
  - Hyperresonance to percussion of chest wall
  - Ipsilateral absence of breath sounds
  - Contralateral tracheal shift
  - Distended neck veins?
  - Differentiated from cardiac tamponade by hyperresonance to percussion over tension pneumo

- **Treatment**
  - 14 gauge catheter 2nd ICS midclavicular line chest tube
Flail chest

- Results from comminuted fractures of at least three adjacent ribs with associated costochondral separation or sternal fracture
- Accompanied by hemothorax or pulmonary contusion
- Patients with 3 or more rib fractures have greater likelihood of hepatic or splenic injury
- S/S
  - Paradoxical chest wall movement and/or splinting due to intense pain
Flail chest cont’d

- Chest Xray and ABG confirm diagnosis
- Treatment
  - O2 with humidification
  - Pain meds:
    - IV
    - thoracic epidural
    - intercostal blocks
Pulmonary contusion

- Intra-alveolar hemorrhage and edema resulting from sudden increase in intra-alveolar pressure and rupture of alveolar-capillary interface
- Difficult to diagnosis; high index of suspicion with thoracic injuries
- Treatment
  - If worsening respiratory failure, intubation with PEEP, frequent suctioning to avoid bronchial plugging and atelectasis, and careful volume resuscitation
ARDS

- Later pulmonary complication
- Attributed to direct thoracic injury, sepsis, aspiration, head injury, massive transfusion, oxygen toxicity, and fat embolism
- Mortality rate reaching 50%
Myocardial contusion

- Associated with blunt trauma
- Contusion most often right ventricle since lies directly posterior to sternum
- S/S
  - Dysrhythmias: heart block to Vfib; ST segment elevation
  - Elevated CPK-MB; ? troponin elevation
  - CHF
  - Anginal pain which may or may not respond to nitrates
Myocardial contusion cont’d

- Treatment
  - Management of dysrhythmias
  - Increase CVP to optimize right ventricular output
Cardiac tamponade

- Life-threatening emergency
- Bleeding into pericardial space, which restricts cardiac filling during diastole and creates a low cardiac output state
- Initial symptoms
  - Dyspnea
  - Orthopnea
  - Tachycardia
Tamponade cont’d

• Classic symptoms
  – Beck’s triad – neck vein distention, hypotension, muffled heart sounds
  – Pulsus paradoxus: > 10 mmHg decrease in blood pressure during spontaneous inspiration
    • May not be evident in hypovolemia

• Treatment
  – Pericardiocentesis: 16 g catheter inserted at the xiphochondral junction toward left scapula at 45° angle
    • If advanced too far, will see ectopy
    • Requires thoracotomy
    • Fluid load and treat with pressors if necessary
    • Avoid bradycardia; Ketamine useful agent
Associated thoracic injuries

- Aortic rupture
- Valvular rupture
- Septal rupture
- Diaphragmatic herniation
- Esophageal rupture
Abdominal and Pelvic trauma

- High risk for exsanguinating hemorrhage and peritonitis
- Results from blunt and penetrating trauma
- Retroperitoneal injuries can damage abdominal aorta, IVC, kidneys, pancreas, duodenum
- Intraperitoneal injuries can injure spleen, liver, stomach, small bowel, colon, rectum
Abdominal and pelvic injuries cont'd

- Intraabdominal injuries associated with paralytic ileus and peritoneal irritation (muscle guarding, tenderness to percussion, abdominal distention)
- >1-3 liters of blood can sequester in abdomen/retroperitoneal space with minimal signs
- Diagnosis confirmed with free air on Xray or FAST or CT or by bloody DPL
Diagnostic peritoneal lavage (DPL)

- Performed when abdominal injury suspected from mechanism of injury
- Not performed routinely now that FAST available
- FAST and DPL can prevent unnecessary exploratory lap
- Can use local with sedation
DPL cont’d

• Peritoneum lavaged with fluid that is then drained by gravity and examined for presence of RBC’s, bile, amylase, and WBC’s
  - Positive finding: >10 cc gross blood
    • >100,000 RBC’s/ml
    • >500,000 WBC’s/ml
    • Amylase > 200 units
    • Bacteria
  - False positive results < 2%
Splenic laceration

- Most common injury in blunt abdominal trauma and with penetrating wounds of left lower thorax and upper abdomen
- Routine splenectomy rare
- Splenorrhaphy (repairing the spleen) more common
  - Decreases incidence of sepsis
  - Can take to angiography to embolize lac
Liver laceration

- Second most common injury associated with abdominal trauma
- Exsanguniating hemorrhage can occur
- Majority of liver injuries (85-90%) heal spontaneously and may only require surgical drainage
Pelvic fractures

- Result in major hemorrhage 25% of time
- Exsanguination 1% of time
- Bleeding results from disruption of veins from bone fragments
- Emergent or elective external fixation can be followed by angiography
  - Arterial bleeding can be embolized
  - Bladder injuries often associated with pelvic fracture
    - Urethrogram should be performed before foley inserted
Abdominal and pelvic trauma

- Anesthetic concerns revolve around hemorrhage, hypothermia, sepsis/peritonitis and impairment of ventilation.
- Warming measures are crucial since large heat loss from open mesentery and shock.
- Avoid N₂O to prevent bowel distention.
- Fluid resuscitation imperative.
- The pelvis can hold up to 3 liters.
Extremity trauma

- Usually not immediately life-threatening and part of secondary survey
- Can be associated with vascular injuries causing hemorrhage, shock, sepsis, fat emboli, and thromboembolic hypoxic respiratory failure
Open fractures

- Ideal to repair in first few hours post injury so full stomach precautions
- Should repair within 6 hours to lessen incidence of sepsis
- If obvious hemorrhage, hold pressure manually; can have MAST pants applied while in field
Vascular trauma

- S/S
  - Pain
  - Pulselessness
  - Pallor
  - Paresthesias
  - Paresis
  - Confirmed with angiography
Compartment syndrome

- Characterized by severe pain in affected extremity
  - Calf pain on dorsiflexion of foot
- Emergency fasciotomy must be done to prevent irreversible muscle and nerve damage
- Diagnosis confirmed by compartment pressures $> 40$ cm H2O
Long bone fractures

- Commonly lead to thromboembolic hypoxic respiratory failure due to fat globules or fracture debris reaching pulmonary vascular bed

- Fat embolism syndrome:
  - Fever
  - Petechiae
  - Dysrhythmias
  - Fat globules in urine, plasma, retinal vessels
  - Mental deterioration 1-3 days post trauma
Fat embolism syndrome cont'd

- **Diagnosis:** Elevated serum lipase, fat in urine, and thrombocytopenia
- **Treatment:** Early fracture stabilization
  - Aggressive cardiovascular and pulmonary support

Support is key to prevention
Anesthetic concerns with extremity trauma

- Positioning
- Associated injuries
- Tourniquets
Crush injuries

- Can occur with blunt and penetrating trauma
- Increased risk of myoglobinuria, leading to rhabdomyolysis
- Always check urine and document color with trauma patients; inform surgeon immediately if becoming bloody
  - Need to hydrate, osmotic diuretics, alkalinize urine to protect kidneys
  - Follow lactate; > 2 can be sign of under resuscitation
WEAR YOUR HELMET AND YOU MAY SURVIVE THE RIDE.

WHEN YOU NEED YOUR HELMET, YOU WON'T HAVE TIME TO GO BACK AND GET IT.
Head injury

- Goal is prevention of secondary brain damage resulting from intracranial bleeding, increased ICP, edema
- Management should include early control of airway, cardiovascular stability, and avoidance of increased ICP
- Patients with suspected head injury should be placed head up position to promote venous drainage and decrease ICP; moderate hyperventilation to 30 mmHg
Spinal cord injury

- High index of suspicion related to mechanism of injury
- Always treat as suspected C-spine injury unless proven otherwise
  - C collar
  - Inline stabilization with intubation
  - RSI/airway adjuncts
Signs and symptoms related to SCI

- Paralysis
- Pain
- Position: patient holding head upright with both hands may indicate Jefferson (hang man) fracture C1; “hold-up” position with arms above head may indicate C4-5 fracture; “prayer position” with arms folded across chest possible C5-6 fracture
S/S of SCI cont’d

- Paresthesias
- Ptosis
- Priapism
SCI

- Leading cause of death at scene: aspiration
- Most injuries occur in males in 20’s-30’s
- Occur from falls, MVC’s, diving injuries, penetrating missiles, sports injuries
- Must obtain lateral C-spine Xray
  - C7 most common site of injury
Anesthetic management with SCI

- Nasal intubation method of choice if patient does not have associated basilar skull fracture/LeFort 2-3 fractures
  - Topical anesthesia
  - Avoid transtracheal block due to increased risk of aspiration and movement of neck with coughing

- Oral intubation: induce patient then remove front of C collar and hold in-line stabilization/RSI
Muscle relaxants with SCI

• Succinylcholine: do not give to patients > 24 hours post massive muscle or denervation injuries, SCI’s, crush injuries or burns
  – Acutely may want to avoid secondary to fasciculations that may exacerbate SCI
  – Can give curarizing dose of NDMR
  – High dose Vec or Roc good alternative
Spinal shock

- Hypotension
- Bradycardia
- Hypothermia/poikilothermia (body temperature migrates toward environmental level)
- More intensified at T6 level and higher

Results from sympathectomy in SCI patients
Spinal shock

- Patients present with hypotension, bradycardia and warm, pink extremities
  - Hemorrhagic shock tend to be hypotensive, tachycardiac with cold, clammy skin
- Treatment:
  - Careful volume resuscitation
    - Unable to maintain adequate cardiac filling pressures but overaggressive fluid administration can precipitate pulmonary edema (neurogenic)
Spinal shock cont’d

- May require pressors ➔ Dopamine 4-5 mcg/kg/min
- Avoid using radial arteries for arterial line if paraplegic
  - If arm embolizes, patient at severe disadvantage
Autonomic hypereflexia

- Seen in 85% of patients with injuries above T5
- S/S
  - Hypertension
  - Bradycardia
  - Dyssrhythmias
  - Cutaneous vasodilation above and vasoconstriction below injury
  - Severe headaches
  - Seizures
  - Loss of consciousness
Autonomic hypereflexia

- Occurs after spinal shock passed
- Usually seen >24 hours post injury and when patients return to OR for subsequent operations
- Caused by stimulation below level of lesion
- Treatment: stop stimulus; deepen anesthesia; cardiovascular support
 Thermal injury

• > 2 million patients will be brought to trauma centers for burns and associated injuries
• Majority are thermal injuries in children < 5 years
• Electrical burns cause tissue damage by thermal injury and injury to underlying structures and heart
• Chemical burns depend on chemical, concentration, and duration of exposure
Degree of burn

- First-degree burn: superficial involving upper layers of epidermis; skin red and edematous and painful like sunburn
- Second-degree burn: partial thickness burns extend damage through dermis; regeneration can occur; blisters develop and have white or red areas that are painful
Degree of burn cont’d

- Third-degree burn: full thickness burn characterized by destruction of all layers of skin, including nerve endings; skin will not regenerate and healing does not occur unless dead tissue debrided and skin grafts placed; skin charred and not painful
- Fourth-degree burn: involve destruction of all layers of skin and extend into subcutaneous tissue, fascia, muscle, and bone
First degree burn (epidermal burn)
Second degree burn (superficial dermal burn)
Third degree burn (sub-dermal burn)
Fourth degree burn
Rule of Nines

- Size of burn estimation to assess total BSA burned
- Body divided into regions that represent 9% or multiples of 9% of total BSA
- Adults: head/neck 9%; arms/hands 9% each extremity; thighs/legs 18% each extremity; anterior/posterior trunk 18% each side; perineum 1%
- Children calculated slightly different due to large head
- Size of hand roughly equal to 1% BSA
Three phases of burn injury

- **Resuscitative phase**
  - First 24 hours
  - Includes airway management and treating any circulatory and associated injuries
  - Suspicion of upper and lower airway injury is increased with singed eyebrows/eyelashes and black soot around nose and mouth
Anesthetic management of burn patient

- Early intubation
- Multiple large bore IV access
- Aggressive fluid resuscitation
- Standard and invasive monitors placed early
  - Needle electrodes
- Temperature regulation
Management cont’d

• Varied drug responses
  - Albumin concentration decreased after 48 hours → albumin-bound drugs (such as benzos and anticonvulsants) have an increased free fraction and prolonged effect
  - Cardiovascular support
  - Require higher than normal doses of NDMR (2-5 times normal dose)
  - Ketamine for dressing changes and escharotomies
Airway injury

- High index of suspicion if loss of consciousness at scene and if fire occurred in closed space

S/S of inhalation injury

- Respiratory irritation (coughing)
- Sore throat
- Dysphagia
- Hemoptysis
- Carbon-colored sputum
- Tachypnea, use of accessory muscles, wheezing
- Crepitus
Inhalation injury

- Hoarseness demands immediate attention → means airway becoming edematous and can quickly obstruct glottis
- Diagnosis made with carboxyhemoglobin levels
- Should be intubated immediately if any suspicion of injury
Carbon monoxide (CO) poisoning

- Results from inhalation of CO produced by fires, exhaust from internal combustion engines and cooking and charcoal stoves
- Produces tissue hypoxia by its 200 times affinity for Hgb compared to oxygen
- COHgb formed → pulse oximeter may display higher than actual O2 saturation
- S/S
  - Tachypnea
  - Cherry red color of blood (only when COHgb >40%)
<table>
<thead>
<tr>
<th>CO HgB level (%)</th>
<th>Manifestations</th>
</tr>
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<tbody>
<tr>
<td>0-5</td>
<td>None</td>
</tr>
<tr>
<td>5-10</td>
<td>Mild H/A, confusion</td>
</tr>
<tr>
<td>11-20</td>
<td>Severe H/A, blurred vision</td>
</tr>
<tr>
<td>21-40</td>
<td>Disorientation, N/V, irritability, syncope</td>
</tr>
<tr>
<td>41-60</td>
<td>Tachycardia, tachypnea, agitation</td>
</tr>
<tr>
<td>&gt;60</td>
<td>Death</td>
</tr>
</tbody>
</table>
CO poisoning

- Treatment: 100% O2 immediately
- Hyperbaric oxygen therapy (HBO) may be initiated if symptoms not abating
Fluid resuscitation

- **Parkland formula**
  - 4ml/kg LR per percent BSA burned
  - ½ given over first 8 hours
  - Rest over next 16 hours
  - In addition to maintenance

- **Brooke formula**
  - 3ml/kg per percent BSA burned
  - ½ over first 8 hours
  - Rest over next 16 hours
Myoglobinuria

- Occurs following rhabdomyolysis and hemoglobinuria due to hemolysis; affects renal blood flow via damage to renal parenchyma
- FFP may protect renal function since it contains haptoglobin, which binds free hemoglobin
- Aggressive fluid resuscitation
- Maintenance of urine output with osmotic diuretics and sodium bicarb to protect kidneys
Debridement and grafting phase

- Multiple skin debridements
- Escharotomies
- Amputations
- Grafts
- Tracheotomies

May still be hemodynamically unstable in this phase
Reconstructive phase
• May continue for rest of life
• Release of contractures
• Multiple plastic surgery
Skin grafting