Objectives

- To understand the pathophysiology of shock
- To appreciate how shock influences the presentation and outcome of the trauma patient
- To discuss the role of a systematic approach to the trauma patient

History

- 1900’s: Influence of WW I / WW II
- 1940’s: Tissue anoxia defined as cause
- 1970’s: Swan Ganz catheter

Definitions

- Oxygen Delivery=
  - cardiac output x
  - \((Hb \text{ g/dL} \times \% \text{sat} \times 1.36 \text{ cc/g})\)
  - \(+ (Po_2 \times .003 \text{cc of } O_2/\text{mm Hg/dL})\)
Importance of Hemoglobin

- What is the ideal H/H for the critically ill patient?
- Consider complications of transfusion:
  - transmission of infection
  - immunosuppression
  - transfusion reactions
  - cost

Transfusion Oxygen Support

ffects of transfusion on oxygen transport

Hemodynamics

- Cardiac performance determined by:
  - preload
  - afterload
  - contractility
  - heart rate
Hypovolemic Shock

- Causes
  - external or internal bleeding
  - gastrointestinal losses
  - third space losses

Classification of Hemorrhage

<table>
<thead>
<tr>
<th>Class</th>
<th>Clinical Signs</th>
<th>% Volume Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Tachycardia</td>
<td>15</td>
</tr>
<tr>
<td>II.</td>
<td>Orthostatic Hypotension</td>
<td>20-25</td>
</tr>
<tr>
<td>III.</td>
<td>Supine Hypotension Oliguria</td>
<td>30-40</td>
</tr>
<tr>
<td>IV.</td>
<td>Obtundation Cardiovascular Collapse</td>
<td>Over 40</td>
</tr>
</tbody>
</table>

Hypovolemic Shock

- Compensated
  - CO maintained
  - low wedge and CVP
- Uncompensated
  - CO decreases
  - low wedge and cvp
  - elevated SVR
Hypovolemic Shock

- **Crystallloids**
  - +low cost and well tolerated
  - - exits vasculature quickly

- **Colloids**
  - +remains intravascular longer
  - - cost and risk of infection transmission

Influence of Catheter Size on Infusion Rate

<table>
<thead>
<tr>
<th>Infusion Device</th>
<th>Length (inches)</th>
<th>Flowrate (ml/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-French Introducer</td>
<td>5½</td>
<td>247</td>
</tr>
<tr>
<td>IV Extension tubing</td>
<td>12</td>
<td>220</td>
</tr>
<tr>
<td>Peripheral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14-Gauge Catheter</td>
<td>2</td>
<td>195</td>
</tr>
<tr>
<td>16-Gauge Catheter</td>
<td>2</td>
<td>150</td>
</tr>
<tr>
<td>Central</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>16-Gauge Catheter</td>
<td>5½</td>
<td>91</td>
</tr>
<tr>
<td>16-Gauge Catheter</td>
<td>12</td>
<td>54</td>
</tr>
</tbody>
</table>

Endpoints of Resuscitation

- **Abramson et al 1993**
  - 100% survival if lactic acid levels normalized within 24 hours
  - 78% survival between 24-48 hours
  - 14% survival > 48 hours

Comparison of the three endpoints

- **Arterial blood gas**
  - Yes
- **Lactate**
  - No
- **pH**
  - Yes

- **Inflammation**
  - No
  - Limited
  - Equilibration

- **Speed**
  - Fast
  - Varies
  - Equilibration

- **Scientific basis**
  - Retrospective
  - Prospective
  - Randomized study

- **Cost**
  - Moderate
  - Least
  - Most expensive

- **Risk**
  - Minimal
  - Minimal
  - Risk of NG tube

Septic Shock

- **Infectious causes**
  - cholangitis
  - pneumonia
  - peritonitis
  - pyelonephritis
  - meningitis

- **Inflammatory causes**
  - crush injuries
  - burns
  - pancreatitis
  - anaphylaxis

- **Presentation**
  - hyper or hypothermic
  - tachycardic
  - tachypneic
  - leukocytosis or leukopenia
  - thrombocytopenia
  - DIC
Septic Shock

- **SG parameters: compensated**
  - CO increased
  - low wedge pressure
  - decreased SVR

- **SG parameters: uncompensated**
  - CO decreased
  - high SVR
  - low oxygen consumption

Septic Shock

- **Complement Cascade**
  - C3a, C5a
  - increases vascular permeability, vasodilation, chemotaxis

- **Plasma Kinins**
  - Bradykinin
  - increases vascular permeability, vasodilation, edema

Complement Cascade

- C3a, C5a
- increases vascular permeability, vasodilation, chemotaxis

Plasma Kinins

- Bradykinin
- increases vascular permeability, vasodilation, edema

Cytokines

<table>
<thead>
<tr>
<th>Cytokine</th>
<th>Source</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>TNFα</td>
<td>macrophages, T cells</td>
<td>activates macrophages, T cells, and NK cells, induces TNF-α production</td>
</tr>
<tr>
<td>IFNγ</td>
<td>activated T cells</td>
<td>activates macrophages, T cells, and NK cells, induces TNF-α production</td>
</tr>
<tr>
<td>IL-6</td>
<td>activated T cells</td>
<td>induces TNF-α, IL-1, and IL-8 production</td>
</tr>
<tr>
<td>IL-1β</td>
<td>activated T cells</td>
<td>induces TNF-α, IL-1, and IL-8 production</td>
</tr>
</tbody>
</table>

Cardiogenic Shock

- **Presentation**
  - c/o chest pain, diaphoresis, confusion
  - appearance may be ashen or cyanotic with cool skin and mottled extremities
  - JVD and pulmonary rales
  - 3rd and 4th heart sounds
Cardiogenic Shock

- **Swan Ganz findings:**
  - A-V O₂ difference > 5.5 ml/dc
  - CI < 2.2 L/min/m²
  - wedge > 15mmHg

Mortality Among Study Patients

- **Strengths of Hochman paper**
  - prospective randomization
  - outcomes similar for revascularized study and non-study population

- **Weaknesses of Hochman paper**
  - lack of statistical power to detect 9% difference in mortality at 30 days
  - small sample of pts > 75 years

**Recommendations**

- early revascularization with CABG or angioplasty
- further study into revascularization in pts older than 75 years
Neurogenic Shock

- **Causes**
  - traumatic cervical spinal cord transection
  - spinal anesthesia
  - acute gastric dilation
  - drugs

- **Presentation**
  - hypotensive
  - bradycardic
  - pink, warm skin
  - obvious neurologic deficits

- **Swan parameters**
  - CO may be low or normal
  - decreased SVR
  - decreased PVR
  - decreased CVP

- **Treatment**
  - R/O other causes of shock
  - hemodynamic stabilization
  - control spine

Role of Steroids

- **NASCIS II trial**
  - randomized, controlled, double blinded
  - methylprednisolone vs naloxone vs placebo
  - treatment for 23 hours
  - blunt trauma pts only
  - outcomes at 6 weeks and 6 months
Role of Steroids

- **NASCIS III**
  - treated pts with methylprednisolone or tirilazad mesylate
  - treatment to 23 or 48 hours
  - blunt trauma pts only
  - functional independence measure
  - outcomes at 6 weeks and 6 months

Role of Steroids

- **Shortcomings of NASCIS II**
  - creation of subgroups based on data
  - some subgroup sizes too small
  - outcomes not correlated clinically

- **Shortcomings of NASCIS III**
  - no placebo group
  - subgroups based on data

Role of Steroids

- **Important findings of NASCIS**
  - overall mortality rates similar between pts treated with steroids and control group
  - FIM significantly improved in overall function, self care, and sphincter control

Role of Steroids

- **Recommendations for treatment of spinal cord injuries after blunt trauma:**
  - within 3 hours of injury treat with 23 hours of high dose methylprednisolone
  - within 3-8 hours of injury treat with 48 hours of this steroid
  - beyond 8 hours of injury do not administer steroids

Four Stages Care of Trauma Patient

- **Primary survey**
- **Resuscitation**
- **Secondary survey with diagnostic evaluation**
- **Definitive care plan**
Primary Survey

- A - airway with C-spine protection
- B - breathing
- C - circulation
- D - disability:
  - neurologic disability
- E - exposure / environment control:
  - completely undress the patient but prevent hypothermia
- It is designed to identify all immediate life threatening injuries!

Resuscitation

- Simultaneously with primary survey
- Airway is secured; ventilation is performed
- Intravenous lines are established and fluid resuscitation with balanced fluid solution is done
- Gross bleeding is controlled
- Neurologic deficit is identified
- Patient is exposed

The Secondary Survey

- Detail physical examination from head to toes
- Identify life threatening and occult injuries
- Tests:
  - CBC
  - basic chemistries
  - ABG,XRs:
    - Lat C-spine
    - AP CXR,pelvic film
    - blood for type and cross match

After Secondary Survey

- Re-exam the patient
- Re-check the vitals signs
- Prioritize the injuries
- Definitive plan

Airway Management

- Protecting, providing, and maintaining airway
- Failure to obtain an airway- a common cause of preventable death
- Cause: simple injuries; intoxication
- Think airway-with sudden deterioration

Risks for Airway Problems

- Injuries to the head or neck that cause obstruction or have an altered level of consciousness (injury, alcohol, drugs)
- GCS < 8 requires definitive airway
- Facial injuries
- Neck injuries (tracheal, vascular)
Identification of airway problem

- Talk to the patient
- Listen for abnormal airway: stridor, snoring, gurgling- all suggest supraglottic injuries
- Dysphonia or pain on speaking implies obstruction at laryngeal level

Airway Management

- Rule #1: Always assume that patient has neck injury
  - maintain immobilization in neutral position
  - avoid: hyperextension, hyperflexion or rotation of the neck
- Rule #2 Lack of neurologic deficit does not exclude cervical spine injury

Airway Management

- Chin lift, jaw thrust, suction:
  - airway secured- oral or nasal airway: no spontaneous ventilation- ventilate with bag
  - spontaneous breathing- supply oxygen
- Airway at risk: Endotracheal intubation
- Failed orotracheal intubation: surgical airway

Breathing

- Airway patency does not assure adequate ventilation
- Lung function, chest wall, diaphragm
- Expose; auscultate, palpate
- Identify pulmonary pathology
Tension Pneumothorax: Diagnosis

- Respiratory distress, subcutaneous emphysema, hypotension, distended neck veins
- Tracheal deviation away from the affected side
- Decreased breath sound on the affected side

Tension Pneumothorax: Treatment

- Needle decompression
- Tube thoracostomy

Flail Chest

- Two or more ribs fractured in at least two places with paradoxical movement
- Associated lung contusion underestimated on CXR
- Respiratory failure may not be immediate

Breathing: Pitfalls

- Dyspneic or tachypnic patient: think problem with airway
- In a ventilated patient, vigorous bagging or positive pressure ventilation may compromise ventilation
- CXR after intubation

Circulation

- Exam the pulses:
  - a SBP of 60 - palpable carotid pulse
  - a SBP of 70 - palpable femoral pulse
  - a SBP of 80 - palpable radial pulse
- Assume: hypotension from hemorrhage
- Control external bleeding before restoring circulation
- Manual compression; avoid blind clamps

The Treatment: Initial Step

- Intravascular replacement
- In adults: initial bolus 2 liters
- In children: 20 cc/kg/body weight
- Blood and blood product- type specific or O-negative
- Adjunct: Pneumatic antishock garment (PASG)- buckled into place around the legs, pelvic fractures
- Release them gradually
Assessment of Organ Function

- Level of consciousness
- Temperature
- Skin color
- Pulse rate and character

Circulatory Management

- Control hemorrhage
- Restore volume
- Reassess
- Caution:
  - elderly
  - athletes
  - children
  - medications

Disability

- Baseline neurologic evaluation
- GCS scoring
- Pupillary response
- Observe for deterioration

Disability

- Glasgow Coma Scale
  - eye (1-4)
  - verbal (1-5)
  - motor (1-6)
  - worst: 3  best: 15

Exposure/Environment

- Disrobe patient
  - necessary to completely evaluate patient for all injuries
  - log roll patient to look at back and spine
- Maintain normothermia
  - necessary to avoid problems with coagulopathy

Adjuncts to primary survey

- Vital signs
- Pulse oximeter and CO2
- Urinary and gastric catheters unless contraindicated
- Laboratory values
- Plain films
- ECG
Secondary survey

- Head to toe exam
- Finger in every orifice
- Reevaluate hemodynamics
- Determines subsequent work up and interventions
  - FAST, CT’s, Angio, OR

Case Presentation

- 50 years old male, found in the parking lot. Unknown mechanism or history. Brought to ER. Hemodynamically unstable. 2 chest tubes, 6 uPRBC, 4 Liters of crystalloid BP 120s.
- To the CT scan: Unstable again
- To OR emergently
- What might one find?
Conclusions

- Shock is fundamentally a deficiency in tissue oxygen perfusion
- Hypovolemic shock is the most commonly encountered form in the trauma patient
- A systematic approach is vital to provide efficient and effective care