Shock Recognition and Treatment

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Disclosure

• Employment: UPMC
  – ROC: Pittsburgh Resuscitation Network
  – DoD Prehospital Administration of Plasma (PAMPer)
  – DoD TXA in hemorrhagic Shock (STAAMP)
  – MedEvac Foundation
  – PEMF: Remote Ischemic Conditioning

Learning Objective

• Describe how to identify shock
• Delineate the categories of shock
• Discuss potential strategies for management
• Review current controversies in Shock
Shock

• Shock is a “reduction in tissue perfusion leading to cellular organ dysfunction and death.”
• “The rude unhinging of the machinery of life” - Gross
• Inadequate delivery of oxygen to tissues
• Early recognition of shock may be complicated by patient decompensation, medications, or premorbid conditions.

Mechanisms of Shock

- **Pulse Pressure (↓ CO)**
  - **Cardiogenic**
    - ACS
    - HF
    - Myocarditis
  - **Obstructive**
    - Tamponade
    - Pneumothorax
    - Pulmonary Embolus
  - **Hypovolemic**
    - Hemorrhage
    - Dehydration

- **Pulse Pressure (↓ SVR)**
  - **Distributive Shock**
    - Sepsis, Anaphylaxis
      - Vasodilation (Pipes)
    - Tachycardia
    - Neurogenic Shock
    - Vasodilation
    - Sympathectomy
    - Spinal Shock

Presentation of Shock

- **Hypovolemic** (Hemorrhage)  Flat neck veins, tachycardia, pallor
- **Obstructive**  Distended neck veins, tachycardia
  - Tension PTX- unilateral breath sounds, SQ emphysema
  - Pulmonary Embolus- Tachycardia, tachypnea, chest pain
- **Cardiogenic**  Distended neck veins, tachycardia and cyanosis
- **Distributive**  Flat neck veins, tachycardia, pallor
  - Sepsis- Fever
  - Neurogenic- pink skin and bradycardia
  - Anaphylaxis- Rash, exposure
## Recognition of Shock

- SBP <90 mmHg
  - <110 mmHg (Elderly)
  - 70-2 (Age) in Children <10
- HR > 120 BPM
- SI (HR/SBP) > 0.9
- Lactate ≥ 4 mmol/L
- Findings of Decreased Perfusion
  - AMS
  - Skin pallor, mottling, or cyanosis
  - Cap refill >2 sec.
  - Urine output <30 ml/hr.

## How is Shock Recognized?

- 82 y/o male, h/o HTN, unrestrained driver of car that struck guardrails. Immobilized; Head with 2 cm laceration; bleeding controlled; GCS= 15 with a patent airway. The patient has a severe laceration to the left arm. A bulky dressing is placed.
- Vitals: HR: 81 (NSR) RR: 20 BP: 109/74 SpO2: 100% on 15 L NRBM
- Is this patient in shock?
- What prehospital treatment would you order?

## How is Shock Recognized?

- Patient was taken to the OR for operative management of extremity trauma.
- Found to have a Left PTX, Left 5-9 rib fx.
- C2 and C7 fractures.
- Patient required admission to the ICU for 26 days. Total LOS was 31 days.
Occult or Cryptic Shock

• Inadequate delivery of oxygen or nutrients to meet the metabolic needs of tissues with abnormalities in vital signs.

• What are abnormal vital signs?
• What adjunctive technologies can help us identify occult shock?
• What treatment should be initiated once shock is recognized?

Vital Signs: Blood Pressure

• What is hypotension?
• SBP <90?
  – Even a single episode of hypotension predicts increased mortality- Shapiro, JEM 2003
  – Low volume or delayed resuscitation for penetrating injury- Russell, J of Trauma 1992
  – Mortality of trauma patients presenting with a SBP<90 is as high as 65%

Controversy: What Blood Pressure?

• Dutton-SBP of 70 or pulse in hemorrhage
• Rivers-MAP of 65 or SBP 90 goal in EGDT
• Estridge- 110 for trauma
• Heffernan-120 for geriatric shock
• Spaite- 144 for traumatic brain injury
• SV varies as a function of Preload, Afterload and Contractility
  • Preload - Hypovolemia or ↓ SVR
  • Afterload - Obstruction or ↑ SVR
  • Contractility - Pump failure

CO = SV x HR

BP = CO x SVR

SBP → CO (Pump & Tank)
DBP → SVR (Pipes)

Pulse Pressure = SBP - DBP

Treatment of Hypotension

Blood Pressure
120/80 (92)
80/60 (66)
100/40 (59)

<table>
<thead>
<tr>
<th>↓ Pulse Pressure</th>
<th>↑ Pulse Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ SVR</td>
<td>↓ SVR</td>
</tr>
</tbody>
</table>

Rx = ?
IVF's

RX = ?
Pressors
Vital Signs: Heart Rate

• What is Tachycardia?
  – ATLS guideline: >100
• What conditions affect a tachycardic response?
• Does Heart Rate predict outcomes?
  – Bleeding? McGee, JAMA 1999
  – Injury Severity? Brasel, J of Trauma 2007
  – Mortality in hypotensive patients? Demetriades, J of Trauma 1998

Abnormal HR

• Elevated HR
  – Hypoxia
  – ↑ WOB
  – Hypotension/Shock
  – Hypoglycemia
  – Anemia
  – ↑ DO2 (fever, thyroid storm, exercise, etc)
  – Medications (Intoxication & Withdrawal)
  – Pain/Anxiety

• Low HR
  – Hypoxia
  – Meds
  – AMI (post, right)
  – Vasovagal
  – Hypothermia

Vital Signs: Respiratory Rate

• Commonly used in validated triage scales.
  – Revised Trauma Score (RTS)
  – Simple Triage And Rapid Transport (START)
• May be particularly useful when other tools are limited or not available.
  – Respiratory rate > 25 breaths/min is a useful triage tool.
    • Husum, J of Trauma 2003
Vital Signs: End Tidal CO2

- Can be used to assess perfusion during cardiac arrest.
- End Tidal CO2 less than 15 during CPR probably indicates ineffective CPR.

Vital Signs: Others?

- Shock Index (SI)
  - HR/SBP 0.5-0.7 Normal 0.8 or > is predictive of severe illness. (Rady, Ann of E Med 1994)
  - SI may provide a means to monitor acute hypovolemia and circulatory failure. (Rady, Resuscitation 1992)
- Pulse Pressure
  - Narrowed pulse pressure is an early sign of hypovolemic shock
  - Widened pulse pressure is an early sign of septic shock

Adjunctive Tools: Lactate

- Serum lactate is marker of organ oxygen supply/demand mismatch, and is directly related to mortality in patients with sepsis, myocardial infarction, and trauma.
- Prehospital lactate identifies a cohort of patients with normal initial vital signs who required intensive resuscitation during the first 24 hours of hospitalization.
Lactate

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Lac &lt; 2.5</th>
<th>Lac ≥ 2.5</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Hospital Death, n (%)</td>
<td>1 (4)</td>
<td>23 (90)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Emergent operation, n (%)</td>
<td>1 (4)</td>
<td>22 (90)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Emergent vasopressor use, n (%)</td>
<td>1 (4)</td>
<td>22 (90)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Emergent blood transfusion, n (%)</td>
<td>7 (96)</td>
<td>9 (11)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>MODS, n (%)</td>
<td>1 (4)</td>
<td>23 (90)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>ISS, score (IQR)</td>
<td>4 (4-14)</td>
<td>10 (5-24)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Abbrev, score (IQR)</td>
<td>1 (0-2)</td>
<td>1 (0-4)</td>
<td>0.08</td>
</tr>
<tr>
<td>Length of stay, days</td>
<td>4 (2-7)</td>
<td>5 (3-32)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Admission to ICU, n (%)</td>
<td>58 (20)</td>
<td>138 (60)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Length of stay in ICU, days</td>
<td>9 (5-2)</td>
<td>2 (8-4)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>pH</td>
<td>7.39 ± 0.3</td>
<td>7.31 ± 0.1</td>
<td>0.08</td>
</tr>
<tr>
<td>Base Deficit</td>
<td>2.8 ± 2.3</td>
<td>4.3 ± 3.3</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Base Deficit

- Base deficit is a marker of impaired oxygen utilization.
- The amount of acid that must be removed to return the body to a normal pH.
- >6 is considered markedly abnormal
- >8 is associated with a 25% chance of mortality — Rutherford, J of Trauma 1992

Tissue Oximetry

- Near infra-red spectroscopy may be able to determine oxygen consumption and delivery in peripheral tissue.
- Prehospital use of a vascular occlusion test (VOT) with tissue oximetry can predict mortality and the need for inpatient resources.
Tissue Oximetry

- The sensitivity of StO2 is increased by performing a regional stress test.

Heart Rate Variability (HRV)

- A measure of beat to beat variation which is associated with changes in the autonomic nervous system.
- As compensatory mechanisms are depleted heart rate variability decreases.
- Decreased HRV represents cardiac uncoupling and is associated with shock.
- Cardiac uncoupling is an independent predictor of death throughout the ICU stay and appears to increase in response to inflammation, infection, and multiple organ failure – Norris et al., Ann Surg 2006.
Heart Rate Variability (HRV)

- HRV measures can be used to predict which septic patients in the emergency department (ED) will progress to septic shock. - Chan and Kuo, Accad Emerg Med 2007
- HRV in trauma patients is a better predictor of survival than standard physiologic measurements (Vitals signs and GCS). - Cooke et al., J of Trauma 2006

Ultrasound

- Useful for the recognition of shock and for directing therapy.
- FAST is used for termination of care - Eckstein, PEC 2005
- FAST is used in the field as an adjunct to triage - Sztajnkrycer et al., PEC 2006
- FAST is used in a helicopter to direct treatment - Melanson et al., PEC 2001
- Systematic Review of Prehospital US in Trauma - O’Dochartaigh and Douma, Injury 2015
- Five Year Retrospective - O’Dochartaigh and Douma, PEC, 2016

Scenario

- You are consulted for a patient who struck a guardrail with his motorcycle. The crew notes that there is a large amount of blood running down the side of the gurney from the patient’s left thigh area. They have placed a tourniquet and the bleeding has slowed but not stopped.

- The patient is awake but not alert GCS 11, he has a BP of 68/32, HR 128, SpO2 not obtainable due to perfusion. The crew has placed bilateral IO’s and given 1L of NS.
Hypovolemic Shock for EMS

• Source Control
  – Tourniquets, T-POD, Splints
  – Hemostatic Agents (Quickclot, Combat Gauze)
  – Tranexamic Acid
  – Source Control
    • Obstructive (Tamponade, PTX)
    • Distributive Shock (Spinal, Neurogenic)

• Volume Resuscitation
  – Crystalloid is BAD, NS is Evil
  – Resuscitate to SBP 90 in penetrating injury
  – Hemorrhage: FFP first then PRBCs

Hypovolemic Shock for EMS

• Vasopressors
  – Rapidly titrate Levophed to 0.3 mcg/kg/min
  – If ineffective consider 2nd Agent
  • Vasopressin 0.04 u/min- acidosis, GI hemorrhage (may have to increase dose)
  • Epinephrine 0.05–0.15 mcg/kg/min- bradycardia, if in extremis there is no max dose

• Adjunctive Therapy
  – Ketamine (Sedation RSI)
  – Bicarbonate (pH <7.1)
  – Calcium (if giving more than 5U of any blood product)
Treatment of Shock: Obstructive

- Chest Wall Trauma, COPD, or Airway Manipulation plus any of the following:
  - Difficulty ventilating
  - Hypotension
  - Subcutaneous emphysema
  - JVD
  - Tracheal Deviation
- Manage the Airway
- Needle Decompress at the 2nd Intercostal space mid-clavicular line or 4th intercostal space mid-axillary line
- Repeat as necessary

Secondary Injury

Address the abnormal vital signs
- Hypoxia
- Hypotension
- Hyper or hypocarbia
- Hypothermia

Controversy: Treatment of Shock

- ABCs or CABs?
- Prevent secondary injury
- Determine the etiology of the shock state
- Resuscitation
- Deliver the patient to definitive care
ABC vs. CAB

- Approach may vary based on the presentation
- Patients who are peri-arrest benefit from CAB
  - Cardiac Arrest: Compressions first
  - Exsanguinating hemorrhage: control bleeding
- Patients with primary respiratory issues still require ABC
  - Even in these circumstances it may be beneficial to delay definitive airway management

Controversies

- Volume for Hemorrhagic Shock
  - Evidence for resuscitation to SBP of 70-90
  - Large volume fluids may result in:
    - Dislodged clot
    - Hypothermia
    - Hyperchloremic Acidosis (NS)
    - Dilutional Coagulopathy
    - Disruption of endothelium and inflammation
- Interventions vs. Transport to Definitive Care
  - Delay for IV access or therapy may outweigh benefit
  - Blood products are superior to fluids as initial resuscitative fluid

Fluid Resuscitation:

- Large Volume Crystalloids
  - Increase mortality
  - Worsen coagulopathy of trauma and TBI
- Hypotensive Resuscitation with Blood
  - Expensive, limited availability and storage
  - Patients remain coagulopathic and hypothermic
- Plasma or plasma derivatives
  - Treats coagulopathy
  - Increases survival as part of Damage Control Resuscitation
Controversies in Hemorrhage?

- STOP THE BLEEDING
  - External
    - Extremity: Direct Pressure, Tourniquet
    - Junctional: External Compression Device
    - Cavity: Direct pressure, hemostatic dressing
  - Internal
    - Reverse Coagulopathy
    - TXA
    - OR

Vasopressors

Vasopressors should be initiated if the patient has not responded to the initial volume challenge
- Distributive (Needed to increase SVR)
- Obstructive (only adjunctive)
- Cardiogenic (may be harmful 2/2 afterload)
- Hypovolemic (in conjunction with volume)

TXA – CRASH 2

- Prospective, randomized controlled trial
- Over 20,000 patients
- TXA significantly reduced all causes mortality from 16.0% to 14.5%
- TXA significantly reduced death from bleeding
CRASH-2: Timing of TXA

- Subgroup analysis of 20,211 trauma patients based on time of administration of TXA
- Timing: only deaths due to bleeding
- Risk of death due to bleeding reduced (5.3% vs 7.7%) if TXA given within 1 hour of injury. At 1-3 hrs after injury, also significant (4.8 vs 6.1%)

Take-Home Points

- Early identification and treatment of shock reduces mortality
- Normal vital signs does not = normal perfusion
- Treatment of shock varies by etiology (category)
- Treatment in the field should not delay definitive care

Take-Home Points

- Have an understanding of the diagnostic limitations and the use of fluids and vasopressors.
  - Clinical aspects of EMS = 40% of tests items
- Take home points
  - Cause of shock state is difficult to assess so standardized approach is needed
  - Volume resuscitation is dependent on etiology
  - Vasopressor options are limited
  - Accurate dosing of vasopressors is challenge for EMS
Acknowledgement

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