Hemorrhagic Shock
Objectives

At the conclusion of this presentation the participant will be able to:

• Define hemorrhagic shock.
• List common causes of hemorrhagic shock in the trauma patient.
• Recognize the signs and symptoms of hemorrhagic shock.
• Explain the importance of early control of hemorrhage in trauma patients.
• Describe initial management of hemorrhagic shock.
• Describe ongoing evaluation of the trauma patient with hemorrhagic shock.
Hemorrhagic Shock

What is the definition of shock?

Inadequate tissue perfusion
Historic Trauma Trimodal Death Distribution

- Immediate (60%)
- Early (30%)
- Late (10%)

Sobrino & Shafi, 2013
Heart Rate + Stroke Volume = Cardiac Output

Factors influencing Stroke Volume:
- Afterload
- Preload
- Contractility
Injuries Associated with Massive Hemorrhage

- Chest
  - Aorta
  - Vena Cave
  - Hemothorax
- Abdomen
  - Spleen
  - Liver
- Pelvis
- Long bone
  - Femur
  - Humerus
- External bleeding
  - Various external sources such as the scalp
  - Don’t forget to exam the posterior surfaces!

Don’t underestimate the bleeding from soft tissue injury
Confounding Factors

- Patient's age
- Pre-existing disease/meds
- Severity of injury
- Access to care
- Golden hour
- Duration of shock
- Amount of prehospital fluid
- Presence of hypothermia
Classic Signs & Symptoms of Shock

- Changing mentation/confusion
- Rapid shallow breathing
- Hypotension
- Tachycardia
- Weak Pulse
- Cool, clammy, skin
- Prolonged capillary refill
- Narrowed pulse pressure
- Decreased urine output
Hemorrhagic Shock

Classes of Shock
<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CLASS I</th>
<th>CLASS II (MILD)</th>
<th>CLASS III (MODERATE)</th>
<th>CLASS IV (SEVERE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximate blood loss</td>
<td>&lt;15%</td>
<td>15–30%</td>
<td>31–40%</td>
<td>&gt;40%</td>
</tr>
<tr>
<td>Heart rate</td>
<td>↓</td>
<td>←/↑</td>
<td>↑</td>
<td>↑/↑↑</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>←</td>
<td>←</td>
<td>←/↓</td>
<td>↓</td>
</tr>
<tr>
<td>Pulse pressure</td>
<td>←</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Respiratory rate</td>
<td>←</td>
<td>←</td>
<td>←/↑</td>
<td>↑</td>
</tr>
<tr>
<td>Urine output</td>
<td>←</td>
<td>←</td>
<td>↓</td>
<td>↓/↓</td>
</tr>
<tr>
<td>Glasgow Coma Scale score</td>
<td>←</td>
<td>←</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Base deficit&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0 to –2 mEq/L</td>
<td>–2 to –6 mEq/L</td>
<td>–6 to –10 mEq/L</td>
<td>–10 mEq/L or less</td>
</tr>
<tr>
<td>Need for blood products</td>
<td>Monitor</td>
<td>Possible</td>
<td>Yes</td>
<td>Massive Transfusion Protocol</td>
</tr>
</tbody>
</table>

* Base excess is the quantity of base (HCO₃⁻, in mEq/L) that is above or below the normal range in the body. A negative number is called a base deficit and indicates metabolic acidosis.

Heart Rate and Blood Pressure

Heart rate

- Assess for rate and quality.
- Check central vs distal.
- A rapid heart rate and poor skin signs should be considered shock until it can be ruled out.

Blood pressure

- Does not define shock.
- Can be normal until class 3 of hemorrhagic shock.
- An increase in BP does not mean there is an increase in cardiac output.
Pulse Pressure / Respiratory Rate

- **Pulse Pressure**
  - Narrowed pulse pressure suggests significant blood loss.
  - Result of increasing diastolic pressure from compensatory catecholamine release.
  - **Watch for a trend!**

100/60 100/64 100/68 100/74

- **Respiratory rate**
  - Increased rate of breathing can occur for various reasons.
  - Rule out respiratory cause:
    - Tension pneumothorax
    - Can be normal until class 3 of hemorrhagic shock
Urine Output and Mental Status

Urine Output

- Used to monitor renal perfusion and guide resuscitation efforts.
  - 0.5 mL/kg/hr
- Better indicator than BP.
- Hematuria can indicate retroperitoneal bleeding.

Changes in mental status

- One of the first signs of shock.
- Indicator of perfusion.
- Could be affected by drugs and alcohol.
- Hypoxia or head injury until proven otherwise.
Base Deficit (BD)

- Sensitive measure of inadequate perfusion
- Normal range -3 to +3
- Performed as part of an ABG
- Admission BD correlates to blood loss
- Worsening BD:
  - Ongoing bleeding
  - Inadequate volume replacement

<table>
<thead>
<tr>
<th>Blood Gas Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
</tr>
<tr>
<td>pCO₂</td>
</tr>
<tr>
<td>pO₂</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Acid Base Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>↓ cHCO₃⁻(P)c</td>
</tr>
<tr>
<td>↓ cBase(B)c</td>
</tr>
<tr>
<td>↓ cBase(Ecf)c</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electrolyte Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>cK⁺</td>
</tr>
<tr>
<td>cNa⁺</td>
</tr>
<tr>
<td>↓ cCa²⁺</td>
</tr>
<tr>
<td>cCa²⁺(7.4)c</td>
</tr>
<tr>
<td>cCl⁻</td>
</tr>
</tbody>
</table>
Hemorrhagic Shock

Assessment
Assessment

Primary Assessment

- Airway
- Breathing
- Circulation
- Disability
- Exposure
Diagnostic Tools

- Focused Abdominal Sonography for Trauma (FAST)
- Chest X-ray (CXR)
- Pelvic X-ray
- Diagnostic peritoneal lavage (DPL)
- Computed Tomography (CT)
Shock Index (SI)

- SI = HR / SBP
- Elevated early in shock
- Normal 0.5 - 0.7
- SI > 0.9 predicts:
  - Acute hypovolemia in presence of normal HR & BP
  - Marker of injury severity & mortality
  - Post-intubation hypotension
- Caution in Geriatrics
  - May underestimate shock due to higher baseline SBP
- Uses
  - Prehospital use → triage
  - Predict risk for mass transfusion
Hemorrhagic Shock

Treatment
Treatment

ATLS:
After 20 years of high-volume fluid resuscitation
• Chasing tachycardia
• Using Crystalloid > Blood
• Little evidence of improved survival

Current consensus:
Damage Control Resuscitation
• Permissive Hypotension
• Hemostatic Resuscitation
• Damage Control Surgery
Damage Control Resuscitation

Permissive Hypotension

Damage Control Surgery

Hemostatic Resuscitation
Permissive Hypotension

• Restricted fluid administration
• Avoid “popping the clot”
• Accepting limited period (< 2 hours) of suboptimum end organ perfusion
• Titrate to Mean Arterial Pressure (MAP)
# BP Measurements

<table>
<thead>
<tr>
<th>Systolic</th>
<th>Diastolic</th>
<th>Pulse Pressure</th>
<th>MAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>80</td>
<td>40</td>
<td>93</td>
</tr>
<tr>
<td>115</td>
<td>75</td>
<td>40</td>
<td>88</td>
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<tr>
<td>110</td>
<td>75</td>
<td>35</td>
<td>87</td>
</tr>
<tr>
<td>105</td>
<td>70</td>
<td>35</td>
<td>82</td>
</tr>
<tr>
<td>100</td>
<td>70</td>
<td>30</td>
<td>80</td>
</tr>
<tr>
<td>95</td>
<td>65</td>
<td>30</td>
<td>75</td>
</tr>
<tr>
<td>90</td>
<td>60</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>85</td>
<td>55</td>
<td>30</td>
<td>65</td>
</tr>
<tr>
<td>80</td>
<td>50</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>75</td>
<td>50</td>
<td>25</td>
<td>58</td>
</tr>
<tr>
<td>70</td>
<td>45</td>
<td>25</td>
<td>53</td>
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<tr>
<td>65</td>
<td>40</td>
<td>25</td>
<td>48</td>
</tr>
<tr>
<td>60</td>
<td>35</td>
<td>25</td>
<td>43</td>
</tr>
</tbody>
</table>

**Normal MAP:** 70-100

**Coming Soon? New Target MAP:** 50-70
Hemostatic Resuscitation

- Early diagnosis in ED
- 1:1:1 ratio (pRBC to Plasma to Platelets)
- Use of the following products:
  - Cryoprecipitate
  - Minimal crystalloids
  - Stop the bleeding
Coagulopathy

Hypothermia

Acidosis

Trauma

Triad of Death
Hypothermia

Defined:
• Core Temp < 35C (95F)

Action:
• ↓ coagulation factors
• ↑ platelet dysfunction

Classification:
• Mod 32-34 C (90-93 F)
• Severe <32 C (< 90 F)

T < 32C = 100% mortality in the face of trauma

Moderate To Severe Hypothermia Occurs In <10% of Trauma
Acidosis

• Effects:
  • Altered hemostasis
  • Myocardial depression

• Correlates with:
  • Depth of shock
  • Degree of tissue injury

• Assessed:
  • pH
  • Base Deficit
  • Lactate

• pH < 7.2
  • Initial BD ≥ 6
    • Predicts transfusion
    • Increased ICU days
    • Risk for MSOF

• Initial BD ≥ 7.5
  • ↑ mortality
Trauma Coagulopathy Theory

Trauma → Hemorrhage → Shock

- Inflammation
- Pre-existing Disease
- Meds
- Genetics

Resuscitation

- Dilution
- Acidosis
- Hypothermia

Fibrinolysis

Factor consumption

Activation Protein C

Now termed...

Trauma Induced Coagulopathy (TIC)

Acute Coagulopathy of Trauma & Shock (ACoTS) or Acute Trauma Coagulopathy (ATC)
Treatment Goals

- Provide adequate ventilation (Airway)
- Provide adequate oxygenation (Breathing)

Circulation
- Stop the bleed
- Restore circulating volume
- Involve a surgeon
- Transfer to appropriate level of care!!
Mechanical Means for Controlling Hemorrhage

- Direct pressure
- Packing the wound
- Splinting long bone fracture
- Operative intervention
- Angioembolism

For more information on “Stop the Bleed” initiative, please visit: www.stopthebleed.org
Mechanical Means for Controlling Hemorrhage

Pelvic Binders or a Sheet
- Reduces pelvis volume
- Tamponade effect

Tourniquets
- Good outcomes
- Safe and effective
Fluid Resuscitation
Principles of IV Access

- Fastest, simplest route best (antecubital or forearm)
  - Large bore, minimum 18g short catheter
  - Flow limited by IV gauge and length
  - Warm fluids to prevent hypothermia
- Consider Intraosseous (IO) **early** as rescue device
- Femoral or Subclavian/Internal Jugular are preferred central line sites
Intraosseous Devices

• Temporary access
• Children & adults
• Insertion can be done quickly
• Sites vary depend on the device
• Common site (lower leg and upper arm)
• Avoid fracture/injury sites
• Fluid/blood/meds can be administered
• Flow rates up to 6 L/hr with pressure bag
• Risk: extravasation → compartment syndrome
Fluid Administration Balance

Too little…
- Ongoing shock
- Continued acidosis
- Coagulopathy
- Myocardial dysfunction
- Renal failure
- Death

Too much…
- Increased bleeding
- Clot disruption
- Dilution coagulation factors
- Compartment syndromes
- Transfusion concerns
  - Inflammation
  - Immunosuppression
  - Transfusion Related Acute Lung Injury (TRALI)
Fluid Resuscitation Guidelines

- **Class I**
  - Body can compensate within 24 hours
  - Monitor for the need for crystalloids or blood products

- **Class II**
  - Crystalloid infusion required
  - Blood products may be needed

- **Class III**
  - Crystalloid infusion required
  - Blood products will be necessary

- **Class IV**
  - Aggressive management to avoid death
  - Institute the massive transfusion protocol

Limit crystalloids to 1 liter in adults
Crystalloids (Isotonic Solutions)

Balanced electrolyte solutions are similar to extra cellular fluid (ECF). Rapidly equilibrates across compartments.

Only 25% remains in IVS after 17 minutes!
NS vs. LR

Normal Saline
- Na, Cl
- Fluid of choice for blood
- Con:
  - Hyperchloremic acidosis
  - Retention/overload and electrolyte imbalance with large quantities

Lactated Ringers
- Na, Cl, K, Ca, Lactate
- Fluid of choice per ATLS
- Con:
  - Immune modulation
# Blood Administration

## Traditional Management

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Blood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Give 2 Liters ↓ →</td>
<td>PRBC 5-10 u ↓</td>
</tr>
<tr>
<td>Continue IV’s wide open</td>
<td>Wait for labs ↓</td>
</tr>
<tr>
<td></td>
<td>Plasma ↓</td>
</tr>
<tr>
<td></td>
<td>Platelets ↓</td>
</tr>
</tbody>
</table>

## Emerging Management

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Blood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimize</td>
<td>1:1 or 1:2 (Plasma: RBC)</td>
</tr>
<tr>
<td></td>
<td>Protocolize</td>
</tr>
<tr>
<td></td>
<td>Massive Transfusion Protocol</td>
</tr>
</tbody>
</table>
Massive Transfusion

- Best when guided by a protocol
- RBC’s and Plasma must be warmed
- Monitor closely for coagulopathy or confounding factors:
  - Hypothermia
  - Acidosis
  - Hypocalcemia
- Protocol example: Assessment of Blood Consumption (ABC Score)
  - Pulse >120
  - SBP < 90
  - + FAST
  - Penetrating trauma to the torso
* Two more would indicate the need to activate the MTP
Autotransfusion

- Consider for patients with massive hemothorax
  - Indicated for isolated chest injury
  - Diaphragmatic injury is a contraindication to autotransfusion
- Often requires an anticoagulant to be added (i.e. Sodium citrate)

- Do not delay definitive treatment to set up the autotransfuser
- Follow the manufacture's recommendations/organizational policy for the device in your facility
Massive Transfusion Protocol (MTP)
## Advantages of Blood Products

<table>
<thead>
<tr>
<th></th>
<th>Packed Red Blood Cells</th>
<th>Plasma</th>
<th>Platelets</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action</strong></td>
<td>Carries Oxygen</td>
<td>Coagulation Factors</td>
<td>Aggregation</td>
</tr>
<tr>
<td></td>
<td>No clotting factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Replenishes normal plasma and blood volume</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1 unit</strong></td>
<td>~300 ml (Hct 55%)</td>
<td>~250 ml</td>
<td>~25 ml individual unit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>~150 pooled unit</td>
</tr>
<tr>
<td><strong>Dose</strong></td>
<td>↑ Hgb by 1 g/dl</td>
<td>↑ coags by 2.5% (Need at least 4 u for significant change)</td>
<td>1 unit Apheresis (pooled)</td>
</tr>
<tr>
<td></td>
<td>↑ Hct by 3%</td>
<td></td>
<td>↑ 25,000-50,000 per u</td>
</tr>
<tr>
<td></td>
<td>In the non-bleeding pt</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Storage</strong></td>
<td>-4 C</td>
<td>Non-Trauma Center</td>
<td>Room temp Agitated</td>
</tr>
<tr>
<td></td>
<td>Progression:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emerg Uncrossmatched (immediate)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type Specific (20 min)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cross Matched (60 min)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Progression</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Cross Matched (60 min)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Non-Trauma Center</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frozen</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thaw time</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 u in 30 minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trauma Center</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Room Temp</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Good for 5 days</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor wastage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Response to Resuscitation

<table>
<thead>
<tr>
<th></th>
<th>Rapid Responders</th>
<th>Transient Responders</th>
<th>Minimal or No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vital Signs</strong></td>
<td>Return to normal</td>
<td>Improves initially then</td>
<td>No change</td>
</tr>
<tr>
<td></td>
<td></td>
<td>deteriorates</td>
<td></td>
</tr>
<tr>
<td><strong>Blood Loss (Estimated)</strong></td>
<td>&lt; 15%</td>
<td>15 – 40%</td>
<td>&gt; 40%</td>
</tr>
<tr>
<td><strong>Blood products required</strong></td>
<td>Low</td>
<td>Moderate to High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Blood preparation</strong></td>
<td>Type and Crossmatch</td>
<td>Type Specific</td>
<td>Massive Transfusion</td>
</tr>
<tr>
<td><strong>Operative Intervention/ Angioembolism</strong></td>
<td>Unlikely</td>
<td>Likely</td>
<td>Immediate</td>
</tr>
<tr>
<td><strong>Need for surgeon</strong></td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
</tr>
</tbody>
</table>
## Assessment vs. Resuscitation Endpoints

<table>
<thead>
<tr>
<th>Initial Assessment</th>
<th>Resuscitation Endpoints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentation</td>
<td>pH</td>
</tr>
<tr>
<td>Skin Perfusion</td>
<td>Serum Lactate</td>
</tr>
<tr>
<td>Pulse</td>
<td>Base Deficit</td>
</tr>
<tr>
<td>Blood Pressure</td>
<td>Hemodynamic stability</td>
</tr>
<tr>
<td>Pulse Pressure</td>
<td>Echocardiography</td>
</tr>
<tr>
<td>Shock Index</td>
<td>StO2 (NIRS)</td>
</tr>
<tr>
<td>Urine Output</td>
<td></td>
</tr>
</tbody>
</table>
Hemorrhagic Shock

Laboratory Tests
Type and Crossmatch

Emergency Uncrossmatched

- O+ Males
- O- Females/Peds

Type Specific

- ABO & Rh Compatible

Crossmatched

- ABO & Rh Type Antibodies

Immediate

10 minutes

60 minutes
Hemoglobin / Hematocrit

- Unreliable estimation of acute blood loss
- Lag time of several hours
- Baseline value for comparison only
- May be dilutional or falsely elevated
Arterial pH

Part of the arterial blood gas (ABG)

Acidosis - Serum pH < 7.20

Ongoing Marker of Severe Physiologic Derangement

- Decreased cardiac contractility
- Decreased cardiac output
- Vasodilation and decreased BP
- Decreased hepatic and renal blood flow
Lactic Acid

- Lactate or “lactic acid” is a normal product of cellular metabolism.
- Lactate itself is NOT toxic to cells or tissue.
  - Normal level of venous lactate is < 2.2 mmol/L
- Initial response occurs due to shift to anaerobic metabolism.
- Indirect measure of oxygen debt

**Lactate Clearance:**
Liver 60%
Kidney 30%
Heart ≈5%
Skeletal Muscle ≈5%
International Normalized Ratio (INR)

- Test of clotting (extrinsic pathway)
- Internationally accepted method of reporting prothrombin (PT) results worldwide

<table>
<thead>
<tr>
<th>Population</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>0.8 - 1.2</td>
</tr>
<tr>
<td>Anticoagulant Use</td>
<td>2.0 - 3.0</td>
</tr>
<tr>
<td>Trauma</td>
<td>&gt; 1.5 = coagulopathy</td>
</tr>
</tbody>
</table>
Thromboelastographic (TEG)

- Whole blood test
- Measuring hemostasis
  - Clot initiation to clot lysis
  - Net effect of your components
Tranexamic acid (TXA)

• TXA is an anti-fibrinolytic that inhibits both plasminogen activation and plasmin activity.
• This prevents clot break down and promotes new clot formation.
• Inexpensive ($80/dose) and proven safety profile.

Example of TXA Protocol
• Administer within 1-3 hours of injury
• 1 unit of blood
• 1 gram bolus of TXA
• 1 gram infusion over 8 hours
Fresh Whole Blood

• Whole blood closely matches the losses experienced with the hemorrhage
• Better concentration of coagulation factors
  • Whole blood requires less additives
• Being studied for use in civilian trauma
Recombinant Factor VIIa

- Off label use in trauma: Refractory bleeding in trauma
- Activates Extrinsic coagulation cascade
- Correct before use:
  - Hypofibrinogenemia
    - Cryoprecipitate
  - Thrombocytopenia
    - Platelets
  - Hypothermia
    - Correct Temperature
  - Acidosis
    - Consider Bicarbonate

- Include in the Massive Transfusion Protocol (Example)
  - Do not use too early or too late
  - Administer between 8 - 20 PRBC's
  - Recommended dose: 100 mcg/kg
  - Expensive:
    - 100mcg
      \[ \times 70kg = 7,000mcg = \$7,700 \]
  - Repeated at 1–2 hour intervals if required
Fibrinogen Concentrate (FC)

- Produced from pooled human plasma
  - Standardized fibrinogen concentration per vial (900 – 1300 mg of fibrinogen)
- Key role in clot formation due to fibrin production
  - Conversion to fibrin is catalyzed by thrombin
  - Induces platelet activation and aggregation by binding to glycoprotein GPIIb/IIIa receptors
- Literature in trauma
  - Positive relationship between plasma fibrinogen levels and survival
  - Reduction in transfusion requirements
  - Dosing strategy of 2 – 4 grams utilized in TIC
Prothrombin Complex Concentrate (PCC)

• Mechanism
  • Replenishes vitamin K dependent clotting factors (II, VII, IX, X)
  • Promotes conversion of fibrinogen to fibrin and cross-linked fibrin clot formation

• Reduced thrombin formation
  • Expected when procoagulant activity is < 30%
  • Occurs with blood loss > 150 – 200% of estimated blood volume

• Fibrinogen in trauma
  • Inadequate fibrinogen levels due to dilutional effects
  • Hyperfibrinolysis
  • Fibrinogen synthesis inhibition
  • Fibrin polymerization interference
Near Infrared Spectroscopy (NIRS)

Skeletal muscle StO2
- Measures hemoglobin oxygen saturation in tissue
- Tracks systemic O2 delivery
- Continuously and Noninvasively
- Comparable results to BD and Lactate
  - Predicts MSOF
  - Predicts Mortality
  - Research ongoing as resuscitation endpoint
Summary

- Use an organized approach to assessing trauma patients
- Recognize the presence of shock
- Stop the bleeding
- Appropriate use of diagnostic tools
- Assess for coagulopathy early
- Limit the use of crystalloids to 1 liter
- Use a Massive Transfusion Protocol
- Use damage control resuscitation techniques
Hemorrhagic Shock

1. An early sign of occult hemorrhagic shock is:
   a. Widened pulse pressure
   b. Elevated shock index
   c. Hypothermia
   d. Apnea

2. During the primary survey the initial management of a bleeding patient is:
   a. Provide O2 and ventilation
   b. Prevent heat loss
   c. Direct pressure to external signs of hemorrhage
   d. Initiate IV access

3. Causes of lethal major blood loss and ongoing hemorrhage can be concealed. Which injury has the greatest potential to sequester blood?
   a. Pneumothorax
   b. Head laceration
   c. Pelvic fracture
   d. Amputation

4. Isotonic crystalloids:
   a. Remain in the vascular space
   b. Enhance immune system function
   c. Include Hetastarch and Albumin
   d. Rapidly equilibrate across compartments

5. Urinary output is a clinical measure of a patient in shock since it reflects:
   a. Fluid overload
   b. Catecholamine levels
   c. Serum sodium
   d. Organ perfusion

6. Lab values that are indicators of acidosis include:
   a. pH, Base deficit, Lactate levels
   b. Potassium, sodium, calcium
   c. BUN, Creatinine
   d. Hemoglobin, hematocrit
7. A reliable tool for measuring tissue perfusion when there is metabolic acidosis and ongoing hemorrhage is:
   a. Pulse oximetry
   b. Base deficit/excess
   c. Creatinine
   d. Lactate levels

8. The goal of fluid resuscitation is:
   a. Only achieved with central venous access
   b. Restore adequate tissue perfusion
   c. To provide an initial infusion of 2 liters of crystalloids for all patients
   d. To only administer colloids

9. The most accurate definition of the shock state is:
   a. The level of carbon dioxide in the blood exceeds 50mmHg
   b. Inadequate perfusion to meet end organ oxygenation requirements
   c. Metabolic needs increase and there is a concurrent decrease in body temperature
   d. Cell permeability loss, and oxygen and nutrients cannot be transported to the cell

10. Which would be the first choice for intravenous line placement during initial resuscitation?
    a. External jugular
    b. Subclavian vein
    c. Antecubital vein
    d. Saphenous vein

11. Class III shock results from _________% of acute blood loss.
    a. Greater than 40%
    b. 30-40%
    c. 15-20%
    d. Less than 15%
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References

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