SHOCK – A PRIMER FOR THE EMT

Definitions

- **Shock**: “The body’s response to poor perfusion”
  - AKA: Hypoperfusion
- **Perfusion**: “The process by which oxygenated blood is delivered to the body’s tissue and wastes are removed from the tissue”

Aerobic Metabolism: “Metabolism with oxygen”
Anaerobic Metabolism: “Metabolism without oxygen”

Decreased perfusion leads to:
- Shock
- Anaerobic metabolism
- Build up of toxins

Fluids and Electrolytes

- **Water**
  - 60%
  - Mixed with proteins and electrolytes
  - Sent to various compartments in the body
- **Intracellular fluid** ~ 75%
- **Extracellular fluid** ~ 25%
  - Interstitial fluid ~ 17.5%
  - Intravascular fluid ~ 7.5%
Electrolytes

- Substances that dissociate into electrically charged particles when placed into water.
- Charged particles are called "ions".
  - Positive charge = "cation"
  - Negative charge = "anion"

Cations and Anions

- Cations - positively charged
  - Sodium Na+
  - Potassium K+
  - Calcium Ca++
  - Magnesium Mg++
- Anions - negatively charged
  - Chloride Cl-
  - Bicarbonate HCO₃-
  - Phosphate PO₄-

Cations

- Sodium (Na+)
  - Most prevalent cation in the extracellular fluid
  - Plays a major role in regulating the distribution of water
- Potassium (K+)
  - Most prevalent cation in the intracellular fluid
  - Transmission of electrical impulses

"Next of Kin"

- "N"ext
  - Sodium (Na+)
  - Most prevalent cation in the extracellular fluid
- "K"in
  - Potassium (K+)
  - Most prevalent cation in the intracellular fluid
Cations

• Calcium (Ca++)
  - Muscle contraction
  - Nervous impulse transmission
• Magnesium (Mg++)
  - Several biochemical processes
  - Closely associated with phosphate in many processes

Anions

• Chloride (Cl–)
  - Most prevalent anion in the extracellular fluid
  - Fluid balance and renal function
• Bicarbonate (HCO₃–)
  - Principle buffer of the body
  - Neutralizes highly acidic hydrogen ion (H+)

Anions

• Phosphate (HPO₄²–)
  - Major intracellular anion
  - Important in body energy stores
  - Helps maintain acid-base balance

Cellular Membranes

• Permeability
  - The degree to which a substance is allowed to pass through a cell membrane
• Semipermeable
  - Cell membranes that allow only certain substances to pass through them
**Diffusion**

- Movement of solutes from an area of greater solute concentration to an area of lower solute concentration

**Osmosis**

- Movement of water from an area of lower solute concentration to an area of higher solute concentration

**Active Transport**

- Movement of a substance across the cell membrane against the osmotic gradient
- Faster than diffusion
- Requires energy

  *Example: Sodium-Potassium Pump*

**Facilitated Diffusion**

- Requires the assistance of “helper proteins”
  - Protein binds to molecule changing its configuration
- May or may not require energy

  *Example: Insulin & Glucose*
### Crystalloids

<table>
<thead>
<tr>
<th>Isotonic Fluids</th>
<th>Hypertonic Fluids</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Lactated Ringers</td>
<td>- 3% NS</td>
</tr>
<tr>
<td>- Normal Saline</td>
<td>- 10% NS</td>
</tr>
</tbody>
</table>

### Isotonic Solutions

- State in which solutions on opposite sides of a semi-permeable membrane are equal in concentration
- There is **NO** fluid shift!

### Hypotonic Solutions

- State in which a solution has a lower solute concentration on one side than the other
- There is a shift **into the intracellular fluid**!

### Hypertonic Solutions

- State in which a solution has a higher solute concentration on one side than the other
- There is a fluid shift **into the interstitial fluid**!
Colloids

- Contain proteins or other high-molecular-weight-molecules
  - Tend to stay in vasculature for extended periods of time
- Have "colloid osmotic pressure"
  - Tend to attract water into the intravascular spaces

- Plasma Protein Fraction
  - Contains albumin & saline
- Salt-Poor Albumin
  - Contains only human albumin
- Dextran
  - Large sugar molecule
- Hetastarch (Hespan)
  - Sugar molecule

Blood Components

- Plasma 54%
- Red Blood Cells 45%
- White Blood Cells 1%
- Platelets 1%

- Plasma
  - Fluid portion of blood
  - Contains proteins, carbohydrates, amino acids, lipids, & mineral salts
- Erythrocytes
  - Most numerous cells in blood
  - Carry hemoglobin
**Blood Components**

- **Leukocytes**
  - Fight infection
  - Produce antibodies
- **Platelets**
  - Essential for clot formation

**Hematocrit**

- Percentage of red blood cells in whole blood
  - Women
    - 42 (+/- 5)
  - Men
    - 45 (+/- 7)

**Blood Typing**

<table>
<thead>
<tr>
<th>TABLE 8-2 Blood Typing—ABO System</th>
<th>Antibody Present in Serum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Type</td>
<td>Antigen Present on RBC</td>
</tr>
<tr>
<td>O</td>
<td>None</td>
</tr>
<tr>
<td>AB</td>
<td>A and B</td>
</tr>
<tr>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

**Blood Donor Compatibility**

<table>
<thead>
<tr>
<th>TABLE 8-3 Compatibility Among ABO Blood Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cells of Donor</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>ABO</td>
</tr>
<tr>
<td>AB</td>
</tr>
<tr>
<td>B</td>
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<tr>
<td>A</td>
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<td>O</td>
</tr>
</tbody>
</table>
Let’s Look at Perfusion

The Fick Principle

Adequate perfusion requires that all components of the “Fick Principle” are in place!

Fick Principle

1. Adequate concentration of inspired oxygen
2. On-loading of oxygen to red blood cells at lungs
3. Delivery of red blood cells to tissue cells
4. Off-loading of oxygen from red blood cells to tissue cells

Fick Principle

1. Adequate concentration of inspired oxygen requires:
   - Adequate ventilation
   - High concentration of inspired oxygen
   - Unobstructed air passages
2. On-loading of oxygen to red blood cells at lungs requires:
   - Minimal obstruction across alveolar-capillary membrane and
   - Appropriate binding of oxygen to hemoglobin

3. Delivery of red blood cells to tissue cells requires:
   - Normal hemoglobin levels
   - Circulation of oxygenated cells to tissues
   - Adequate cardiac function
   - Adequate volume of blood flow
   - Proper routing of blood through vasculature

4. Off-loading of oxygen from red blood cells to tissue cells requires:
   - Close proximity of tissue cells to capillaries
   - Ideal pH
   - Ideal temperature

Remove any component from the "Fick Principle" and shock will follow!
Metabolism

• Cells require a continuous supply of nutrients
  - Ex: Glucose, Oxygen
• Workload demands determine the rate of need
• The body automatically adjusts

Cellular Respiration

• Breakdown of food into energy
  - Aerobic
  - Anaerobic

Aerobic Metabolism

• Required fuels
  - Glucose
  - Oxygen
• Waste products
  - Pyruvic acid
  - Lactic acid
  - Carbon dioxide
• Method of excretion
  - Respiration
  - Urination

Anaerobic Metabolism

• Uses glucose only
• Almost 20 times less efficient than aerobic
• Causes dramatic increase in lactic acid production, and therefore metabolic acidosis
• Vascular dilation follows, causing a further shift in fluids out of the vascular space and into the interstitial space
• Further, potassium shifts out of the cell, and sodium in, which causes cell membrane instability
Death Cometh

- Brain and Lungs
  - Die within 4 to 6 minutes without oxygen
- Organs
  - Die within 45 to 90 minutes without oxygen
- Skin and muscle
  - Die within 4 to 6 hours without oxygen

The Cardiovascular System’s Role

The Pump, The Fluid, & The Container!

The Pump

- Blood Pressure
- Systemic
- Vascular Resistance
- Stroke Volume
- Heart Rate
- Myocardial Contractility
- Preload
- Afterload
**Stroke Volume**

- Amount of blood ejected from the heart with every contraction
- Affected by:
  - Preload
  - Contractility
  - Afterload

**Stroke Volume**

- Normal
  - 60–100cc per beat for average adult
- Ejection Fraction
  - Percentage of blood in the ventricle that is ejected during systole, > 50%, or a way to measure the “efficiency” of the “fuel pump”

**Preload**

- Heart muscle is stretched as chambers fill with blood between contractions.
- Stretching muscle fibers before contraction increases strength of contraction.

**Preload**

- Influenced by volume of blood returning to heart.
  - More blood returning increases preload; less blood returning decreases preload.
  - More stretch of muscles means more forceful contraction.
  - Frank Starling’s Law
Frank Starling’s Law

- More the heart is filled during diastole, the greater the quantity of blood that will be pumped during systole.
- Increase in volume stretches the heart muscle and increases stroke volume and thus increases cardiac output.
- Think of a “rubber band”

Contractility

- Contractility is extent and velocity of muscle fiber shortening.
- Influenced by:
  - Oxygen supply and demand
  - Sympathetic stimulation
  - Electrolyte balance
  - Calcium

Afterload

- Pressure ventricular muscles must generate to overcome higher pressure in aorta.
- Greater afterload means harder work for ventricles to eject blood into arteries.
- Dictated to large degree by blood pressure.

Cardiac Output

- Amount of blood ejected from the heart each minute
- Affected by:
  - Stroke Volume
  - Heart Rate

Cardiac Output = Stroke Volume X Heart Rate
**Blood Pressure**

- Force that blood exerts against arterial walls
- Affected by:
  - Cardiac Output
  - Systemic Vascular Resistance

\[ \text{BP} = \text{Cardiac Output} \times \text{Systemic Vascular Resistance} \]

**The Fluid**

- Significant fluid loss
  - Adult = 1 liter
  - Child = ½ liter
  - Infant = 100 to 200 mL
- Decreased
  - Hematocrit
  - Hemoglobin
  - Remember the ‘Fick Principle’

**The Container**

- Continuous, closed, pressurized pipeline that moves blood through body.
- Elastic blood vessels adjust fluid volume of container.
  - Systemic Control
  - Local Control
- Affects amount of blood returning to heart and amount of tissue oxygenation.

**The Nervous System & Its Role!**
Receptors
- Sensory nerve endings that sense changes in blood pressure or carbon dioxide
- Baroreceptors (pressure) located in:
  - Aortic arch
  - Walls of the atria
  - Vena cava
  - Carotid sinus
- Chemoreceptors (CO2) located in:
  - Brain and spinal cord
- Notify the sympathetic nervous system

Sympathetic Nervous System
- "Fight or Flight" response
  - Increases heart rate
  - Stimulates the heart to beat more forcefully
  - Respirations Increase
  - Release of norepinephrine
    - "Clamps down" on blood vessels
    - Kidneys decrease urinary output to conserve water

The Stages of Shock
- Compensated Shock
  - AKA: Nonprogressive Shock
- Uncompensated Shock
  - AKA: Progressive Shock
- Irreversible Shock

Compensated Shock
- Earliest phase
- Up to 15-25% blood loss
- Body compensates
  - Activates the sympathetic nervous system
**Compensated Shock**

- **Signs / Symptoms**
  - Altered LOC
  - Increased pulse rate
  - Increased respiratory rate
  - Pale, cool skin

**Decompensated Shock**

- **Blood volume drop greater than 15–25%**
- **Mechanisms no longer able to maintain**
  - Even more norepinephrine is released
- **Cardiac output drops**

**Decompensated Shock**

- **Signs / Symptoms more obvious, plus**
  - Additional increase in pulse and breathing
  - Cool, clammy skin
  - Decreased capillary refill
  - Narrowing of pulse pressure
  - Sweating
  - Increased anxiety and confusion
  - Nausea and vomiting
Irreversible Shock

- Rapid deterioration of the cardiovascular system
- Greater blood shunting to heart and brain
- Cell death begins
  - May develop over several days
Types of Shock

- Hypovolemic shock
- Cardiogenic shock
- Neurogenic shock
- Anaphylactic shock
- Septic shock

Hypovolemic Shock

- Most common form of shock
- Loss of blood or fluid from body
  - Internal or external hemorrhage
  - Burns
  - Severe dehydration
- All patients in shock should be considered as hypovolemic until proven otherwise

Cardiogenic Shock

- Caused by profound failure of the heart
  - Severe MI
  - Severe heart failure
  - Trauma to the heart
- There is good peripheral vascular resistance and adequate blood volume, but the heart is not pumping properly

Neurogenic Shock

- The nervous system is no longer able to control the diameter of the blood vessels
- Leads to relative hypovolemia
- Usually from severe brain or spinal column injury
- May have unusual Signs / Symptoms
Anaphylactic Shock

- Caused by exposure to a substance to which the patient is highly allergic
  - Skin contact – poison ivy, poison oak
  - Injections – medications, insects, stings
  - Inhalation – molds, pollen, perfumes
  - Ingestion – chocolate, shellfish, peanuts

Anaphylactic Shock

- Histamine release causes:
  - Sudden, severe bronchoconstriction
  - Intense vasodilation
  - Leaking of fluid from vessels due to a change in permeability

Anaphylactic Shock: Signs & Symptoms

- Sense of uneasiness or agitation
- Swelling
  - Hands, tongue, or pharynx
- Skin flushing and hives
- Tachycardia
- Coughing, sneezing, or wheezing
- Tingling, burning, or itching
- Abdominal pain
- Profound hypotension
- Decreased LOC

Septic Shock

- Caused by an infection resulting in massive vasodilation
  - Blood plasma lost through vessel walls
  - Results in a relative hypovolemia
- S/S
  - May be febrile
  - May have warm trunk, cool extremities
  - Whole body cool is BAD
Management of the Patient in Shock

- Work to maintain adequate blood pressure and perfuse vital organs.
- Rapid assessment and immediate transportation are essential for patient survival.

Management of the Patient in Shock

- Evaluation directed at assessing oxygenation and perfusion of body organs
- Goals of pre-hospital care include:
  - Ensuring a patent airway
  - Providing adequate oxygenation and ventilation
  - Restoring perfusion

Level of Consciousness

- Assessed throughout initial survey.
- Better indicator of tissue perfusion than most other vital signs.
- Assume altered mental status is due to decreased cerebral perfusion.

Level of Consciousness

- Restlessness or agitation
- Disorientation
- Confusion
- Inability to respond
- Belligerent or combative behavior
- Unresponsive
Airway

- Opening the airway
  - Head-tilt, chin-lift
  - Modified jaw thrust
- Sounds that may indicate airway obstruction include:
  - Snoring (tongue)
  - Gurgling (liquids such as blood or vomitus)
  - Stridor (foreign body/swelling)

- Use airway adjuncts if necessary.
- Endotracheal intubation is preferred to prevent aspiration of blood.
- Clear blood or fluids with suction.
- Remove large foreign objects with finger sweep.

Ventilation & Oxygenation

- LOOK, LISTEN & FEEL, for air exchange.
- RATE, DEPTH, and QUALITY of respirations.

- Provide 100% oxygen with nonrebreather mask at 10 to 15 L/min.
  - Ensure reservoir remains inflated at end of each inspiration.
- For assisted ventilations, supply 100% oxygen via bag-valve-mask.
Circulation

- Look for and control obvious external bleeding.
- Assess RATE, RHYTHM, & QUALITY of pulse.
- Palpable pulse location may provide estimate of systolic pressure.
- Note color, appearance, and temperature of skin.

- A fast, weak, or thready pulse suggests decreased circulatory volume
- Color, appearance, and temperature of the skin
  - Pale
  - Mottled
  - Cyanotic
- Capillary refill

Circulation

- Control any obvious external bleeding
  - Direct pressure
  - Tourniquet
- Remember compensatory mechanisms can maintain a 10 to 15% volume loss

- Elevate patient's legs.
- Apply, and if necessary inflate the pneumatic anti-shock garment.
- Place 2 large bore IV lines.
Pneumatic Anti-Shock Garment

- Tool to care for hypotension and shock.
- Helps control bleeding by applying pressure to blood vessels.

PASG Indications

- Hypovolemic shock from any cause.
- Hypotension secondary to decreased cardiac output.
- Fracture stabilization.
- Criteria for PASG include systolic blood pressure below 50 mm Hg with obvious signs and symptoms of shock.

PASG Contraindications

- Pulmonary edema (absolute contraindication).
- Abdominal compartment inflation is contraindicated in:
  - Pregnancy
  - Respiratory distress of any nature
  - Evisceration
  - Cases of impaled objects in abdomen

PASG Complications

- Use in presence of chest injuries.
- May increase bleeding in intrathoracic cavity leading to tension hemopneumothorax.
- Will increase breathing difficulty in patient with flail segment.
**Fluid Replacement**

- IV lines are used to counter blood loss by introducing fluid into intravascular space.
- Fluids help restore circulating volume until body can manufacture more blood.
- Patient in hypovolemic shock needs at least two IV lines.

**Maintain Body Temperature**

- Maintain body temperature as close to normal as possible.
- Pay attention to:
  - Environmental / Weather Conditions
  - Temperature of oxygen and IV fluids
  - Location of patient
- Protect patient from elements.

- Remove wet clothing.
- Cover patient to prevent heat loss.
- Too much heat produces vasodilation, counteracting body's vasoconstrictive compensatory efforts.
**Keys to Success!**

- Maintain a high level of suspicion
- Anticipate the potential for shock
- Do not get “tunnel vision”
  - Ensure a patent airway
  - Provide adequate oxygenation and ventilation
  - Restore perfusion

**Questions?**