Shock, Fluid & Buffer Therapy

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Learning Objectives:
- Explain the etiologies, manifestations and management of shock.
- Describe specific agents used to maintain blood pressure, fluid balance and pH, along with their actions, effects and complications.

Categories & Complications

Shock
Definition - inadequate perfusion of tissues to meet metabolic requirements.
- anaerobic metabolism - lactate
- release of intracellular substances to system
- accumulation of metabolic wastes

Categories
- Hypovolemic
- Distributive
- Cardiogenic

Hypovolemic shock
- Blood volume loss
  - Hemorrhage
  - Burns
  - Dehydration
    - heat exhaustion
    - diarrhea, vomiting
    - inadequate intake
**Distributive shock**
- blood pressure loss due to fluid distribution outside intravascular space or vasodilation.
  - third spacing: water in interstitial space
    - infusion with crystalloids
    - plasma protein deficit

**Cardiogenic shock**
- Ineffective cardiac pump
  - myocardial infarction: loss of contractile tissue
  - cardiomyopathy: ventricular dilation, loss of contractility
  - mechanical abnormalities
    - valvular disease
    - septal defects: high output failure
    - obstructive defects

**Complications**
- Acute respiratory distress syndrome (ARDS)
- Multiple organ system failure
  - cardiac
  - hepatic
  - renal
  - gastrointestinal

**Complications**
- Hypoxic-ischemic encephalopathy (HIE)
  - increased intracranial pressure (ICP)
  - when ICP equals mean arterial pressure, cerebral perfusion pressure equals zero.

**Manifestations**

FYI - Link to article on shock
http://www.emedicine.com/med/topic2114.htm

FYI - Link to information on HIE
http://www.emedicine.com/ped/topic149.htm
### General Manifestations
- Hypotension - PSys < 90 mm Hg
- Tachycardia
- Slow capillary refill
- CNS signs - vertigo, syncope, coma
- Pallor
- Oliguria, anuria
- Decreased transcutaneous PO2

FYI - Link to article on transcutaneous PO2 and shock
http://pediatrics.aappublications.org/cgi/content/abstract/65/5/881

### Specific Manifestations
- Hemorrhagic
  - low Hb, Hct
  - decreased CVP
- Dehydration
  - elevated Hb, Hct
  - decreased CVP

### Specific Manifestations
- Anaphylactic
  - history of bite, ingestion
  - pruritus (itching)
  - urticaria (hives)
  - laryngospasm
  - bronchospasm

FYI - Link to information on anaphylaxis

### Specific Manifestations
- Urticaria (hives)

Link to picture of hives
http://4.bp.blogspot.com/_iE08ptrg_HHo/SYxzoD214-I/AAAAAAAAAok/SXkrlBv83Io/s400/pbpn+-+hives.jpg

Link to another picture of hives

### Specific Manifestations
- Septic
  - signs of infection - fever, etc.
  - increased cardiac output (QT)
  - decreased C(a-v)DO2

### Shock - Specific Manifestations
- Cardiogenic
  - signs of MI
  - pulmonary edema
  - elevated PCWP (>25 mm Hg)

FYI - Link to article on cardiogenic shock
Management of Shock

**Hypovolemic shock**
- Vasopressors contraindicated for hypovolemia because of physiologic vasoconstriction
- Replacement of the specific fluids lost to circulation is necessary

**Blood products - hemorrhage**
- Whole blood
- Plasma
- Packed red blood cells

**Colloids - remain in intravascular space**
- Temporary for hemorrhage
- Manage third spacing by drawing fluid from interstitium

FYI - Link to article on colloids vs. crystalloids in shock
http://ccforum.com/content/4/S2/S16

**Colloids - remain in intravascular space**
- Common fluids
  - Human albumin - research questions its use
  - Dextran large carbohydrate molecule
  - Hetastarch (Hespan)

**Crystalloids - much loss to interstitial (third) space**
- Primary for dehydration, burns
- Common fluids
  - NaCl - 0.9%, 0.45%
  - Dextrose - in water or saline
  - Ringer's solution
  - Ringer's lactate - solution of choice for resuscitation
### Hypovolemic shock
- **Crystalloid solutions**
  - Ringer’s solution
    - NaCl
    - MgCl2
    - Na2HPO4
    - NaHCO3

- **Dehydration, burns**
  - Ringer’s lactate
    - NaCl
    - Na lactate
    - KCl
    - CaCl

### Monitoring fluid volume
- **Blood products**
- **Immune reactions; e.g. anaphylaxis**
- **Non-immune reactions; e.g., fluid overload**
- **Infections; e.g., HIV**

<table>
<thead>
<tr>
<th>Complications of Fluids</th>
<th>Blood products</th>
</tr>
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<tbody>
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<td><strong>Immune reactions; e.g. anaphylaxis</strong></td>
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<td><strong>Transfusion related acute lung injury (TRALI)</strong></td>
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</tbody>
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FYI - Link to article on transfusion risks
http://www.webmd.com/a-to-z-guides/blood-transfusion-risks-of-blood-transfusion

FYI - Link to article on TRALI
http://www.scbcinfo.org/publications/bulletin_v3_n1.htm
Complications of Fluids

- **Crystalloids**
  - Reduced colloid osmotic pressure (COP) ==> 3rd spacing
  - Electrolyte, pH imbalance
- **Dextrose (glucose)**
  - Hypercapnia, acidemia
  - Hyperglycemia

Anaphylactic shock

- **Epinephrine**
  - Vasoconstriction
    - Increase blood pressure
    - Reverse mucosal edema
  - Bronchodilation

- **Diphenhydramine (Benadryl)** - Inhibit action of histamine
- **Steroids**, e.g., hydrocortisone - Helps body cope with stress
- **Beta-agonist**; e.g., albuterol - Bronchodilation

Distributive shock

- **Crystalloids**
- **Vasopressors**
  - Epinephrine
  - Norepinephrine
  - Dopamine
  - Vasopressin
  - Neosynephrine

- **Anaphylactic shock**

- **Distributive shock**

  - Septic (distributive) shock
    - Antibiotics
    - Vasopressin (Pitressin)

  - Cause by toxins, drugs
    - Vasopressors
    - Removal of toxin, drug
      - Diuresis
      - Dialysis
      - Antidotes
      - Antitoxins

FYI - Link to article on vasopressin in septic shock
http://journal.ics.ac.uk/pdf/1201011.pdf
Cardiogenic shock
- vasopressors
- nitrates
- surgery, angioplasty
- intra-aortic counterpulsation
- inotropic agents
  - dobutamine
  - dopamine
  - milrinone (Primacor)

Complications of vasopressors
- peripheral tissue necrosis
- renal failure
- hypertension
- increased myocardial work

Buffer Therapy
- Purpose: to reverse acid-base imbalance, usually acidemia
  - NaHCO3 action: provides HCO3- $$\Rightarrow [H^+ + [HCO_3^-]] \Rightarrow H_2O + CO_2$$
  - depends on ventilation to excrete CO2

Buffer Therapy
- NaHCO3 complications
  - Respiratory acidemia if CO2 not excreted
  - Metabolic alkalemia (overdose)
  - Hypernatremia
  - Cerebral edema

Buffer Therapy
- NaHCO3 contraindications
  - pH >7.20
  - severe hypernatremia, often associated with renal failure
Buffer Therapy

- NaHCO3 Administration titrated with blood pH

\[ \text{HCO3 (mEq)} = \text{kg} \times (15 - \text{observed HCO3}) \times 0.5 \]

Buffer

- Tris-hydroxymethyl aminomethane-THAM (Tromethamine)- reverses acidemia without excretion of CO2
  - Action- organic proton acceptor

Buffer

- THAM
  - Indications
    - metabolic acidemia with hypernatremia
    - acidemia in conjunction with limitations in ventilation-permissive hypercapnia

FYI - Link to article on THAM and permissive hypercapnea

Buffer

- THAM
  - Complications
    - apnea
    - hypoglycemia
    - hypokalemia
    - alkalosis
    - tissue necrosis from infiltration

Buffer

- Tribonat
  - Currently used in Europe
  - Ingredients
    - NaHCO3
    - THAM
    - acetate
    - PO4
Buffer
- Tribonat - advantages
  - minimal effect on PCO2
  - minimal overcorrection risk
  - less Na than NaHCO3
  - no tissue irritability

Summary & Review
- Shock categories
  - hypovolemic
  - distributive
  - cardiogenic
- Shock - manifestations
  - general
  - category - specific

Summary & Review
- Shock management
  - fluid replacement
  - vasopressors
  - cardiotonics
- Buffers
  - NaHCO3
  - THAM
  - Tribonat

References

END