Trauma Resuscitation

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Hemodynamic Consequences of Trauma

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- Hemorrhage
  - External & Internal
- Thoracic Injury
  - Cardiac contusion
  - Tension Pneumothorax
- Closed head injury & Cushing Reflex

Hemodynamic Consequences of Trauma

- Shock
  - Inadequate oxygen to sustain aerobic metabolism in vital cells of essential organs
  - Delivery vs uptake

Shock

- Hemorrhage is the most common cause of shock in trauma
- Other causes: Cardiogenic, Neurogenic, Obstructive, Vasogenic, Endocrine

Shock

- Hemorrhagic Shock Pathophysiology
  - Acute decrease in circulating blood volume
  - Compensatory increase in sympathetic activity

Shock

- Mechanisms for Compensation
  - Epi/norepi released from adrenal gland
  - Peripheral and mesenteric vasoconstriction to shunt blood to central compartment

Shock

- Mechanisms for Compensation
  - JG cells release renin-> angiotensin II
    - vasoconstriction
  - Release of ADH from hypothalmus
    - reabsorbtion of Na+/H2O

Shock

- Hemorrhagic (Hypovolemic)Shock
  - Signs & Symptoms
    - Associated with tachycardia, narrow pulse pressure, cold, clammy skin, pallor

Goals of Resuscitation

Goals of Resuscitation

- Early Phase:
  - Prevent a worsening of acidosis and an increase in serum lactate
  - Maintain adequate oxygen carrying capacity and tissue perfusion while optimizing hemostatic conditions

Goals of Resuscitation

- Early Phase
  - SBP 80-100 mm Hg
  - Hct: 25-30%
  - platelets: > 50,000
  - PT/PTT, Ca++: “normal” range
  - temperature: > 35* C

Goals of Resuscitation

- Late Phase (once definitive control of hemorrhage established):
  - SBP >/= 100 mm Hg
  - HR: </= 100 beats per minutes
  - pH: ~ 7.40
  - Hct: >/= 25%

Goals of Resuscitation

- Late Phase
  - PT/PTT: "normal" range
  - Serum Lactate: "normal" range
  - Urine Output: adequate (0.5cc/kg/hr)

Goals of Resuscitation

- Achieve Hemostasis
- IMPORTANTLY
  - Adequate volume loading is the first goal
  - Adequate intravascular volume is necessary for pressors/inotropes to be effective

Fluid Resuscitation

Initial treatment of hemorrhagic shock is to attempt to stabilize hemodynamics by administering fluids and blood products as required to maintain tissue perfusion

IV solutions can sustain hemodynamics and deliver adequate oxygenation to healthy patients who have lost as much as 30% of their total blood volume

Crystalloid vs Colloid

- Crystalloid Benefits:
  - May replace intravascular & interstitial fluid losses
  - Decreased blood viscosity may improve perfusion
  - Inexpensive

- Crystalloid Problems
  - Intravascular 1/2 life is 20-30 minutes
  - Potential peripheral/pulmonary edema
  - Need for large quantities (3x blood loss)

- Colloid Benefits:
  - Longer intravascular 1/2 life (3-4 hours)
  - Less volume required (1x blood loss)
  - Potential for less peripheral edema

- Colloid Problems
  - Expensive
  - Leaky capillary membranes may worsen edema
  - Side effects: allergic reaction (albumin, gelatins), antiplatelet effects (dextran, hetastarch)

New England Journal of Medicine

- Randomized double blind study of 6997 ICU patients received LR vs 4% albumin for resuscitation
- No difference in mortality, organ failure, dialysis, ICU/hospital days

Cochrane Database

- Reviewed randomized trials that investigated colloid vs crystalloid resuscitation in critically ill patients
- No evidence that colloids reduced the risk of death in trauma, burn and post surgical patients

Guidelines

- Crystalloids in sufficient amounts are as effective as colloids
- Severe intravascular deficits are more rapidly corrected with colloids

Guidelines

- Consider Colloid Resuscitation
  - Severe intravascular deficit prior to arrival of blood for transfusion
  - Resuscitation in presence of protien losing conditions (burns)

Blood Products

Initial treatment of hemorrhagic shock is to attempt to stabilize hemodyanamics by administering fluids and blood products as required to maintain tissue perfusion

Classification of Hemorrhage

- Class I: up to 15% of blood volume
  - Normal pulse and blood pressure
- Class II: up to 30% of blood volume
  - Tachycardia, decreased UOP, anxiety

Classification of Hemorrhage

- Class III: up to 40% blood volume
  - Tachycardia, hypotension, tachypnea, oliguria, anxiety
- Class IV: > 40% blood volume
  - marked tachycardia & hypotension, tachypnea, anuria, confusion, lethargy

When to Transfuse?

- Lower limit of human tolerance to acute normovolemic anemia has not been established

When to Transfuse?

- Precise threshold for transfusion is not supported in literature
- Red cells should usually be given when hemoglobin is low (<6mg/dl in young, healthy patients)

When to Transfuse?

- Red cells are usually not necessary when hemoglobin concentrations are > 10mg/dl
- Above altered in consideration of ongoing blood loss

When to Transfuse?

- Intermediate hemoglobin concentration
  - Ongoing tissue ischemia
  - Potential/actual ongoing blood loss
  - Patient's volume status
  - Risk factors for tissue ischemia
    - low cardiopulmonary reserve
    - high VO_2

Intraoperative/Postoperative: When to Transfuse

- Similar guidelines
- Monitor Blood Loss
  - Surgical field, lap sponges, microvascular oozing (coagulopathy)
  - Monitor Hct/hemoglobin

Intraoperative/Postoperative: When to Transfuse

- Monitor Blood Loss
  - Presence of inadequate perfusion/ oxygenation of vital organs
    - Blood pressure, heart rate, urine output, oxygen saturation, mental status changes

Goals of Transfusion

- Maintain adequate intravascular volume and blood pressure with crystalloids or colloids until the criteria for red blood cell transfusion listed above is met

Goals of Transfusion

- Adequate quantities of red blood cells should be transfused to maintain organ perfusion

Management of Coagulopathy

- Platelet Transfusion
  - <50,000 cell/mm_3 in bleeding patient
  - <20,000 cell/mm_3 in non-bleeding patient
  - Not indicated in count > 100,000 cell/mm_3

- Platelet Transfusion
  - 1 platelet concentration will increase platelet count ~10,000 cell/mm_3
  - 6-8 platelet concentrations usually given for a goal platelet count > 50,000 cell/mm_3

Management of Coagulopathy

- Fresh Frozen Plasma
  - Control of excessive microvascular bleeding
  - Dilutional coagulopathy
    - patient transfused > 1 blood volume (~70cc/kg)

- Fresh Frozen Plasma
  - Urgent reversal of warfarin
  - Correction of factor deficiency
  - Heparin resistance (AT III deficiency)

- Give FFP to achieve minimum 30% of plasma factor concentration
  - 10-15ml/kg FFP, or
    - 4-5u platelet concentrates
    - 1u single donor platelet aphoresis
    - 1u fresh whole blood
  - Warfarin reversal: (4-5ml/kg)FFP

Management of Coagulopathy

- Cryoprecipitate Transfusion
  - Serum fibrinogen < 80-100 mg/dL
  - Correction of excessive microvascular bleeding in massively transfused patient

Management of Coagulopathy

- Cryoprecipitate Transfusion
  - Congenital fibrinogen deficiency
- Unit of cryo contains 150-250mg/dL of fibrinogen
- unit of platelets contains 2-4mg/mL fibrinogen

Vasopressors

Phenylephrine

- Synthetic noncatecholamine
- Selective alpha-1 agonist
- Primarily arteriolar vasoconstriction, minimally venous
- Short duration: < 5 minutes
- Rapid metabolism by MAO

Phenylephrine

- Indications:
  - Hypotension due to peripheral vasodilation (anesthetic agents, spinal shock)

Phenylephrine

- Advantages
  - Increased perfusion pressure to brain, kidneys, heart without increased myocardial contractility
- Disadvantages
  - Decreased SV due to increased afterload; may increase PVR

Phenylephrine

- Administration
  - Bolus OK via peripheral line; central line prefered with infusion
  - Infusion: 0.5-10mcg/kg/minute
  - IV bolus: 1-10mcg/kg

Ephedrine

- Plant-derived alkaloid with sympathomimetic effects
- Mild direct alpha 1, beta 1,2 effects
- Indirect NE release from neurons
- Offset 5-10 minutes
- Renal elimination, no MAO/COMT metabolism

Ephedrine

- Indications
  - Hypotension due to low SVR, low CO
    - especially if HR is low
    - Useful in hypotension due to spinal/ epidural anesthesia

Ephedrine

- Advantages
  - Correct sympathectomy
  - Does not reduce blood flow to placenta
- Disadvantages
  - Blunted efficacy if NE stores depleted

Ephedrine

- Administration
  - Peripheral line OK
  - 5-10mg bolus, repeated

Norepinephrine

- Primary physiologic postganglionic sympathetic neurotransmitter
- Direct alpha 1,2, beta 1 agonist
- Limited beta 2 effect
- Offset by neuronal reuptake and MAO/ COMT metabolism

Norepinephrine

- Advantages
  - Direct adrenergic antagonist
  - Redistributes blood flow to brain, heart
- Disadvantages
  - Reduced organ perfusion
  - Skin necrosis with extravasation

Norepinephrine

- Indications
  - Peripheral vascular collapse
    - septic shock
    - spinal shock
  - Increased SVR when phenylephrine has failed

Norepinephrine

- Administration
  - By central line only
  - 2-12 mcg/min; start 0.5-1 mcg/min

Inotropes

Dobutamine

- Synthetic catecholamine
- Direct beta 1 agonist; limited beta 2, alpha 1 effects
- Increased inotropy, peripheral vasodilator
- COMT metabolism

Dobutamine

- Indications
  - Low CO states (cardiogenic)
    - especially with increased SVR or PVR

Dobutamine

- Advantages
  - Afterload reduction may increase LV and RV systolic function
- Disadvantages
  - Tachycardia/arrhythmias, hypotension, nonselective vasodilator may = steal phenomenon

Dobutamine

- Administration
  - Central line
  - Infusion: 2-20 mcg/kg/minute

Dopamine

- Catecholamine precursor to NE & epinephrine
- Direct action: alpha 1; beta 1,2; DA1
  - dose dependent
- Indirect: release of stored neuronal NE
- Offset: reuptake, MAO, COMT metabolism

Dopamine

- Advantages
  - ? increased renal perfusion
  - Blood flow shifted from skeletal muscle to renal/ splanchnic beds
  - BP response easy to titrate: inotropic & vasoconstrictor properties

Dopamine

- Indications
  - Hypotension due to low CO or SVR
  - Temporary therapy of hypovolemia

Dopamine

- Disadvantages
  - arrhythmogenic
  - Indirect-acting component: diminished response in catecholamine depleted patients
  - Increased MVO2
  - Increased PVR

Dopamine

- Administration
  - 1-3 mcg/kg/min: DA1; increased renal and mesenteric blood flow
  - 3-10 mcg/kg/min: beta 1,2; increased HR, contractility
  - > 10 mcg/kg/min: alpha; increased SVR, PVR, HR, arrhythmias

Dopamine

- Administration
  - Central Line
  - Infusion: 1-20 mcg/kg/min

Epinephrine

- Catecholamine endogenously produced by adrenal medulla
- Direct agonist: alpha 1,2; beta 1,2
- Offset: reuptake and MAO, COMT metabolism

Epinephrine

- Indications
  - Cardiac arrest (asystole/VF/PEA)
  - Anaphylaxis
  - Cardiogenic Shock
  - Bronchospasm
  - Reduced CO after CPB
  - Hypotension with spinal/epidural anesthesia

Epinephrine

- Administration:
  - Low dose (10-30ng/kg/min): primarily beta 2 receptor activation; vasodilation
  - Moderate dose (30-150ng/kg/min): beta > alpha receptor activation
  - High Dose (> 150ng/kg/min): alpha > beta receptor activation

Epinephrine

- Administration
  - Allergic reaction (IM): 10mcg/kg (max 400mcg)
  - Shock, hypotension:
    - bolus: 0.03-0.2 mcg/kg
    - infusion:0.01-0.3 mcg/kg/min
  - Resuscitation: 0.5-1 mg

In Summary

Summary

- Hemorrhage is the most common cause of trauma related shock
  - Achieve hemostasis
  - Resuscitate to “early phase” goals
  - Consider other etiologies

Summary

- Fluid Resuscitation:
  - Crystaloids in sufficient amounts are as effective as colloids
  - Colloids more rapidly correct severe intravascular deficits
    - "Bridge" to blood products

Summary

- Red Cell Transfusion
  - Hemoglobin < 6mg/dL
  - Higher threshold if ongoing blood loss; high risk comorbidities

Summary

- Platelet transfusion
  - Bleeding: < 50,000
  - Risk spontaneous hemorrhage < 20,000
  - 6-8 concentrates for goal > 50,000

Summary

- FFP, Cryoprecipitate
  - Microvascular bleeding (oozing)
  - Factor deficiency/fibrinogen deficiency

Summary

- Know pharmocology of pressors/inotropes
- Tailor use of pressor/pharmacology