Transfusion Strategies

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Summary

• Why transfuse?
• When transfuse?
• What to transfuse?
• Problems!
Why?
Blood Functions

• $O_2$ delivery
• Glucose delivery
Platelets

Normal

Intraoperative bleeding

Spontaneous bleeding
Estimated Blood Volume

- Premature infant = 100-120 ml/kg
- Full-term infant = 90 ml/kg
- Infant 3-12 months = 80 ml/kg
- Older = 70 ml/kg
When
Preoperative Evaluation

- Review previous medical records
- Interview patient
- Evaluate bleeding risk of surgery

- factor VIII deficiency
- sickle cell anemia
- idiopathic thrombocytopenic purpura
- liver disease
- hemoglobin
- hematocrit
- coagulation profile
Intraoperative Evaluation

1. monitor amount of blood loss
2. monitor hemoglobin / hematocrit
3. monitor for presence of inadequate perfusion / oxygenation of vital organs
Perfusion Assessment

• Pulse – presence / quality / regularity
  – rhythm
  – systolic blood pressure
  – no carotid / femoral ? – cardiopulmonary arrest
• Color – skin / nail beds / mucus membranes
• Skin temperature – cool = decreased perfusion
• Skin moisture – dry = good perfusion
• Capillary refill > 2s ≈ poor perfusion
  (influenced by many other factors)
Maximum Allowable Blood Loss

\[
\frac{EBV \times (HCT - \text{target HCT})}{HCT}
\]
## Classification of Hemorrhagic Shock

<table>
<thead>
<tr>
<th></th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
<th>Class IV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amount of blood loss</strong></td>
<td>&lt; 750 ml (&lt; 15%)</td>
<td>750-1500 ml (15-30%)</td>
<td>1500-2000 ml (30-40%)</td>
<td>&gt; 2000 ml (&gt; 40%)</td>
</tr>
<tr>
<td><strong>Heart rate (bpm)</strong></td>
<td>Normal</td>
<td>&gt; 100</td>
<td>&gt; 120</td>
<td>&gt; 140</td>
</tr>
<tr>
<td><strong>Ventilatory rate</strong></td>
<td>Normal</td>
<td>20-30</td>
<td>30-40</td>
<td>&gt; 35</td>
</tr>
<tr>
<td><strong>Systolic blood pressure</strong></td>
<td>Normal</td>
<td>Normal</td>
<td>Decreased</td>
<td>Greatly decreased</td>
</tr>
<tr>
<td><strong>Urine output (ml/hr)</strong></td>
<td>Normal</td>
<td>20-30</td>
<td>5-15</td>
<td>Minimal</td>
</tr>
</tbody>
</table>

- **Compensated**
  - Respond well to **crystalloid**
  - Minutes to live
- **No longer able to compensate**
  - Will require **transfusion**
  - Minutes to live
Hemorrhage Control

• Direct pressure
  – pressure to site of bleeding
  – 4x4 dressing / shirt / cloth
  – one person job

• Tourniquets
  – use if direct pressure does not work on extremity
  – very effective in severe hemorrhage
  – width of 4 inches (10 cm)
Hemorrhage Control

• Impaled objects
  – do NOT remove
  – apply pressure on either side of object

• Elevation / ‘pressure points’ do not work
What to transfuse
Blood Component Therapy

• Whole blood:
  – 40% hematocrit

• Packed red blood cells (PRBC):
  – volume 250-300 ml
  – hematocrit of 70-80%
  – increases adult Hb ~ 1 g/dl
  – increases HCT ~ 3%.
Universal Donor

= Group O, Rh-

• should be reserved for patients close to exsanguination
• should **not** be given as whole blood
  – serum contains high anti-A and anti-B titres which may cause hemolysis of recipient red cells.
• If > 4 units group O, Rh- **whole** blood is given, type-specific blood should **not** be given subsequently
  – high anti-A and anti-B titres could hemolyse donor blood.
• if < 10 units of group O, Rh- **PRBCs** is given may be switched to type-specific blood
  – insignificant risk of hemolysis from small volume of plasma in PRBCs
Blood Component Therapy

Platelets
• One platelet concentrate will increases platelet count 5-10x10⁹/l
• usual dose is 1 platelet concentrate per 10 kg body weight
• single-donor platelets obtained by apheresis = 6 platelet concentrate
• platelets are stored at room temperature
• risks of platelet infusions:
  – sensitization reactions (human leukocyte antigens on platelet cell membranes)
  – transmission of viral diseases.
• During surgery platelet transfusions are probably not required unless count is less then 50,000/mm³
FFP / cryo

Fresh frozen plasma (FFP):
- 250 cc/bag
- contains all coagulation factors except platelets.

Cryoprecipitate:
- 10-20 mL/bag
- contains 100 units factor VIII-C, 100 units factor vWF, 60 units factor XIII, and 250 mg fibrinogen
- used for factor VIII deficiency and hemophilia
How much

Fluid replacement equivalents

• Crystalloid: 3 cc/1 cc EBL
• Colloid: 1 cc/cc EBL
• Whole blood: 1 cc/cc EBL
• Packed red blood cells: $\frac{1}{2}$ cc/cc EBL
Complications
Complications - Risks

1. Minor allergic reactions (fever, chills, rash): 1-5:100
2. Nonfatal hemolytic transfusion reactions: 1:6 000
3. ABO incompatibility: 1:33 000
4. Anaphylactic shock: 1:500 000
5. Fatal hemolytic transfusion reaction: 1:500 000 to 800 000
6. HIV infection: 1:450 000 to 660 000
7. Hepatitis
   - Hepatitis A: 1:1 million
   - Hepatitis B: 1:30 000 to 250 000
   - Hepatitis C: 1:30 000 to 150 000
8. Bacterial contamination
   - Red cells: 1:500 000
   - Platelets: 1:12 000
9. Acute lung injury: 1:5 000
Complications - Nonhemolytic transfusion reactions

- 0.5-1.0% of transfusions
- febrile reactions
- due to recipient antibodies against donor antigens on leukocytes / platelets

- treat with slow infusion and antipyretics.
Major Concerns

1. transfusion related acute lung injury (TRALI)
2. bacterial contamination of platelets
3. ABO incompatibility.
Complications – hemolytic transfusion reactions

= transfusion of RBCs to a patient with preexisting antibody

Acute hemolytic transfusion reaction
• 1:10,000
• 20-60% mortality
• usually due to donor blood ABO incompatibility;
• complement activation → hemolysis and may result in DIC;
• headache, chills, nausea, vomiting, skin flushing, fever, flank pain, hypotension, dyspnea, bleeding / hemoglobinuria
• acute renal failure may occur

Delayed hemolytic transfusion reaction
• occurs 1:33,000
• 3-10 dys later
• previously sensitized patients.
Tx hemolytic transfusion rxns

1. Stop the transfusion
2. Maintain urine output at a minimum of 75ml/h by:
   1. Generously administer fluids IV and possibly mannitol (12.5 - 50 grams, over a 5 minute period)
   2. If fluids / mannitol ineffective, than furosemide (20-40 mg).
   3. Prevent hypotension
3. Alkalinize the urine (40-70 mEq/70 kg sodium bicarbonate)
   • repeat urine pH determinations indicate the need for additional bicarbonate.
5. Determine platelet count, PTT, serum fibrinogen level.
6. Return unused blood to blood bank for crossmatch and send blood sample for antibody screen and direct antiglobulin test.
Complications – Transfusion-related lung injury

= noncardiogenic pulmonary edema
• Onev of most common causes of transfusion-related deaths (50%)
• immune reactivity of certain leukocyte antibodies
• signs and symptoms 1-2 h after transfusion
• maximum force within 6 h
• hypoxia, fever, dyspnea, and fluid in the ETT
• no specific therapy – stop transfusion & supportive measures.
• most patients recover in 96 h
Complications – Bacterial Contamination

• leading cause of death from blood transfusions
• most frequently platelets
Complications – allergic reactions

Allergic reactions
• 3% of transfusions (20% platelet transfusion)
• immunoglobulin alloantibodies react against substances in the donor plasma with activation of mast cells and histamine release
• abrupt onset of pruritic erythema / urticaria on arms and trunk
• minimized with slow infusion and antihistamines.

Anaphylaxis
• occurs in IgA deficient patients who have developed anti-IgA
• immune complex activates mast cells, basophils, etc.
• results in hypotension, dyspnea, laryngeal edema, wheezing and possibly shock
• treat like severe allergic reaction.
Complications – Metabolic abnormalities

1. Decreased pH - due to increased H\(^+\) production.
2. Increase K\(^+\) - due to cell lysis
   • increases with duration of storage
3. Citrate toxicity:
   • Liver metabolises citrate to bicarbonate → metabolic alkalosis
   • Citrate binds calcium → hypocalcemia
4. Hypothermia
   • avoid with blood warmers (except for platelets)
Complications - Coagulopathy

- Usually only after massive transfusion (> 10 units).
- Dilutional thrombocytopenia
  - most common cause of abnormal bleeding in massive transfusion
  - responds quickly to platelet transfusions.
- Low Factors V and VIII
  - very labile in stored blood – may decrease to 15-20% normal – usually enough for hemostasis.
- Disseminated Intravascular Coagulation
  - activation of the clotting system → hypercoagulable state
  - deposition of fibrin in microvasculature
  - secondary activation of fibrinolysis
  - consumption of factors and platelets.
Massive transfusions

Defined as

- the replacement of a patient's total blood volume in less than 24 hours
- the acute administration of more than half the patient's estimated blood volume per hour.