

# Transfusion Therapy

## Type and Screen/Crossmatch

### Type and Screen (takes 30-120 min, lasts 72 hr)

- ABO-Rh typing and antibody screen
  - Recipient serum + type O RBCs for presence of A or B antibodies - no agglutination = negative screen
  - If antibody screen is positive the serum is tested further
  - Recipient RBCs for presence of A or B antigens

### Type and Crossmatch (if T&S negative takes 30-60 min)

- Immediate phase: recipient serum + donor cells test for recipient Ab to donor (5 minutes)
- Incubation phase: incubate products from first test to look for incomplete recipient Ab to donor ie. Rh system
- Indirect Antiglobulin test: antiglobulin serum to products of first two tests to look for incomplete recipient Ab to Rh, Kell, Duffy, and Kidd

## Packed Red Blood Cells

### Definition, Use, & Storage

- Single donor; volume 250-300 ml with Hct ~70%.
- 1 unit pRBCs  $\uparrow$  adult Hgb ~1 g/dl or Hct ~3%.
- 10 ml/kg PRBC  $\uparrow$  Hct 10%
- Stored at 4°C in CPD (21 days), CPDA (35 days), or Adsol (42 days).
- CPDA:
  - Citrate (anticoagulant) - also binds iCa
  - Phosphate (buffer)
  - Dextrose (energy source)
  - Adenosine (precursor to ATP synthesis)

## Packed Red Blood Cells

### Indications (ASA Guidelines)

1. H/H < 6/24 in young, healthy patients
2. Usually unnecessary when H/H >10/30 g/dl
3. At Hgb 6-10 g/dl, the decision to transfuse is based on:
  1. ongoing indications of organ ischemia
  2. potential or ongoing blood loss
  3. volume status
  4. risk factors for complications of inadequate O<sub>2</sub>.

### Note:

1. Solutions incompatible with pRBC:  
LR (theoretical clot formation due to calcium  
D5W, plasmanate, 0.2% saline (hemolysis)

## Platelets

### Definition, Use, & Storage

- Platelet Concentrate (PC)
  - Platelets from one donated unit, vol = 50-70 ml; ↑ plt ~5000-10,000.
  - "6-pack" = 6 pooled PCs; rarely used anymore
- Apheresis Unit
  - Platelets from a single donor; vol = 200-400 ml; ↑ plt ~50,000.
- Can give ABO-incompatible platelets, Rh tested only
- Stored at room temperature for ≤5 days.

### Indications (ASA Guidelines)

1. Rarely when plt > 100,000
2. Usually when plt < 50,000 (spontaneous bleed at < 20K)
3. When plt 50-100,000, based on risk of bleeding
4. With platelet dysfunction (e.g. CPB, plt inhibitors)

## Fresh Frozen Plasma

### Definition, Use, & Storage

- Fluid portion from whole blood
- Contains all coagulation factors (except platelets)
- 1 unit increases clotting factors 2-3%
- Use ABO-compatible; Rh-incompatible is OK
- Stored frozen; takes 30 min to thaw; use within 24 hrs of thawing

### Indications (ASA Guidelines)

1. Urgent reversal of Coumadin
2. Correction of known factor deficiency
3. Correction of 1) microvascular bleeding with INR > 1.5, 2) INR > 2, or 3) PTT > 2x normal
4. During massive transfusion (before lab results available)
5. Heparin resistance (i.e. antithrombin III deficiency) in patients requiring heparinization.

## Cryoprecipitate

### Definition

- Fraction of plasma that precipitates when FFP is thawed.
- Contains Factors VIII, XIII, I (fibrinogen), and fibronectin
- 1 unit contains ~5X more fibrinogen than 1 unit FFP.
- Use within 4-6 hours after thawed if want to replace Factor VIII

### Indications (ASA Guidelines)

1. Rarely when fibrinogen >150 mg/dl
2. When fibrinogen <100 mg/dl with microvascular bleeding
3. During massive transfusion when fibrinogen level not available
4. Bleeding patients with vWF disease
5. Congenital fibrinogen deficiency

## Equations

### Arterial O<sub>2</sub> Content

$$\begin{aligned}
 C_aO_2 &= O_2\text{-Hb} + \text{Dissolved } O_2 \\
 &= (\text{Hb} \times 1.36 \times S_aO_2/100) + (P_aO_2 \times 0.003) \\
 &= (15 \times 1.36 \times 100\%) + (100 \times 0.003) \\
 &\approx \underline{20 \text{ cc } O_2/\text{dl}}
 \end{aligned}$$

### Allowable Blood Loss

$$\text{ABL} = \frac{[\text{Hct (start)} - \text{Hct (allowed)}] \times \text{EBV}}{\text{Hct (start)}}$$

### Volume to Transfuse

$$\text{Volume} = \frac{[\text{Hct (desired)} - \text{Hct (current)}] \times \text{EBV}}{\text{Hct (transfused blood)}}$$

### Estimated Blood Volume (ml/kg)

Preemie	100
Term	90
< 1 year	80
1-6 years	75
Male	70
Female	65
Obese	≤60

## Transfusion-Related Infections

### Viral

- CMV >1:100
- Hepatitis B 1 in 220,000
- Hepatitis C 1 in 1,600,000
- HIV 1 in 2,000,000

(Figures based on 2000-2001 estimated risk)

### Bacterial

- Most common with platelets (1:2000) due to their storage in dextrose at room temperature.
- pRBCs not a major source (1:500,000) due to their storage at 4°C, but Yersinia is most likely organism.

**Blood is screened for HCV, HBV core Ab, HIV-1, HIV-2, HTLV, syphilis**

## Transfusion Reactions

### Febrile Non-Hemolytic Reaction

- Benign; occurs with 0.5-1% of transfusions
- R/O acute hemolytic reaction
- Treatment: Tylenol, Benadryl, supportive care

### Allergic/Anaphylactic Reaction

- Occurs within minutes; life-threatening
- Signs/Symptoms: shock, angioedema, ARDS
- Treatment: D/C blood, fluids, Epi, antihistamines, ACLS

### Acute Hemolytic Reaction

- Due to ABO incompatibility
- Symptoms (fever, chills, flank pain) masked by GA; watch for hypotension & brown urine; monitor for ARF and DIC.
- Treatment: D/C blood, maintain alkaline UOP (NaHCO<sub>3</sub>, mannitol, Lasix), supportive care.

### Transfusion-Related Acute Lung Injury (TRALI)

## TRALI

- An acute RDS that occurs ~4 hours after transfusion.
- Incidence: 1 in 1120 (but underreported)
- Mortality 5-10%
- Due to plasma-containing products (platelets and FFP > pRBCs) - usually donor origin antibodies to leukocytes
- Signs & symptoms: Dyspnea, hypoxemia, hypotension, fever, pulmonary edema.
- Diagnosis of exclusion: first R/O sepsis, volume overload, and cardiogenic pulmonary edema
- Treatment: supportive care, similar to ARDS (O<sub>2</sub>, mechanical ventilation, volume)
- TRALI is usually self-limited and resolves within 48 hours.

## Massive Transfusion

### Definition

- Acute administration of greater than 1 blood volume (~10 units) in 24 hours.
- At Stanford, calling the blood bank for the Massive Transfusion Guideline (MTG) will get you 6 pRBCs, 4 FFP, and 1 unit of platelets.

### Consequences

1. Hypothermia
  - Blood products are stored cold - use a fluid warmer!
2. Coagulopathy
  - a. Dilutional thrombocytopenia
    - Platelet count likely <100,000 after ~10 units pRBCs
  - b. Dilutional coagulopathies
    - ↓ Factors V & VIII ("labile factors") in stored blood
    - Hypofibrinogenemia

## Massive Transfusion

### Consequences

#### 3. Citrate Toxicity

- Citrate is in CPDA storage solution as a  $\text{Ca}^{2+}$  chelator.
- Massive transfusion can cause an acute hypocalcemia.
- Binds magnesium as well causing hypomagnesemia

#### 4. Acid-Base Abnormalities

- At 21 days, stored blood has pH  $<7.0$ , due mostly to  $\text{CO}_2$  production, which is rapidly blown off after transfusion.

#### 5. Hyperkalemia

- $\text{K}^+$  moves out of pRBCs during storage.
- If EKG changes occur, stop transfusion and treat hyperkalemia.

#### 6. Impaired $\text{O}_2$ -Carrying Capacity (?!?!)

- 2,3-DPG decreases in stored blood, causing a left-shifted  $\text{O}_2$ -Hb dissociation curve.

## References

- ASA Task Force on Perioperative Blood Transfusion and Adjuvant Therapies. 2006. Practice guidelines for perioperative blood transfusion and adjuvant therapies. *Anesthesiology*, **105**: 198-208.
- Goodnough LT. 2003. Risks of blood transfusion. *Crit Care Med*, **31**: S678-86.
- Morgan GE, Mikhail MS, and Murray MJ. *Clinical Anesthesiology, 4th ed*. New York: McGraw-Hill Companies, Inc., 2006.