4 Blood Products and Blood Transfusion

Done By:
Fatmah Alshehry

Reviewed By:
Ibrahim Abunohaiah

جامعة الملك سعود
King Saud University

COLOR GUIDE: • Females' Notes • Males' Notes • Important • Additional

Objectives

1. Indication of Blood Transfusion.
2. Blood Groups.
3. Blood Components.
4. Blood Transfusion Complications and Treatment "How to manage Acute Hemolytic Transfusion Reaction".
5. Alternative to Blood Products.

Transfusion Therapy:

- 60% of blood transfusion occurs perioperatively.
- The Anesthesiologist is responsible of Perioperative transfusion.

Blood Transfusion:

- Up to 30% of blood volume can be treated with crystalloids. E.g. if patient's Hgb is 14 and he bleeds around 1.5 L, he can be managed with Crystalloids. Actually the type of fluid replacement therapy depends on:

1. Patient's condition.
2. Patient's co morbidities.
3. Patient's Hgb level.

   E.g. in case if the patient is bleeding, blood transfusion is the choice while if he is fasting and refused oral fluids the I.V. fluid (D5 water and half normal saline = Na concentration is 75 meleq\L) to restore electrolyte balance.

   Ringer's lactate is very close to the physiological fluids but is contraindicated in patients with (renal impairment, liver impairment and diabetes). Also it can not be mixed with blood.

Note:

The three major classes of replacement fluids are:

- Crystalloid solutions – includes saline solutions, buffered solutions, (eg, Ringer's lactate, bicarbonate buffered 0.45% saline), some chloride-restrictive fluids (e.g., Hartmann's)
- Colloid-containing solutions – includes albumin solutions, hyperoncotic starch, dextran, gelatin
- Blood products or substitutes – includes packed red cells, blood substitutes

http://www.uptodate.com/contents/treatment-of-severe-hypovolemia-or-hypovolemic-shock-in-adults#H5

Why blood transfusion is necessary?

1. To increase oxygen carrying capacity. "It is the first answer when someone asks about the necessary of blood transfusion"
2. Restoration of red cell mass in case of bleeding, traumatic patient, post operative or intra operative surgery and major vascular injury.
3. Correction of bleeding induced by platelet dysfunction or thrombocytopenia. E.g. ALL and idiopathic thrombocytopenia.
4. Correction of bleeding induced by coagulation factors deficiencies which may be caused by hemophilia, liver impairment and DIC.

Oxygen Delivery:

- Oxygen Delivery (DO2) is the oxygen that is delivered to the tissues
  DO2 = COP x CaO2
- Cardiac Output (COP) = HR x SV
- Oxygen Content (CaO2) = (Hgb x 1.39) O2 saturation + PaO2 (0.003)

O2 saturation can be measured by using oximetry and PaO2 can be measured by using blood gas.

- Hgb is the main determinant of oxygen content in the blood. So to increase O2 concentration, Hgb level must be increased by blood transfusion.

Therefore: DO2 = HR x SV x CaO2

- If HR or SV are unable to compensate, Hgb is the major determinant factor in O2 delivery.

HR will be fixed if the patient on beta blockers or Ca channel blockers or has AV block.
SV will be fixed if the patient has obstructive cardiac lesion like aortic or mitral stenosis.

In both situation, those compromised patient can not compensate to blood loss so must be supported with blood transfusion when Hgb level is 10 gm\dl or less.

- Healthy patients have excellent compensatory mechanisms and can tolerate Hgb levels of 7 gm/dL. They will receive fluid only if they lose blood, otherwise they can compensate lower level of Hgb up to 7 gm\dl.
- Compromised patients may require Hgb levels above 10 gm/dL. If they start bleeding there is no face of tachycardia which is the first sign of bleeding to maintain BP then immediately develop hypotension affecting the O2 delivery to the tissues especially the coronary arteries, kidneys and brain.

Transfusion Trigger:

Hgb level at which transfusion should be given varies with patients and procedures.

Tolerance of acute anemia depends on:

- Maintenance of intravascular volume.
- Ability to increase cardiac output.
- Increases in 2,3-DPG to deliver more of the carried oxygen to tissues.

O2 disassociation curve is shifted to right which means the Hgb affinity with O2 is less and it will give O2 to the tissues.

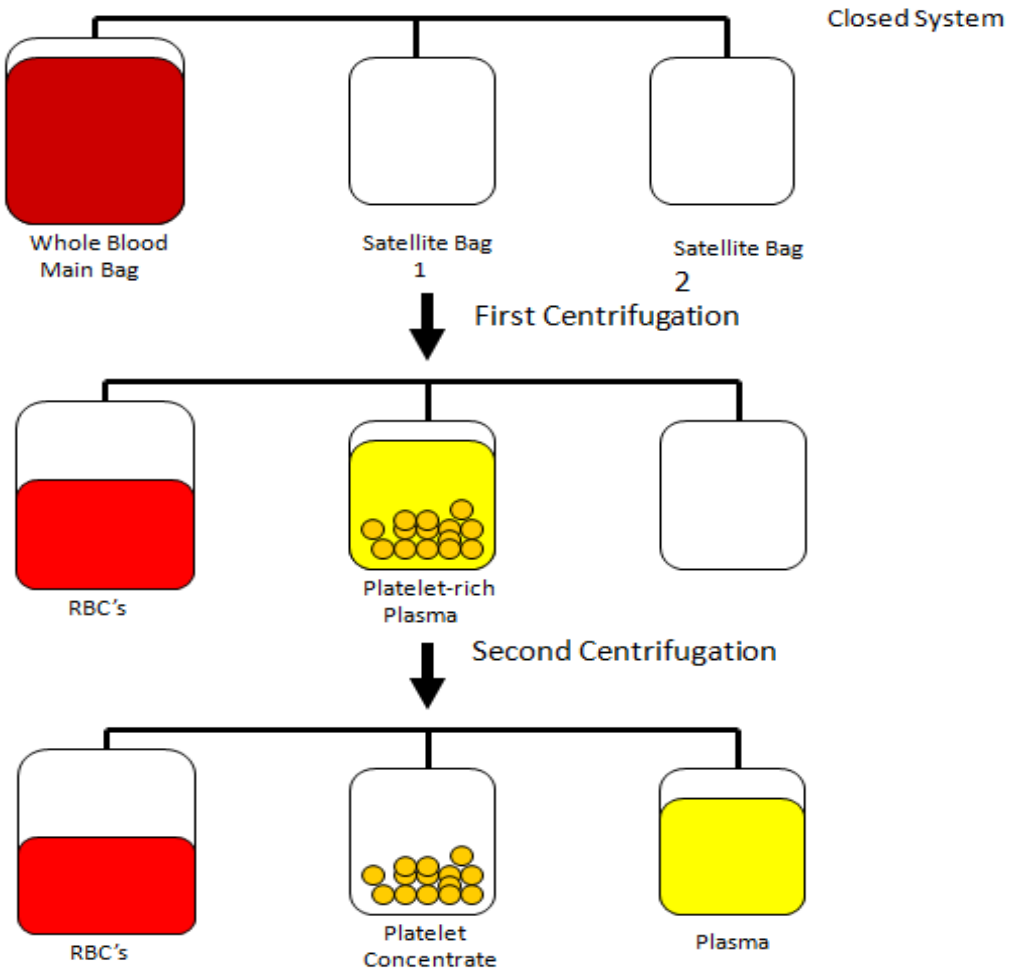
Note:

Causes of right shifted O2 disassociation curve includes:
1. Increase temperature.
2. Acidosis.
3. Low pH.
4. High altitude.
5. Anemia.

Blood Components:

- Prepared from whole blood collection.
- Whole blood is separated by differential centrifugation which done in 2 steps.

Differential Centrifugation:



- In case of thrombocytopenia, platelet will be transfused.
- In case of coagulation deficiency disorders, plasma will be transfused.

Antigen:

Is a foreign substance that can elicit an immune (antibody) response.

Antibodies:

Specific immunoglobulin's produced in response to an antigenic challenge.

Two major antigen systems on the red blood cell are the ABO system and the Rhesus (Rh) system.

- Group A individuals have the A antigen present on their red blood cells.
- Group B individuals have the B antigen present on their red blood cells.
- Group AB individuals have antigens A and B present on their red blood cells.
- Group O have neither antigens A nor B present on their red blood cells

Normal healthy individuals make antibodies against the A and B antigen

The antibodies are found in the individual's plasma and are referred to as naturally occurring.

- Group A individuals have anti B antibodies.
- Group B individuals have anti A antibodies.
- Group O individuals have anti A and anti B antibodies.
- Group AB individuals have no antibodies.

The Rh system encompasses multiple antigens.

- Rh (D) negative indicates that the Rh (D) antigen is not present on the red cell.

Universal Blood:

Blood group O- is considered the universal donor for red cells because it lacks the A and B antigen for Antibodies to act upon.(e.g emregency unknown blood group pt.)

Blood group AB is considered the universal donor for platelets.

Blood Groups:

	Antigen on Plasma		Incidence	
Blood Group	Erythrocyte	Antibodies	White	African-
A	A	Anti-B	40%	27%
B	B	Anti-A	11	20
AB	AB	None	4	4
O	None	Anti-A Anti-B	45	49
Rh	Rh		42	17

Cross Matching:

Major: Donor's erythrocytes incubated with recipients plasma.
Minor: Donor's plasma incubated with recipients erythrocytes.

Agglutination:

- Occurs if either is incompatible.

Type Specific:

- Only ABO-Rh determined; chance of hemolytic reaction is 1:1000 with TS blood

Type and Screening:

Donated blood that has been tested for ABO/Rh antigens and screened for common antibodies. (*Not mixed with recipient blood* "there is no cross matching").

- Used when usage of blood is unlikely, but needs to be available *(hysterectomy).*
- Allows blood to available for other patients as cross mathing **has Not been done.**
- Chance of hemolytic reaction: 1:10,000.

Blood Components:

- Packed red blood cells (pRBC's).
- Platelet concentrate.
- Fresh frozen plasma (contains all clotting factors).
- Cryoprecipitate like plasma but contains higher conceterations of factors VIII and fibrinogen; used in Von Willebrand's disease)
- Albumin.
- Plasma protein fraction.
- Leukocyte poor blood.
- Factor VIII.
- Antibody concentrates is rerly used.

Packed Red Blood Cells:

1 unit = 250 ml. Hct of 1 unit pRBC's. = 70-80%.

- 1 unit pRBC's raises Hgb 1 gm/dL.
- Mixed with saline Packed cells should never be given directly, they must be diluted with saline (imagine packed cells as a bag of honey which is hyperosmolar)
- LR (lactate ringer) has Calcium which may cause clotting if mixed with pRBC's due to the bound formation between Ca and Na citrates that was added to the stored RBCs.
- Hct = Hgb x 3
- Normal Hct ranges from 35% - 45%

RBC Transfusions:

Adminstration:

- Dose:

- Usual dose of 10 cc/kg especially in pediatrics infused over 2-4 hours and it will increase Hgb level by 1mg\dl.
- Maximum dose 15-20 cc/kg can be given to hemodynamically stable patient like in sickle cell anemia crisis or sickle cell sequstred RBCs in spleen.

> ***Note:***
>
> *Maximum time is 4 hours other wise the RBCs will become expired.*
>
> *Higher doses than 20 cc\kg may lead to pulmonary embolism.*

- Procedure:

- May need Premedication (Tylenol and/or Benadryl in concious patients to prvent fever and pruiritic transfusion reaction).
- Filter use—routinely leukodepleted.
- Monitoring—VS q 15 minutes, clinical status.
- Do NOT mix with medications.

- Complications:

- Rapid infusion may result in Pulmonary edema.
- Transfusion Reaction.

Platelet Concentrate:

Storage

Up to 5 days at 20-24° **so this make it the most blood product that transmit infections.**

Indications

- Thrombocytopenia, Plt <15,000
- Bleeding and Plt <50,000
- Invasive procedure and Plt <50,000

Considerations

- Contain Leukocytes and cytokines.
- 1 unit/10 kg of body weight increases Plt count by 50,000
- Donor and Recipient must be ABO identical.

Plasma FFP:

Contents

Coagulation Factors (1 unit/ml)

Storage

FFP--12 months at –18 degrees or colder

Indications

Coagulation Factor deficiency, fibrinogen replacement, DIC, liver disease, exchange transfusion "sickler patient", massive transfusion.

Considerations

- Plasma should be recipient RBC, ABO compatible.
- In children, should also be Rh compatible.
- Usual dose is 20 cc/kg to raise coagulation factors approx 20%.

Blood Transfusion Complications:

Physical:

- Circulatory overload - Embolism (air, micro aggregate) - Hypothermia

Immunological

- Pyrogenic - Type 1 hypersensitivity - Graft versus host reactions.

Biochemical

- Acid base disturbances - Hyperkalaemia - Citrate toxicity especially in liver impairment condition and massive transfusion.
- Impaired oxygen release due to induced metabolic alkalosis.

Infective

HIV-hepatits-CMV-parovirus 19.

Hemolytic transfusion reaction

Disseminated intravascular coagulation is an uncontrolled activation of coagulation system.

Acute Transfusion Reactions:

- Acute Hemolytic Reactions (AHTR)
- Febrile Reactions (FNHTR)
- Allergic Reactions

TRALI "transfusion related acute lung injury" Clinical syndrome similar to ARDS

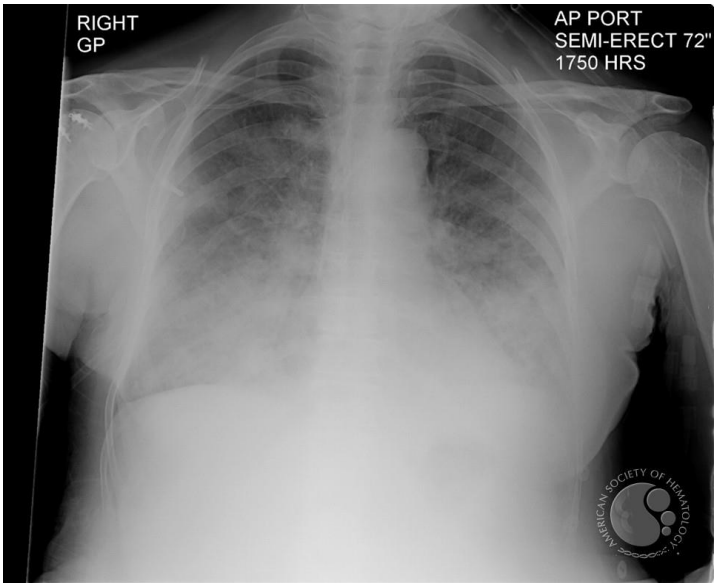
- Occurs 1-6 hours after receiving plasma-containing blood products.
- Caused by WBC antibodies present in donor blood that result in pulmonary leukostasis
- Treatment is supportive
- High mortality
- There will be damage to the alveoli by the donor's WBCs and antibodies, causing pulmonary leukocytosis. The lung will be white because of this reaction.

- Coagulopathy with Massive transfusions (>10 units) may lead to dilution of platelets and factor V and VIII.
- Bacteremia (More common and more severe with platelet transfusion (platelets are stored at room temperature))

Organisms

o Platelets—Gram (+) organisms, ie Staph/Strep
o RBCs—Yersinia, enterobacter

- Risk increases as blood products age (use fresh products for immunocompromised)



Note:

TRALI
After the blood transfusion, the patient is desaturated and has shortness of breath.

The patient is referred to the ICU as an ADRS condition.

Other Complications:

- Decreased 2,3-DPG with storage leading to left shifted O2 disassociation curve and metabolic alkalosis.

- Citrate (it added to the stored blood) it metabolites to bicarbonate wich bound to Calcium which decrease the Ca binding capacity in the coagulation cascade(anticoagulant).
- Microaggregates (platelets, leukocytes)prvented by micropore filters controversial.
- Hypothermia: warmers used to prevent.

Signs of Complication are easily masked by general anesthesia:

In sever situations, signs include: Free Hgb in plasma or urine.
Acute renal failure.
Disseminated Intravascular Coagulation (DIC).

Early signs and symptoms of comlications include:

- Flushing.
- Tachycardia.
- Hypotension.
- Fever.
- Oosing in surgical site.

Transmission of Viral Diseases:

- Human immunodeficiency virus (HIV)
  22 day window for HIV infection and test detection.
- Hepatitis virusis B and C.
- West Nile virus (WNV).
- Cytomegalovirus (CMV).
- Human T-cell lymphotrophic viruses (HTLVs).
- Parvovirus B19.

Acute Hemolytic Reactions (AHTR):

- MOST important complication
- Occurs when incompatible RBCs (usually ABO or Rh) are transfused into a recipient who has pre-formed antibodies
- Antibodies activate the complement system, causing intravascular hemolysis > hemoglobinuria
- This hemolytic reaction can occur with as little as 1-2 cc of RBCs
- Labeling error is the most common problem
- Can be fatal
- Symptoms occur within minutes of starting the transfusion and they include:
  - Tachycardia. - Hypotension. - Oozing from surgical sits. "early symptoms"
  - Hemoglobin urea. - Renal shut down. "sever condition"

Treatment of Acute Hemolytic Reactions:

- Immediate discontinuation of blood products and send blood bags to lab.
- Support patients hemodynamic (fluid vasopressors).
- Maintenance of urine output with crystalloid infusions.
- Administration of mannitol or Furosemide for diuretic effect.

Monitoring in AHTR:

- Monitor patient clinical status and vital signs
- Monitor renal status (BUN, creatinine)
- Monitor coagulation status (DIC panel– PT/PTT, fibrinogen, D-dimer/FDP, Plt, Antithrombin-III)
- Monitor for signs of hemolysis (LDH, bili, haptoglobin)

Blood Bank Work-up of AHTR:

- ✓ Check paperwork to assure no errors
- ✓ Check plasma for hemoglobin
- ✓ Repeat crossmatch
- ✓ Repeat Blood group typing
- ✓ Blood culture

Massive blood transfusion

Defined one of three ways

- Acute administration of more than 1,5 times of estimated blood volume.
- The replacement of patients blood volume by stored bank blood in less than 24 hours.
-The acute administration of more than blood volume in less than 24 hours

Note:

Blood volume formula

Neonate	*- 90 ml/kg*
Infants 2 years ago	*- 80ml/kg*
Adult male	*- 70ml/kg*
Adult female	*- 60ml/kg*

Basic screening test after six-unit transfusion:

- Hemoglobin and platelets count.
- Coagulation profile (Pt prothrompine time , activated partial thromboplastine time).
- Plasma fibrinogen concentration.
- Fibrin degradation products.
- PH from arterial blood gas analysis.

Note:

Blood Transfusion Protocol:
If pRBCs units exceed more than 4 units then add with each 1 pRBCs unit 1 FFP unit + 1 platelet unit.

- Plasma Electrolyte.

Massive blood transfusion Complication:

- DIC
- Coagulopathy due to dilutional thrombocytopeniaa nd dilution of the coagulation factors
- Citrate Toxicity: does not occur in most normal patients unless the transfusion rate exceeds 1 U every 5 min or the patient has liver impairment
- Hypothermia
- Postoperative metabolic alkalosis is the most consistent acid–base abnormality after massive blood transfusion.
- Hyperkalemia:

Serum Potassium Concentration

The extracellular concentration of potassium in stored blood steadily increases with time.
The amount of extra-cellular potassium transfused with each unit less than 4 mEq per unit. Hyperkalemia can develop regardless of the age of the blood when transfusion rates exceed 100 mL/min.

***Note:** treatment of hyperkalemia:*

*If the patient is anesthetic, hyperventallation will cause respiratory alkalosis and this will shift K from intravascular compartement into cellular compartement.

Hyperkalemia with acidosis treated with HCO3 + D5 water + insulin.

Diagnosis of DIC:

- Increase APTT , PT , fibrin degradation product
- Decrease platelet count , fibrinogen concentration

Treatment of DIC:

- 4 units of FFP.
- 6-8 units of platelets.
- Cryoprecipitate if fibrinogen level less than 1 g/l.
- PH less than 7,2 administrate 50 mmol bicarbonate.
- Recombinant activated factor VIIa if bleeding continue in spite of use FFP, platelets and cryoprecipatae.

Alternatives to Blood Products

- Autotransfusion
- Blood substitutes

Note:

Cranioplasty is the most bleeding surgery for neurosurgery of pediatrics. There is 2 - 3 blood exchange intra operatively.

Auto-transfusion techniques:

❖Pre-deposit transfusion

- blood collection begins 3-5 weeks preoperatively (2-4 units store).
- Eliminates risk of viral transmission.
- Reduces risk of immunological reactions.
- Collection is expensive and time consuming.
- Only suitable for elective surgery.

❖Intra-operative acute normovolemic hemodilution

- 1-1.5L can be collected with volume replacement.
- Blood stored in OR.
- Re-infused during or after surgery.
- Cheaper than pre-deposit.
- Little risk of clerical error.
- Suitable for elective surgery.

❖Intra-operative cell salvage

- Shed blood is collected from surgical field
- Heparin added.
- Cells washed with saline and concentrated by centrifugation.
- Concentrate transfused.
- Large volume could be used.
- Platelets and clotting factors are consumed.
- Suitable for cardiac surgery.
- Contraindicated in contaminated surgical field. E.g. abdominal sepsis and peritonitis and in cancer patient to prvent transmitting cancerous cells.

Administering Blood and blood Products:

- ✓ Consent necessary for elective transfusion
- ✓ Unit is checked by 2 people for Unit #, patient ID, expiration date, physical appearance.
- ✓ pRBC's are mixed with saline solution (not LR)
- ✓ Products are warmed mechanically and given slowly if condition permits
- ✓ Close observation of patient for signs of complications
- ✓ If complications suspected, infusion discontinued, blood bank notified, proper steps taken.

Intraoperative and Postoperative Management of Blood Loss and Transfusions include:

(A) Red blood cell transfusion.
(B) Management of coagulopathy.
(C) Monitoring and treatment of adverse effects of transfusion.

Recommendations from ASA:

1. Monitoring for blood loss.
2. Monitoring for inadequate perfusion and oxygenation of vital organs (blood pressure, heart rate, oxygen saturation, urine output, electrocardiography).
3. Monitoring for transfusion indications (hemoglobin and hematocrit).

Transfusion Therapy Summary:

- Decision to transfuse involves many factors.
- Availability of component factors allows treatment of specific deficiency.
- Risks of transfusion must be understood and explained to patients and patient should be consented.
- Vigilance necessary when transfusing any blood product.

SUMMARY

1. 60% of Blood Transfusions occur intra-operatively and up to 30% of blood volume can be treated with crystalloids.
2. Blood is only given when the Hgb level is low to increase O carrying capacity.
3. Hgb is the main determinant of oxygen content in the blood.
4. Blood group O- is considered the universal donor for red cells because it lacks the A and B antigen.
5. Blood group AB is considered the universal donor for platelets.
6. Whole blood is separated by differential centrifugation which done in 2 steps
7. Acute Transfusion Reactions: - Acute Hemolytic Reactions (AHTR) - Coagulopathy with massive transfusions.
8. Alternatives to Blood Products: Blood substitutes & Auto transfusion (It has 3 techniques):
   1\ Pre-deposit transfusion.
   2\ Intra-operative acute normovolemic hemodilution.
   3\ Intra-operative cell salvage.
9. Intraoperative and Postoperative Management of Blood Loss and Transfusions
   (A) Red blood cell transfusion.
   (B) Management of coagulopathy.
   (C) Monitoring and treatment of adverse effect of transfusion.

Questions

1) The universal blood donors for the ABO system are?
   a. A.
   b. B.
   c. O.
   d. AB.

2) Patient was started with blood transfusion (PRBC). After about 10 minutes the patient complains of light headness,nausea,vomiting , he complains of severe pain in both loin and desaturation(95%), what's the most likely diagnosis ?
   a. Blood transfusion infection.
   b. Hemolytic anemia.
   c. Anaphylaxis.
   d. Acute pulmonary edema.

3) Standard screening tests on donor's blood include all the followings except:
   a. Hepatitis C.
   b. Hepatitis B.
   c. Rubella.
   d. Syphilis.

Answers:

1st Questions: c

2nd Questions b

3rd Questions: c