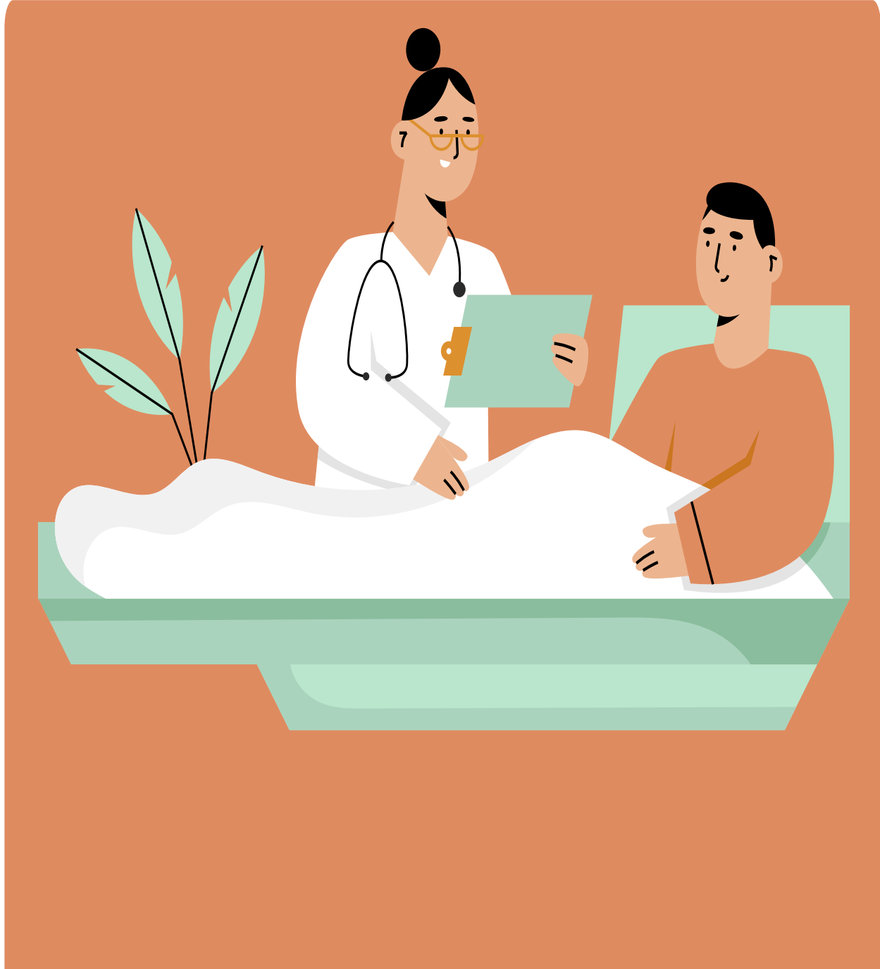
MED437
KING SAUD UNIVERSITY

SURGERY TEAM 437



Blood Products & Transfusion

Objectives:

1. Indication of blood transfusion
2. Blood groups
3. Blood component
4. Blood transfusion complication & reatment
5. Alternatives to Blood Products

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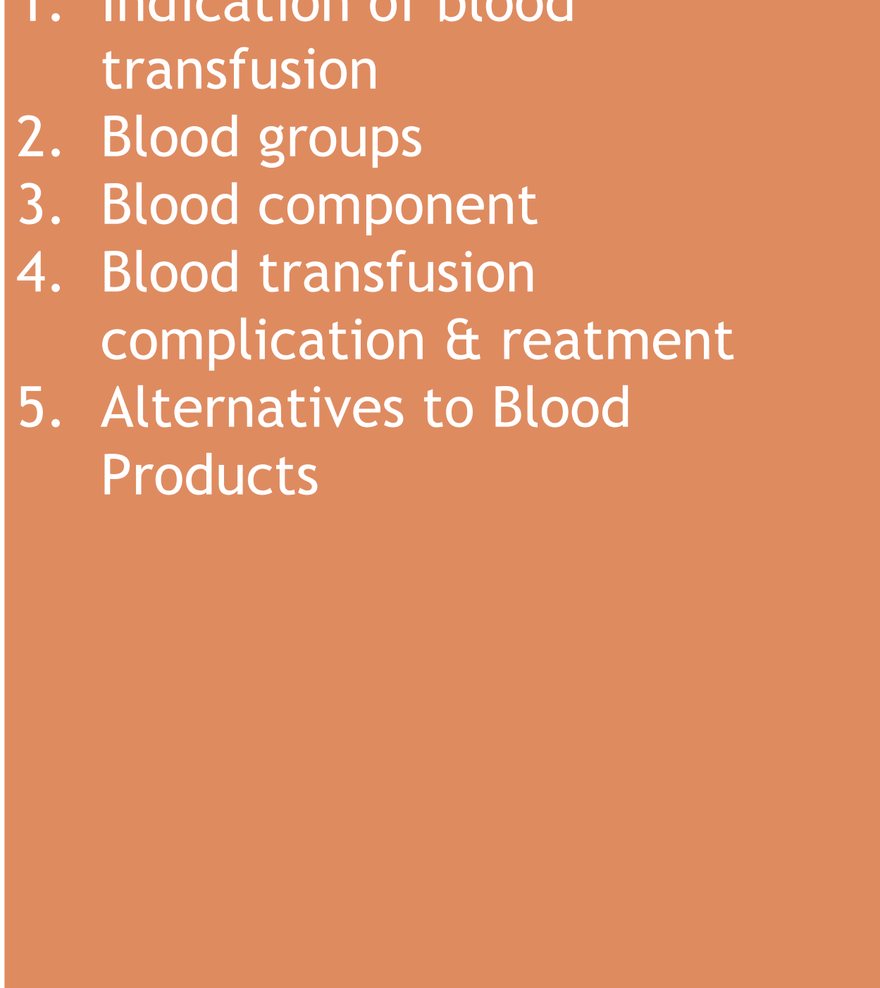
Color Index:

- Important
- Doctor's Notes
- Extra
- Davidson's

Editing File / Feedback



Blood Transfusion

- The era of modern blood transfusion began in the early 1900s with discovery of the ABO red cell antigen system.
- During world War I, it was known that adding citrate (anticoagulant) enabled the storage of anticoagulated blood.

Definition:
The transfer of blood or blood products(plasma,platelets,ETC) from one person (donor) into another person's blood (recipient).
Sources of blood:
1. Autologous blood: Using your own blood.
2. Donor (Allogeneic) blood: Using someone else's blood.

Blood Donations: Depends on age & health of the donor.

Blood Collection (Blood Banking)

Blood centers are processing more than 90% of the units collected (They keep the blood safe & do some tests to make sure that the blood is suitable to use)

➔ **Traditional allogeneic** (human to human) donation methods still predominate, but increasing use is being made of red cell apheresis technology* (They now only give the component the patient needs, which is more beneficial because you can get different components and give it to more than one person from one donor only.

* It's a method by which red cells are separated from the blood at the time of collection, with the rest returned to circulation.

Anticoagulants in Blood

You can't store blood without them!

- Blood collection bags contain an **anticoagulant-preservative** of (CPDA-1):
  1. **C**itrate: prevents calcium from triggering the coagulation pathway.
  2. **P**hosphate: in the form of 2,3-DPG, gives nutrition to RBCs.
  3. **D**extrose: provide energy to RBCs
  4. **A**denine: prolong storability by maintaining ATP to the RBC. It is very important to provide 2,3-DPG which helps in oxygen delivery.

- **CPDA-1** ensures a shelf life (24 hours after infusion → viability of at least 70% of the RBCs) of 35 days and hematocrit of 70 to 80% for PRBCs hemoglobin should be between 70%-80%.
- **Adsol**, **Nutricel**, **Optisol** are additive solutions which (doctor skipped it)
  1. Provide **additional nutrients** → extending maximum storage to 42 days for RBCs.
  2. ↓**Viscosity** → which makes infusion easier.
- Some people donate their own blood for themselves in the future in case they need it (Autologous transfusion).

Storage of Blood

Amazing video about Oxygen-HB dissociation curve. Video.

- Storage impairs red cells function. Transfused blood delivers O2 to the tissues less efficiently. Because storaged blood loses 2,3-DPG leading to increased oxygen affinity, thus, less oxygen delivered to tissues.
- Refrigerated at **1** to **6°C** (usually **4°C** ideally).
- Cell metabolism continues and changes occur → (↓in **pH** and↓in the levels of **2,3-DPG**)
  - So when the pH goes down, oxygen carrying capacity shift to the right (low O2 affinity) then the level of 2,3-DPG falls. Once it falls, the oxygen carrying capacity shift to the left. So, it is a contradictory one shift to the right and one shift to the left so cells won't function properly.
- The deformability of RBCs makes them, over time, more spherical and rigid → increasing resistance to capillary flow (Remember normally RBCs are concave in shape which make it easy for them to pass across the capillaries.So when they become spherical in shape it will be difficult to pass across the capillaries and they will rapture,so its better to use it as quickly as possible.)
- Platelets are stored by agitation,platelets have to stay moving, if we stopped that they will clot
- Cell leakage of **Potassium** (≈ **6** mEq/U) by the end of 2-3 weeks you will have hyperkalemia, dangerous!

Blood Typing *2 images were in the slides Image 1 + Image2*

Identified Red Blood Cell (RBC) Antigens:

- **ABO** and related carbohydrate antigens (**H**, **P**, **I**, and Lewis), the **48 Rh system** antigens, and more than 200 non-ABO/Rh antigens.
- Blood specimen from the patient is sent for the following tests: **ABO grouping**, **Rh typing**, and an **antibody screen** for unexpected (non-ABO/Rh) antibodies.
- **Group A** ⟶ Anti-B antibodies, A Antigen.
  - **A+** is the second most frequent (1 in 3 = 34%) **/ A-** isn't very common (1 in 16 = 6.3%)
- **Group B** ⟶ Anti-A antibodies, B antigen. Less than 10% of the population
  - **B+** (1 in 12 = 8.5%) **/ B-** (1 in 67 = 1.5%)
- **Group AB** ⟶ no antibodies, A & B antigens (universal donor of plasma)
  - **AB+** (1 in 29 = 3.5%) **/ AB-** (1 in 167 = 1%)
- **Group O** ⟶ Anti-A & Anti-B antibodies, no antigens
  - **O+** is the most frequent (1 in 3 = 39%) **/ O-** (1 in 15 = 6.6%)

Blood Typing

A. **Forward type:** determines the ABO and Rh phenotype of the recipient's RBCs antiserum directed against the A, B, and D antigens. (this method is not enough).
B. **Reverse type** (cross matching) : detects isoagglutinins in the patient's serum and should correlate with the ABO phenotype, or forward type.
C. **Rh** typing can usually be determined by adding a **commercial reagent (anti-D)** to recipient RBCs. a test used for blood transfusion and pregnant women.
   a. Clinical importance: Any Rh negative female above\near the age of childbearing we should never give her any blood other than Rh negative group, if we did she will develop antibodies so the next child will have ***erythroblastosis fetalis*** (rupture of the child's RBCs).
   b. (In case she is married to a Rh positive guy, she won't have any problem with her first pregnancy but the second pregnancy she has to take Anti-D injection)

- Those with type **AB** blood form no ABO group antibodies. (**universal recipient**).
- Those with type **O** have antibodies against both. (**universal donor**)
  - They are always kept in the ER for emergency.

Type & Screen

- The type and screen for antibodies allows quicker selection of appropriate banked blood **for complete crossmatch** if a transfusion is ordered.
- **When a blood transfusion is ordered, a formal crossmatch SHOULD be done** by mixing recipient serum with donor RBCs as a final compatibility test prior to transfusion.

If the surgeon is unsure about the possibility of bleeding he will ask for the blood to be typed and screened, but not cross matched, they will keep two blood units in the fridge without cross matching.

Crossmatch

Done using a Coombs test (with serum incubated to **37**° C), or the more rapid "**immediate spin crossmatch**" at room temperature, which will detect only ABO incompatibility. It can detect incompatibilities that were missed with the Antibody screen. (coombs test is the best for cross matching)
If the patient bleeds the surgeon will call the blood bank and ask for the blood to be crossmatched, crossmatching takes 45 min so timing is crucial! Anticipate and tell! Incase of an emergency always use (o-) even without crossmatching.

Blood and Products Transfusion. Why?

- Increase oxygen carrying capacity.
- Restoration of red cell mass. oxygen delivery depends on rbc mass
- Correction of bleeding caused by platelet dysfunction.
- Correction of bleeding caused by factor deficiencies. (hemophilia, von-willebrand, liver disease).
- Correction of anemia.

Oxygen Delivery

- **Oxygen Delivery (DO2)** is the oxygen that is delivered to the tissues.
  - **DO2= COP x CaO2**
- **Cardiac Output (CO)** = HR x SV
- Arterial Oxygen Content (CaO2): the amount of oxygen bound to hemoglobin plus the oxygen dissolved in plasma.
- **CaO2(Arterial Oxygen content)= (Hgb x 1.39** = amount of O2 carried by each gram of hemoglobin**) x O2 Saturation + (PaO2 x 0.003** = dissolved part**)**
- O2 saturation is normally 95-100%
  - **Hgb** is the main determinant of **oxygen** content in the blood.
- Therefore: **DO2 = HR x SV** (stroke volume) **x CaO2**
- If HR or SV are unable to compensate, Hgb is the major determinant factor in O2 delivery.

Administration

- **Legal Aspects:**
  - Two qualified personnel check it at the bedside to prevent a potentially fatal clerical error.
  - **Recipient (ID)** mrn is extremely important taken from the patient's file directly **& unit identification,** confirmation of compatibility, expiration date.
  - **60%** of transfusions occur perioperatively.
  - Responsibility of transfusing perioperatively is with the **anesthesiologist**.
- Urgent transfusion situations require flow rates faster than gravity can provide:
  1. Pressure bags that completely encase the blood bag and apply pressure evenly to the blood bag surface.
  2. If external pressure is anticipated → **large-bore needles** are recommended for venous access to prevent hemolysis.
  3. If only a **small-gauge needle** is available → the transfusion may be diluted with normal saline, but this may cause unwanted volume expansion. (lactate ringer should not be used with the blood transfusion because it contains calcium which may lead to clotting.)

Management

Determinant factors:

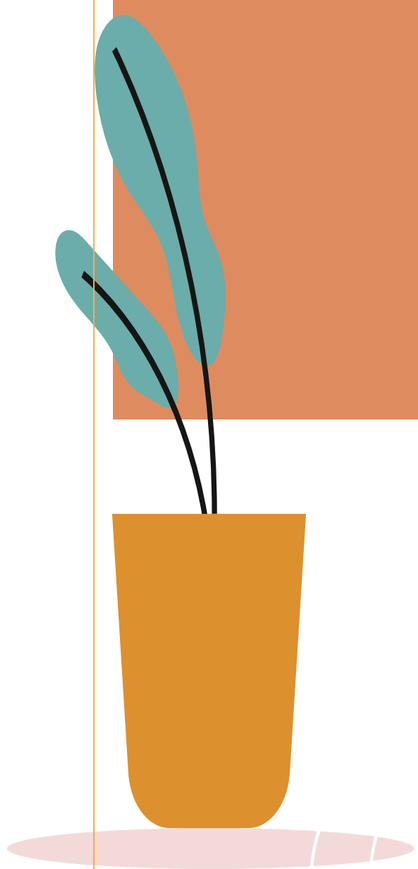
1. Patient's age.
2. Severity of symptoms.
3. Cause of the deficit. Eg.in iron deficiency anemia give supplements and wait for the response before transfusion.
4. Underlying medical condition(Ex:Sickle cell anemia) → don't give blood very fast!
5. Ability to compensate for decreased oxygen-carrying capacity.decided by age & situation
6. Tissue oxygen requirements are all considered.eg.heart tissue in MI.

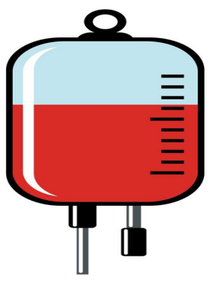
A. Clinical Evaluation

- Appearance (pallor, diaphoresis).
- Mentation (alert, confused).
- Heart rate.
- Blood pressure.
- Nature of the bleeding (active, controlled, uncontrolled).
  - Active = stop bleeding, controlled = adjust it, uncontrolled = give more blood.
  - For Each 500 ml blood loss Hb will drop 1 gram.
  - People can't tolerate losing more than 20% of blood.

B. Laboratory Evaluation

1. Hgb.
2. Hematocrit (Volume percentage of RBCs in blood).
3. Platelets.
4. Clotting function (coagulation profile).





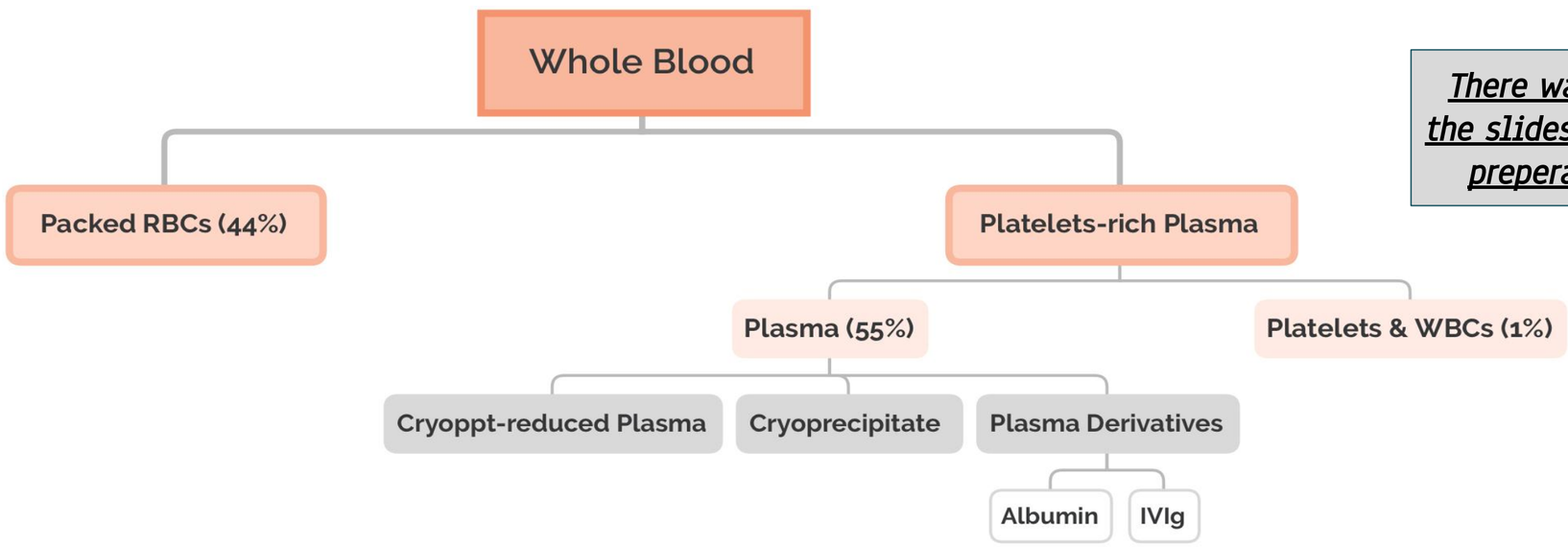
When to Transfuse?

★ **TRICC (Transfusion Requirements in Critical Care)** trial, demonstrated that in the critical care setting, a transfusion threshold of 7 g/dL of Hb was as safe as a threshold of 10 g/dL.

- Patient can compensate with Hb as low as 7 g/dL, if he reaches it give him blood, if he is above it you don't need to give him.
- Healthy pt can compensate with low Hb.(6 or 7 g/dL). IHD pt can't.
- So don't transfuse til Hb is 7 g/dL (or 10 g/dL in IHD pts)
- For elderly patients or those with cardiovascular or respiratory disease, who may tolerate anaemia poorly, transfusion should be considered at a haemoglobin concentration of %80 g/L to maintain a haemoglobin level of around 100 g/L.

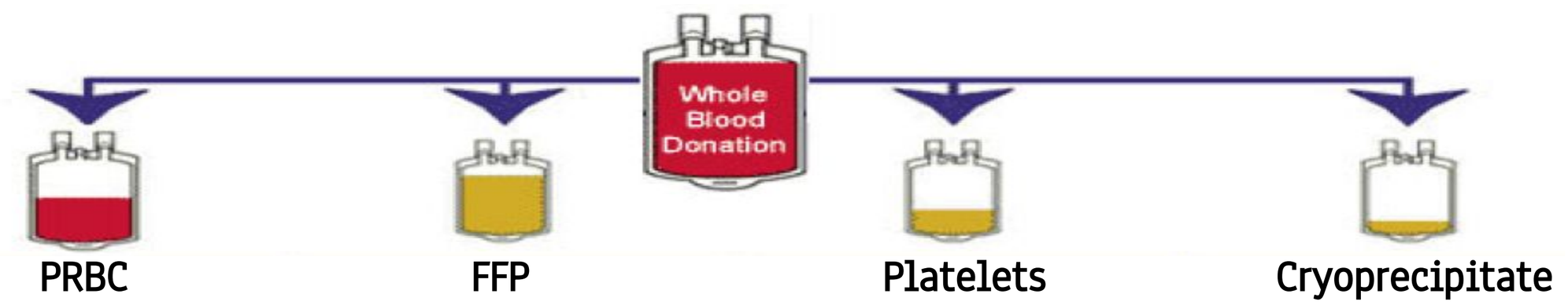
★ A subgroup analysis generated some concern that patients with **ischemic heart disease (IHD)** benefit from higher transfusion threshold.

Blood & its Components



There was Image in the slides about Blood preperation click

- **Whole Blood** is not as economical as component therapy, although there has recently been renewed interest in the benefits of using fresh whole blood in military field hospitals.
- In modern transfusion medicine **whole blood is rarely used.**
- The more components the more chances of **allergies** and reactions.
  - If you give pt more than 4 units of blood, you should give for each unit FFP, platelets & cryoprecipitate (critical for preventing DIC)



The Potential of Human Blood

Red Blood Cells	FFP	Concentrate of platelets	Cryoprecipitate
To increase the amount of RBC after trauma or surgery or to treat severe anemia	To correct a deficiency in coagulation factors or to treat shock due to plasma loss from burns or massive bleeding	To treat or prevent bleeding due to low platelet levels To correct function; platelet problems	To treat fibrinogen deficiencies
Storage Period			
42 days in the refrigerator or 10 years in the freezer	1 year in the freezer	5 days at room temperature	1 year in the freezer

Blood & its Components

Packed Red Blood Cells (PRBC)

- Given to improve oxygen delivery to tissues at the microvascular level.
- American Society of Anesthesiologists:
  1. Transfusion is rarely needed with a Hgb concentration Greater than 10 g/dL. they should be agitated 24 hours all year to prevent clotting.
  2. Always needed when the Hgb is less than 6 g/dL. (asses the case for yourself)
  3. Patients with a Hgb between 6 and 10 mg/dL require careful clinical judgment.
- Ischemic heart disease may render patients more intolerant of anemia, although more research is needed to clarify whether transfusion benefits these patients. Take care, don't allow them to drop below 10g /dl.
- Physicians would still transfuse a patient with ongoing hemorrhage & unstable vital signs despite adequate fluid resuscitation & would occasionally consider withholding transfusion for Hgb levels even lower than 6 g/d in a young, healthy, asymptomatic patient without ongoing hemorrhage.
  (Don't do it, if the patient is bleeding but his hemoglobin level is good resuscitate with fluide ,3 crystalloids and 1 colloid if the patient loses 20% of his blood volume then replace blood).
- In an average adult, 1 U of PRBCs increases the Hgb by about 1 g/dL or the hematocrit by about 3%.
- Most transfusions are given over 60 to 90 minutes (not longer than 4 hours) because blood will expire or sometimes become infected by then
- Unused blood should be returned promptly to the blood bank because any units unrefrigerated for more than 30 minutes is discarded.
- RBCs should be infused alone or with 0.9% NaCl (should be isotonic) through a 170µm clot-screen filter.
- **NEVER mixed with:** only use saline
  - Lactated Ringer's solution→can lead to clotting due to presence of Ca In the solution
  - Calcium containing solutions; may cause clumping or clots
  - Dextrose (Hypotonic); may cause hemolysis or clumping
  - Medications
  - Hypertonic solutions

Fresh Frozen Plasma (FFP)

- A unit of FFP typically has a volume of 200 to 250 mL, must be ABO compatible, and is given through blood tubing within 2 to 6 hours of thawing. (defrosting using a hot water bath مثل الدجاج اذا طلعناه من الفريزر لازم نذوب الثلج قبل الطبخ)
- It contains all clotting factors.
- It should be given in doses calculated to achieve a minimum of 30% of plasma factor concentration, traditionally calculated as 10 to 15 mL/kg.

- ABO specific should be given

Blood & its Components

Platelets

- Cross-matching is unnecessary, BUT..Rh-negative patients should receive Rh-negative platelets. (may cause Rh sensitization).
- In adults the traditional dose has been 4 to 6 U (a "six pack"of platelets).
  - Other blood components are not present in packed RBC so once blood is transfused, they start to deplete necessitating their replacement.
- In children it is **1U/10 kg body** weight.
- Platelet concentrates are indicated in thrombocytopenia, when platelet function is defective, and in patients receiving massive blood transfusions when there is microvascular bleeding (oozing from mucous membranes, needle puncture sites and wounds).

Cryoprecipitate

- Cryoprecipitate is a source of fibrinogen, factor VIII , & von Willebrand Factor (vWF).
- It is ideal for supplying fibrinogen to the volume-sensitive patient.
- When factor VIII concentrates are not available, cryoprecipitate may be used since each unit contains approximately 80 units of factor VIII.
- Cryoprecipitate may also supply vWF to patients with dysfunctional (type II) or absent (type III) von Willebrand disease

Characteristics of Selected Blood Vomponents

Components	Volume/ mL	Content	Clinical Response
PRBC	180-200	RBCs with variable leukocyte content & small amount of plasma	Increase hemoglobin 10 g/L & hematocrit 3%
Platelets	50-70	$5.5x10^{10}$/RD unit	Increase platelet count 5000-10,000 uL
	200-400	$\geq 3x10^{11}$ /SDAP (Single Donor Apheresis Platelets) products.	CCI $\geq 10x10^{9}$/L within 1h and $\geq 7.5x10^{9}$/L within 24h post-transfusion
Fresh Frozen Plasma (FFP)	200-250	Plasma proteins, coagulation factors, protein C and S, antithrombin	Increase coagulation factors about 2%
Cryoprecipitate	10-15	Cold - insoluble plasma proteins, fibrinogen, factor VIII, vWF	Topical fibrin glue, also 80 IU factor VIII

Adverse Reactions of Blood Transfusion

- ★ The most common reactions **are not life threatening**, although serious reactions can present with mild symptoms and signs.
- ★ Reactions can be reduced or prevented by modified (filtered, washed, or irradiated) blood components, (especially with pts with multiple blood transfusions).

Immunological Reaction

A. Acute
- Hemolytic
- Febrile-Non hemolytic
- Transfusion-related Acute Lung Injury (TRALI)
- Urticarial (allergic)
- Anaphylactic

B. Delayed
- Hemolytic
- GVHD
- Purpura

Non Immunological Reaction

A. Acute
- Fluid overload
- Hypothermia
- Electrolyte toxicity

B. Delayed
- Iron overload
- Infections
  - Sometimes cannot be detected in the donor's blood.

1. Immune-mediated Reactions:

Acute Hemolytic Transfusion Reactions (AHTR)	
Clinical Features	- Immune-mediated hemolysis occurs when the recipient has preformed antibodies that lyse donor erythrocytes (develops within minutes). - The ABO isoagglutinins are responsible for the majority of these reactions, although all antibodies directed against other RBC antigens, i.e., Rh, Kell, and Duffy, may result in hemolysis. - AHTR presents as hypotension, tachypnea, tachycardia, ever, chills, (when a patient complains of chest pain or discomfort think of transfusion reaction) hemoglobinemia, hemoglobinuria, chest and/or flank pain (if pt is awake), and discomfort at the infusion site.
Laboratory Evaluation	1. Measurement of serum haptoglobin. 2. Lactate dehydrogenase (LDH). 3. Indirect bilirubin levels (send the blood back to the bank to confirm whether the blood was meant for this particular patient)
Management	- The immune complexes that result in RBC lysis can cause renal dysfunction and failure. - Diuresis should be induced with intravenous fluids and furosemide or mannitol. - Tissue factor released from the lysed erythrocytes may initiate DIC (disseminated intravascular coagulation). - Coagulation studies like prothrombin time (PT), activated partial thromboplastin time (aPTT), fibrinogen & platelet count should be monitored in patients with hemolytic reactions. - **Transfusion must be stopped immediately, intravenous access maintained, and the reaction reported to the blood bank.**

Adverse Reactions of Blood Transfusion

Febrile Non-Hemolytic Transfusion Reactions (FNHTR)	
Clinical Features	- The most frequent reaction associated with the transfusion of cellular blood components - These reactions are characterized by chills and rigors and a ≥1°C rise in temperature. - Develops late in course of transfusion. Usually mild, full recovery expected.

Allergic Reactions	
Clinical Features	- Urticarial reactions are related to plasma proteins found in transfused components..
Management	- Mild reactions treated symptomatically by temporarily stopping the transfusion and administering antihistamines - diphenhydramine, 50 mg orally or IM

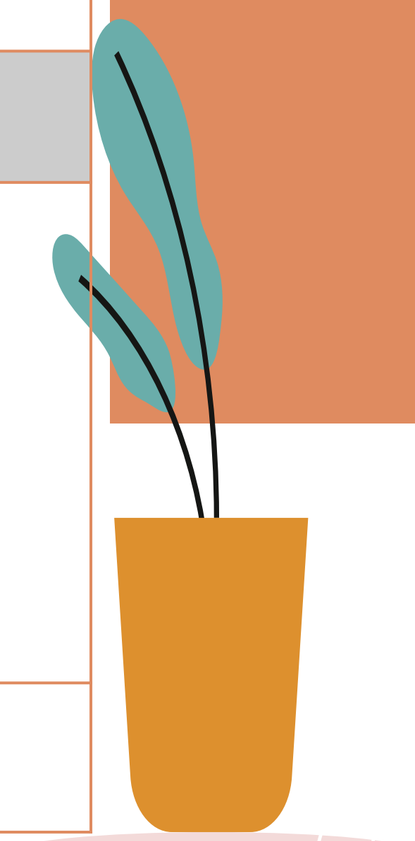
Anaphylactic Reactions	

Clinical Features	- Very very rare
	- This severe reaction presents after transfusion of a few milliliters of the blood component.
	- **Symptoms and signs:**
	  - Difficulty in breathing, coughing, nausea and vomiting, hypotension, bronchospasm, loss of consciousness, respiratory arrest, and shock.
	  - You may need to perform CPR if your patient enters a cardiac arrest.

Management	- **Stopping the transfusion**, maintaining vascular access, and administering **epinephrine** (0.5–1 mL of 1:1000 dilution subcutaneously). - Glucocorticoids may be required in severe cases.

Graft-Versus Host Disease (GVHD)	
Clinical Features	- Is A frequent complication of allogeneic stem cell transplantation, in which lymphocytes from the donor attack & cannot be eliminated by an immunodeficient host. - Mediated by donor's T lymphocytes that recognize host HLA antigens as foreign & mount an immune response - **Symptoms and Signs:** - fever, **cutaneous eruption**, diarrhea, & liver function abnormalities.

Transfusion-Related Acute Lung Injury	
Clinical Features	- Presents as acute respiratory distress either during or within 6 h of transfusing the patient. - Characterised by respiratory compromise and signs of noncardiogenic pulmonary edema, including bilateral interstitial infiltrates on chest x-ray. - Develops within **4 hours** of transfusion. Dyspnoea,cough, fever, hypoxia, pulmonary infiltrates (ARDS).
Management	Supportive, and patients usually recover without sequelae (complications).



Adverse Reactions of Blood Transfusion

2. Non-Immunological Reactions:

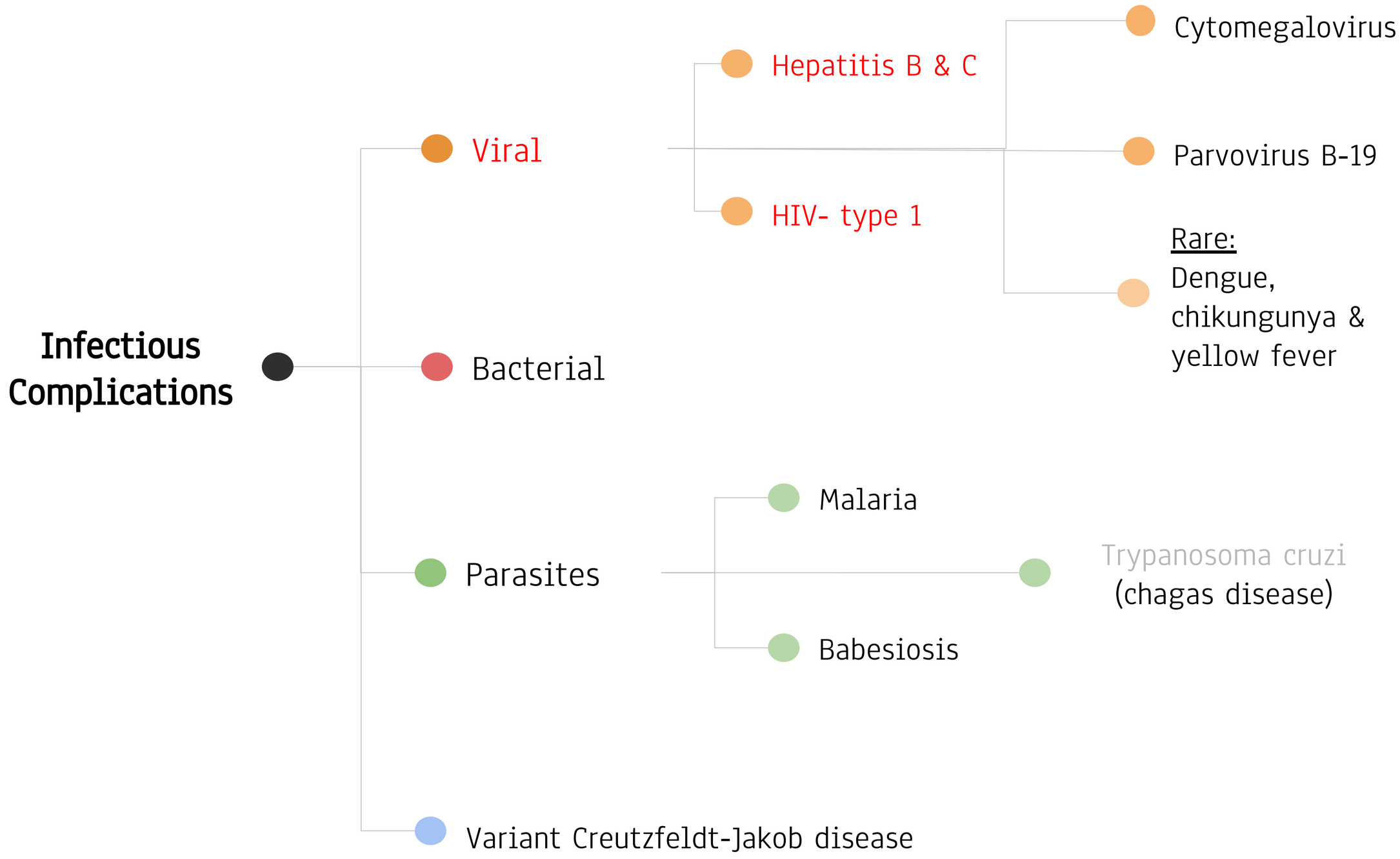
Fluid Overload	
Clinical Features	- Blood components are excellent volume expanders, & transfusion may quickly lead to volume overload. - Monitoring the rate and volume of the transfusion and using a diuretic can minimize this problem. If the patient is getting worse give a diuretic to reduce volume.

Electrolyte Toxicity	
Clinical Features	- RBC leakage during storage increases the concentration of K+ in the unit. - Citrate, commonly used for anticoagulation,chelates the calcium and thereby inhibits the coagulation cascade. - Hypocalcemia, manifested by circumoral numbness and/ or tingling sensation of the fingers and toes, may result from multiple rapid transfusions. - Citrate is quickly metabolised to bicarbonate, calcium infusion is seldom required in this setting.

Hypothermia	
Clinical Features	- Refrigerated (4°C) or frozen (-18°C or below) blood components can result in hypothermia when rapidly infused. - Cardiac dysrhythmias can result from exposing the sinoatrial node to cold fluid - Use of an in-line warmer will prevent this complication.

Iron Overload	
Clinical Features	- Each unit of RBCs contains 200–250 mg of iron. Symptoms and signs of iron overload affecting endocrine, hepatic, and cardiac function are common after 100 units of RBCs have been transfused (total-body iron load of 20 g (e.g. thalassemia)). - Preventing this complication is by using alternative therapies (e.g., erythropoietin) and judicious transfusion is preferable and cost effective. - Chelating agents, such as deferoxamine and deferasirox, are available, but the response though is often suboptimal

Adverse Reactions of Blood Transfusion



- Transferred easily because we cannot test each and every agent since testing would be cumbersome and take too long.
- Geographic migration and travel of donors shift the incidence of these rare infections.

Alternative to Transfusion

- Autologous blood your own blood is the best option when transfusion is anticipated. The cost-benefit ratio of autologous transfusion remains high.
- No transfusion is a zero-risk event; clerical errors and bacterial contamination remain potential complications even with autologous transfusions.
- Massive blood transfusion defined as giving whole blood volume in 24 hour.

Recall:

Which electrolytes is most likely to fall with infusion of stored blood? And Why?
Ionized calcium ; the citrate preservative used for storage of blood binds serum calcium.
What changes occur in the storage of PRBCs?
Decrease in Ca++ , 2,3-DPG and PMN.
Increase in K+ and H+ (reduce PH)
What is the thrombocytopenia?
Low platelet count (less than 100,000).
How much one unit of PRBCs will increase hematocrit?
Hematocrit is Hb level x 3 ⟶ about 3-4%
What are common causes of thrombocytopenia in surgical patient?
Sepsis, H2 blockers, heparin, massive transfusion , DIC, antibiotics , spurious lab value, Swann-Ganz catheter.
What common medication could cause irreversible platelet dysfunction?
Aspirin (inhibits cyclooxygenase) .
What can be given to help correct platelet dysfunction from uremia , aspirin or bypass?
DDAVP (desmopressin)
What are general guidelines for blood transfusion?
Acute blood loss, Hb less than 10 with COPD or CAD, or healthy symptomatic patient with Hb less than 6.
Why not infuse lactated ringer's (LR)?
calcium in LR may result in coagulation within IV line.
For how long packed RBCs stored?
about 6 weeks (42 days).
What is the most common cause of transfusion reaction?
ABO incompatibility as result of clerical error.
What are the symptoms of hemolytic transfusion reaction?
Fever, chills, nausea , vomiting , hypotension, lumbar pain, chest pain, abnormal bleeding.
What is the treatment for transfusion hemolysis?
Stop transfusion, provide fluids, perform diuresis by lasix to protect kidneys, alkalinize urine (bicarbonate) and give pressors as needed
What component of blood can cause fever?
WBCs
When should aspirin administration be discontinued pre-operativly?
At 1 week because platelets live 7 to 10 days (must use judgment if patient at risk for MI, stroke because it may be better to continue and use excellent surgical hemostasis in these patients.
What can move the oxyhemoglobin dissociation curve to the right?
Acidosis, 2,3- DPG, fever, elevated PCO2 (to the right means greater ability to release the O2 to the tissues.
What is the normal of RBC and platelet?
RBCs :120 days.
Platelets : 7-10 days.
What are the the coagulation factor deficient in hemophilia A and B?
Hemophilia A : factor 8
Hemophilia B : factor 9
How hemophilia A and B inherited?
sex linked recessive
What is the preoperative treatment of hemophilia A?
Factor 8 infusion
What is willebrand's disease inherited?
Is autosomal dominant disease which is caused by deficiency in von willebrand factor (vWF) and factor VIII:C.
What is used to correct willebrand's disease?
DDAVP or cryoprecipitate
What coagulation study is abnormal in hemophilia A, B and willebrand's disease?
Hemophilia A : elevated PTT.
Hemophilia B : elevated PTT.
Willebrand's disease : elevated bleeding time
What is the effect of deficiency in protein C, protein S or antithrombin III?
Hypercoagulable state.
What is the most common inherited hypercoagulable state?
Factor V leiden

Summary

Anticoagulants in Blood

Blood collection bags contain an anticoagulant-preservative of:
● Citrate. ● Phosphate: provides 2,3-DPG which helps in oxygen delivery. ● Dextrose. ● Adenine.
Ensure a shelf life of 35 days and hematocrit of 70 to 80% for packed red blood cells. Additive solutions (Adsol, Nutricel, Optisol):

1. Provide additional nutrients > extending maximum storage to 42 days.
2. Reduce viscosity.

Blood Storage

- Impairs RBCs function.
- Should be stored at a temperature from 1 to 6C.
- Makes the RBCs more spherical and rigid overtime, increasing resistance to capillary flow.
- Cell leakage of potassium > hyperkalemia.

Blood Typing

Blood specimen from the patient is sent for the following tests:

1. ABO grouping: A, B, AB, O.
2. Rh typing: +ve or -ve.
3. Antibody screen for unexpected (non-ABO/Rh) antibodies.

Any Rh -ve mother should only be given Rh -ve blood, if she got Rh +ve blood and got pregnant the child will have erythroblastosis fetalis. So she has to take Anti-D injections before getting pregnant.

- Forward Typing: Determines the ABO and Rh phenotype.
- Reverse Typing = Crossmatch = Coombs test: Confirms the absence of reactions between the patient's blood and the donor's serum and vice versa.
- Make sure you check for Hepatitis A, B and C, malaria and HIV.

Why do we transfuse blood?

1. To increase O2 carrying capacity.
2. Restoration of red cell mass.
3. Correction of bleeding caused by platelet dysfunction.
4. Correction of bleeding caused by factor deficiencies.
5. Correction of anemia.

Oxygen Delivery

CaO2 = (Hgb x 1.39) x O2 saturation + (PO2 x 0.003)

- Hgb is the main determinant of oxygen content in the blood.
- Don't give blood too fast to any conditions that restrict the heart's ability to accommodate an increase in blood volume.

Indications for Blood Transfusion:

1. Normal patients: if Hb is 7 g/dL or less.
2. Cardiac patients: if Hb is 10 g/dL or less.

Red Blood Cells	FFP	Concentrate of platelets	Cryoprecipitate
Increase the amount of RBC after trauma or surgery or to treat severe anemia	Correct a deficiency in coagulation factors or to treat shock due to plasma loss from burns or massive bleeding	Treat or prevent bleeding due to low platelet levels Correct function; platelet problems	Treat fibrinogen deficiencies
Store for 42 days in the refrigerator or 10 years in the freezer	Store for 1 year in the freezer	Store for 5 days at room temperature	Store for 1 year in the freezer

Adverse Reactions of Blood Transfusion

Immunological Reaction

A. **Acute**
   - Hemolytic
   - Febrile-Non Hemolytic
   - Transfusion-related Acute Lung Injury
   - Urticarial (allergic)
   - Anaphylactic
B. **Delayed**
   - Hemolytic
   - VHD

Non Immunological Reaction

A. **Acute**
   - Fluid overload
   - Hypothermia
   - Electrolyte toxicity
B. **Delayed**
   - Iron overload
   - Infections

Quiz

1. **What is the solution, if added to donated blood, would maximize the storage duration of RBCs?**
   A. CPDA-1
   B. 2,3 DPG
   C. Optisol

Explanation: CPDA-1 is important because it contains phosphate in the form of 2,3 DPG which functions in oxygen carriage, but optisol is one of the additive solutions which increase storage of RBCs to 42 days instead of 35, when only CPDA is added.

2. **A 26 year old mother of B- blood type had a miscarriage due to an unfortunate case of erythroblastosis fetalis, what could be the cause?**
   A. She received a blood transfusion of an Rh+ blood type
   B. She was impregnated by an Rh+ father
   C. Her first baby was of Rh+ blood type
   D. All of the above

Explanation: Rh incompatibility is more dangerous than ABO incompatibility in cases of erythroblastosis fetalis. The mother could have developed antibodies against the Rh+ factor from all 3 routes. If she married an Rh+ father, there is a chance that her first child was Rh+ as well, so her body created antibodies against the Rh factor, which attacked the RBCs of her second Rh+ baby during pregnancy.

3. **In donating blood, what is the factor that we can increase to have better tissue perfusion?**
   A. Oxygen carrying capacity
   B. Hemoglobin
   C. Partial pressure of O2
   D. Oxygen saturation

Explanation:
$CaO_2 = (Hgb \times 1.39) \times O_2\ Saturation + (PaO_2 \times 0.003)$
CaO_2 is the amount of oxygen bound to hemoglobin plus the oxygen dissolved in plasma.
Out of all the components of it's equation, Hgb is the major determinant of oxygen content in the blood.

4. **After his blood transfusion, a 45 y/o male patient developed signs of hypotension, tachycardia, fever, chills, hemoglobinemia, and flank pain. What are the findings you would see in a lab analysis?**
   A. Decreased haptoglobin, increased LDH
   B. Increased haptoglobin, increased LDH
   C. Absent haptoglobin, decreased LDH
   D. Decreased haptoglobin, absent LDH

Explanation: Haptoglobin is normally present in the plasma and binds to free hemoglobin from lysed red cells, preventing its toxic effects. Because haptoglobin levels become depleted (due to the action of phagocytosis by macrophage) in the presence of large amounts of free hemoglobin, decreased haptoglobin is a marker of hemolysis. LDH is an enzyme that is released from damaged tissue cells into the plasma.

1. C
2. D
3. B
4. A

Quiz

5. **After blood transfusion of packed RBCs, a patient developed a blood clot due to adding THIS solution to the RBCs:**
   A. 0.9% NaCl in the same line
   B. Lactate Ringer's solution in the same line
   C. 0.9% NaCl in a different line
   D. Lactate Ringer's solution in a different line

Explanation: RBCs should be infused alone or with 0.9% NaCl (should be isotonic), NEVER mixed with: Lactated Ringer's solution can lead to clotting due to the added calcium (give in another line)

6. **In an average adult, 1 U of PRBCs increases the Hgb by about**
   A. 1 g/dL
   B. 2 g/dL
   C. 3 g/dL
   D. 4 g/dL

7. **RBCs should never be infused with all of these fluids except:**
   A. Lactated Ringer's solution
   B. Dextrose
   C. 0.9% NaCl
   D. Hypertonic solutions

8. **from a Legal Aspects how many qualified people should be checking the transfusion procedure**
   A. 2
   B. 3
   C. 4
   D. 5

9. **which of these should be monitored in patients with hemolytic reactions:**
   A. prothrombin time (PT)
   B. activated partial thromboplastin time (aPTT)
   C. platelet count
   D. all of the above

10. **when will RBCs become no longer good to use?**
   A. after 52 days in the refrigerator
   B. after 42 hours in the refrigerator
   C. after 11 months in the freezer
   D. after 5 weeks in the freezer

11. **For a 70 kg patient, 1 unit of platelets transfusion increases platelets count by approximately:**
   A. 500-1000
   B. 5000-10000
   C. 15000-20000
   D. 25000-30000

11. B
10. A
9. D
8. A
7. C
6. A
5. B