

II. Blood and Blood Components

A. Goals of blood collection, preparation and storage

1. Maintain viability and function.
2. Prevent physical changes.
3. Minimize bacterial contamination.

B. Anticoagulants Preservative Solutions

1. Anticoagulant prevents clotting and preservatives provide proper nutrients for continued metabolism of cells during storage.
2. Heparin
 - a. Serves as an anticoagulant only.
 - b. Must be transfused within 48 hours preferably within 8 hours.
3. Anticoagulant/preservatives approved for whole blood storage are:

	Citrate Phosphate Dextrose (CPD)	Citrate Phosphate Dextrose Adenine (CPD-A1)
Storage Time	21 days	35 days
Temperature	1-6 C	1-6 C
	Slows glycolytic activity so dextrose is not rapidly consumed	
Adenine	None	Added adenine provides substrate from which RBCs can synthesize ATP during storage, improves viability
Volume	450 mLs \pm 10%	450 mLs \pm 10%
Dextrose - supports continuing ATP generation by glycolytic pathway		
Citrate - prevents coagulation by binding ionized calcium which is required for coagulation cascade		

3. Additive solutions - refer to ADSOL handout
 - a. System consists of primary bag with satellite bags attached, one of which contains the additive solution, 3 formulations AS-1, AS-3, and AS-5.
 - b. Unit drawn into the primary bag containing CPD anticoagulant.
 - c. Platelet rich plasma is removed and a second preservative solution which consists of saline, adenine, glucose and mannitol (SAGMAN) is added to the RBCs to extend red cell storage to **42 days** and has a final hematocrit of 66%.
 - d. Plasma must be removed within 72 hours of collection.

C. Changes Which Occur During Blood Storage

1. Shelf life or expiration date.
 - a. Maximum allowable storage time results in 75% recovery
 - b. 75% recovery means that at least 75% of the transfused cells remain in the recipient's circulation 24 hours **after** transfusion.
2. Storage lesion
 - a. Refers to the measurable biochemical changes which occur when blood is stored at 1-6 C.
 - b. Oxygen dissociation curve is affected by biochemical changes and may cause increased affinity of hemoglobin for oxygen.
 - 1) Low 2,3-DPG levels cause greater affinity for oxygen resulting in less O₂ to be released.
 - 2) pH drops due to cellular metabolism, causes 2,3-DPG levels to fall.
 - 3) Following transfusion stored donor rbc's regenerate ATP and 2,3-DPG levels.
 - c. Few functional platelets left and number of viable red cells decreases.
3. Storage lesion clinically significant for infants and patients needing massive transfusion.
4. Other biochemical changes which occur include:
 - a. ATP decreases
 - b. Potassium increases in plasma.
 - c. Sodium decreases in plasma.
 - d. Plasma hemoglobin increases in plasma.

G. Preparation of components

1. To prevent partial activation of coagulation system unit should be collected within 15 minutes with minimal trauma to the tissues.
2. Blood for components drawn into primary bag with attached satellite bags to avoid breaking the hermetic seal when removing components (closed system).
3. If hermetic seal is broken ***component must be transfused within 24 hours if stored at 1-6 C or within 4 hours if stored at 20-24 C.***
4. To prepare components, blood must not be chilled and ***platelets must be removed within 8 hours of collection.***
 - a. Centrifuge blood using a "light" spin (2000xg, 3").
 - b. Break integral seal, express platelet rich plasma (top layer) into satellite bag then seal tubing between primary and satellite bag, place primary bag with RBCs at 1-6 .
 - c. Centrifuge platelet rich plasma using a "heavy" spin (5000 x g, 5 minutes).
 - d. Express the supernatant platelet-poor plasma into the second transfer bag and seal the tubing.
 - e. Place plasma at -18 C or lower (**FDA requires it to be frozen solid within 8 hours of collection**), platelets are stored at 20-24 C with constant agitation.
 - f. To make cryoprecipitate thaw frozen plasma at 1-6 C. When plasma has a slushy consistency remove the plasma to satellite bag, leaving behind the precipitated CRYO.
 - g. Store CRYO at -18 C or lower. Can refreeze plasma to be used as single donor plasma.
 - h. The red blood cells which have been left in the primary bag may be handled in 2 ways.
 - 1) If collected in CPD will have a 21 day expiration.
 - 2) Add an additive solution to the RBCs, unit will have 42 day expiration.
 - 3) All liquid RBCs are stored at 1-6 C.

- i. In summary the following components are routinely prepared from a unit of whole blood:
 - 1) Packed Red Blood Cells (RBC)
 - 2) Fresh Frozen Plasma (FFP)
 - 3) Cryoprecipitate (CRYO)
 - 4) Single donor plasma (SDP)
 - 5) Platelets (PC or RD PC) - NOTE- nationally going to pheresis platelets.
- 5. Sterile docking device allows tubing to be separated and joined with other tubing without exposure to bacterial contamination.
 - a. Used primarily to add additional satellite bags to donor units which allows aliquoting of the unit, each aliquot retains the original expiration date.
 - b. May also be used to "pool" units of platelets and cryo.

E. General Information About Blood Components

- 1. Blood is separated into components to allow treatment of patients with specific blood products for their needs.
- 2. Advantages of separation of Whole Blood into components:
 - a. Allows optimum survival for each component.
 - b. Transfusion of only that component of blood the patient needs.
- 3. Transfusion practice:
 - a. Transfusion of blood or blood components requires a doctors prescription.
 - b. All blood and components must be administered through a filter.
 - c. Infuse as quickly as the patient can tolerate it, preferably within 4 hours.
 - d. All D negative recipients should be transfused with D negative **cellular** products.
 - f. When possible components should be ABO identical and must be ABO compatible.
 - e. "**Universal Donor**" for cellular products is group O, for plasma products it is group AB.
- 4. Fresh Whole Blood
 - a. Donor blood is not usually available until 12-24 hours after phlebotomy
 - b. Candidates for fresh whole blood (<7-10 days old) are:
 - 1) Newborns needing exchange transfusion so full levels of 2,3-DPG are available.
 - 2) Patient reacquiring leukoreduced blood products.
- 5. Summary of component storage temperatures:
 - a. Liquid RBCs 1-6 C.
 - b. PLTS, thawed CRYO and Granulocytes 20-24 C (RT).
 - c. Any frozen plasma component < -18 C.
 - d. Any liquid plasma component 1-6 C EXCEPT thawed CRYO

F. Cellular Blood Components

- 1. **Whole Blood (WB)**
 - a. Clinical indications for use of WB are **extremely** limited.
 - b. Used for massive transfusion to correct acute hypovolemia such as in trauma and shock.
 - c. Rarely used today, platelets non-functional, labile coagulation factors gone.
 - d. **Must** be ABO **identical**.

2. **Red Blood Cells, Packed Cells (RBCs)**
 - a. Used to treat symptomatic anemia and routine blood loss during surgery
 - b. Hematocrit is approximately 80% for non-additive (CPD), 60% for additive (ADSOL).
 - c. Allow WB to sediment or centrifuge WB, remove supernatant plasma.

3. **Leukocyte Reduced Red Blood Cells (LR-RBC)**
 - a. Leukocytes in blood products can induce adverse affects during transfusion, primarily febrile, non-hemolytic reactions.
 - b. Present thinking attributes reactions to cytokines produced by leukocytes in transfused units.
 - c. Other explanations to reactions include: immunization of recipient to transfused HLA or granulocyte antigens, micro aggregates and fragmentation of granulocytes.
 - d. Historically, indicated only for patients who had 2 or more febrile transfusion reactions, now a commonly ordered, popular component.
 - e. "CMV" safe blood, since CMV lives in WBCs.
 - f. Most blood centers now leukoreduce blood immediately after collection.
 - g. Bed side filters are available to leukoreduce products during transfusion.

4. **Washed Red Blood Cells (W-RBCs)**
 - a. Washing the unit removes plasma proteins, platelets, WBCs and micro aggregates which may cause febrile or urticarial reactions.
 - b. Patient requiring this product is the IgA deficient patient with anti-IgA antibodies.
 - c. Prepared by using a machine which washes the cells 3 times with saline to remove and WBCs.
 - d. Two types of labels:
 - 1) Washed RBCs - do not need to QC for WBCs.
 - 2) Leukocyte Poor WRBCs, QC must be done to guarantee removal of 85% of WBCs. No longer considered effective method for leukoreduction.
 - e. Expires 24 hours after unit is entered.

5. **Red Blood Cells Frozen; Red Blood Cells Deglycerolized (D-RBC)**
 - a. Blood is frozen to preserve: rare types, for autologous transfusion, stock piling blood for military mobilization and/or civilian natural disasters.
 - b. Blood is drawn into an anticoagulant preservative.
 - 1) Plasma is removed and glycerol is added.
 - 2) After equilibration unit is centrifuged to remove excess glycerol and frozen.
 - c. Expiration
 - 1) If frozen, 10 years.
 - 2) After deglycerolization, 24 hours.
 - d. Storage temperature
 - 1) high glycerol -65 C.
 - 2) low glycerol -120 C, liquid nitrogen.
 - e. ***Deglycerolization*** of donor unit, removal of glycerol.
 - 1) Thaw unit at 37C, thawed RBCs will have high concentration of glycerol.
 - 2) A solution of glycerol of lesser concentration of the original glycerol is added.
 - 3) This causes glycerol to come out of the red blood cells slowly to prevent hemolysis of the RBCs.
 - 4) After a period of equilibration the unit is spun, the solution is removed and a solution with a lower glycerol concentration is added.
 - 5) This procedure is repeated until all glycerol is removed, more steps are required for the high glycerol stored units.
 - 6) The unit is then washed.

6. **Rejuvenated Red Blood Cells**
 - a. A special solution is added to expired RBCs up to 3 days after expiration to restore 2,3-DPG and ATP levels to prestorage values.
 - b. Rejuvenated RBCs regain normal characteristics of oxygen transport and delivery and improved post transfusion survival.
 - c. Expiration is 24 hours or, if frozen, 10 years.

7. **Platelets (PLTS), Platelet Concentrate (PC) or Random Donor Platelet Concentrate (RD-PC)**
 - a. Used to prevent spontaneous bleeding or stop established bleeding in thrombocytopenic patients.
 - b. Prepared from a single unit of whole blood.
 - c. Due to storage at RT it is the most likely component to be contaminated with bacteria.
 - d. Therapeutic dose for adults is 6 to 10 units.
 - e. Some patients become "refractory" to platelet therapy.
 - f. *Expiration is 5 days as a single unit, 4 hours if pooled.*
 - g. Store at 20-24 C (RT) with constant agitation.
 - h. D negative patients should be transfused with D negative platelets due to the presence of a small number of RBCs.

8. **Platelets Pheresis, Apheresis Platelet Concentrate, Single Donor Platelet Concentrate (SD-PC)**
 - a. Used to decrease donor exposure, to obtain HLA matched platelets for patients who are refractory to RD-PC or prevent platelet refractoriness from occurring.
 - b. Prepared by hemapheresis, stored in two connected bags to maintain viability.
 - c. One pheresed unit is equivalent to 6-8 RD-PC.
 - d. Store at 20-24 C (RT) with agitation for *5 days, after combining, 24 hours*
 - i. D negative patients should be transfused with D negative platelets due to the presence of a small number of RBCs

9. **Granulocytes**
 - a. Primary use is for patients with neutropenia who have gram negative infections documented by culture, but are unresponsive to antibiotics.
 - b. Therapeutic efficacy and indications for granulocyte transfusions are not well defined.
 - c. Better antimicrobial agents and use of granulocyte and macrophage colony stimulating factors best for adults, best success with this component has been with babies
 - d. Daily transfusions are necessary.
 - d. Prepared by hemapheresis.
 - e. Expiration time is 24 hours but best to infuse ASAP.
 - f. Store at 20-24 C.

G. Plasma Components

1. **Fresh Frozen Plasma (FFP)**

- a. Used to replace labile and non-labile coagulation factors in massively bleeding patients OR treat bleeding associated with clotting factor deficiencies when factor concentrate is not available.
- b. *Must be frozen within 8 hours of collection.*
- c. Expiration
 - 1) frozen - 1 year stored at <-18 C.
 2. frozen - 7 years stored at <-65 C.
 - 3) thawed - 24 hours

- d. Storage temperature
 - 1) frozen -18 C, preferably -30 C or lower
 - 2) thawed - 1-6 C
- e. Thawed in 30-37C water bath or FDA approved microwave
- f. Must have mechanism to detect units which have thawed and refrozen due to improper storage.
- g. Must be ABO compatible

2. **Plasma, Liquid Plasma, Recovered Plasma and Source Plasma**

- a. Used to treat patients with stable clotting factor deficiencies for which no concentrate is available or for patients undergoing therapeutic plasmapheresis.
- b. Prepared by separating the plasma from the RBCs **on or before the 5th day after expiration** of the whole blood.
- c. Once separated can:
 - 1) Freeze, store at -18 C for 5 years
 - 2) If not frozen, called liquid plasma, store at 1-6 C for up to 5 days after expiration of WB.
- d. Once FFP is one year old can redesignate as Plasma, expiration is 5 years.

3. **Pooled Plasma/Solvent Detergent Treated**

- a. Most recently licensed product.
- b. Prepared from pools of no more than 2500 units of ABO specific plasma frozen to preserve labile coagulation factors.
- c. Treated with chemicals to inactivate lipid-enveloped viruses.
- d. Contains labile and non-labile coagulation factors but lacks largest Von Willebrand's factor multimers.
- e. Used same as FFP.
- f. Safety concerns
 - 1. Decreases disease transmission for diseases tested for.
 - 2. Doesn't inactivate viruses with non-lipid envelopes: parvo virus B19, hepatitis A, and unrecognized pathogens.

4. **Cryoprecipitate (CRYO), Factor VIII or Anti-Hemophilic Factor (AHF)**

- a. Cold insoluble portion of plasma that precipitates when FFP is thawed at 1-6C.
- b. Cryoprecipitate contains high levels of **Factor VIII and Fibrinogen**, used for treatment of hemophiliacs and Von Willebrands when concentrates are not available.
- c. Used most commonly for patients with DIC or low fibrinogen levels.
- d. *A therapeutic dose for an adult is 6 to 10 units.*
- e. Can be prepared from WB which is then designated as "Whole Blood Cryoprecipitate Removed" or from FFP
 - 1) Plasma is frozen.
 - 2) Plasma is then thawed at 1-6 C, a precipitate forms.
 - 3) Plasma is centrifuged, cryoprecipitate will go to bottom.
 - 4) Remove plasma, freeze within 1 hour of preparation
- f. Storage Temperature
 - 1) Frozen -18 C or lower
 - 2) Thawed - room temperature

- g. Expiration:
 - 1) Frozen 1 year
 - 2) Thawed 6 hours
 - 3) Pooled 4 hours
- h. Best to be ABO compatible.

H. Irradiation of Blood Components

1. Cellular blood components are irradiated to destroy viable T- lymphocytes which *may cause Graft Versus Host Disease (GVHD)*.
2. GVHD is a disease that results when immunocompetent, viable lymphocytes in donor blood engraft in an immunocompromised host, recognize the patient tissues as foreign and produce antibodies against patient tissues, primarily skin, liver and GI tract. The resulting disease has serious consequences including death.
3. GVHD may be chronic or acute
4. Patients at greatest risk are severely immunosuppressed, immunocompromised, receive blood donated by relatives, or fetuses receiving intrauterine transfusions
5. Irradiation inactivates lymphocytes, leaving platelets, RBCs and granulocytes relatively undamaged.
6. Must be labeled "irradiated".
7. *Expiration date of Red Blood Cell donor unit changes to 28 days.*
8. May be transfused to "normal" patients if not used by intended recipient.

I. Donor Blood Inspection and Disposition

1. It is required that donor units be inspected periodically during storage and prior to issuing to patient.
2. The following may indicate an unacceptable unit:
 - a. Red cell mass looks purple or clots are visible.
 - b. Zone of hemolysis observed just above RBC mass, look for hemolysis in sprigs, especially those closest to the unit.
 - c. Plasma or supernatant plasma appears murky, purple, brown or red.
 - d. A greenish hue **need not** cause a unit to be rejected.
 - e. Inspect platelets for aggregates.
 - f. Inspect FFP and CRYO for signs of thawing, evidence of cracks in bag, or unusual turbidity in CRYO or FFP (i.e., extreme lipemia).
3. If a unit's appearance looks questionable do the following:
 - a. Quarantine unit until disposition is decided.
 - b. Gently mix, allow to settle and observe appearance.
4. If bacterial contamination is suspected the unit should be cultured and a gram stain performed.
 - a. Positive blood cultures usually indicative of:
 - 1) Inadequate donor arm preparation
 - 2) Improper pooling technique
 - 3) Health of donor - bacteremia in donor
 - b. If one component is contaminated, other components prepared from the same donor unit may be contaminated.
5. Reissuing blood cannot be done unless the following criteria is met:
 - a. Container closure must not have been penetrated or entered in any manner.
 - b. Most facilities set 30" time limit for accepting units back, warming above 6-10C even with subsequent cooling increases RBC metabolism producing hemolysis and permitting bacterial growth.

- c. Blood must have been kept at the appropriate temperature.
- d. One sealed segment must remain attached to container.
- e. Records must indicate that blood has been reissued and inspected prior to reissue.

J. Transportation of blood and blood components

1. WB and RBC
 - a. Sturdy well insulated cardboard and/or styrofoam container, wet ice in ziplock bag to cool, temperature must be monitored.
 - b. Mobile collection units should transport blood ASAP and leave at RT if platelets are to be made.
 - c. In-house transport place in cooler with wet ice and thermometer, monitor temperature every 30 minutes.
2. Frozen components
 - a. Temperature must be maintained at or below required storage temperature.
 - b. Use dry ice in well insulated container.
3. Platelets and granulocytes
 - a. Maintain at 20-24 C.
 - b. Transport in well insulated containers **without** ice.
 - c. Commercial coolers available to maintain at 20-24C.
4. Handling donor units
 - a. Should **not** remain at RT unnecessarily, when blood is issued it should be transfused as soon as possible.
 - b. When numerous units are removed from fridge, remove fluid filled container with a thermometer at same time as blood, when temperature reaches 6 C return to fridge.

K. Records

1. Must be made concurrently with each step of component preparation, being as detailed as possible for clear understanding.
2. Must be legible and indelible.
3. Must include dates of various steps and person responsible.

EXAM 1 ONLINE