



Blood Products

BLOOD BLOODERS?

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Whole Blood

100%

55%

45%

Plasma

100%

electrolytes,
vitamins, gases,
hormones

H_2O
91.5%

Proteins
7.5%

Solutes/
waste
1%

RBCs
99%

Formed Elements

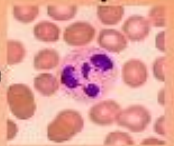
100%

Platelets
WBCs 1%

WBC concentration

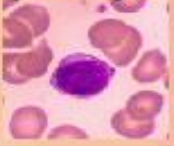
Neutrophil

65%



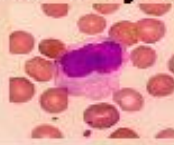
Lymphocyte

23%



Monocyte

5%



Eosinophil

4%



Basophil

1%

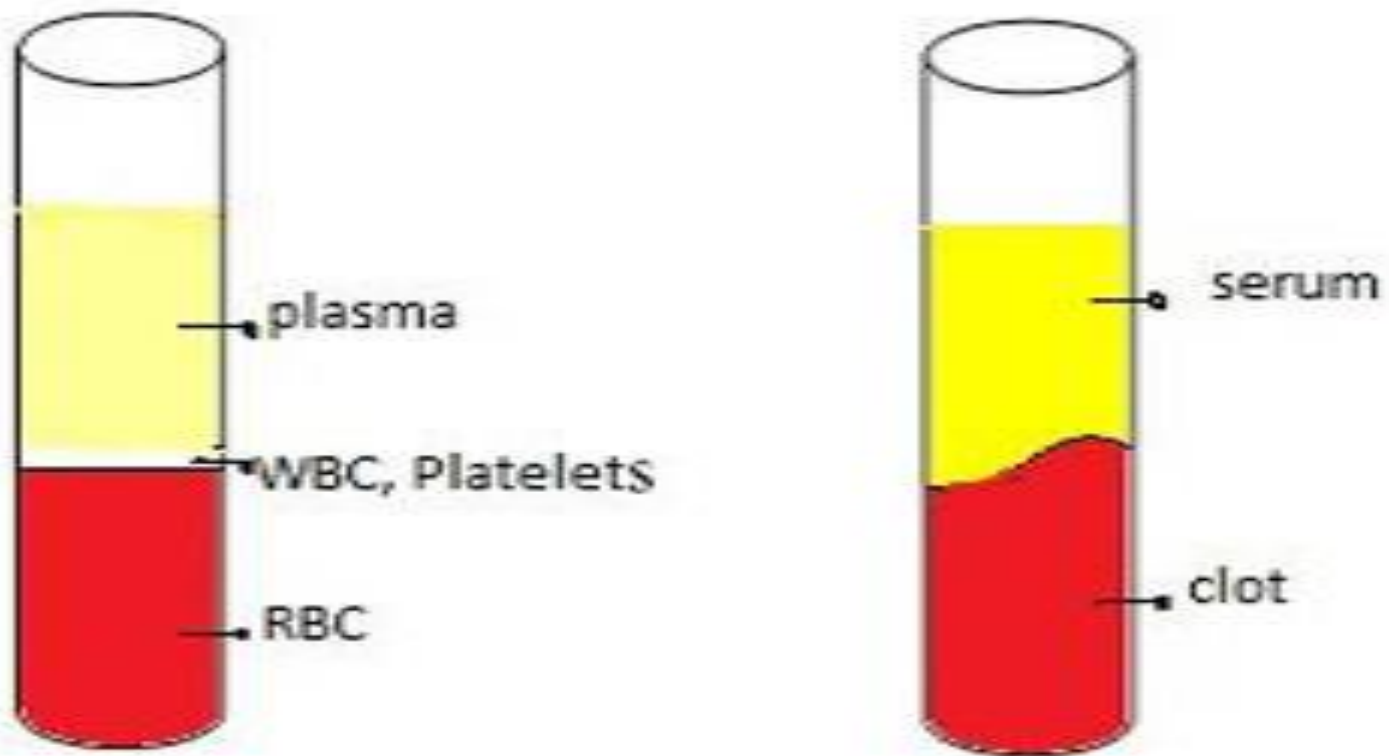


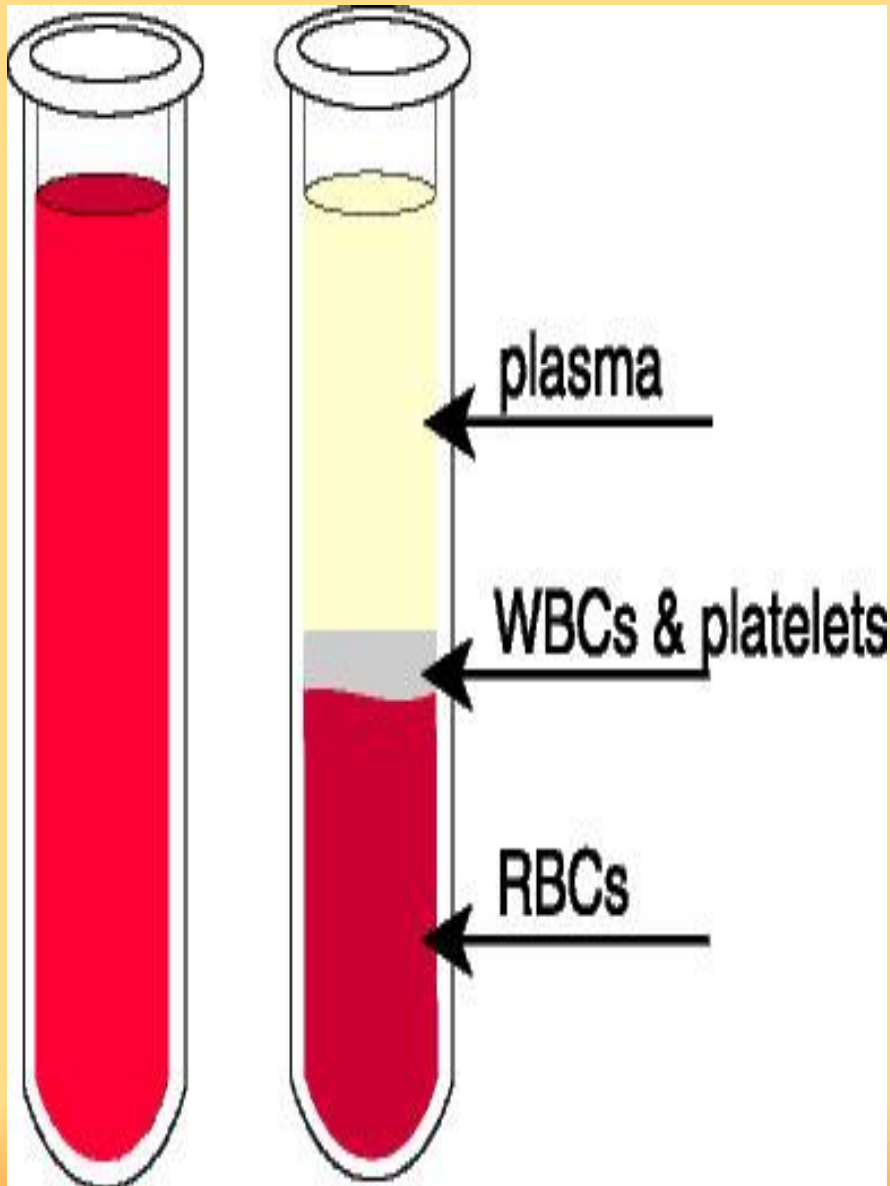
fibrinogen- 7%, made
by liver

Plasma Protein composition

Albumins 54% smallest, most abundant. transport fatty acids	Globulins 38% from plasma & liver cells; 38% Gamma Globulins Immunoglobulins	Fibrinogen 7% + trace substances
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Blood Products





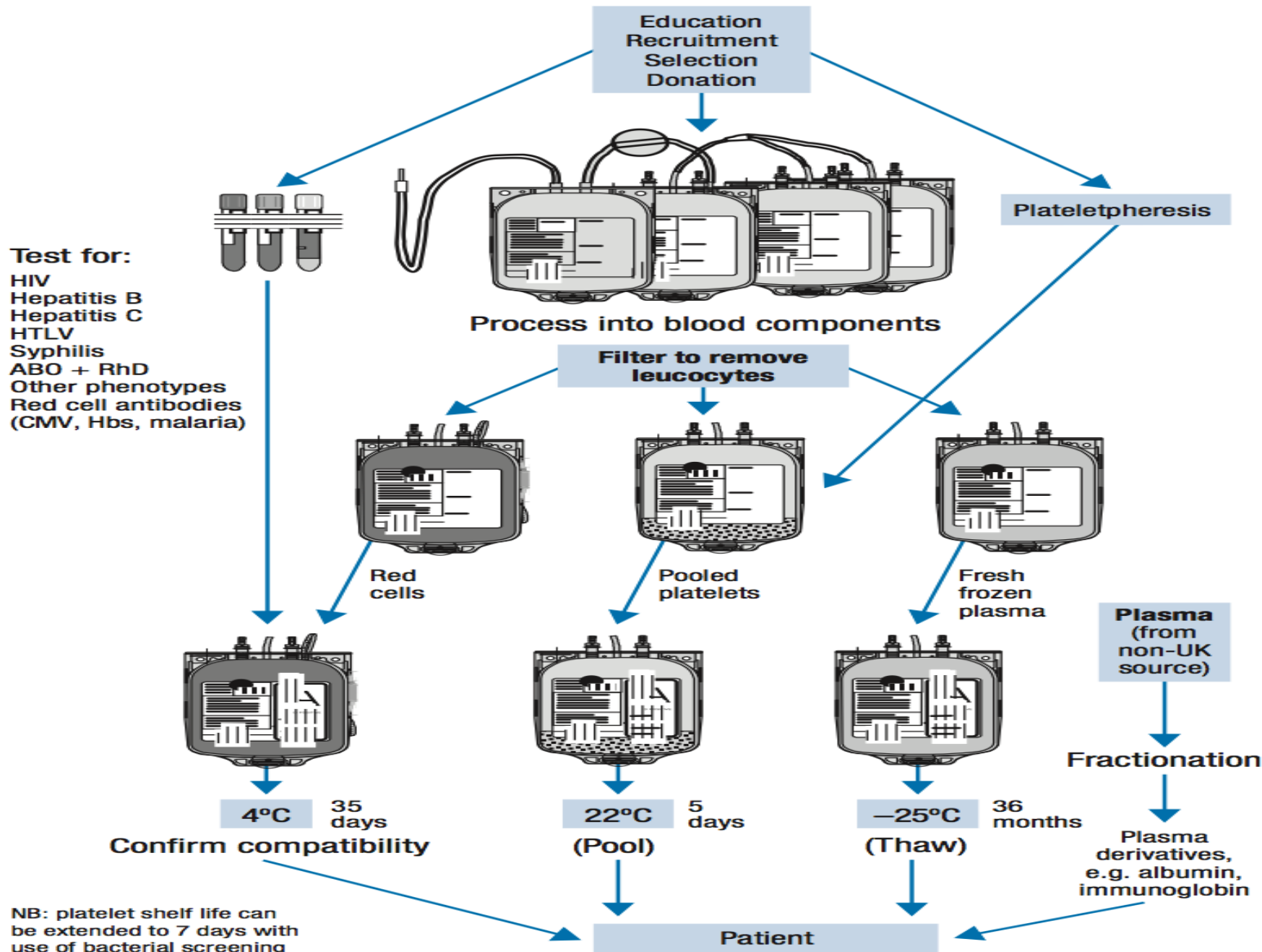
- Whole blood
- Packed red blood cells
- Random-donor platelets concentrates
- Single-donor platelets concentrates
- Leukocyte-poor (reduced) red cells
- Irradiated blood products
- Washed red blood cells
- FFP
- Cryoprecipitate
- Leukocyte (granulocyte)
- IVIG
- Factor concentrate

Blood Products

- **Blood components** prepared in the blood transfusion centre (red cells, platelets, fresh frozen plasma and cryoprecipitate)
- **Plasma derivatives** manufactured from pooled plasma donations in plasma fractionation centres (such as albumin, coagulation factors and immunoglobulins).

Blood Products

- Whole blood (450 mL) in various anticoagulants
- Whole blood is first separated into **PRBCs** and **platelet-rich plasma** by slow centrifugation.
- Platelet-rich plasma is then centrifuged at high speed to yield 1 unit of **(RD) platelets** and one unit of **FFP**.
- **Cryoprecipitate** is produced by thawing FFP to precipitate plasma proteins → centrifugation.



Whole Blood

- Both O₂-carrying and vol expansion.
- 405–495 mL (470 mL), 63 mL of CPD
- For acute hemorrhage >25% blood loss
- Stored at 4°C
- Plt dysfunction and coagulation degradation
- Fall 2,3-DPG :increase O₂ affinity
- Not readily available



Packed Red Blood Cells

- Restore oxygen carrying capacity in anaemia or blood loss where alternative treatments are ineffective or inappropriate.
- They must be ABO compatible with recipient
- Adequate oxygenation with Hb 70 g/L in normovolemic without cardiac disease



Leukocyte Reduction

- To prevent certain adverse reactions:
- CMV & vCJD risk-reduction,
- reduces febrile reactions and
- alloimmunisation to white cell (including HLA) antigens.
- Prestorage filtration superior to bedside filtration (cytokines).
- $<1 \times 10^6$ leucocytes in the pack



Washed Red Cells

Indicated :

- for recurrent or severe allergic or febrile reactions to red cells, and
- severely IgA-deficient when IgA-deficient are not available.
- Either manually (24-hour shelf life) or, automated (shelf life 14 days)

Irradiated Red Cells

- Indicated for patients **at risk of transfusion-associated graft-versus-host disease.**
- Irradiated by gamma or X-rays within 14 d of donation and has shelf life 14 d from irradiation.



Alloimmunization to blood transfusion

- immune response to the donor antigens resulting in various clinical consequences, depending on the blood cells and specific antigens involved.
 - 1) red blood cell (RBC)-specific antigens;
 - 2) human leukocyte antigens (HLAs),
 - 3) platelet-specific antigens (human platelet antigens [HPAs]).

Alloimmunization to blood transfusion

- Blood group antigens are diverse in structure, function, and immunogenicity.
- In addition to red blood cells (RBCs), a recipient of an RBC transfusion is exposed to donor plasma, white blood cells, and platelets; the potential contribution of these elements to RBC alloimmunization remains unclear.
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diagnosis of alloimmunization

- The first step for diagnosis of alloimmunization is assessment of a person's medical history and any signs or symptoms.
- In addition, there are several types of diagnostic tests for alloimmunization, most involving blood samples.
- The test used varies depending on the individual's current condition.
- Only antibodies for the **ABO and Rh** antigens are routinely tested, but there are other blood antigens that may rarely cause alloimmunization.

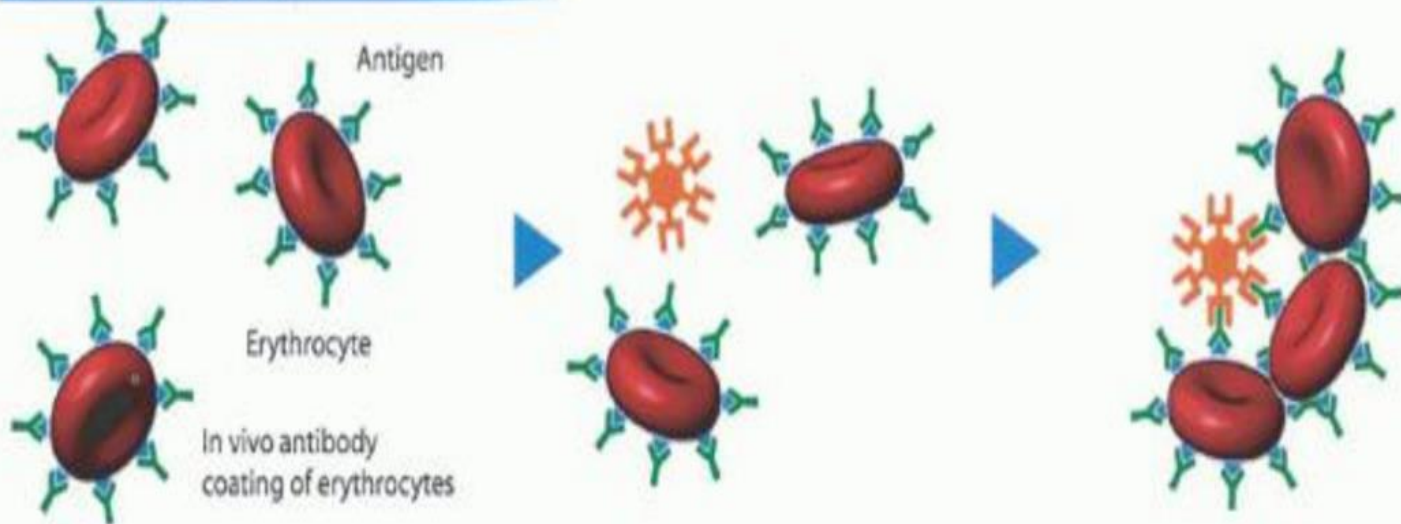
prevent alloimmunization

- The initial blood test screening will check for the individual's blood type and antibodies.
- If the antibody screen is positive, further testing may occur to determine the particular antibodies that are present within the person's blood.
- Then the individual who requires a transfusion will be matched to a donor's blood that is the same blood type and does not contain the specific antigens the recipient has antibodies against.
- This screening process will minimize the risk of alloimmunization during future blood transfusions.

prevent alloimmunization

- For pregnant individuals who are RhD negative, formation of antibodies to D antigen can be prevented by giving them anti-D immune globulin (RhoGAM) in the third trimester. This will clear the RhD positive red blood cells from the body before delivery of the baby, when exposure to the D antigen would otherwise occur.

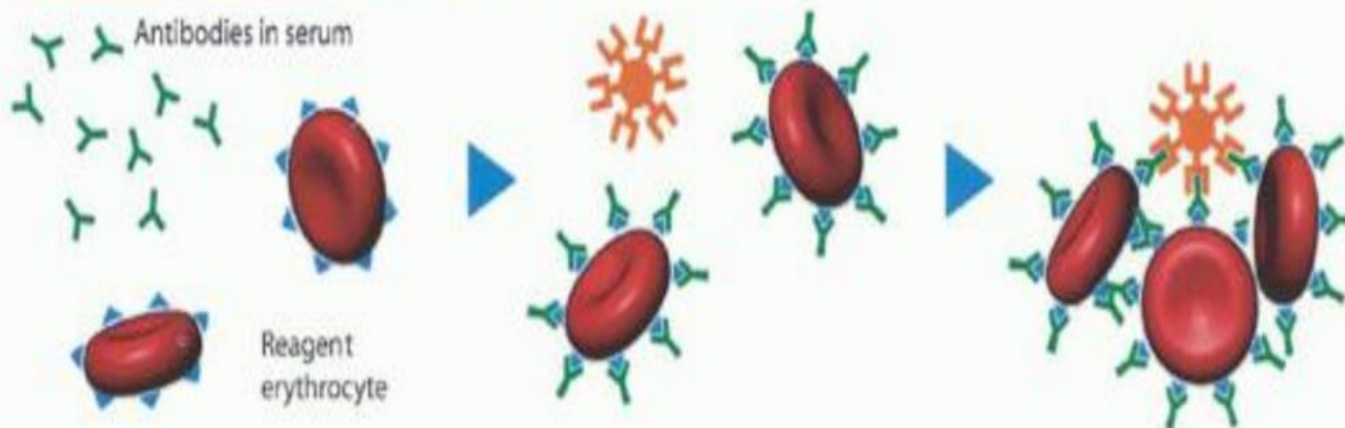
Direct Antiglobulin Test



Anti-IgG AHG reagent added
after erythrocytes are washed

AHG reagent causes IgG-coated
erythrocytes to agglutinate

Indirect Antiglobulin Test



ADVERSE REACTIONS TO BLOOD TRANSFUSION

Acute Hemolytic Transfusion Reactions (AHTR)

- The **ABO isoagglutinins** are responsible for the majority of these reactions. (Immune-mediated hemolysis)
- However, alloantibodies directed against other RBC antigens, **i.e., Rh, Kell, and Duffy**, are responsible for more fatal hemolytic transfusion reactions.
- hypotension, tachypnea, tachycardia, fever, chills, hemoglobinemia, hemoglobinuria, chest and/or flank pain, and discomfort at the infusion site.

Delayed Hemolytic Transfusion Reactions (DHTRs)

- These reactions occur in patients previously sensitized to RBC alloantigens who have a **negative alloantibody screen due to low antibody Levels.**
- The alloantibody is **detectable 1–2 weeks** following the transfusion, and the posttransfusion DAT may become positive due to circulating donor RBCs coated with antibody or complement.
- No specific therapy is usually required, although additional RBC transfusions may be necessary.

Delayed Serologic Transfusion Reactions (DSTRs)

- Delayed serologic transfusion reactions are similar to DHTR, because
- the DAT is positive and
- alloantibody is detected;
- however, RBC clearance is not increased.

Febrile Nonhemolytic Transfusion Reaction (FNHTR)

- is The **most frequent reaction** associated with the transfusion of cellular blood components .
- These reactions are characterized by chills and rigors and a $\geq 1^{\circ}\text{C}$ rise in temperature.
- Antibodies directed against **donor leukocyte and HLA antigens** may mediate these reactions;
- thus, **multiply transfused patients** and **multiparous women** are felt to be at increased risk.

Febrile Nonhemolytic Transfusion Reaction (FNHTR)

- The use of **leukocyte-reduced blood products** may prevent or delay sensitization to leukocyte antigens and thereby reduce the incidence of these febrile episodes.
- Cytokines released from cells within stored blood components may mediate FNHTR; thus, **leukoreduction before storage** may prevent these reactions.

Allergic Reactions

- Urticarial reactions are related to **plasma proteins** found in transfused components.
- Mild reactions may be treated symptomatically by temporarily **stopping** the transfusion and administering antihistamines.
- The transfusion may be completed after the signs and/or symptoms resolve.
- Patients with a history of allergic transfusion reaction should be **premedicated with an antihistamine**.
- Cellular components can **be washed to** remove residual plasma for the extremely sensitized patient.

Anaphylactic Reaction

- This severe reaction presents after transfusion of **only a few milliliters of the blood component**.
- Symptoms and signs include difficulty breathing, coughing, nausea and vomiting, hypotension, bronchospasm, loss of consciousness, respiratory arrest, and shock.
- Treatment includes **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.

Anaphylactic Reaction

- Patients who are IgA-deficient, <1% of the population, may be sensitized to this Ig class and are at risk for anaphylactic reactions associated with plasma transfusion.
- Individuals with severe IgA deficiency should therefore receive only IgA-deficient plasma and washed cellular blood components.
- Patients who have anaphylactic or repeated allergic reactions to blood components should be tested for IgA deficiency.

Graft-Versus-Host Disease

- (GVHD) is a frequent complication of allogeneic stem cell transplantation, in which lymphocytes from the donor attack and cannot be eliminated by an immunodeficient host.
- Transfusion-related GVHD is mediated by **donor T lymphocytes that recognize host HLA antigens** as foreign and mount an immune response, which is manifested clinically by the development of fever, a characteristic cutaneous eruption, diarrhea, and liver function abnormalities.
- transfusion-associated GVHD (TA-GVHD) is characterized by **marrow aplasia and pancytopenia**.

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Graft-Versus-Host Disease

- TA-GVHD is highly **resistant to treatment** with immunosuppressive therapies, including glucocorticoids, cyclosporine, antithymocyte globulin, and ablative therapy followed by allogeneic bone marrow transplantation.
- Clinical manifestations appear **at 8–10 days**, and death occurs **at 3–4 weeks** after transfusion.
- **TA-GVHD can be prevented by irradiation of cellular components** (minimum of 2500 cGy) before transfusion to patients at risk.
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Graft-Versus-Host Disease

Patients at risk for TA-GVHD include

- fetuses receiving intrauterine transfusions,
- selected immunocompetent (e.g., lymphoma patients) or
- immunocompromised recipients,
- recipients of donor units known to be from a blood relative, and
- recipients who have undergone marrow transplantation.
- Directed donations by family members should be discouraged (they are not less likely to transmit infection); lacking other options, the blood products from family members should always be irradiated.

Transfusion-related acute lung injury (TRALI)

- is the most common cause of transfusion related fatalities.
- The recipient develops symptoms of **hypoxia** ($P_{aO_2}/F_{iO_2} < 300$ mmHg) and signs of **noncardiogenic pulmonary edema**, including bilateral interstitial infiltrates on chest x-ray, either **during or within 6 h of transfusion**.
- Treatment is supportive, and patients usually recover without sequelae.
- TRALI usually results from the transfusion of donor plasma that contains high-titer anti-HLA class II antibodies that bind recipient leukocytes.

Transfusion-related acute lung injury (TRALI)

- The leukocytes aggregate in the pulmonary vasculature and release mediators that increase capillary permeability.
- Testing the donor's plasma for anti-HLA antibodies can support this diagnosis. The implicated **donors are frequently multiparous women.**
- The transfusion of plasma from male and nulliparous women donors reduces the risk of TRALI.

NONIMMUNOLOGIC REACTIONS

- Fluid Overload
- Hypothermia
- Electrolyte Toxicity
- Iron Overload
- Hypotensive Reactions
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NONIMMUNOLOGIC REACTIONS

Bacterial Contamination: Most bacteria do not grow well at cold temperatures; thus, PRBCs and FFP are not common sources of bacterial contamination. However, some gram-negative bacteria can grow at 1–6°C. *Yersinia*, *Pseudomonas*, *Serratia*, *Acinetobacter*, and *Escherichia* species have all been implicated in infections related to PRBC transfusion. Platelet concentrates, which are stored at room temperature, are more likely to contain skin contaminants such as gram-positive organisms, including coagulase-negative staphylococci.

It is estimated that 1 in 1000–2000 platelet components is contaminated with bacteria.

INFECTIOUS COMPLICATIONS

- **Viral Infections:** Blood donations are tested for HbsAg, antibodies to HCV and HCV RNA, HIV-1, HIV-1 p24 antigen, and HIV RNA using NAAT.
- **Other Infectious:** Agents Various parasites, including those causing malaria, babesiosis, and Chagas' disease, can be transmitted by blood transfusion.

Platelets

- Until late 1960s platelets were unavailable for transfusion except in fresh whole blood.

Difficulties in preparing of platelets :

- **Clump**
- **Refrigeration** severely reduced survival
- Room temperature increase **bacterial** overgrowth.



Indication

- Low plt count or plt dysfunction
- Threshold for prophylactic platelet : 10,000/ μ L
- Without fever or infections, 5000/ μ L may be sufficient.
- For invasive procedures, 50,000/ μ L.
- 5-8 RDs or SDAPs
- without consumption [splenomegaly, fever, DIC], increase platelet count 10,000/uL.

Platelets

- Platelet transfusion should be **avoided** in TTP/HUS & HIT.
- ITP: while platelet Tx not indicated routine, may utilized in significant clinical bleeding.

Platelets

- Platelets have ABO Ag on their surface and may have reduced survival if transfused to an ABO-incompatible, not usually significant.
- Anti-A or anti-B in plasma of plt : rarely cause haemolysis (small children)
- Group O ideally only be given to group O.
- RhD - should be given to RhD - where possible, (especially women of child-bearing).
- anti-D

Single & Random donor

Platelets are produced in two ways:

1. Whole blood donations are centrifuged and the buffy coats (between the red cell and plasma layers) from four donations are pooled in the plasma of one of the donors

Apheresis technology :

2. plts obtained from a single donor by apheresis (may give 2-3 at a single session and 24 times in a year).



wiseGEEK



Platelet Refractoriness

Causes : alloimmunization, fever, sepsis, bleeding, splenomegaly, DIC, drugs, heparin, ABO mismatch, male, females >2 pregnancies

MultipleTx (Cellular elements and plasma proteins) :
alloimmunized to HLA- class I & plt-Ag

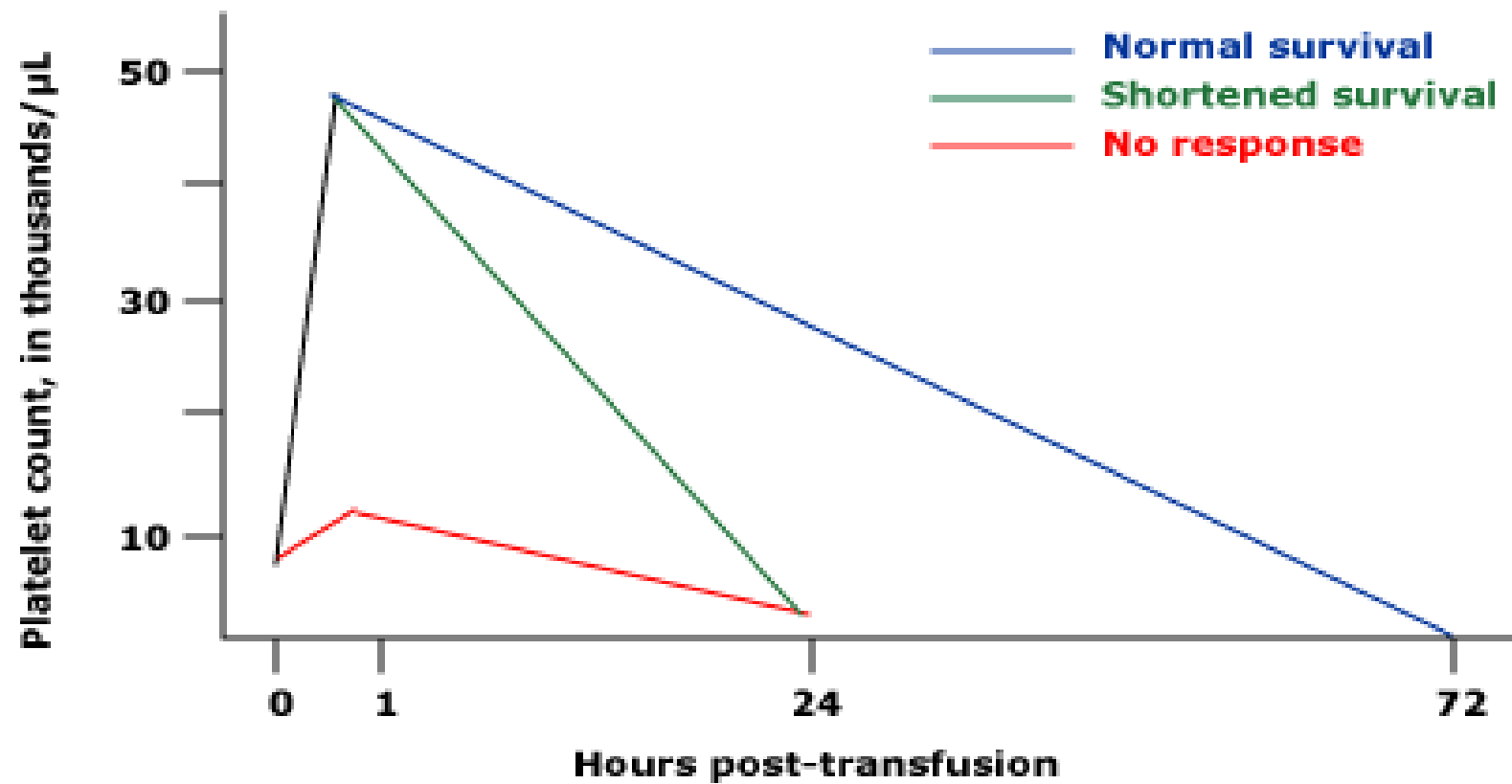
Rx : **leukocyte-reduced** **ABO-identical** **HLA-matched**
SDAPs

Platelet Refractoriness

- Refractoriness to plt or **corrected count increment (CCI)**:

$$\text{CCI} = (\text{post-pre} / \text{transfused plt} \times 10^{11}) \times \text{BSA}$$

- Acceptable CCI is $10 \times 10^9/\text{mL}$,
- and after 18–24 h increment of $7.5 \times 10^9/\text{mL}$



Irradiated & Washed Platelets

- Platelets may be **irradiated** to **prevent TA-GvHD** in susceptible patients.
- **Washing**: to remove most of plasma plts are resuspended in 200 mL of plt additive solution.
- Indicated for: **recurrent severe allergic or febrile reactions** to standard plt transfusions.
- Shelf life is reduced to 24 h after preparation.

Human leucocyte antigen (HLA)-selected platelets

- Indicated for patients refractory to random platelet components because of development of HLA Ab class I after previous transfusions
- HLA-typed platelet by apheresis
- Irradiated

Platelet

- Platelets are **stored** in temperature-controlled incubators (20–24°C) with constant agitation (refrigerated plts rapidly removed from circulation).
- Bacterial screening has allowed some Blood Services to extend shelf life from 5 to 7 days.

massive transfusion

- the administration of **10 units** or more of whole blood or packed red blood cells (PRBCs) **within 24 hours**.
- The primary objective of a massive transfusion is to prevent fatal outcomes resulting from critical hypoperfusion-related complications while striving to attain hemostasis.
- cardiac and vascular surgeries
- gastrointestinal and obstetrical hemorrhages,
- liver transplants, and trauma.
- Although massive transfusions are relatively rare, patients in need of such transfusions often experience high mortality rates.

Complications

- monitoring of acid-base status, electrolytes, body temperature, volume status, tissue oxygenation, and coagulation parameters is essential.
- Non-fatal complications are observed in over 50% of patients when transfusing more than 5 units of blood products.
- Coagulopathy
- Metabolic Abnormalities
- Sodium citrate and citric acid can result in metabolic alkalosis and hypocalcemia when added to blood products during storage to prevent coagulation. Furthermore, alkalosis can lead to hypokalemia.
- Hypothermia
- Transfusion-Related Acute Lung Injury (TRALI)
- Transfusion-Associated Circulatory Overload (TACO)
- ...

iron overload

- Complications of chronic iron overload in thalassemia patients & ... include:
- cardiac disease (including heart dysfunction and arrhythmias),
- pulmonary hypertension,
- bone disease (including osteoporosis), endocrine diseases (including hypothyroidism and hypogonadism),
- liver fibrosis and cirrhosis.

