Introduction of IV Fluid and Blood transfusion
Outline

• DISTRIBUTION of Body Fluid Compartments
• Normal values in extracellular space
• Normal maintenance need
• Osmolality, Osmolarity and Tonicity
WATER

- Building material
- Solvent \textit{(Q: types of solution and solutes )}
- Reaction medium and reactant
- Carrier for nutrient and waste products
- Thermoregulation
- Lubricant and shock absorber
Distribution of Body Water

- Total Body Water (TBW) equals to 60% of total body weight in adult males. *(WHY?)*
- In females, the percentage is around 55%, while in infants is around 75%.
- Obese individuals have less TBW per weight than non-obese individuals.
- Using a 70 Kg male as an example, TBW is 42 Liters.
Body Fluid Compartments

**TBW:** 55-60% of the BW in men and 45-50% in young women

- **Total Body Water (TBW)**
  - (70Kg man)
  - 42 litres
  - \( \text{TBW} = 0.6 \times \text{Body weight} \)

- **Extracellular Fluid Volume (ECF)**
  - 1/3 of Total Body Weight = 14 Litres
  - **Interstitial Fluid**
    - 3/4 of ECF = 10.5 Litres
  - **Plasma**
    - 1/4 of ECF = 3 Litres

- **Intracellular Fluid Volume (ICF)**
  - 2/3 of Total Body Weight = 28 Litres
  - **Transcellular Fluid**
    - 0.5 Litre
Fluid Compartments are divided by water-permeable membranes.....(Q).

- Intracellular space is separated from the extracellular space by the cell membrane.

- The capillary membrane separates the components of the extracellular space.

- **Transcellular fluid**: Transcellular fluid is the portion of TBW contained within epithelial lined spaces. It is the smallest component of extracellular fluid, e.g. cerebrospinal fluid, and ocular fluid, joint fluid.
Body Fluid Compartments

Total Body Water (TBW)

- Intracellular fluid (2/3 of TBW)
- Extracellular fluid (1/3 of TBW)
  - Interstitial fluid (3/4 of extracellular fluid)
  - Plasma fluid (1/4 of extracellular fluid)
  - Plasma membrane
  - Capillary endothelium

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Moises Dominguez
Body Fluid Compartments

Fig. 25.1 Summary of body fluid regulation, including the major body fluid compartments.
INPUT, OUTPUT

• **Input**: Oral, Enteral, Intravenous

• **Output**: ‘**Sensible**’: that it is easily seen and measured e.g. urine output and loses from the gastrointestinal tract.

• ‘**Insensible**’: not seen and not easy to quantify e.g. sweat, and water vapor in exhaled gases.
<table>
<thead>
<tr>
<th>Fluid Input (intake)</th>
<th>Fluid Output (losses)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source</strong></td>
<td><strong>Volume (L)</strong></td>
</tr>
<tr>
<td>Drinking</td>
<td>1.5</td>
</tr>
<tr>
<td>Food</td>
<td>0.5</td>
</tr>
<tr>
<td>Metabolic</td>
<td>0.5</td>
</tr>
<tr>
<td>Total</td>
<td>2.5</td>
</tr>
</tbody>
</table>

SWEATING ....1H=1L
URINE = Na(90ml) .....K(60-100ML)
The main extracellular electrolyte is Na and the main intracellular electrolyte is K

<table>
<thead>
<tr>
<th>Extracellular Fluid</th>
<th>Intracellular Fluid</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Na</strong>⁺</td>
<td>142 mEq/L</td>
</tr>
<tr>
<td><strong>K</strong>⁺</td>
<td>4 mEq/L</td>
</tr>
<tr>
<td><strong>Ca</strong>²⁺</td>
<td>5 mEq/L</td>
</tr>
<tr>
<td><strong>Mg</strong>²⁺</td>
<td>3 mEq/L</td>
</tr>
<tr>
<td><strong>Cl</strong>⁻</td>
<td>103 mEq/L</td>
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<tr>
<td><strong>HCO₃</strong>⁻</td>
<td>28 mEq/L</td>
</tr>
<tr>
<td>Phosphates</td>
<td>4 mEq/L</td>
</tr>
<tr>
<td><strong>SO₄</strong>²⁻</td>
<td>1 mEq/L</td>
</tr>
<tr>
<td>Osmolality</td>
<td>281 mOsm/L</td>
</tr>
</tbody>
</table>
Osmolarity and Osmolality

- **Osmola(R)ity**: No. of osmoles of solute particles per unit **VOLUME** of solution and has units **osmoles\liter**.

- **Osmola(L)ity**: No. of osmoles of solute particles per unit **WEIGHT** of solvent and has units **osmoles \kilogram**.
Tonicity

• A way of describing the relative solute concentration of two solution which are separated by selectively-permeable membrane (often called a semi-permeable membrane)
• In clinical practice the tonicity ....
• fluid administered IV relative to the tonicity of internal environment of RBCs
Approach to fluid therapy
approach

• Like we said in surgical practice patients who are expected to undergo surgery are kept NPO, so fluid replacement (IV) is necessary.
• Also as you know during surgery the patient is expected to lose some degree of fluid based on the surgery
• So if the patient is kept NPO, there is no input, only output (kidney, skin, lungs, feces), the patient may enter the surgery with a preexisting deficit that will predispose to complications, like?
  • Acute renal failure
  • hypovolemia
Formula

lets keep in mind that NPO will cause fluid and electrolyte deficits not just water loss from the body. Our maintenance fluid therapy has a simple equation; they sometime call it the 4 2 1

As you can see It depends On body weight This is for water.
Formula

• Now like we said we lose water and electrolytes, we managed the water now we need to manage the electrolyte loss by either the type of solution of adding electrolytes to the solution.
• Daily requirements for:
  • Na: 1-2 mEq/Kg BW/day
  • Ka: 1-2 mEq/Kg BW/day
  • CL: 1.5 mEq/Kg BW/day

• Just for knowledge:
  • 1 mmol of sodium or potassium = 1 mEq
  • 2 mmol of Ca+2 = 1 mEq
Let's talk more clinical now

- The most common maintenance fluid is D5 ½ NS with 20 or 40 mEq KCL (because as we said normal saline doesn’t have potassium)
- But usually its 20 mEq because with 40 you have higher risks on the cardiac conducting system
- 20 mEq of potassium = 1500 mg (daily requirement 3.5-4.6 g)
- 5 mEq of sodium = 100 mg (daily requirement of < 2 g)
- So if we have an adult male patients that weighs 70kg, what is the maintenance therapy plan for him? You tell me...
  - = 10x4 + 10x2 + 50x1 = 110 ml/hour x 24 hours = 2640 so roughly 2.5 liters
  - Na = 1.5 mEq x 70 = 105 mEq/day
  - K= 1 x 70 = 70 mEq/day
  - So our choice is D5 ½ NS + KCL
Deficit

• So clinically a patient presenting for surgery after an overnight fast without any fluid intake will have a preexisting deficit which is proportional to the duration of fast.

• So let's say as a definition: it's the fluid that has already been lost, in contrast to replacement which we will talk about in a minute which refers to both the deficit + ongoing losses + future losses.

• Now how can we calculate the deficit??

• Same as maintenance therapy formula, it will give a rough estimate because in reality we have renal conservation so the deficit will be less.
deficit

• When replacing the deficit we give an infusion rate higher than the normal maintenance rate until the deficit is corrected
• Its about 3 to 4 times the maintenance rate
• Once its corrected u go back to the same rate as before

• Now what if the duration of fasting is unknown or it is known but the patient has abnormal fluids losses (sweating, diarrhea, ascites), what will we do?
• We will approximate bases on clinical data (physical exam)
• This is effected by the chronicity of the condition so the longer the worse the deficit
• So we look at signs of hypovolemia......
## Degree of dehydration

<table>
<thead>
<tr>
<th>Clinical signs</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
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</thead>
<tbody>
<tr>
<td>Decrease in body weight</td>
<td>3-5%</td>
<td>5-10%</td>
<td>10-15%</td>
</tr>
<tr>
<td>Skin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turgor</td>
<td>normal</td>
<td>decreased</td>
<td>Markedly decreased</td>
</tr>
<tr>
<td>Color</td>
<td>normal</td>
<td>pale</td>
<td>markedly decreased</td>
</tr>
<tr>
<td>Mucous membranes</td>
<td>Dry</td>
<td></td>
<td>Mottled or gray; parched</td>
</tr>
<tr>
<td>Hemodynamic signs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse</td>
<td>normal</td>
<td>slight increase</td>
<td>tachycardia</td>
</tr>
<tr>
<td>Capillary refill</td>
<td>2-3 s</td>
<td>3-4 s</td>
<td>&gt;4 s</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>normal</td>
<td></td>
<td>low</td>
</tr>
<tr>
<td>Perfusion</td>
<td>normal</td>
<td></td>
<td>circulatory collapse</td>
</tr>
<tr>
<td>Fluid loss</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urinary output</td>
<td>mild oliguria</td>
<td>oliguria</td>
<td>anuria</td>
</tr>
<tr>
<td>Tears</td>
<td>Decreased</td>
<td></td>
<td>absent</td>
</tr>
<tr>
<td>Urinary indices</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific gravity</td>
<td>&gt;1.020</td>
<td></td>
<td>anuria</td>
</tr>
<tr>
<td>Urine [Na+]</td>
<td>&lt;20 mEq/L</td>
<td></td>
<td>anuria</td>
</tr>
</tbody>
</table>
• But as you can see this is not very rational or this is hard and a very rough estimate
• So a more rational approach is to diagnose that we actually have a deficit then just treat based on restoration of vital signs and maintaining a good urine output (.5-1 ml/kg per hour) and correction of base deficit if present
• To achieve this usually the main stay is 1-2 liters of isotonic fluid, 1 liter bolus/hour followed by a continuous infusion and monitoring
• The crystalloid given depends on the particular electrolyte profile
replacement

• Replacement of fluids can be pre or intraoperatively

• When replacing fluids we have to know from which compartment is the fluid lost (blood, GI, thirst space) so we can give the correct type of fluid needed
Blood loss

• Briefly because my college's will talk about blood products
• Most common way to estimate blood loss during surgery is to measure blood in:
  • Suction container
  • Visually (soaked sponges (4x4, 10 ml), soaked lap (100-150ml))
• And even serial hematocrit can be done in long surgeries
• And like we know each ml of blood needs about 3 to 4 ml of crystalloids or 1 ml of colloid
Third space loss

- What is third space?
- It's a space that is neither the intra or extracellular compartments
- Like?
- In ascites bowel lumen

Thirst space loss or third spacing??

When too much fluid from the intravascular space moves into the interstitial or third space (non functional areas) that causes serious problems; hypotension, reduced CO, edema
Third space

• The estimation of fluid loss is very hard here, if we have ascites we can do aspiration or maybe nasogastric tube in ileus mthln

• Example:
  • 70 kg patient with ileus, lost 2l of fluid in a nasogastric aspirate, aspirate has 240 mEq of sodium and 20 mEq of potassium

• What is the replacement therapy and what type of fluid would u use?

• Lets take it step by step
• We start by the maintenance which like we calculated is approximately 2.5 L
• We add these to the 2 liters he lost so now we need 4.5 L
• Now the sodium like we said in maintenance 105 mEq add the 240 lost so we need 345 mEq
• Potassium lost is 20 so also add 105 we need 125 mEq of potassium
• So we can start with 2 bags of normal saline (has about 300 mEq of sodium)
• Then 1 liter of ¼ NS about 39 mEq of sodium
• And add 1 liter of D5 with 120 kcl (6 bags each 20 mEq)
Intra-op thirdspacing

- Intra op its highly dependent on type of surgery and size of incision!
- Usually replaced by lactated ringer solution
- Small excision: 1-3 ml/kg/hour (like hernia)
- Medium excision: 3-7 ml/kg/hour (uncomplicated sigmoidectomy)
- Large incisions: 9-11 ml/kg/hour (pancreatoduodenectomy)
## GI loss

<table>
<thead>
<tr>
<th></th>
<th>Volume</th>
<th>Na⁺</th>
<th>K⁺</th>
<th>Cl⁻</th>
<th>HCO₃⁻</th>
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<tbody>
<tr>
<td>Plasma</td>
<td>−</td>
<td>140</td>
<td>5</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>Gastric secretions</td>
<td>2500</td>
<td>50</td>
<td>10</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Intestinal fluid (upper)</td>
<td>3000</td>
<td>140</td>
<td>10</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>Bile and pancreatic secretions</td>
<td>1500</td>
<td>140</td>
<td>5</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>Mature ileostomy</td>
<td>500</td>
<td>50</td>
<td>5</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Diarrhoea (inflammatory)</td>
<td>−</td>
<td>110</td>
<td>40</td>
<td>100</td>
<td>40</td>
</tr>
</tbody>
</table>

*If gastrointestinal loss continues for more than 2–3 days, samples of fluid and urine should be collected regularly and sent to the laboratory for measurement of electrolyte content.*
Intra op replacement

• A few words only:
• Blood loss we replace with crystalloids or colloids to maintain intravascular volume
• Now if the danger of anemia outweighs the risk of transfusion, at this point further blood loss is replaced with transfusion of rbc's to maintain hemoglobin
• And like we explained before depending of type of surgery and wound and so on we replaced fluids lost during surgery
A brief note

• There is something called Allowable Blood Loss:
• Which is the amount of blood lost that doesn’t need resuscitation
• Which can be calculated by $\text{EBV} \times (\text{Hi-Hf})/\text{Hi}$
• Estimated blood volume (75ml/kg in males, 65ml/kg females)
• Initial hemoglobin
• Final hemoglobin
INTRAVENOUS FLUIDS
Types of IV fluids

- Crystalloids
- colloids
Crystalloids are aqueous solutions of low molecular weight ions, with or without glucose. That are often considered as the initial resuscitation fluid in patients with hemorrhagic and septic shock, in burn patients, in patients with head injury (to maintain cerebral perfusion pressure), and in patients undergoing plasmapheresis and hepatic resection.

Solutions are chosen according to the type of fluid loss being replaced:

- For losses primarily involving water, replacement is hypotonic solutions also known as maintenance type solutions like: Dextrose solution 5%
- If losses involve both water and electrolytes replacement is with isotonic electrolytes solutions or replacement type solutions like: ringer’s lactate
Examples of crystalloid solutions are:

- Normal saline
- Dextrose solution 5%
- lactated Ringer’s solution
- others
<table>
<thead>
<tr>
<th>Solution</th>
<th>Glucose (g/L)</th>
<th>Na⁺</th>
<th>K⁺</th>
<th>Ca²⁺</th>
<th>Cl⁻</th>
<th>Lactate</th>
<th>PO₄³⁻</th>
<th>Mg²⁺</th>
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<tbody>
<tr>
<td>5% Dextrose (D₅W)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>10% Dextrose (D₁₀W)</td>
<td>100</td>
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<tr>
<td>Normal Saline (NS)</td>
<td>0</td>
<td>154</td>
<td>0</td>
<td>0</td>
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<tr>
<td>D₅NS</td>
<td>50</td>
<td>154</td>
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<td>0</td>
<td>154</td>
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<tr>
<td>D₅¹/₂NS</td>
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<td>0</td>
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<td>0</td>
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<tr>
<td>0.2% NS</td>
<td>0</td>
<td>31</td>
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<td>0</td>
<td>31</td>
<td>0</td>
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<tr>
<td>3% NaCl</td>
<td>0</td>
<td>513</td>
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<td>0</td>
<td>513</td>
<td>0</td>
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<tr>
<td>Ringer's Lactate (LR)</td>
<td>0</td>
<td>130</td>
<td>4</td>
<td>3</td>
<td>109</td>
<td>28</td>
<td>0</td>
<td>0</td>
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<tr>
<td>D₅LR</td>
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<td>3</td>
<td>109</td>
<td>28</td>
<td>0</td>
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</tr>
</tbody>
</table>
Normal saline or sodium chloride 0.9%

is a mixture of sodium chloride in water that is slightly hypertonic and contains more chloride than ECF, when given in large volumes, it produces hyperchloremic metabolic acidosis because of its high chloride content and lack of bicarbonate.

In addition, chloride-rich crystalloids such as normal saline may contribute to perioperative acute kidney injury. Therefore, we prefer balanced salt solutions for most intraoperative uses.

Normal saline is the preferred solution for

1. hypochloremic metabolic alkalosis
2. diluting packed red blood cells prior to transfusion (because of calcium and lactate in ringers lactate it’s prohibited)
Five percent dextrose in water (D5W)

It is a hypotonic, isosmotic solution that doesn’t contain electrolytes.

Dextrose solution is equivalent to administering water that’s why:
1. It is used for replacement of pure water deficits.
2. As a maintenance fluid for patients on sodium restriction (hypernatremia).
3. It prevents the catabolic state (hypoglycemia and ketosis) that follows prolonged fasting.

***More concentrated dextrose solutions (10%, 20% and 50%) are available but their use is limited to the management of diabetic patients and patients of hypoglycemia.***
lactated Ringer’s solution

• Ringer's lactate solution or (Hartmann's solution), is a mixture of sodium chloride, sodium lactate, potassium chloride, and calcium chloride in water

• Uses of ringer lactate
  1. It is used for replacing fluids and electrolytes in those who have low blood volume or low blood pressure.
  2. It may also be used to treat metabolic acidosis in cases other than those caused by lactic acidosis
  3. And to wash the eye following a chemical burn
Other types of solutions:

• **Plasmalyte**: is a family of balanced crystalloid solutions with multiple different formulations available.
  - It closely mimics human plasma in content of electrolytes, osmolality and pH that’s why it is a replacement type solution.

• **Hypertonic 3% saline** is employed in therapy of severe symptomatic hyponatremia.
colloids

Are those containing high mw substances that exert an oncotic pressure
indications for colloids include

1. fluid resuscitation in patients with severe intravascular fluid deficits (eg, hemorrhagic shock) prior to the arrival of blood for transfusion

2. fluid resuscitation in the presence of severe hypoalbuminemia or conditions associated with large protein losses such as burns.

(Replacing an intravascular volume deficit with crystalloids generally requires three to four times the volume needed when using colloids, this justifies their indication for the use where more than 3_4 liters of crystalloid solution has been injected)
The 2 categories of colloids are

1. Natural (human albumin)
2. Artificial (gelatins, dextrans and hydroxyethyl starches)
• **Albumin** :
  • Half life = 1.6 hours in plasma
  • Stays in intravascular space
  • 5% solution isotonic, 10% and 25% hypertonic
  • Expands volume 5x in 30 minutes and its effect lasts 1-2 days
    Side effects:
    1. Volume overload
    2. Fever ?? Pyrogens in albumin
    3. Defects in hemostasis
• Synthetic colloids include gelatins and dextrose starches

• **Dextran**
• High molecular weight polysaccharide (40000 >coagulation effect than dextran 70000 )
• 10% solution in NS or D5W
• SE: anaphylaxis, coagulopathy ,renal failure
• is used as a volume expander but also reduces blood viscosity, von Willebrand factor antigen, platelet adhesion, and red blood cell aggregation ,that’s why it is used by microsurgeons to improve microcirculatory flow and decrease risk of microthrombus formation
• hydroxyethyl starch (the best colloid)

• is highly effective as a plasma expander and is less expensive than albumin. Allergic reactions are rare, but anaphylactic reactions have been reported.

• Hetastarch can decrease von Willebrand factor antigen levels, may prolong the prothrombin time, and has been associated with hemorrhagic complications. It is potentially nephrotoxic.
• Differences between colloids and crystalloids
  1. Colloids are more expensive than crystalloids
  2. Colloids have higher molecular weight
  3. Half life of crystalloids is between 15 to 20 minutes while colloids last 2-3hrs
  4. Colloids act as plasma expanders
Blood transfusion
Blood transfusion is an important part of day-to-day clinical practice. Blood and blood products provide unique and life-saving therapeutic benefits to patients. However, due to resource constraints, it is not always possible for the blood product to reach the patient at the right time. The major concern from the point of view of both user (recipient) and prescriber (clinician) is for safe, effective and quality blood to be available when required.
Bedside clinicians and medical interns are in the forefront of patient management. They are responsible for:

1. completing blood request forms,
2. administering blood,
3. monitoring transfusions
4. being vigilant for the signs and symptoms of adverse reactions
Principles of clinical transfusion practice

1. The patient with acute blood loss should receive effective resuscitation (intravenous replacement fluids, oxygen and other medication) immediately and the need for transfusion is estimated thereafter.

2. The patient’s hemoglobin (Hb) value, although important, should not be the sole deciding factor in the decision to transfuse blood. This decision should be supported by the need to relieve clinical signs and symptoms and to prevent significant morbidity or mortality.

3. Clinicians should be aware of the risk of transfusion transmissible infections in blood products prescribed for patients.

4. Transfusion should be prescribed only when the benefits to the patient are likely to outweigh the risks.

5. Clinicians should clearly record the reason for ordering a transfusion (clinical diagnosis).

6. Trained staff should monitor a patient undergoing transfusion and respond immediately there are signs of an adverse effect.
* Transfusion of blood and products should be undertaken only to treat a condition that would lead to significant morbidity or mortality and that cannot be prevented or managed effectively by other means
Blood components

A blood component is a constituent of blood, separated from whole blood, such as:

1. Red cell
2. Plasma
3. Platelet
4. Cryoprecipitate, prepared from fresh frozen plasma; rich in Factor VIII and fibrinogen

A plasma derivative is made from human plasma proteins prepared under pharmaceutical manufacturing conditions, such as: 1. Albumin 2. Coagulation factor concentrates 3. Immunoglobulin
Clinical Transfusion Procedure

- **Indications for blood transfusion**
  - 1. To increase the oxygen capacity of blood by giving red cells.
  - 2. To restore the blood volume to maintain effective tissue perfusion.
  - 3. To replace platelets, coagulation factors and other plasma proteins.

- **Blood may be needed in the following circumstances:**
  - 1. Blood loss:  – Bleeding – Trauma
  - 2. Inadequate production:  – Diseases such as thalassemia, leukaemia
  - 3. Excessive destruction of cells:  – Disease  – Mechanical
Whole blood

• Whole blood is no longer commonly available or used

• **Infection risk:** Capable of transmitting an agent present in cells or plasma which was undetected during routine screening for TTIs, i.e. HIV, hepatitis B & C, syphilis and malaria.

• **Storage:** Between +2°C and +6°C in an approved blood bank refrigerator, fitted with a temperature monitor and alarm.

• **Indications:** 1. Red cell replacement in acute blood loss with hypovolaemia. 2. Exchange transfusion.

• **Contraindications:** Risk of volume overload in patients with: 1. Chronic anemia. 2. Incipient cardiac failure.
Red cell concentrates [packed red blood cells (PRBC)]

• Packed red blood cells (PRBCs) are made from a unit of whole blood by centrifugation and removal of most of the plasma, leaving a unit with a hematocrit of about 60%. One PRBC unit will raise the hematocrit of a standard adult patient by 3%.

• Infection risk: Same as for whole blood. Indications: Replacement of red cells in anaemic patients
Platelet

• A single platelet unit is derived from one whole blood unit collected. Platelets are stored at room temperature and CANNOT be frozen. They must be used in 5 days. Pooled platelets from multiple donors from whole blood collections are cheaper to produce.

• **Infection risk:** Bacterial contamination affects about 1% of pooled units.

• **Indications:** Treatment of bleeding due to: 1. Thrombocytopenia. 2. Platelet function defects. 3. Prevention of bleeding due to thrombocytopenia as in bone marrow failure.

• **Contraindications:** 1. Idiopathic autoimmune thrombocytopenic purpura (ITP)(due to their rapid destruction by the underlying auto-immune process). 2. Thrombotic thrombocytopenic purpura (TTP)(associated with arterial thrombi, acute myocardial infarction and in-hospital mortality and exacerbation ttp ). 3. Untreated DIC. 4. Thrombocytopenia associated with septicaemia, or in cases of hypersplenism.
Fresh frozen plasma

- **FFP** is plasma prepared from whole blood, either from the primary centrifugation of whole blood into red cells and plasma or from a secondary centrifugation of platelet rich plasma. The plasma is rapidly frozen to −25°C or colder within 8 hours of collection and contains normal plasma levels of stable clotting factors, albumin, immunoglobulin and Factor VIII.

- **Infection risk:** Capable of transmitting any agent present in cells or plasma which was undetected by routine screening TTIs, including HIV, hepatitis B and C, syphilis and malaria.

- **Storage:** FFP is stored at −25°C or colder for up to 1 year. Before use, it should be thawed in the blood transfusion centre between +30°C and +37°C.
Indication Of FFP transfusion

- **Definite indications:**
  1. Replacement of a single coagulation factor deficiency, where a specific or combined factor concentrate is unavailable or contraindicated.
  2. Immediate reversal of warfarin effect where prothrombin complex concentrate is unavailable.
  3. Thrombotic thrombocytopenic purpura.
  4. Inherited coagulation inhibitor deficiencies where specific concentrate is unavailable.
  5. C1 esterase inhibitor deficiency where specific concentrate is unavailable.

- **Conditional indications:**
  1. Acute DIC if there are coagulation abnormalities and patient is bleeding.
  2. Liver disease, with abnormal coagulation and bleeding
  3. Cardiopulmonary bypass surgery – use in the presence of bleeding but where abnormal coagulation is not due to heparin. Routine perioperative use is not indicated.
  4. Severe sepsis, particularly in neonates (independent of DIC).
  5. Plasmapheresis.
  6. Massive blood transfusion
Cryoprecipitated anti-haemophilic factor (Cryo-AHF)

• **Cryoprecipitate (cryo)** contains a concentrated subset of FFP components including fibrinogen, factor VIII coagulant, vonWillebrand factor, and factor XIII.

• **Infection risk:** As for plasma

• **Storage:** At –25°C or colder for up to 1 year.

**Indications:** As an alternative to Factor VIII concentrate in the treatment of inherited deficiencies of:

• 1. von Willebrand Factor (von Willebrand’s disease).

• 2. Factor VIII (haemophilia A).

• 3. As a source of fibrinogen in acquired coagulopathies; e.g. DIC

• 4. Can be used in isolated Factor XIII deficiency.
Monitoring the transfusion

- It is essential to take baseline observations and to ensure that the patient is monitored during the transfusion in order to detect any adverse event as early as possible.

- Before commencing the transfusion, it is essential to encourage the patient to notify a nurse or doctor immediately if he or she becomes aware of any discomfort such as shivering, flushing, pain or shortness of breath or begins to feel anxious.

- Ensure that the patient is in a setting where he or she can be directly observed.

- For each unit of blood transfused, monitor the patient: - Before starting the transfusion (baseline observation).
  - 15 minutes after starting the transfusion.
  - At least every hour during transfusion.
  - Carry out a final set of observations 15 minutes after each unit has been transfused.
Documentation of the transfusion

- **Monitor the patient before, during and on completion of the transfusion.**
- At each of these stages, record the following information on the patient’s chart:
  - Patient’s general appearance.
  - Temperature.
  - Pulse.
  - Blood pressure.
  - Respiratory rate.

- **Make note of the following:**
  - Time the transfusion started.
  - Time the transfusion was completed.
  - Volume and type of blood products transfused.
  - Unique donation number of all products transfused.
  - Any adverse effect.

- **Identify and respond immediately to any adverse effect, by stopping the transfusion**
• Severe reactions most commonly present during the first 15 minutes of a transfusion. All patients and in particular, unconscious patients should be monitored during this period and for the first 15 minutes of each subsequent unit.
Transfusion reaction

- Acute TR (<24 hours)
- Delayed TR (>24 hours)
Complications of Blood Transfusion
Complications of Blood Transfusion

IMMUNE COMPLICATIONS
- HEMOLYTIC REACTIONS
  - ACUTE
  - DELAYED
- NON HEMOLYTIC IMMUNE REACTIONS

INFECTIONOUS COMPLICATIONS
- VIRAL INFECTIONS
- BACTERIAL INFECTIONS
- PARASITIC INFECTIONS
• The most common complications of transfusion are febrile nonhemolytic.
• The most serious complications are acute hemolytic reaction due to ABO incompatible transfusion and transfusion-related acute lung injury, which have very high mortality rates.
1. Hemolytic Reactions

Hemolytic reactions usually involve specific destruction of the transfused red cells by the recipient’s antibodies. Less commonly, hemolysis of a recipient’s red cells occurs as a result of transfusion of red cell antibodies. Incompatible units of platelet concentrates, FFP, clotting factor concentrates, or cryoprecipitate may contain small amounts of plasma with anti-A or anti-B (or both) alloantibodies. Transfusions of large volumes of such units can lead to intravascular hemolysis.

Hemolytic reactions are commonly classified as either acute (intravascular) or delayed (extravascular).
Acute Hemolytic Reactions

The most common cause is misidentification of a patient, blood specimen, or transfusion unit, a risk that is not abolished with autologous blood transfusion. In anesthetized patients, an acute hemolytic reaction may be manifested by 1. a rise in temperature 2. unexplained tachycardia 3. hypotension 4. hemoglobinuria 5. diffuse oozing in the surgical field, or a combination of these findings. DIC, shock, and kidney acute failure can develop rapidly. The severity of a reaction often depends upon the volume of incompatible blood that has been administered.
Management of hemolytic reactions can be summarized as follows:

1. If a hemolytic reaction is suspected, the transfusion should be stopped immediately and the blood bank should be notified.
2. The unit should be rechecked against the blood slip and the patient’s identity bracelet.
3. Blood should be drawn to identify hemoglobin in plasma, to repeat compatibility testing, and to obtain coagulation studies and a platelet count.
4. A urinary bladder catheter should be inserted, and the urine should be checked for hemoglobin.
5. Forced diuresis should be initiated with mannitol and intravenous fluids, and with a loop diuretic if necessary.
Delayed Hemolytic Reactions

also called extravascular hemolysis—is generally mild and is caused by antibodies to non-D antigens of the Rh system or to foreign alleles in other systems such as the Kell, Duffy, or Kidd antigens.

By the time significant amounts of these antibodies have formed (weeks to months), the transfused red cells have been cleared from the circulation. Moreover, the titer of these antibodies subsequently decreases and may become undetectable.

Reexposure to the same foreign antigen during a subsequent red cell transfusion, however, triggers an anamnestic antibody response against the foreign antigen. The hemolytic reaction is therefore typically delayed 2 to 21 days after transfusion, and symptoms are generally mild, consisting of malaise, jaundice, and fever. The patient’s hematocrit typically fails to rise, or rises only transiently, in spite of the transfusion and the absence of bleeding. The serum unconjugated bilirubin increases as a result of hemoglobin breakdown.
2. Nonhemolytic Immune Reactions

1. Febrile Reactions
2. Urticarial Reactions
3. Anaphylactic Reactions
4. Transfusion-Related Acute Lung Injury
5. Transfusion-Associated Circulatory Overload
6. Graft-Versus-Host Disease
7. Post-Transfusion Purpura
8. Transfusion-Related Immunomodulation
Febrile Reactions

White cell or platelet sensitization is typically manifested as a febrile reaction. Such reactions are relatively common (1–3% of transfusion episodes) and are characterized by an increase in temperature without evidence of hemolysis. Patients with a history of repeated febrile reactions should receive leukoreduced transfusions only.
Urticarial Reactions

Urticarial reactions are usually characterized by erythema, hives, and itching without fever. They are relatively common (1% of transfusions) and are thought to be due to sensitization of the patient to transfused plasma proteins. Urticarial reactions can be treated with antihistaminic drugs (H1 and perhaps H2 blockers) and steroids.
Anaphylactic Reactions

Anaphylactic reactions are rare. These severe reactions may occur after only a few milliliters of blood has been given, typically in IgA-deficient patients with anti-IgA antibodies who receive IgA containing blood transfusions. Such reactions require treatment with epinephrine, fluids, corticosteroids, and H1 and H2 blockers.

Patients with IgA deficiency should receive thoroughly washed packed red cells, deglycerolized frozen red cells, or IgA-free blood units.
Transfusion-Related Acute Lung Injury

It presents as acute hypoxia and noncardiac pulmonary edema occurring within 6 h of blood product transfusion. It occur with transfusion of any blood component, but especially platelets and FFP. Treatment is similar to that for acute respiratory distress syndrome, with the important difference that TRALI may resolve within a few days with supportive therapy.

The incidence of TRALI, until recently the leading cause of transfusion-related death, has markedly declined with the recognition that the presence of HLA antibodies in donor plasma is the principal TRALI risk factor.
Transfusion-Associated Circulatory Overload

Transfusion-associated circulatory overload (TACO) occurs when blood products are administered at a rate greater than the patient’s cardiac output, usually in a massive haemorrhage resuscitation scenario. This is most likely to occur when the provider administering blood products has not recognized that the source of bleeding has been successfully controlled.

TACO has replaced TRALI as the leading transfusion-related risk for trauma patients.
Post-Transfusion Purpura

It is a potentially fatal thrombocytopenic disorder that occurs, rarely, following blood or platelet transfusion. It results from development of platelet alloantibodies that destroy the patient’s own platelets.

The platelet count typically drops precipitously 5 to 10 days following transfusion.

Treatment may include intravenous IgG and plasmapheresis.
1. Viral Infections

A. Hepatitis (B&C)
Most acute cases are anicteric. **Hepatitis C is the more serious infection;** most cases progress to **chronic hepatitis,** with **cirrhosis** developing in 20% of chronic carriers and **hepatocellular carcinoma** developing in up to 5% of chronic carriers.

B. Acquired Immunodeficiency Syndrome (AIDS)
All blood is tested for the presence of anti-HIV-1 and anti-HIV-2 antibodies. The requirement for donor blood testing by the U.S. Food and Drug Administration (FDA) has decreased the risk of transfusion-transmitted HIV.
MASSIVE BLOOD TRANSFUSION

It is most often defined as the need to transfuse the patient’s total estimated blood volume in less than 24 h, or one-half the patient’s total estimated blood volume in 1 h. For most adult patients, the total estimated blood volume is the equivalent of 10 to 20 units. The approach to massive transfusion (and to lesser degrees of transfusion) elucidates that the outcomes have improved with concurrent transfusion of packed red cells, FFP, and platelets to avoid dilutional coagulopathy.
1. Coagulopathy

The most common cause of nonsurgical bleeding following massive blood transfusion is dilutional thrombocytopenia, which is caused by platelet loss out of the body and platelet dilution with replaced red cells and crystalloids.

This thrombocytopenia is transient and the platelet count will usually return to normal once the patient's circulation equilibrates. Although clinically significant dilution of coagulation factors may also occur.
2. Citrate Toxicity

Calcium binding by the citrate preservative can rise in importance following transfusion of large volumes of blood or blood products. Clinically important hypocalcemia, causing cardiac depression, will not occur in most normal patients unless the transfusion rate exceeds 1 unit every 5 min, and intravenous calcium salts should rarely be required in the absence of measured hypocalcemia.

Because citrate metabolism is primarily hepatic, patients with hepatic disease or dysfunction (and possibly hypothermic patients) may demonstrate hypocalcemia and require calcium infusion during massive transfusion, as may small children and others with relatively impaired parathyroid–vitamin D function.
3. Hypothermia

Massive blood transfusion is an absolute indication for warming all blood products and intravenous fluids to normal body temperature. Ventricular arrhythmias progressing to fibrillation often occur at temperatures close to 30°C, and hypothermia will hamper cardiac resuscitation. The customary use of rapid infusion devices with efficient heat transfer capability has decreased the incidence of transfusion-related hypothermia.
4. Acid–Base Balance

Although stored blood is acidic due to the citric acid anticoagulant and accumulation of red cell metabolites (carbon dioxide and lactic acid), metabolic acidosis due to transfusion is uncommon because citric acid and lactic acid are rapidly metabolized to bicarbonate by the normal liver. However, in the situation of massive blood transfusion, acid–base status is largely dependent upon tissue perfusion, rate of blood transfusion, and citrate metabolism.
5. Serum Potassium Concentration

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