Reviewed By
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7- Intravenous Fluid Resuscitation & Blood Transfusion

Objectives

- To estimate the perioperative fluid requirement and to prescribe /calculate fluid therapy.
- Identify perioperative factors affect the patient fluid requirements
- To detect the common conditions associated with preoperative fluids deficit
- To assess a patient with a volume deficit
- -Describe different fluids components and illustrate the advantages and disadvantages of each type.
- Recognize the different types of blood and blood products and to discuss the indications of each type and complications.

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Editing file

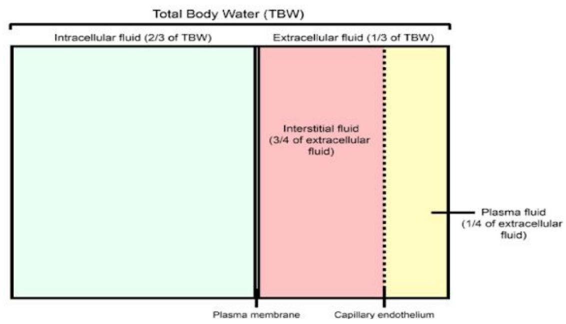
Case discussion

Physiology

●Total body water (TBW)

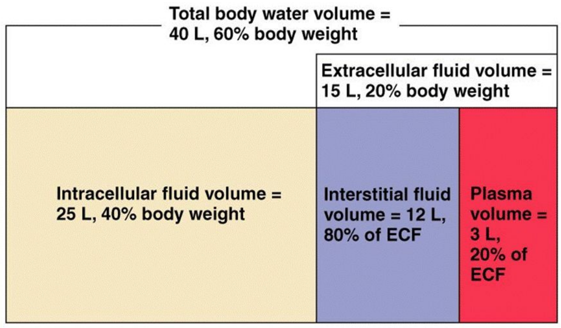
It varies with age and gender.
The 70 kg (standard male) contains 42L
- **60%** body weight in males
- 50% body weight in females
- **80%** body weight in **newborn**

Less in obese: fat contains little water.



●Body water compartments [1-2]

Intracellular water: 2/3 of TBW
Extracellular water: 1/3 of TBW
- Extravascular water: ¾ of extracellular water
- Intravascular water: ¼ of extracellular water



●Electrolyte physiology

Primary ECF cation is **Na**
- Very small contribution of K, Ca^{+2} , & Mg^{+2}

Primary ICF cation is **K** (controlled by cell membrane Na/K ATPase pump and the water by simple diffusion)
- Smaller Contribution from Mg^{+2} & Na

Fluid & electrolyte regulation:

Volume regulation	Plasma osmolality regulation [3]	Sodium concentration regulation
Volume sensors	**Osmotic sensors** (Osmolality indicates the concentration of all the particles dissolved in body fluid.)	
• Antidiuretic hormone • Renin-angiotensin-Aldosterone system • Baroreceptors in carotid arteries & aorta • Stretch receptors in atrium & juxtaglomerular apparatus • Cortisol stress hormone	• Arginine-vasopressin (ADH) • Central and peripheral osmoreceptors	•Renin-angiotensin/aldosterone system • Macula Densa of JG apparatus

The aim of maintenance of fluid, electrolytes, acid-base balance & blood volume:
The final goal is the **delivery of adequate oxygen to the tissues**

Factors affecting oxygen delivery equation includes:

- Cardiac output (= stroke volume × heart rate)[1];
- Haemoglobin concentration;
- Oxygen saturation

Desirable outcome of fluid resuscitation:
(Avoid overhydration/ overfluid)

- No peripheral edema or pulmonary edema.
- No ARDS

1- Also by preload, afterload and contractility. Stroke volume : amount of blood ejected by LV each beat.
2- Water moves through cells by osmotic pressure passively, normal electrolyte balance is important for normal myocardial, neurological function and acid-base balance and eventually normal O2 delivery to tissues
- **Doctor started with a 2 scenarios:**
1) 25 y/o patient comes to the ER with acute appendicitis, they called the surgical team for assessment and they decided that he needed an appendectomy. He has a 2 day history of nausea, vomiting and can't tolerate oral intake. In ER he is febrile with tachycardia and hypotension.
- Does he need blood or fluids? Fluids.

2) A patient involved in RTA, had severe splenic rupture, liver laceration and severe bleeding, he lost more than 20% of his total blood volume and had tachycardia and hypotension.
- Does he need blood or fluids? We will start with fluids and then for sure he will need blood.

Assessment of Fluid Status

- Input and output chart.
- blood pressure: supine and standing.
- heart rate (increases to compensate)
- skin turgor (more dry) and capillary refill.
- urinary output.
- serum electrolytes/osmolarity. (especially if there is vomiting and diarrhea)
- mental status. (affected with dehydration)
- Non/Minimal invasive monitors: arterial line wave and measurement of SVV,CI, TTE or TEE, Massimo measurement of PVI.
- Invasive monitors: CVP (normal 4-8 mmHg), pulmonary artery catheter.

Perioperative Fluid Requirements

The following factors must be taken into account:

1. Maintenance fluid requirements.
2. NPO and other deficits e.g NG suction.
3. Third space losses.
4. Replacement of blood loss.
5. Special additional losses: **Nausea, Vomiting**, diarrhea.

1. Maintenance Fluid Requirements:

- **Insensible losses** such as evaporation of water from the respiratory tract, sweat, feces, urinary excretion occur continually.
- How to calculate? by "4-2-1 Rule"[1]
  - 4 ml/kg/hr for the first 10 kg of body weight.
  - 2 ml/kg/hr for the second 10 kg of body weight.
  - 1 ml/kg/hr for subsequent body weight.
  - Extra fluid for fever, tracheotomy, denuded surfaces.

2. NPO and other deficits:

- NPO deficit is aka fasting deficit. It's only given to those who didn't receive the maintenance fluid
- NPO deficit = number of hours NPO x maintenance fluid requirements .[2]
- NPO = Ringer's lactate
- Bowel prep may result in up to 1 L fluid loss.
- Measurable fluid losses e.g. NG suctioning, vomiting, ostomy output, biliary fistula & tube.

3. Third place losses:

- **Isotonic transfer of ECF from functional body (intravascular) fluid compartments to non-functional (interstitial) compartments (fluid leakage)**
- Depends on:
  - Location, duration and type of surgical procedure.[3]
  - Amount of tissue trauma.
  - Ambient temperature.
  - Room ventilation.
- **Replacing third space losses:**
  - Superficial surgical trauma: 1-2 ml/kg/hr, eg. laparoscopy and hands surgeries
  - **Minimal surgical trauma: 3-4 ml/kg/hr :** Head & neck, **hernia**, knee surgery.
  - Moderate surgical trauma: 5-6 ml/kg/hr : **Hysterectomy**, chest surgery.
  - Severe surgical trauma: 8-10 ml/kg/hr (or more) : Abdominal Aortic. Aneurysm(**AAA**) repair, open nephrectomy.

1- For example pt 70 kg > first hour 10 x 4 = 40 > second hour 10 x 2 = 20 > we have 50 kg left so 50 x 1 = 50 > total = 110 ml/hr.
2- Continue on example (if the Pt is on NPO for 10 hours) then 10 x 110 = 1100 ml.
3- In open procedures we need more fluid replacement than in closed procedures.

Perioperative Fluid Requirements

4. Blood loss:[1]

- **Each 1 cc of blood loss is replaced by 3 cc of crystalloid solution** (the crystalloid solutions leave the intravascular space). Whereas, each 1 cc blood loss is replaced by 1 cc of **colloid** solution[2].
- When using blood products or colloids replace blood loss volume per volume

5. Other additional losses:

- Ongoing fluid losses from other sites: Gastric drainage, Ostomy output, Diarrhea.
- Replace **volume per volume** with crystalloid solutions.

Example: 62 y/o male, 70 kg, for laparotomy bowel resection (**hemicolectomy**), NPO after 22:00, surgery at 8:00, 3 hours procedure, 500 cc blood loss., What are his estimated intraoperative fluid requirements?

- Maintenance: 110 x 3h = 330 ml
- Fluid deficit (NPO): 110 x 10h = 1100 ml+1000 ml for bowel prep = 2100 ml total deficit (replace ½ first h, ¼ 2nd hour, ¼ 3rd hour).
- **Third space losses:** 6 ml/kg/hr x (70) x 3 hrs = 1260 ml.
- Blood loss: 500 ml x 3 = 1500 ml.
- Total = 330 + 2100 + 1260 + 1500 = 5190 ml

Intravenous fluids

01 Conventional crystalloids

02 Colloids

03 Hypertonic Solutions

04 Blood/blood products & blood substitutes

Crystalloids: Combination of water & electrolytes.

Crystalloids[4]
Half life 20-30 min intravascularly

Hypotonic salt solution
- Electrolyte composition is lower than that of plasma.
- Examples: D5 half normal saline, D5W (water & dextrose).

Isotonic salt solution
- Electrolyte composition & osmolality is similar to plasma.
- **Examples**: normal saline. (balanced salt solution), lactated Ringer's, plasmalyte, Normosol.

Hypertonic salt solution
- 2.7% NaCl.
- Electrolyte composition is higher than the plasma.

1- Not every blood loss in surgery is replaced by blood, to some extent it can be replaced by fluids. Here we are talking about when we can't replace blood loss with fluid.
2- Because colloids do not leave the intravascular space and thus they are given to patients with severe hypotension to enhance the perfusion.

Intravenous fluids

Crystalloids:

	Composition	Osmolarity	Disadvantages
Normal saline (0.9% NaCl)	Isotonic 0.9%: 9g/L, Na 154, Cl 154	304 mosmol/l nearly similar to plasma	Hyperchloremic acidosis Metabolic acidosis[5]
Lactated ringer [1] Most physiological solution	Na 130, Cl 109, K 4, Ca 3, Lactate 28 [2]	- 273 mosmol/l nearly similar to plasma. - Sydney Ringer 1880 - Hartmann added lactate = LR - Minor advantage over NaCl, both are similar.	- Not to be used as diluent for blood (Ca citrate [3]). - Low osmolarity, may lead to high ICP[4]. - Caution in kidney failure, in brain injury, high blood sugar [2]
Dextrose 5% water (D5W)	50 g/l dextrose & water	253 (hypotonic, low)	- Enhances CO_2 production. - Enhances lactate production. - **Aggravate ischemic brain injury** [6] (C/I in pts with head injury)

Advantages of Crystalloids in trauma

- Balanced electrolyte solutions.
- Buffering capacity (Lactate).
- Easy to administer.
- No risk of adverse reactions, **no anaphylactic effect.**
- No disturbance of hemostasis.
- Promote diuresis.
- Inexpensive.

Hypertonic saline:

- Fluids containing sodium concentrations **greater** than normal saline.
- Available in 1.8 %, 2.7%, 3%, 5%, 7.5%, 10% solutions.
- **Hyperosmolarity** creates a gradient that draws water out of cells; therefore, cellular dehydration is a potential problem. [5]

Advantages

- Small volume for resuscitation.
- Osmotic effect.
- Inotropic effect (increase calcium influx in sarcolemma).
- Increase MAP, CO.
- Increase renal, mesenteric, splanchnic, coronary blood flow.

Disadvantages

- Increase hemorrhage from open vessels.
- Hypernatremia.
- Hyperchloremia.
- Metabolic acidosis.

1- LR is preferred in resuscitation unless there is contraindication, also known as Hartman solution. It has lower risk of hyperchloremic acidosis due to lower Cl concentration.
2- Lactate is converted to sugar in the liver which lead to increase blood sugar. However, it can be used for diabetic pts with controlled HbA1c
3- Risk of clot formation.
4- Example in head injury > we use normal saline.
5- Not used in fluid resuscitation, we use it in electrolytes balance.

Intravenous fluids

Colloids:[7]

- Fluids containing molecules sufficiently large enough to prevent transfer across capillary membranes.
- Solutions stay in the space into which they are infused (remain intra-vascular).
- Examples: hetastarch (Hespan), **albumin**, dextran.

	Osmolality	Na	Cl	K
D5W	253	0	0	0
0.9 NS	308	154	154	0
LR	273	130	109	4.0
Plasma-lyte	294	140	98	5.0
Hespan	310	154	154	0
5% Albumin	308	145	145	0
3% Saline	1027	513	513	0

Advantages

- Prolonged plasma volume support.[1]
- Moderate volume needed.
- Minimal risk of tissue edema.
- Enhances microvascular flow.

Disadvantages

- Risk of volume overload.
- Adverse effect on hemostasis.
- Adverse effect on renal function.
- Anaphylactic reaction[8].
- Expensive.
- Coagulopathy.

Colloids examples

Gelatins [2]	Albumin [2]
Derived from hydrolyzed bovine collagen. Metabolized by serum collagenase. 0.5-5 hrs. **Disadvantages**: • Histamine release "very rare" (H1 blockers recommended) • Decrease Von W factor (VWF) and cause bleeding • Bovine spongiform encephalopathy, 1:1000.000	Heat treated preparation of human serum. -**Diluted albumin : 5% (50 g/l) is used for volume expansion**, half of infused volume will stay intravascular used in volume resuscitation -**Concentrated albumin : 25% (250 g/l) used only in case of hypoalbuminemia**, given by infusion -20% (200 g/l) -Half life **20 h** intravascularly **Disadvantages**: • Cardiac decompensation after rapid infusion of 20-25% albumin. • Decreased ionized Ca^{+2}.[3] • Impaired Na+/water excretion from renal dysfunction[4]
Hetastarch (Hespan) [4]	**Pentastarch**
Synthetic, 6% preparation in isotonic saline MW 240,000D, dose 20 ml/kg/day. Disadvantages: • Hyperamylasemia • Allergy • Coagulopathy	10%: MW: 200,000D, DS 0.5 Low cost. Extensive clinical use in sepsis, burns. Potential to diminish vascular permeability & reduces tissue edema
Tetrastarch (Voluven)	**Dextran [5]**
MW 130,000 D Used for volume therapy. Dose: 50 ml/kg/day	**It inhibits platelet aggregation (bleeding).**

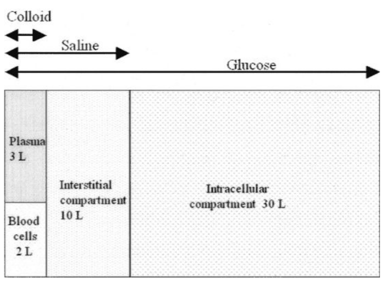
1- Gives long term hemodynamic stability.
2- Gelatins and Albumins are the most common colloids used in the OR, these two are the most important.
3- Because Ca^{2+} will bind with albumin and will be in the non-ionized form.
4- You have to pay a special care for patients with renal dysfunction.
5- polysaccharide.

Intravenous fluids

Crystalloids or Colloids?

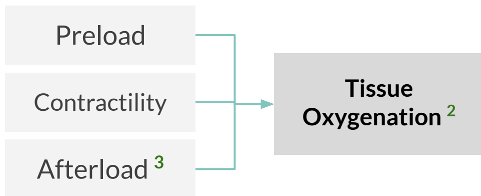
	Crystalloid	Colloid
Intra-vascular resistance	Poor	Good
Hemodynamic stabilization	Transient	Prolonged (advantage)
Required infusion volume	Large [1]	Moderate
Risk of tissue edema	Obvious	Insignificant
Enhancement of capillary	Poor	Good
Risk of anaphylaxis	-	Low to moderate
Colloid oncotic pressure	Reduced	Maintained
Cost	Inexpensive	More expensive

ACS protocol for ATLS: Replace each ml of blood loss with 3 ml of **crystalloid** fluid (3 for 1 rule).
Patient response:
- Rapid
- Transient
- Non-responsive



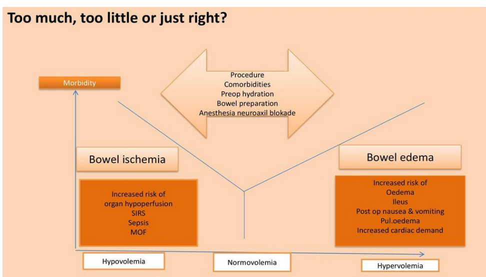
Goal directed fluid therapy in the perioperative setting

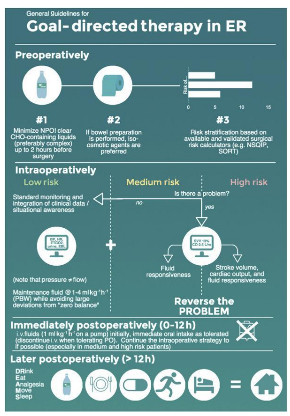
GDT is a term used to describe the use of cardiac output (CO) or similar parameters to guide the IV fluids & inotropic therapy.
- It involves goal directed manipulation of:



- Optimal perioperative fluid management is an important component of the ERAS pathways (Enhanced Recovery After Surgery).
- It can reduce postoperative complications.
- In some low-risk patients undergoing low-risk surgery, a "zero-balance" approach is encouraged.

GDT approach	Zero-balance approach
requires invasive monitoring of dynamic hemodynamic parameters	(restrictive) replaces only fluid lost during the procedure

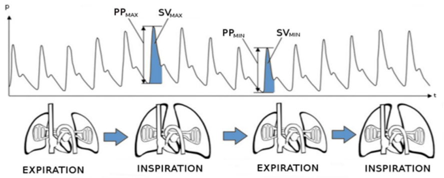




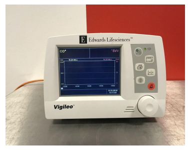
1- Because it will leave the intravascular space and only ⅓ will remain
2- When we give fluids we work on the preload, but the management should include all factors (contractility by administering inotropes and afterload by administering vasoconstrictors) to achieve the goal.
3- Describe cardiac function in septic patient where there's vasodilation & we need to give vasopressors to increase the afterload

Non/Minimal invasive measures

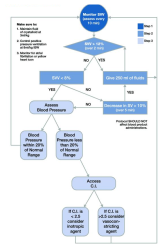
A. Edwards life-science



- measures stroke volume variation (SVV).
  That is "the change in the amount of blood ejected from the left ventricle into the aorta with each heartbeat".
- This is reflected by **arterial blood pressure changes** in relation to the **pattern of respiration** [1].
- Stroke volume variation: (For use on control ventilated patients) Variation in arterial pulsations **caused by** volume changes during positive pressure inspiration [2].
  - ↑ Variation (more than 12) → pt need fluids
  - ↓ or ⇔ the variation → pt doesn't need fluids and if hypotensive other problem need to be sourced



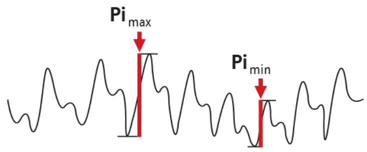
Edward machine



(Only for you)

If the cardiac index is less than 2.5 it's probably problem with the contractility, while if it's more than 2.5 it could be problem with the afterload

B. Masimo measurement of PVI (Pleth Variability Index)



- a noninvasive and continuous measurement of the dynamic changes in perfusion index (Pi) that occur during respiratory cycles, as the basis of a goal-directed fluid therapy (GDFT).
- Pi reflects the amplitude of the pulse oximeter waveform.
- Pi is expressed as a percentage (0.02- 20%).

Transfusion Therapy

- 60% of transfusions occur perioperatively.
- The responsibility of transfusing perioperative is with the anesthesiologist.
- Up to 30% of blood volume can be treated with crystalloids.[2]
- **If blood loss exceeds 20% of blood volume & still there is ongoing bleeding this will necessitate blood transfusion.**

Blood volume formula:

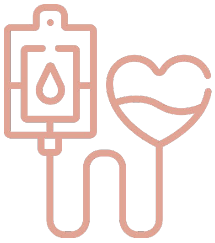
- Neonate – 90 ml/kg
- Infants 2 years old – 80 ml/kg
- Adult female – 60 ml/kg
- Adult male – 70 ml/kg

1) **Estimate the blood volume of an adult female with weight of 50 Kg ?**
   - Answer: 60 ml X 50 Kg = 3000 ml = 3L
   - **How much blood she needs to lose for us to start blood transfusion?** 3000 x 0.2 (20%) = 600 ml
1) **Estimate the blood volume of an adult female with weight of 70 Kg ?**
   - Answer: 60 ml X 70 Kg = 4200 ml = 4.2 L

1- That's why pts should be intubated and ventilated
2- Connected with arterial line.

Transfusion Therapy

Why blood transfusion



- Improvement of oxygen transport
- Correction of bleeding caused by platelet dysfunction
- Restoration of red cell mass
- Correction of bleeding caused by factor deficiencies

When is transfusion necessary?[10]

- **Transfusion trigger:** Hb level at which transfusion should be given
- It varies among patients & procedures.
- Tolerance of acute anemia depends on:
    1. Maintenance of intravascular volume.
    2. Ability to increase cardiac output.
    3. Increases in 2,3-DPG to deliver more of the carried oxygen to tissues.
        a. Hb dissociation curve will shift to the right which leads to more release of oxygen to the tissues.

Oxygen delivery

- **Oxygen delivery (DO_2)** is the oxygen that is delivered to the tissues.

$$DO_2 = CO \times CaO_2$$

CO Cardiac output
- HR x SV

CaO_2 Arterial oxygen content
- (Hb x 1.39 [1]) O_2 Saturation + PaO_2 (0.003)
- Hb is the main determinant of oxygen content in the blood.

Therefore, $DO_2 = HR \times SV \times CaO_2$

- If HR or SV are unable to compensate, Hb is the major determinant factor in O_2 delivery.
- **Healthy patients** have excellent compensatory mechanisms & can tolerate Hb levels of **7 mg/dL.**
- **Compromised patients** may require Hb levels above **10 mg/dL.**

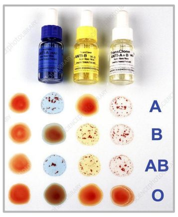
1- Amount of maximum oxygen carrying capacity by Hb

Transfusion Therapy

Blood Group

Blood group	Antigen on erythrocyte	Plasma antibody
A	A	anti-B
B	B	anti-A
AB	AB	none
O	none	anti-A / anti-B
Rh	Rh	

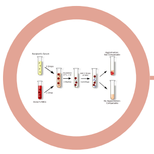
Type & Screen[1]



Donated blood that has been tested for ABO/Rh antigens and screened for common antibodies (NOT mixed with recipient blood).

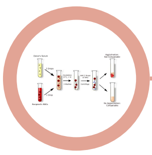
- Used when usage of blood is unlikely, but needs to be available (as in hysterectomy).
- Allows blood to be available for other patients.
- Chance of hemolytic reaction: 1:10,000.

Cross Matches



Major

donor's erythrocytes (packed cells) incubated with **recipient's plasma.**



Minor

donor's plasma incubated with recipient's erythrocyte.

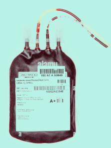
- **Agglutination:** occurs if either is incompatible.
- **Type specific[11]:** Only ABO-Rh determined.
  - The chance of hemolytic reaction is **1:1000** with TS blood.

1- Is the first thing you do, it only focus and tests the recipient blood, it doesn't look at the donor bag of blood. (without cross-match)
Typing: determines the patient's blood type.
Screening: screens the patients for the presence of other known antigens on the patient's RBCs.

Blood components

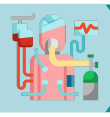
Whole blood is separated by differential centrifugation into:

- Packed red blood cells (pRBC's)
- Fresh frozen plasma; it contains all clotting factors
- Factor VIII
- Others such as antibody concentrate, plasma protein fraction
- Platelets
- **Cryoprecipitate;** it contains factor VIII & fibrinogen.[2]
- Albumin

	Overview	Dose	Indication	Considerations
Whole blood 	The whole blood is stored at 4 ° for up to 35 days.		•Massive blood loss •Trauma •Exchange transfusion	•Use I.V filters •Donor & recipient must be ABO identical
Packed red blood cells 	•1 unit = 250 ml. •**Hct= 70-80%.** •**Mixed with saline**: LR has calcium which may cause clotting if mixed with pRBCs [1]	•**1 unit pRBC raises Hb 1 gm/dl** •Usual dose of 10 cc/kg infused over 2-4 hours.[3] •Maximum dose of 15-20 cc/kg can be given to a hemodynamically stable patient.		**Procedure**: •Filter is used routinely. •Monitoring. •DO NOT mix with medications. **Complications**: •Rapid infusion may result in pulmonary edema. •Transfusion reaction.
Platelet concentrate 	It is stored up to 5 days at **20-24°** Contain leukocytes and cytokines.	Each unit increase platelet count by 10,000-20,000.	•Thrombocytopenia, platelet <15,000. •Bleeding & platelet <50,000. •Non-invasive procedures and platelet **<50,000.**[5] •Invasive major procedures and platelet less than 100,000.	1 unit/10 kg of body weight increases platelet count by 50,000. •Donor & Recipient must be ABO identical [4]
Plasma & FPP 	**Content: coagulation factors** (1 unit/ml) **Storage**: FFP for 12 months at 18 degrees or colder.	•Each unit increases the level of coagulation factors by 2-3%. •Usual dose is 20 cc/kg to raise coagulation factors approximately 20%	•**Correct coagulopathy** •Coagulation factor deficiency. •Fibrinogen replacement •**DIC** •Liver disease •Exchange transfusion •Massive transfusion. •Reversal of anticoagulant agent	•Plasma should be recipient RBC ABO compatible. •In children, it should also be Rh-compatible.

1- But can be transfused in separate with 2 lines.
2- Used in cases of hemophilia & **Von Willebrand disease.** Should be administered Preoperatively.
3- If we need to give it fast in the ER, we give it as a bolus after warming the blood. Why don't we always warm it? because it can cause hemolysis.
4- No need for Rh compatibility except in children.
5- minimal platelets count for patient undergoing surgery is 50,000

Transfusion complications



Hemolytic reactions

acute / delayed

Wrong blood type administered (oops) → Activation of complement system → intravascular hemolysis, spontaneous hemorrhage

Signs:

- **Hypotension**
- **Substernal pain**
- Back pain
- **Fever /Chills**
- Dyspnea
- **Skin flushing**
- Oliguria
- **Dark urine**
- Pallor
- abdominal pain

The signs are easily masked by general anesthesia.

Effects:

- Free Hb in plasma or urine.
- Acute renal failure (oliguria)
- Disseminated intravascular coagulopathy (DIC)

What to do if an AHTR (acute hemolytic transfusion reaction) occurs?

1. **Stop transfusion**
2. ABC's
3. Maintain IV access & run IVF (NS or LR)
4. Monitor & maintain vital signs (BP/Pulse) (**manage hypotension)**
5. Give diuretics (to protect the kidney) **maintain urine output**
6. Obtain blood & urine for transfusion reaction workup
7. Send remaining blood back to blood bank

Blood bank workup of AHTR

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

Monitoring during AHTR

- Monitor patient clinical status & vital signs
- Monitor renal status (BUN, creatinine)
- Monitor coagulation status (DIC panel- PT/PTT, fibrinogen, D-dimer/FDP, platelet, antithrombin-III)
- Monitor for signs of hemolysis (LDH, bilirubin, haptoglobin

Transfusion complications

Febrile reaction (FNHTR)

Most common non-hemolytic reaction & is usually controlled by slowing infusion & giving antipyretics

Allergic reaction

Sx: Increased body temperature, Pruritus, Urticaria.
Rx: Antihistamine and Discontinuation[1]
Prevention: Examination of plasma & urine for free hemoglobin helps rule out hemolytic reactions

Infection

Transmission of viral diseases:

- **Hepatitis C:** 1:30,000 per unit
- **Hepatitis B:** 1:200,000 per unit
- **HIV:** 1:450,000-1:600,000 per unit
    - 22 day window for HIV infection & test detection
- **CMV** may be the most common agent transmitted, but only affects immunocompromised patients.
- **Parasitic & bacterial** transmission is very low.

Others

Transfusion Related Acute Lung injury (TRAL)

Coagulopathy with massive transfusions

- **Decreased 2,3-DPG:** with storage ? significance
    - Increased affinity of O2 to hemoglobin → decrease O2 delivery to tissue → hypoxia
- **Citrate metabolism to bicarbonate:** calcium binding → hypocalcemia
- **Microaggregates** (platelets & leukocytes) micropore filters controversial.
- **Hypothermia:** warmers are used to prevent it.
- **Coagulation disorders:** massive transfusion (>10 units) may lead to dilution of platelets, Factor V & Factor VIII → We need to give coagulation factors
- **DIC:** uncontrolled activation of coagulation system → We Transfuse blood product

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1- If the patient isn't intubated : check if he/she is aware, maintaining his/her airway and has a good IV access. Monitor the BP and pulse, give diuretics and check the Hgb , reread the paperwork and patient's file, redo the cross matching.

Transfusion Therapy

Massive blood transfusion

Usually in trauma patients

- Massive transfusion is generally defined as the **need to transfuse one or two times the patient's' blood volume. In 24Hour**
- For most adult patients, that is the equivalent of **10-20 units**

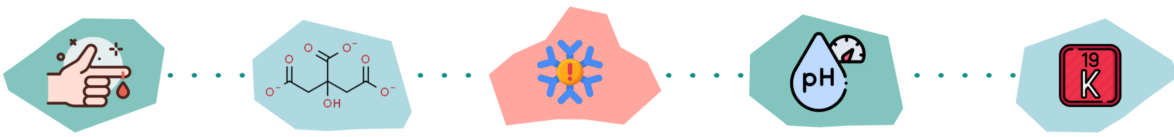
- **Complications:**

Citrate toxicity

does not occur in most normal patients unless the transfusion rate exceeds 1 U every 5 mins.

Acid- base imbalance

The most consistent acid-base abnormality after massive blood transfusion is postoperative **metabolic alkalosis**.



Coagulopathy

due to dilutional thrombocytopenia & dilution of the coagulation factors.
Give platelets and FFP.

Hypothermia

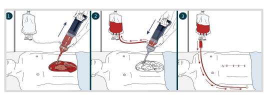
Must use warmers

↑ serum potassium concentration

- The extracellular concentration of potassium in stored blood steadily increases with time.
- **Hypokalemia** is commonly encountered postoperatively, particularly in association with metabolic alkalosis.

Administering blood products

- Consent necessary for elective transfusion.
- Unit is checked by 2 people for unit #, patient ID, expiration date.
- pRBCs are mixed with saline solution (NOT LR).
- Products are warmed mechanically & given slowly (over 2-4h) if condition permits [1].
- Close observation of patient for signs of complications.
- If complications are suspected, infusion discontinued, blood bank notified & proper steps are taken.

Autologous blood	Autotransfusion
Pre-donation of patient's **own blood** prior to elective surgery [2]. • 1 unit donated every 4 days (up to 3 units) • Last unit donated at least 72 hrs prior to surgery. • Reduces chance of hemolytic reactions and transmission of blood-borne diseases. • Not desirable for compromised patients.	• Commonly known as (cell-saver) • Allows collection of blood during surgery for re-administration • RBC's are centrifuged from plasma. • Effective when > 1000 ml are collected 

1- No need for warmers if we're in the OR with an elective case and we are correcting a small decrease in Hgb and using slow infusion because warmers may cause hemolysis of RBCs but we must use it in case of an emergency and rapid infusion
2- Used if the patient has many complaints and can't find a compatible donor. Done in elective surgeries.

Lecture Quiz

Question 1: All of the following fluids are generally considered to be isotonic,except:

A. Lactated Ringer
B. Normal saline
C. D5 normal saline
D. D5¼ normal saline

Question 2: Regarding central venous pressure (CVP) monitoring

A. Low values of <5 mm Hg may be considered normal in the absence of other signs of hypovolemia
B. CVP readings can be interpreted independently of the clinical setting
C. CVP monitoring is never indicated in patients with normal cardiac and pulmonary function
D. In a patient with right ventricular dysfunction, a CVP of 10 mmHg should be considered elevated

Question 3: which of the following about blood transfusion are false?

A. A hemoglobin level of 10 g/dL or less is now considered a typical indication
B. FFP is considered as the first line therapy in coagulopathic hemorrhage
C. Cryoprecipitate is useful in low-fibrinogen states and in factor VIII deficiency
D. Platelets have a shelf life of 3 week
E. Patients can pre donate blood up to 3 weeks before surgery for autologous transfusion

Question 4: : All of the following are signs of dehydration, except

A. Progressive metabolic acidosis
B. Urinary specific gravity > 1.010
C. Urine osmolality < 300 mOsm/kg
D. Urine sodium < 10 mEq/L

Question 5: The most common cause of an acute hemolytic transfusion reaction is

A. An error during type and screen
B. An error during type and crossmatch
C. Misidentification of the patient, blood specimen, or transfusion unit
D. Defective blood filter

Key Answers: **1**- C/ **2**-A / **3**-A&D / 4-C/ 5-C

441 Notes:

1-Main component of our body is water the percentage depends on the gender and age of the patient

2-If we infuse collides it will remain in the intravascular compartment but the saline which is an isotonic solution which is having the same osmolarity of the blood it will remain in the extracellular fluid and other solution like glucose solution it distributed in all parts of the fluid compartments. **Why glucose is going to be distributed in all parts of this and the idea?** Actually what is happening Glucose get water metabolized OK and the remaining is the water. Water can cross all the compartments easily, all the membrane easily. That is why it get distributed in all parts of the all component,

3-What is osmolality? concentration of all chemical particles found in the fluid part of blood
What is the normal osmolality of the plasma? About 290

4- crystalloids when there is combination of water and electrolytes like in case of saline we have NaCl and water. Hypo and hypertonic solutions are not commonly used.

5- basically when you give so much isotonic solution to the patient, this will cause low bicarbonate concentration because the isotonic saline have chloride in it and both (cl and hco3) have the same negative charge so the bicarbonate will be replaced by the chloride which will result in hyperchloremic metabolic acidosis

6- i**t aggravates ischemic brain injury by two mechanisms**:
1-when glucose get metabolized it produces co2 which will cross BBB leading to intracellular acidosis
2- When glucose metabolized more water will be produced which will also cross the blood brain barrier leading to edema

7- the only one that we still use is **albumin** others have more disadvantages than advantages

8- the most common and important disadvantage is **anaphylaxis**

9-if you have hemodynamically unstable patient maybe your calculations are wrong and he lost more than 30% so you need to do blood transfusion. So you have to see all the factors not only the volume of blood loss

10-in normal healthy pt hgb=7. If he have cardiovascular or respiratory disease like copd hgb 10. if the patient is bleeding profusely and hemodynamically unstable consider blood transfusion forget about the numbers.

11- only we do it if we don’t have time in desperate situations

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