جامعة الملك سعود
King Saud University

433
ANAESTHESIA

PERIOPERATIVE FLUID THERAPY

Color reference: Black-slids Green-Notes Blue-Book Red-important

Contact us: Anesthesia433 @gmail.com

MED 433

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.

Physiology Total Body Water (TBW) : Varies with age, gender The70 kg 'standard male' contains 42L :

60% body weight in males

50% body weight in females

80% body weight in new born

Less in obese: fat contains little water

Body Water Compartments :

- **Intracellular water: 2/3 of TBW**
- **Extracellular water: 1/3 TBW**
  - Extravascular water: 3/4 of extracellular water
  - Intravascular water: 1/4 of extracellular water

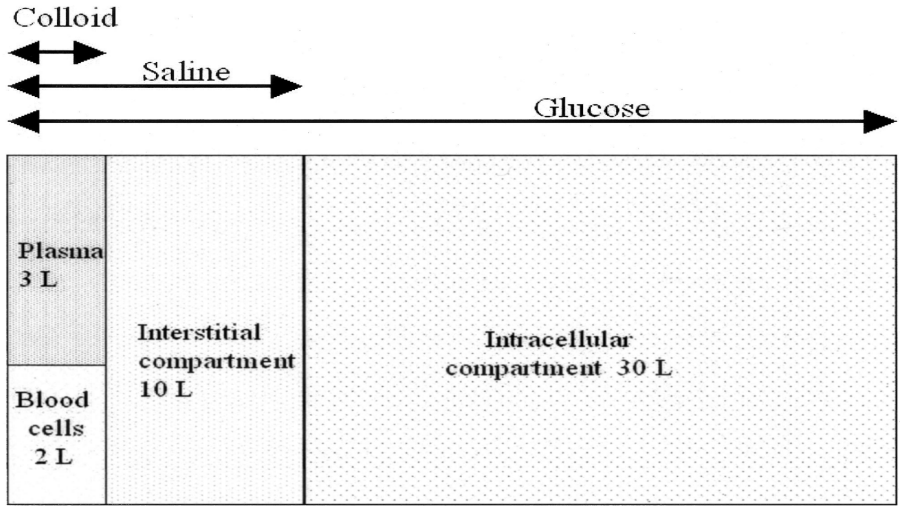
Electrolyte physiology:

- **Primary ECF cation is Na**

  Very small contribution of K, Ca 2+ & Mg2+

- **Primary ICF cation is K**

  Smaller contribution from Mg2+ & Na



The aim of maintenance of fluid, electrolytes, acid base balance and blood volume : is delivery of adequate oxygen to the tissues, ”That’s the important goal of the ABC in emergency”

Factors affecting oxygen delivery equation includes:

- cardiac output (stroke volume × heart rate) ”When we work on the fluid management we work on the stroke volume (which have 3 factors: preload, contractility and afterload) by increasing the preload volume.
- Haemoglobin concentration “managend by giving blood”
- oxygen saturation

Physiology Fluid and Electrolyte Regulation :

- **Volume Regulation**
  - -Antidiuretic Hormone
  - -Renin/angiotensin/aldosterone system
  - -Baroreceptors in carotid arteries and aorta
  - -Stretch receptors in atrium and juxtaglomerular aparatus
  - -Cortisol
- **Plasma Osmolality Regulation**
  - - Arginine-Vasopressin (ADH)
  - -Central and Peripheral osmoreceptors
- **Sodium Concentration Regulation**
  - -Renin/angiotensin/aldosterone system
  - -Macula Densa of JG apparatus

Desirable outcome of fluid resuscitation : No peripheral edema & No ARDS

Assessment of Fluid Status :

-Input and output chart "more accurate in OR because anesthesiologist measures everything"

-Blood pressure: supine and standing

-Heart rate "increase in hypovolemic pt as compensation"

-Skin turgor and capillary refill "more time in hypovolemic pt"

- Urinary output "decrease in hypovolemic pt "

-Serum electrolytes /osmolarity "increase osmolarity"

-Mental status "changes will happen in sever cases"

-CVP (normal 4-8 mmHg)

Perioperative Fluid Requirements : VERY IMPORTANT "NEXT SLIDES"

The following factors must be taken into account:

1- Maintenance fluid requirements

2- NPO and other deficits: NG suction, bowel preparations.

3- Third space losses

4- Replacement of blood loss

5- Special additional losses: diarrhea

1-Maintenance Fluid Requirements:

•Insensible losses such as evaporation of water from respiratory tract, sweat, feces, urinary excretion

"Occurs continually"

• "4-2-1 Rule"

- 4 ml/kg/hr for the first 10 kg of body weight
- 2 ml/kg/hr for the second 10 kg body weight
- 1 ml/kg/hr subsequent kg body weight
- Extra fluid for fever, tracheotomy, denuded surfaces

2- NPO and other deficits : "usually when the pt comes for elective surgery he will fast for at least 6-8 h"

NPO deficit = number of hours NPO x maintenance fluid requirement.

•Bowel prep may result in up to 1 L fluid loss. "give extra 1000ml"

•Measurable fluid losses, e.g. NG suctioning, vomiting, ostomy output, biliary fistula and tube. "Compensate the same amount as the loss"

Example :

If a pt comes for an elective surgery fasting for the past 6h and wasn't connected to IV line during these hours .. We have to compensate for these NPO h , how ?

Suppose we calculated his maintenance is = 1000 , NPO = 6h

NPO deficient = 1000 x 6 = 6000 ml …. How to give it ?

1st h (give ½) = 3000 ml , 2nd h (give ½ of the remaining half) = 1500ml, 3rd h (give the remaining ½) = 1500ml.

3- Third Space Losses :

•Isotonic transfer of ECF from functional body fluid compartments to non-functional compartments. "Happens in procedure like laparotomy or thoracotomy "

•Depends on location and duration of surgical procedure, amount of tissue trauma, ambient temperature, room ventilation.

Replacing Third Space Losses :

- Superficial surgical trauma: 1-2 ml/kg/hr
- Minimal Surgical Trauma: 3-4 ml/kg/hr : head and neck, hernia, knee surgery
- Moderate Surgical Trauma: 5-6 ml/kg/hr : hysterectomy, chest surgery "colon surgery with the opening below the umbilicus"
- Severe surgical trauma: 8-10 ml/kg/hr (or more some time reach 50 ml) : AAA repair, nehprectomy "bowel resection which extended above the umbilicus"

4- Blood loss :

- Each 1cc of blood loss is replaced by *3 cc* of crystalloid solution (crystalloid solutions leave the intravascular space) "a 100 ml blood loss replaced by 300 ml crystalloid"
- When using blood products or colloids replace blood loss volume per volume "a 100 ml blood loss replaced by 100 ml blood "

5- Other additional losses :

- Ongoing fluid losses from other sites:
  - gastric drainage
  - ostomy output
  - diarrhea
- Replace volume per volume with crystalloid solutions "as we said before Compensate the same amount as the loss"

Example :

- 62 y/o male, 70 kg, for laparotomy bowel resection (hemicolectomy)
- NPO after 22:00, surgery at 08:00 (NPO for 10h), received bowel prep (which is usually equal to 1000ml)
- 3 hr. procedure, 500 cc blood loss
- What are his estimated intraoperative fluid requirements?

- Maintenance: 110 x 3hrs = 330mls (110 from 4X10 + 2X10 + 1X50)
- Fluid deficit (NPO): 110 x 10 hrs = 1100 ml + 1000 ml for bowel prep = 2100 ml total deficit : (Replace 1/2 first hr, 1/4 2nd hr, 1/4 3rd hour).
- Third Space Losses: 6 ml/kg/hr x 3 hrs = 1260 mls
- Blood Loss: 500ml x 3 (we multiply by 3 if we replaced by crystalloid, if colloid you five the same amount 500ml) = 1500ml
- Total = 330 +2100+1260+1500 = 5190mls

Intravenous Fluids :

-Conventional Crystalloids -Colloids

-Hypertonic Solutions (type of crystalloid solutions) -Blood/blood products and blood substitutes

1/ Crystalloids :

- Combination of water and electrolytes
  - **Isotonic salt solution:**

    electrolyte composition and osmolality similar to plasma. Example: normal saline and Balanced salt solution (lactated Ringer's, Plasmlyte, Normosol).
  - **Hypotonic salt solution:**

    electrolyte composition lower than that of plasma. Example: D5W and Half normal saline.
  - **Hypertonic salt solution:**

    2.7% NaCl.

Crystalloids solutions : NaCl normal saline

Composition: Isotonic 0.9% : 9g/l, Na=154 , Cl=154

Osmolality: 304mosmol/l

Disadvantages : Hyper- chloremic acidosis "when given aggressively"

Crystalloids : Lactated Ringer's

Composition : Na =130, cl=109, K=4, ca=3, Lactate=28.

Osmolality : 273 mosmol/l

-initially was named :Sydney Ringer 1880

-now called : Hartmann or Lactate Ringer =LR

-Minor advantage over NACL so in resuscitation we can use either normal saline or LR but in OR they prefer LR because it is more compatible with normal fluid physiology.

Disadvantages :

-Not to be used as diluent for blood (Ca citrate in LR will cause clotting)

-Low osmolarity, can lead to high ICP because it can go inside the cells and interstitial space

- Caution in kidney failure because it contain K, in brain injury because of the ICP and lactate which transform to sugar in liver and increase the metabolism of brain , high blood sugar because of lactate

Crystalloids : Dextrose 5%water hypotonic solution

Composition: 50g/l.

Osmolality : 253

Disadvantages :

-enhance CO2 production because if increase the metabolism

-enhance lactate production increase sugar production

-aggravate ischemic brain injury

Crystalloids in trauma : Advantages:

-Balanced electrolyte solutions

-Buffering capacity (specially Lactate)

-Easy to administer

-No risk of adverse reactions

-No disturbance of hemostasis

-Promote diuresis

-Inexpensive

But if it is given aggressively it may leads to :
- Dilutional anemia
- Dilution of coagulation factors and cause more bleeding

2/Hypertonic Solutions : electrolyte composition greater than that of plasma

- **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. That's why it is not used in resuscitation, the only use is treatment of electrolyte imbalance

Advantages :

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

Disadvantages:

- increase hemorrhage from open vessels.
- Hypernatremia
- Hyperchloremia.
- Metabolic acidosis.
- Cellular dehydration

3/ Colloids :

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

Advantages:

- Prolonged plasma volume support
- Moderate volume needed
- Minimal risk of tissue edema
- Enhances microvascular flow

Disadvantages:

- Risk of volume overload
- Adverse effect on hemostasis it may affect the coagulation leads coagulopathies.
- Adverse effect on renal function
- Anaphylactic reaction like albumin
- Expensive

Colloids :

- **Dextran:** Inhibit platelet aggregation – leads to **Bleeding** not used any more

- **Gelatins** - **Albumins**

- **Hetastarch 6% :** synthetic, 6% preparation in isotonic saline MW 240,000 D, **Disadvantages:** Hyperamylesemia, allergy, coagulopathy. Dose 20ml/kg/day.

- **Pentastarch 10% :** MW 200,000 D- DS 0.5, Low cost, Extensive clinical use in sepsis, burns. Potential to diminish vascular permeability and reduces tissue edema

- **Tetrastarch (Voluven) :** MW 130,000 D, Used for volume therapy, Dose: 50ml/kg/day it can leads to coagulopathies

Gelatins

- Derived from hydrolyzed bovine collagen - Metabolized by serum collagenase - can remain in blood vessels 0.5-5hr

Disadvantiges :

- Histamine release (H1 blockers recommended)
- Decreases Von W factor (VWF)
- Bovine Spongiform Encephalopathy > 1:1,000.000 rare

Albumin :

- Heat treated preparation of human serum 5% (50g/l), 25% (250g/l)
- 5% is used for volume expansion, Half of infused volume will stay intravascular thick that's why it is used in resuscitation
- 25% used only in case of hypoalbuminemia

Disadvantages:

- Cardiac decompensation after rapid infusion of 20- 25% albumin
- decreased Ionized ca++
- Impaired Na+Water excretion , leads to renal dysfunction

Crystalloids OR Colloids

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 here we can start with colloids

First start with crystalloids because it will helps more in perfusion > goes to interstitial space and cells

	Crystalloid	Colloid
Intravascular persistence	Poor	Good
Hemodynamic stabilization	Transient	Prolonged
Required infusion volume	Large	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

Transfusion Therapy

- 60% of transfusions occur perioperativly. Responsibility of transfusing perioperatively is with the anesthesiologist.

- Up to 30% of blood volume can be treated with crystalloids.

- If blood loss exceeds 20% they usually go with 20% not 30% of blood volume and still there is on going bleeding this will necessitate blood transfusion.

- Blood volume formula :

* Neonate - 90 ml/kg
* Infants 2 years ago - 80ml/kg
* Adult male - 70ml/kg
* Adult female - 60ml/kg

WHY do we transfuse blood ?

-Improvement of oxygen transport

-Restoration of red cell mass

-Correction of bleeding caused by platelet dysfunction

-Correction of bleeding caused by factor deficiencies

When is Transfusion Necessary ?

- "Transfusion Trigger": Hgb level at which transfusion should be given.
  - Varies with patients and procedures The lowest accepted Hb level in healthy ppl is 7, in compromised ppl is 10
- Tolerance of acute anemia depends on:
  - Maintenance of intravascular volume
  - Ability to increase cardiac output
  - Increases in 2,3-DPG to deliver more of the carried oxygen to tissues if 2,3-DPG increase it will shift the Hb dissociation curve to the right > difficult for hemoglobin to bind to oxygen > lower affinity of Hb to O2 > release it quickly > improve tissue oxygenation ,, this mechanism happens in case of hypoxia.

Oxygen Delivery :

(DO2) is the oxygen that is delivered to the tissues > DO2= COP x CaO2

- Cardiac Output (CO) = HR x SV
- Oxygen Content (CaO2): the arterial content of O2
  - (Hgb x 1.39) O2 saturation + PaO2(0.003)
  - Hgb is the main determinant of oxygen content in the blood

CONT.. Oxygen Delivery :

- Therefore: DO2 = HR x SV x CaO2
- If HR or SV are unable to compensate, Hgb is the major determinant factor in O2 delivery
- Healthy patients have excellent compensatory mechanisms and can tolerate Hgb levels of 7 gm/dL.
- Compromised patients may require Hgb levels above 10 gm/dL.

Cross match : they order it in major procedure like AAA

- Major:
  - Donor's erythrocytes (packed cells) incubated with recipients plasma they mix it to see if there's agglutination or not
- Minor:
  - Donor's plasma incubated with recipients erythrocytes
- Agglutination:
  - Occurs if either is incompatible
- Type Specific:
  - Only ABO-Rh determined; chance of hemolytic reaction is 1:1000 with TS blood

Type and Screen:

- Donated blood that has been tested for ABO/Rh antigens and screened for common antibodies (not mixed with recipient blood) : they order it for minor procedure(book it for the patient) like bowel resection (with no massive bleeding) just in case something happens they then just cross match it and give it to him.
  - Used when usage of blood is unlikely, but needs to be available (hysterectomy).
  - Allows blood to available for other patients.
  - Chance of hemolytic reaction: 1:10,000.

Blood Components :

Whole blood is separated by differential centrifugation

- Packed Red Blood Cells (pRBC's)
- Platelets
- Fresh frozen Plasma, Contain all clotting factors
- Cryoprecipitate contain factor VIII and fibrinogen
- Factor VIII
- Albumin
- Others, antibody concentrate, Plasma protein fraction

Whole Blood :

Storage :

4° for up to 35 days

Indications :

Massive Blood Loss/Trauma/Exchange Transfusion

Considerations :

Use filter .

Donor and recipient must be ABO identical

Packed Red Blood Cells

- 1 unit = 250 ml. Hct. = 70-80%.
- **1 unit pRBC's raises Hgb 1 gm/dL.**
- Mixed with saline because LR has Calcium which may cause clotting if mixed with pRBC's.

RBC Transfusions Administration :

Dose

- Usual dose of 10 cc/kg infused over 2-4 hours
- Maximum dose 15-20 cc/kg can be given to hemodynamically stable patient

Procedure

- Filter use—routinely

Monitoring

- Do NOT mix with medications

Complications

- Rapid infusion may result in Pulmonary edema
- Transfusion Reaction

Platelet Concentrate :

Storage

Up to 5 days at 20-24°

Indications

- Thrombocytopenia, Plt <15,000
- Bleeding and Plt <50,000
- Invasive procedure and Plt <50,000

Considerations

- Contain Leukocytes and cytokines can lead to allergic reaction
- 1 unit/10 kg of body weight increases Plt count by 50,000
- Donor and Recipient must be ABO identical

Plasma and FFP :

Contents

Coagulation Factors (1 unit/ml)

Storage

FFP 12 months at 18° or colder

Indications

Coagulation Factor deficiency, fibrinogen replacement, DIC, liver disease, exchange transfusion, massive transfusion

Considerations

- Plasma should be recipient RBC ABO compatible
- In children, should also be Rh compatible
- Usual dose is 20 cc/kg to raise coagulation factors approx 20%

Transfusion Complications:

- Hemolytic Reactions (acute or delayed)
- Febrile Reactions (FNHTR)
- Allergic Reactions
- TRALI happens in ICU Pt
- Coagulopathy with Massive transfusions
- Infection

1/ Hemolytic:

-Wrong blood type administered (oops).

-Activation of complement system leads to intravascular hemolysis, spontaneous hemorrhage.

Signs: if Pt is awake

- ✓ hypotension,
- ✓ fever, chills
- ✓ dyspnea, skin flushing,
- ✓ substernal pain , Back/abdominal pain
- ✓ Oliguria Dark urine

These Signs are easily masked by general anesthesia so if you in doubt do :

-Free Hgb in plasma or urine

-Acute renal failure So do complete renal profile tests

-Disseminated Intravascular Coagulation (DIC) coagulation profile

2/ Febrile : most common, usually controlled by slowing infusion and giving antipyretics

3/ Allergic : increased body temp., pruritis, urticaria. Rx: antihistamine, discontinuation. Examination of plasma and urine for free hemoglobin helps rule out hemolytic reactions.

4/ Transmission of Viral Diseases:

-Hepatitis C most common complication in healthy individual -Hepatitis B - HIV (22 day window for HIV infection and test detection)

-CMV (may be the most common agent transmitted, but only effects immuno-compromised patients)

-Parasitic and bacterial transmission very low

5/ Decreased 2,3-DPG with storage: Significance? shift of the curve to left > more affinity to O2 and will not release it to tissue

6/ Citrate: metabolism to bicarbonate; Calcium binding

7/ Microaggregates : platelets, leukocytes : micropore filters controversial

8/ Hypothermia: warmers used to prevent

9/ Coagulation disorders: massive transfusion (>10 units) may lead to dilution of platelets and factor V and VIII.

10/ DIC : uncontrolled activation of coagulation system

What to do If an AHTR occurs ?

- ❖ STOP TRANSFUSION
- ❖ ABC's
- ❖ Maintain IV access and run IVF (NS or LR)
- ❖ Monitor and maintain BP/pulse
- ❖ Give diuretic
- ❖ Obtain blood and urine for transfusion reaction workup
- ❖ Send remaining blood back to Blood Bank

Blood Bank Work-up of AHTR

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

Monitoring in AHTR :

- Monitor patient clinical status and vital signs
- Monitor renal status (BUN, creatinine)
- Monitor coagulation status (DIC panel– PT/PTT, fibrinogen, D-dimer/FDP, Plt, Antithrombin-III)
- Monitor for signs of hemolysis (LDH, bili, haptoglobin)

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

- **Coagulopathy** due to dilutional thrombocytopenia. And dilution of the coagulation factors. we start to give FFP if the blood unit given to the pt exceed 4 units.
- **Citrate Toxicity** does not occur in most normal patients unless the transfusion rate exceeds 1 U every 5 min
- **Hypothermia**
- **Acid–Base Balance** The most consistent acid–base abnormality after massive blood transfusion is postoperative metabolic alkalosis
- **Serum Potassium Concentration increase**
  - The extracellular concentration of potassium in stored blood steadily increases with time
  - Hypokalemia is commonly encountered postoperatively, particularly in association with metabolic alkalosis if the pt developed metabolic alkalosis he will have the hypokalemia

Administering Blood Products

-Consent necessary for elective transfusion

-Unit is checked by 2 people for Unit #, patient ID, expiration date.

-pRBC's are mixed with saline solution (not LR)

-Products are warmed mechanically and given slowly if condition permits

-Close observation of patient for signs of complications

-If complications suspected, infusion discontinued, blood bank notified, proper steps taken.

Autologous Blood

- Pre-donation of patient's own blood prior to elective surgery
- 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-bourne diseases
- Not desirable for compromised patients

Auto-transfusion

- Commonly known as "Cell-saver"
- Allows collection of blood during surgery for re-administration
- RBC's centrifuged from plasma
- Effective when > 1000ml are collected

جامعة الملك سعود
King Saud University

Done and Reviewed by:

Munira Almehsen

Leader

Yasmine Alshehri