Water is the most abundant component of the human body~ 60%.

Perioperative Fluid Therapy

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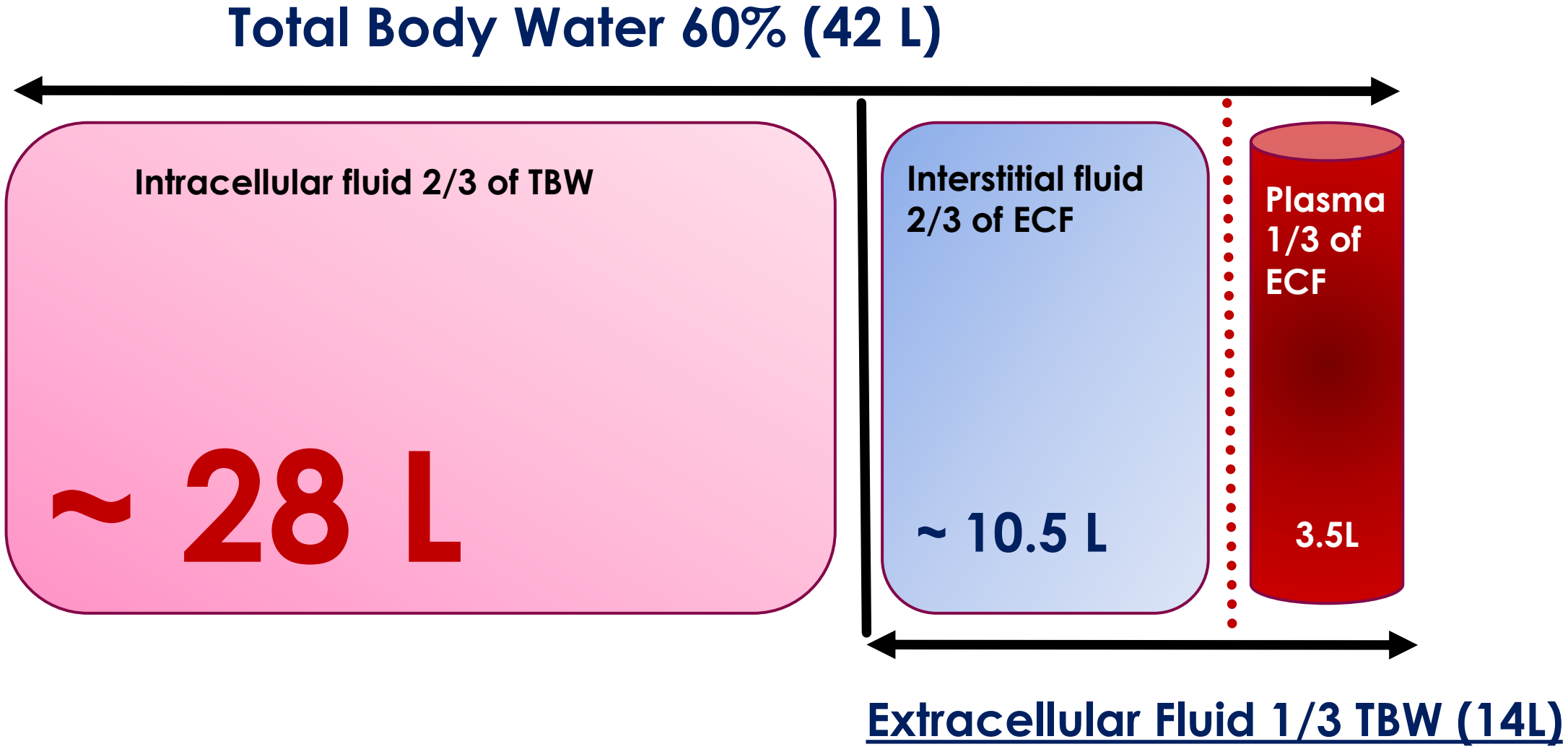
Lecture Objectives

- **To understand body fluid composition.**
- **To understand the basic physiologic principles to guide fluid therapy.**
- **To know the available types of Intravenous fluid.**
- **To know the advantages and disadvantages of each type.**
- **To identify perioperative factors which affect the patient fluid requirements.**
- **To know the different types of blood and blood products.**

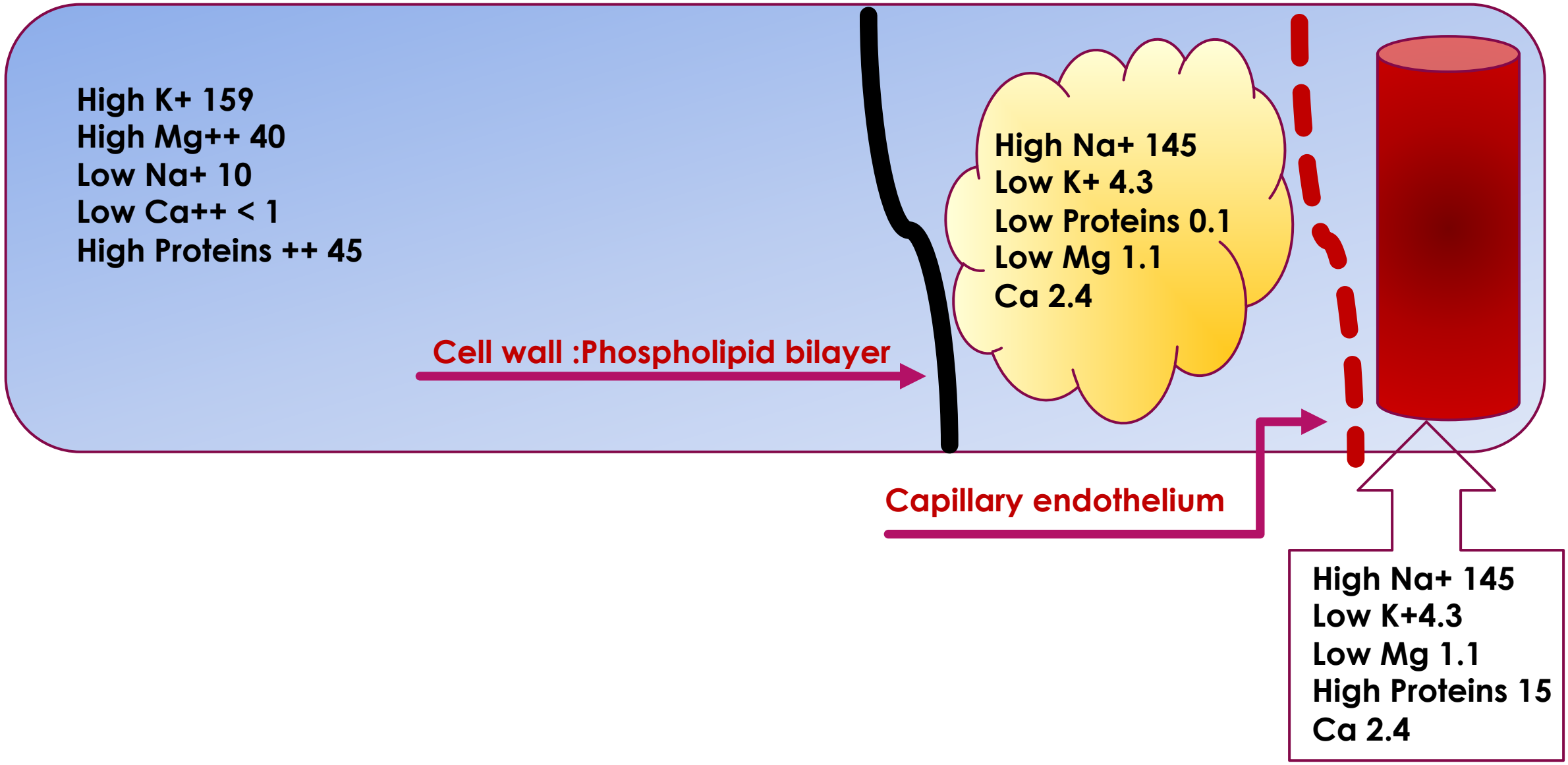
Total Body Water (TBW) Volume

- **The body of a 70 kg (male) contains nearly 42 L of water**
- **60% body weight in males**
- **50% body weight in females**
- **80% body weight in new born**

Body Fluid Compartments



Composition of body fluid compartments:



What controls body fluid content and composition?

Physical sensors:

- Stretch receptors and baroreceptors: Volume, Venous return and cardiac output.

Chemical sensors:

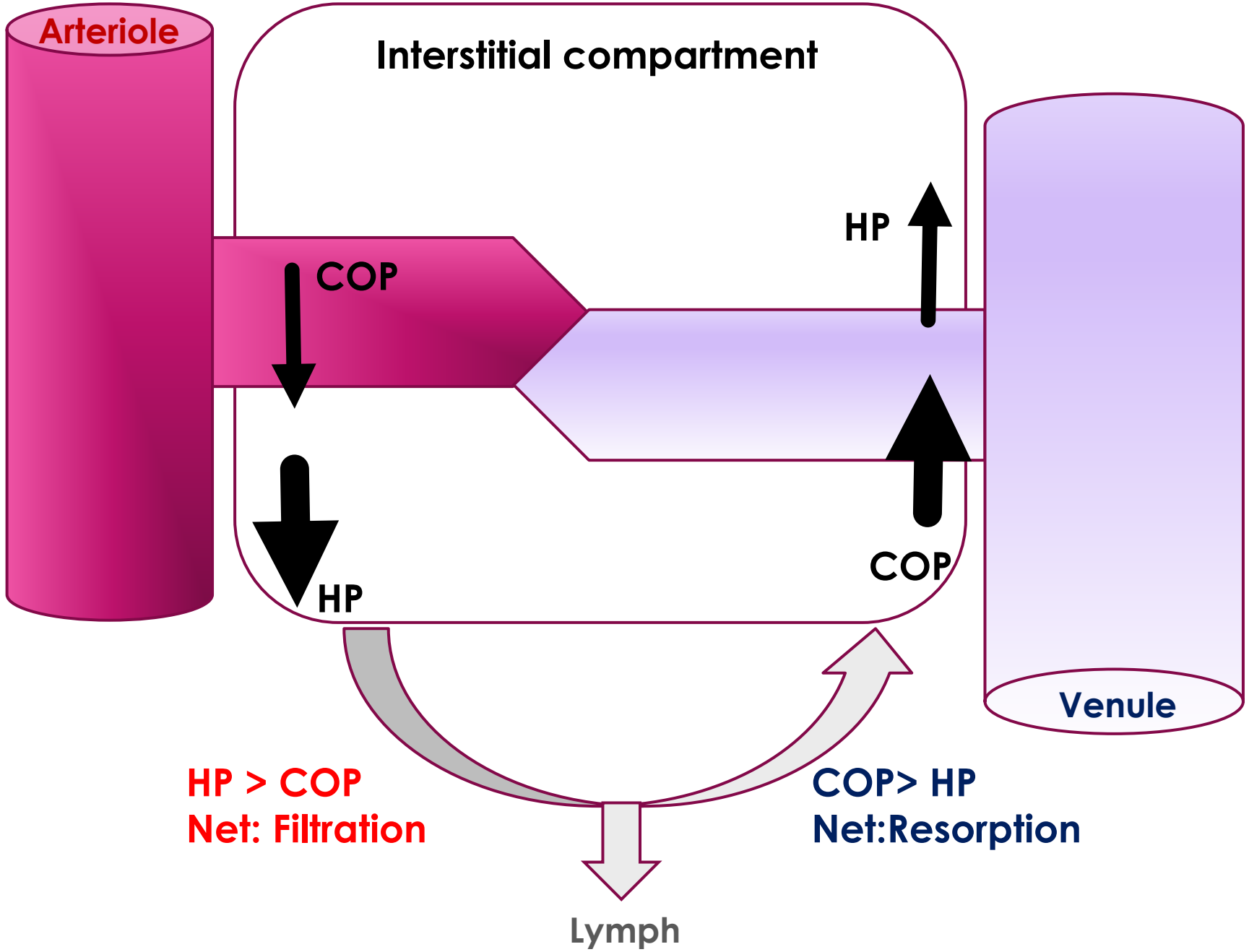
- Osmolarity through osmo-receptors.
- Total body water is controlled primarily through controlling Na+ content i.e. osmolarity.

Neuro endocrine Regulation Process:

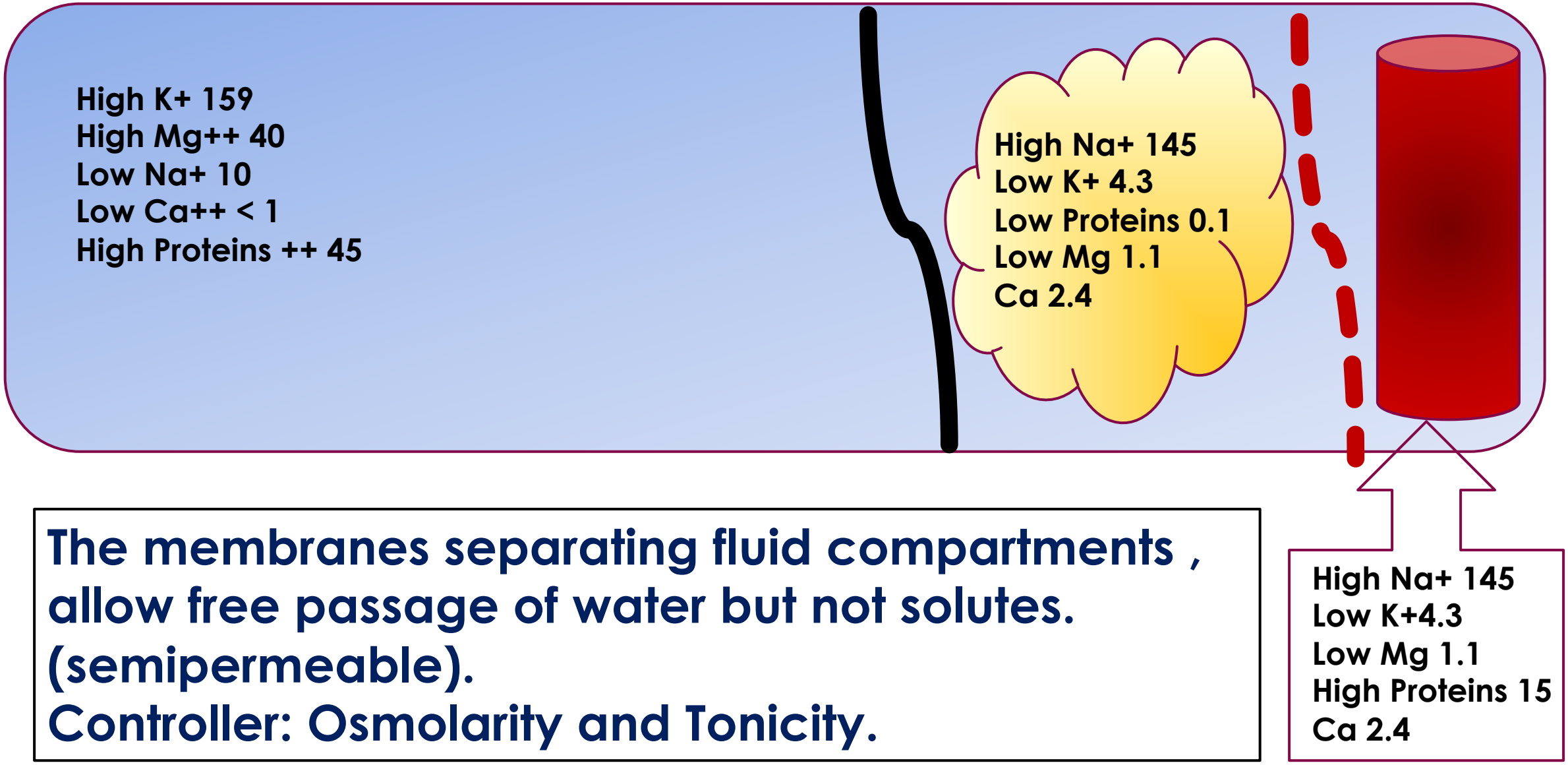
- Reduced volume → low VR→ less stretch→ low ANP and BNP.
- Low volume → increased Renin, ADH and Noradrenaline.
- Renin- sympathetic release → reduced Na+ excretion in kideny, and to water preservation.
- Renin → Angiotensin II and aldosterone release, both increase Na reabsorption.
- High osmolarity→ thirst stimulation→ more water intake.

Fluid movement From IV to ECF : Starling Forces

Hydrostatic Pressure in the capillary (Pc)
Hydrostatic Pressure in the interstitium (Pi)
Oncotic Pressure in the capillary (pc)
Oncotic Pressure in the interstitium (pi)


Arteriole
Interstitial compartment
HP
COP
COP
HP
Venule
HP > COP
Net: Filtration
COP> HP
Net:Resorption
Lymph

Fluid movement between ISF and ICF



The membranes separating fluid compartments , allow free passage of water but not solutes. (semipermeable).
Controller: Osmolarity and Tonicity.

FLUID THERAPY

History of fluid therapy

- Blackfan and Maxcy in 1918 gave 0.8% saline by intraperitoneal injection to nine infants with dehydration and all recovered.
- In 1957, Holliday and Segar described the 4-2-1 rule for fluid maintenance therapy.

Why do we need to give fluids?

Perioperative fluid therapy ensures:

- Adequate organ perfusion(O2)
- Prevent catabolism
- Maintain electrolytes and pH balance.

Goals of fluid Therapy

Hypovolumia **Volume overload**

Clinical indications for fluid therapy:

- Routine maintenance(water, electrolyte, carbohydrate)
- Fluid resuscitation ; (Hypovolemic, distributive shock)
- Replacements(of high output loss)

Assessment of volume status

History and Examination:

Intake, Pulse, BP, CRT, Mucous membranes, skin turgor,JVP, Pulmonary/Peripheral odema

Urine output

Input/output charts.

Fluid responsiveness:

Fluid challenge, Passive leg raising test.

Assessment of volume status

Laboratory:

CBC, Hb,Hct,Urea,Creatinine, electrolytes, Lactate,Acid base balance

Advanced monitoring:

Central Venous Pressure, Echocardiography AND Doppler.

Pulmonary Artery Catheter ; Cardiac output AND PCWP.

Pulse Pressure Variation Index, Plethesmography variation index , Stroke volume variation index.

Basal requirement for adults

- 25-30 ml/kg/day H2O
- 1 mMol/kg K+, Na+, and Cl-
- 50 -100 g/day Glucose to limit starvation ketosis.

1- Maintenance Fluid Requirements

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

Factors which guide fluid therapy

1- Maintenance (Basal) fluid requirement.

2- Fasting deficits.

3- Third space losses/ Insesnible loss

4- Blood loss

5- Special additional losses: , Urine, Vomiting, diarrhea, Stomas, NGT, burns.

2- NPO and other deficits

- NPO deficit = Number of hours NPO x maintenance fluid requirement.

- Measurable fluid losses, e.g. urine output, NG suctioning, vomiting, ostomy output, biliary fistula and tube.

3- Third Space Losses

- Capillary leakage and extravasation of protein rich into interstitial spaces of soft tissues, organs and deep cavities.
- Typically occurs during the first 72 hours.
- Hypoalbuminemia , contribute to third spacing.
- Volume depends on location and duration of surgical procedure, amount of tissue trauma, ambient temperature, room ventilation.

Estimation of Third Space Losses

- Superficial surgical trauma: 1-2 ml/kg/hr
- Minimal Surgical Trauma (Laparoscopy): 3-4 ml/kg/hr
- Moderate Surgical Trauma: 5-6 ml/kg/hr
- Severe surgical trauma: 8-10 ml/kg/hr.

Example

- 62 y/male, 70 kg, for laparoscopic hemicolectomy.
- NPO from 11:00 PM & no IVF given preoperatively.
- Surgery started at 8:00 until 11:00 AM.

- **What is the estimated intraoperative fluid requirement?**

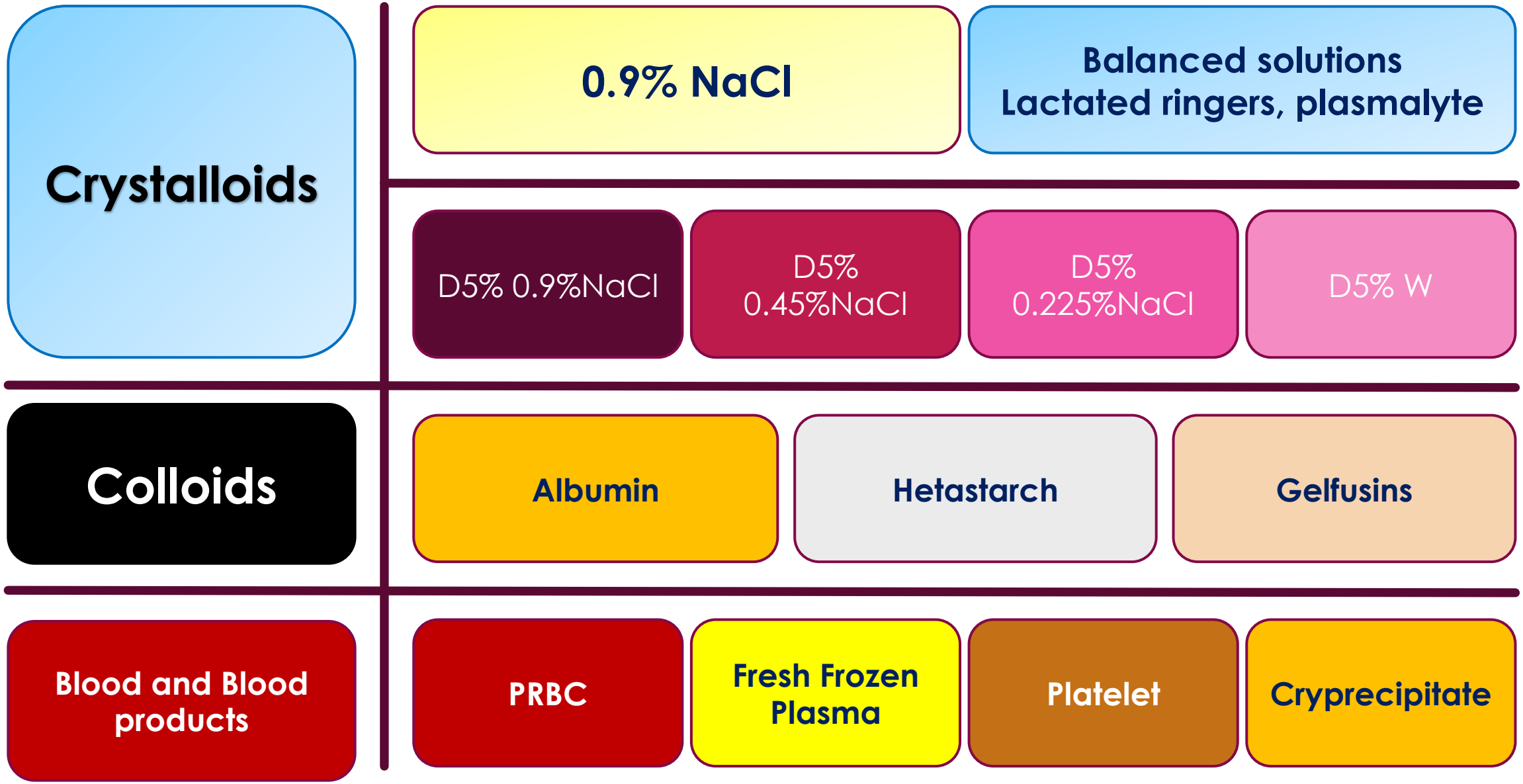
Example (cont.)

- Maintenance: 110 x 3hrs = 330mls
- Fluid deficit (NPO): 110 x 10 hrs = 1100 ml .
- Third Space Losses: 3ml/kg/hr x 3 hrs = 630 mls
- Total = 330 +1100+ 630 = 2060 mls

4- Blood Loss

- Hard to estimate accurately.
- Amount of blood in suction tubes, drains, gauzes.
- Change in Hb and Hct.
- Hemodynamic change.

Available Fluid types


Crystalloids
0.9% NaCl
Balanced solutions
Lactated ringers, plasmalyte
D5% 0.9%NaCl
D5%
0.45%NaCl
D5%
0.225%NaCl
D5% W
Colloids
Albumin
Hetastarch
Gelfusins
Blood and Blood products
PRBC
Fresh Frozen Plasma
Platelet
Cryprecipitate

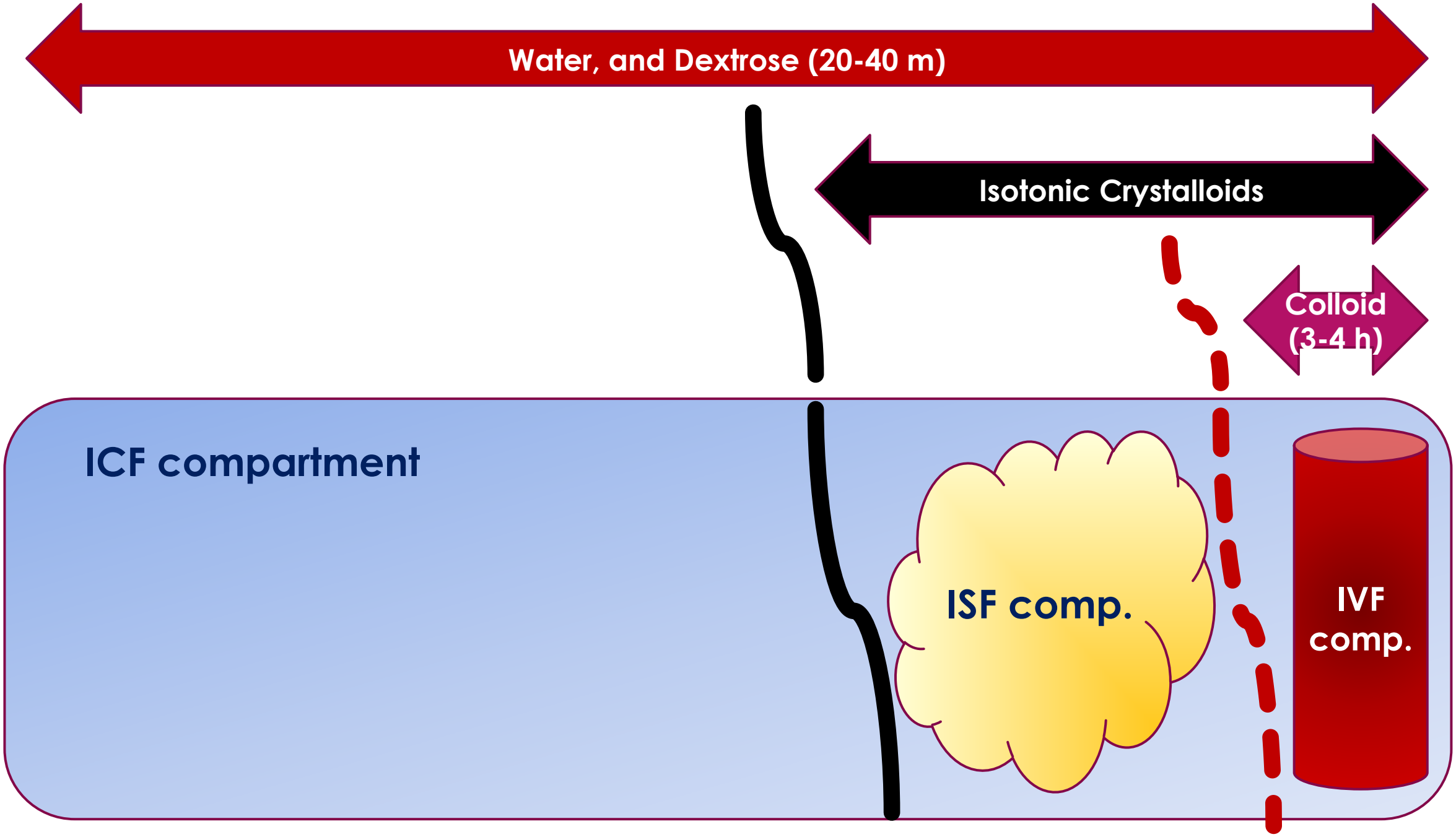

Water, and Dextrose (20-40 m)
Isotonic Crystalloids
Colloid
(3-4 h)
ICF compartment
ISF comp.
IVF
comp.

Figure 11.11 Electrolyte content of commonly used intravenous fluids

Solution	Electrolyte (cations)	Level (mmol L^{-1})	Electrolyte (anions)	Level (mmol L^{-1})	Osmolality (mOsm kg^{-1})
Hartmann's solution	Na, K, Ca	131, 5, 4	Cl, HCO_3	112, 29	281
Normal saline	Na	154	Cl	154	308
5% glucose	Nil	–	Nil	–	278
Glucose-saline (glucose 4%, saline 0.18%)	Na	31	Cl	31	284

Term we need to understand:

- **Isotonic**: Tonicity in clinical practice refers to Na+ concentration. Distribute evenly between IVF and ISF
- **Hypotonic**: lower concentration of Na+ compared to the plasma: will cross cellular wall more and cause cellular swelling.
- **Hypertonic**: higher concentration of Na+ compared to the plasma. Will cause cellular shrinkage through increasing osmotic pressure in ECF.

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 and albumin.

Advantages of Colloids:

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

Disadvantages of Colloids:

- Risk of volume overload
- Adverse effect on hemostasis
- Adverse effect on renal function
- Anaphylactic reaction
- Expensive

Albumin

Heat treated preparation of human serum. Comes in two preparations:

- 5% albumin(50 g/l) 250 mls bottles, used for volume expansion, Half of infused volume will stay intravascular
- 20 % (200 mg/l) 50 ml bottle, used for treatment of hypoalbuminemia.

Transfusion (Blood) Therapy

Transfusion Therapy

Indications for PRBC transfusion perioperatively:

- Bleeding
- Anaemia: Hb; threshold 7g/dl , 10 for patients with IHD.
- ? Haemoglobinopathies

Estimated total blood volume

- Neonates - 90 ml/kg
- Children - 80ml/kg
- Adult males - 70ml/kg
- Adult females - 60ml/kg

American College of Surgeons Classes of Acute Hemorrhage

Factors	I	II	III	IV
Blood loss	<15% (<750ml)	15-30% (750-1500ml)	30-40% (1500-2000ml)	>40% (>2000ml)
Pulse	>100	>100	>120	>140
B.P.	Normal	Normal	↓	↓↓
Pulse pressure	N or ↓	↓	↓↓	↓↓
Capillary refill	<2s	2-3s	3-4s	>5s
Resp. rate	14-20	20-30	30-40	>40
Urine output ml/hr	30 or more	20-30	5-10	Negligible
Mental status	Slightly anxious	Mildly anxious	Anxious & confused	Confused Lethargic

Blood Grouping
ABO & Rhesus System

Blood group	Antigen(s) present on the red blood cells	Antibodies present in the serum	Genotype(s)
A	A antigen	Anti-B	AA or AO
B	B antigen	Anti-A	BB or BO
AB	A antigen and B antigen	None	AB
O	None	Anti-A and Anti-B	OO

Blood transfusion tests:

- Group and screen
- Cross match

Group and Screen (Save)

- Test for patient blood group and availability of antibodies.
- Used when transfusion of blood is unlikely.

Cross Match

- Donor's erythrocytes (packed cells) incubated with recipients plasma.
- Agglutination Occurs if there is incompatibility.
- Used when transfusion is likely or massive bleeding is potential.

Transfusion

Ideally, transfused PRBC should be crossmatched, but:

- Universal donor (O Neg) can be given in emergency when the blood group of the patient is not known.
- If transfusion needed urgently for a patient with known blood gorup, then group specific PRBC should be given.
- Crossmatch generally requires 35 to 45 min.

Platelet Concentrate

- Thrombocytopenia,
- Low platelet perioperatively, bleeding
- During massive transfusion
- 1:1:1 ratio.

Plasma and FFP

- Indications
  - Coagulation Factor deficiency, fibrinogen replacement, massive transfusion, emergency warfarin reversal.
- Massive transfusion ratio 1:1:1

Cryprecipitate

- Derived from Plasma
- Rich in fibrinogen, Von willebrand factor, factor VIII.
- Used in cases of low fibrinogen levels and massive bleeding.

Transfusion Complications

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

Transmission of Viral Diseases:

- 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 and test detection
  - CMV may be the most common agent transmitted, but only effects immuno-compromised patients
  - Parasitic and bacterial transmission very low

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

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.

Blood Preserving Techniques

Autologous Blood donation

- 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 hr prior to surgery
- Reduces chance of hemolytic reactions and transmission of blood-born diseases
- Not desirable for compromised patients.

Autotransfusion

- Commonly known as “Cell-Saver”
- Allows collection of blood during surgery for re-administration
- RBC’s centrifuged from plasma
- Effective when > 1000ml are collected
- Malignancy, Infections, are contraindications

Blood substitutes: oxygen carriers

- Still under research.
- Perfluorocarbons.
- Stromal free hemoglobin.
- Micro-encapsulated hemoglobin.

References and further readings:

- Fundamentals of Anaesthesia, Tim Smith fourth ed. Cambridge.
- Basic physiology for anaesthetists. David Chambers. Cambridge.
- Rapid Review Physiology, T.Brown.Elsevier
- Up-to-date website.

Thank you