FLUID MANAGEMENT AND BLOOD TRANSFUSION

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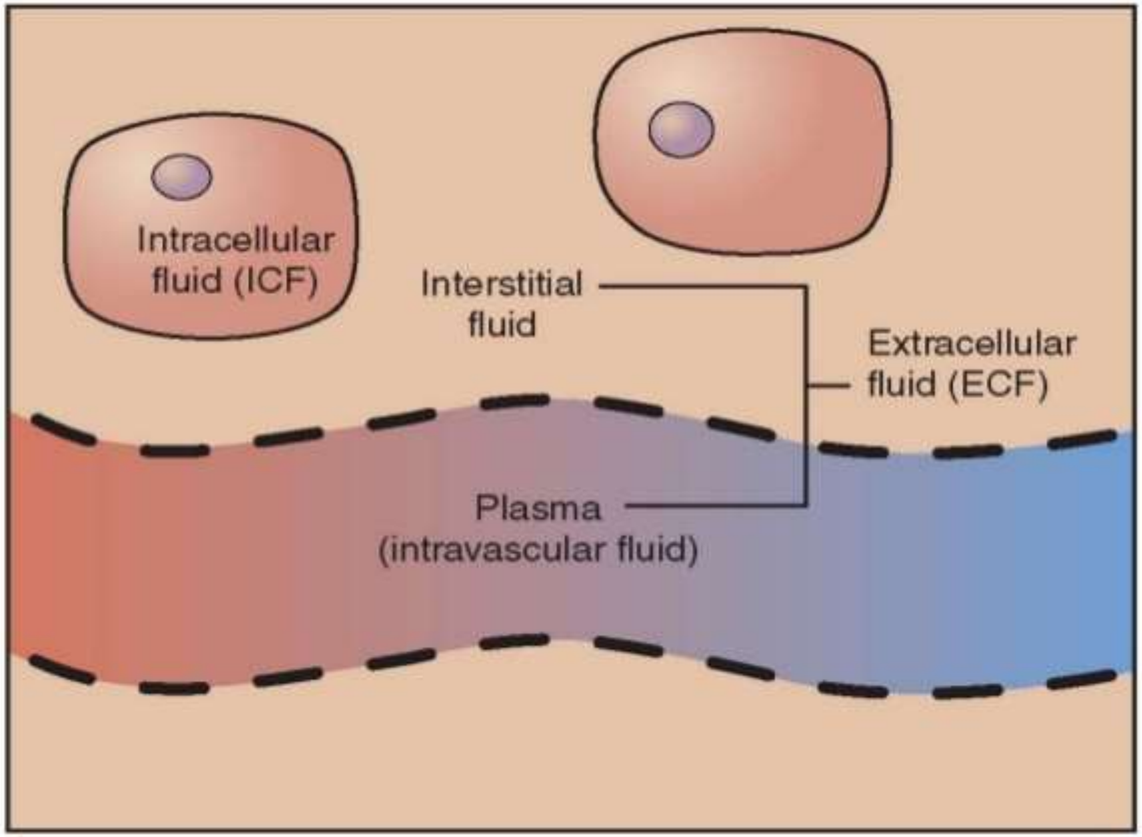
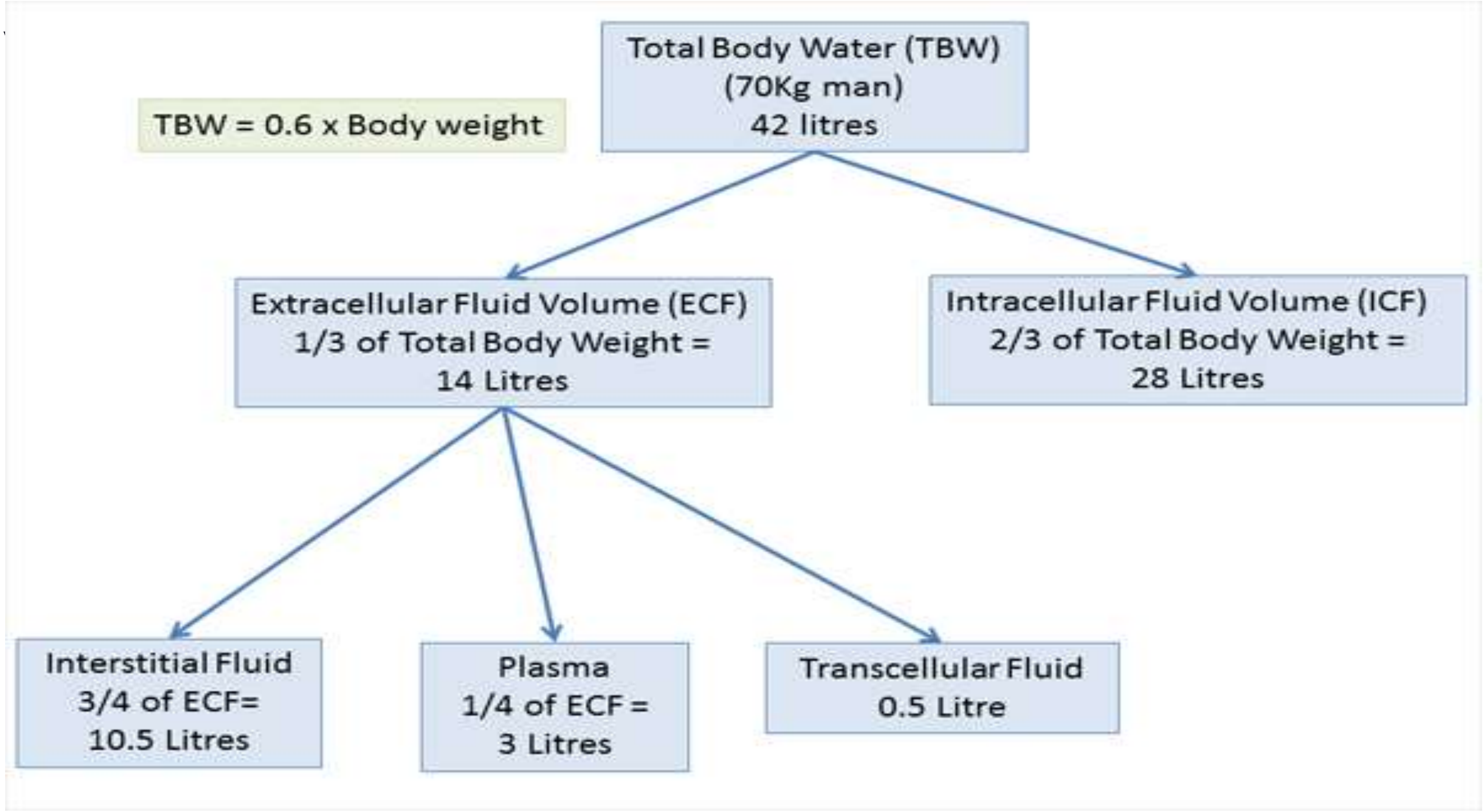
FACHARZT.


Intracellular
fluid (ICF)
Interstitial
fluid
Extracellular
fluid (ECF)
Plasma
(intravascular fluid)

Body Fluid Compartments

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



Body Fluid Composition in Age Groups

AGE	TBW AS % OF TOTAL BODY WEIGHT
Neonate	80
6 months	70
1 year	60
Young adult	60
Elderly	50

Composition of Body Fluid Compartments

Ion	Plasma (mmol/L)	ICF (mmol/L)
Na+	143	9
K+	5	135
Ca2+	1.3	<0.8
Mg2+	0.9	25
Cl-	103	9
HCO3-	24	9
HPO42-	0.4	74
Sulphate-	0.4	19
Proteinate-	1.14	64

ESSENTIAL PRINCIPLES

Osmolarity and Osmolality

- These are ways of quantifying how much of a solute is dissolved in a solution.

- ***Osmola(R)ity*** No. of osmoles of solute particles per unit VOLUME of solution and has units **osmoles/litre**. In the body we use **milliosmole**

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

Plasma Osmolality

Plasma osmolality = 2 (Na + K) + glucose + urea

= 2 (137 + 4.0) + 5.0 + 4

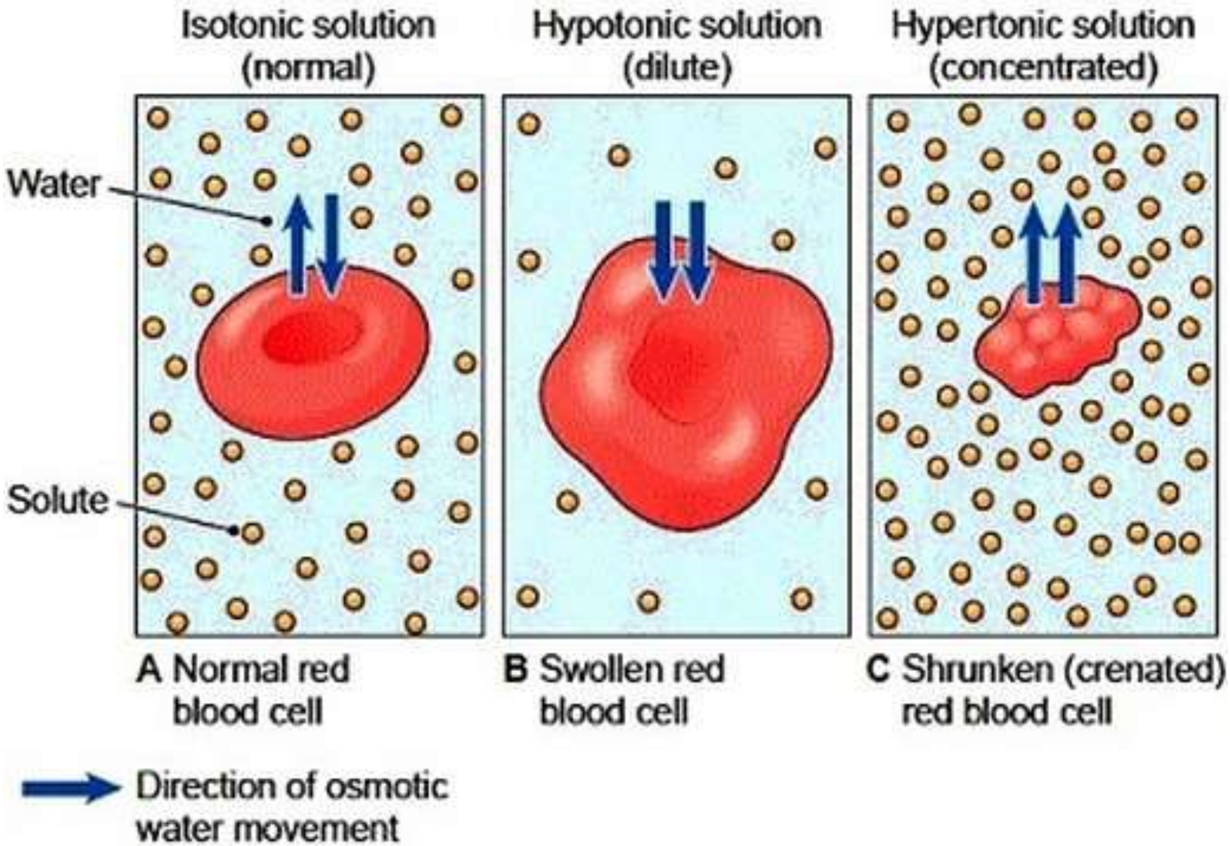
= 291 mosmol/kg H20

Glu: /18

Urea: /2.8

Tonicity

- A way of describing the relative solute concentrations of two solutions which are separated by a selectively-permeable membrane (often called a semi-permeable membrane).


Isotonic solution
(normal)
Hypotonic solution
(dilute)
Hypertonic solution
(concentrated)
Water
Solute
A Normal red
blood cell
B Swollen red
blood cell
C Shrunken (crenated)
red blood cell
Direction of osmotic
water movement

WHAT IS THE ‘NORMAL’ DAILY INTAKE AND OUTPUT OF FLUID AND ELECTROLYTES?

OUTPUT,   INTAKE

- 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.

OUTPUT	
Urine	1500 ml
Gastrointestinal(faeces)	200 ml
Skin(sweat)	400 ml
Respiratory	400 ml
Total	2500
INTAKE	
Drinking	1500 ml
Eating	750 ml
Metabolism	250 ml
Total	2500

- The above volumes do not contain just water but also electrolytes….

ELECTROLYTE	DAILY LOSS / REQUIREME NT	75 Kg PERSON PER DAY
Sodium	1-1.5 mmol/kg	75 - 112.5 mmol
Potassium	1-1.5 mmol/kg	75 – 112.5 mmol
Magnesium	0.1-0.2 mmol/kg	7.5 – 15 mmol
Calcium	0.1-0.2 mmol/kg	7.5 – 15 mmol
Chloride	0.07-0.22 mmol/kg	5.25 – 16.5 mmol
Phosphate	20-40 mmol/kg	1500 – 3000 mmol

Maintenance and Deficit

- Maintenance Vs deficit

- Rule of 4 /2/ 1

- Ex. 70 kg patient

  1st 10 kg: 10 kg * 4 ml = 40 ml / kg

  2nd 10 kg: 10 kg * 2 ml = 20 ml / kg

  3rd 10 kg: 50 kg * 1 ml = 50 ml / kg

Total=110ml/kg

- Ex. Fasting for 10 hr without any intake: 10*110= 1100ml

Allowable Blood Loss (ABL)

- EBV = weight (kg) * Average blood volume
- Allowable Blood Loss = [EBV*(Hi-Hf)]/Hi
- Where:
  - EBV=Estimated Blood Volume
  - Hi= initial hemoglobin (Hct)
  - Hf= final hemoglobin (Hct)

- Normal Hct Values
  - Men 42-52%
  - Women 37-47%

Estimated Blood Volume (EBV)

- Men 75 ml / kg
- Women 65 ml / kg
- Infants 80 ml / kg
- Neonates 85 ml / kg
- Premature Neonates 96 ml / kg

INTRAVENOUS FLUIDS

Types

- Three main types
  - Crystalloids
  - Colloids
  - Blood products

Crystalloids ...

- Solutions that contain a combination of water and electrolytes.

- Divided into "***balanced***" salt solutions (e.g. Ringer's lactate) and ***hypotonic*** solutions (e.g. D5W).

- Classified into three groups based on their predominant use
  - Replacement Solutions
  - Maintenance Solutions
  - Special Solutions

Replacement Solutions

- Used to replace ECF
- All isotonic, usually replace losses that involves both water and electrolytes
- Have a [Na+] similar to that of the ECF which effectively limits their fluid distribution to the ECF compartment.
- Distributes between the ISF ¾ and the plasma ¼ in proportion to their volumes

Ringer's Lactate (Hartman's)

- Na^+ = 131 mmol/L
- Cl^- = 111 mmol/L
- Lactate = 29 mmol/L
- K^+ = 5 mmol/L
- Ca^{++} = 2 mmol/L
- PH = 6.5
- Osmolality = 279 mosm/L
- Potential problem = potassium may accumulate,

Maintenance Solutions

- Isosmotic as administered but not necessarily isotonic
- Usually used when the loss involves mainly pure water
- Ex. D5W, Normal Saline

Normal saline (0.9% saline solution)

- 9 g of NaCl/L water
- 154 mmol/L sodium
- 154 mmol/L chloride
- Osmolality = 308 mosm/L
- PH = 5.0
- Potential problem = hyperchloraemic metabolic acidosis, more likely with renal insufficiency

Special Solutions

- Hypertonic (3%) saline.... hyponatremia
  - 30 gm NaCl, 1027, 4.5 to 7.0

- Half normal saline.... hypernatremia
  - 77 meq/L

- 8.4% Bicarbonate solution... acidosis

- Mannitol 20%....brain oedema, pulmonary oedema


colloids...
500 ml
Dextran 40 Injection I.P.
RALLIDEX D
रैलिडेक्स डी
IN DEXTROSE INJECTION
D
SHREYA
Tetraspan 6%
6% HES
130/0.42
500 ml
B BRAUN
Haemaccel
500 ml

Starches

Colloids

- Colloid: a large molecule that does not diffuse across semipermeable membranes (capillary)

- Exerts an osmotic pressure in the blood, causing fluid to remain within the vascular system. The result is an increase in intravascular volume.

- Two categories of colloid may be defined:
  - Natural (e.g. human albumin)
  - Artificial (e.g. gelatins, dextran and hydroxyethyl starches [HES]).

Albumin

- Half-life ($t_{1/2}$) = 1.6 hours in plasma
- Stays within the intravascular space unless the capillary permeability is abnormal
- 5% solution - isotonic; 20% solutions - hypertonic
- Expands volume 5x its own volume in 30 minutes
- Side effects - volume overload, fever (pyrogens in albumin), defects of haemostasis

Dextran

- High MW polysaccharide
- Dextran 40 - MW 40,000
- Dextran 70 - MW 70,000
- 10% solution in NS or D5W
- Side effects: anaphylaxis, coagulopathy, renal failure
- Dose: limit to 20 ml/kg/day
- Used as antiaggregant in patients undergoing vascular and microvascular surgical procedures

PERIOPERATIVE BLOOD TRANSFUSION

Purpose of Infusion of Fluids and Blood Products

- Maintain organ transfusion
- Normal blood pressure and heart rate, normal mental status (in non-comatose patients), normal oxygen saturation, normal urine output, well perfused extremities

Blood Products

- Whole blood
- Packed Red Blood Cells
- Platelets
- Fresh Frozen Plasma
- Cryoprecipitate
- Human Albumin

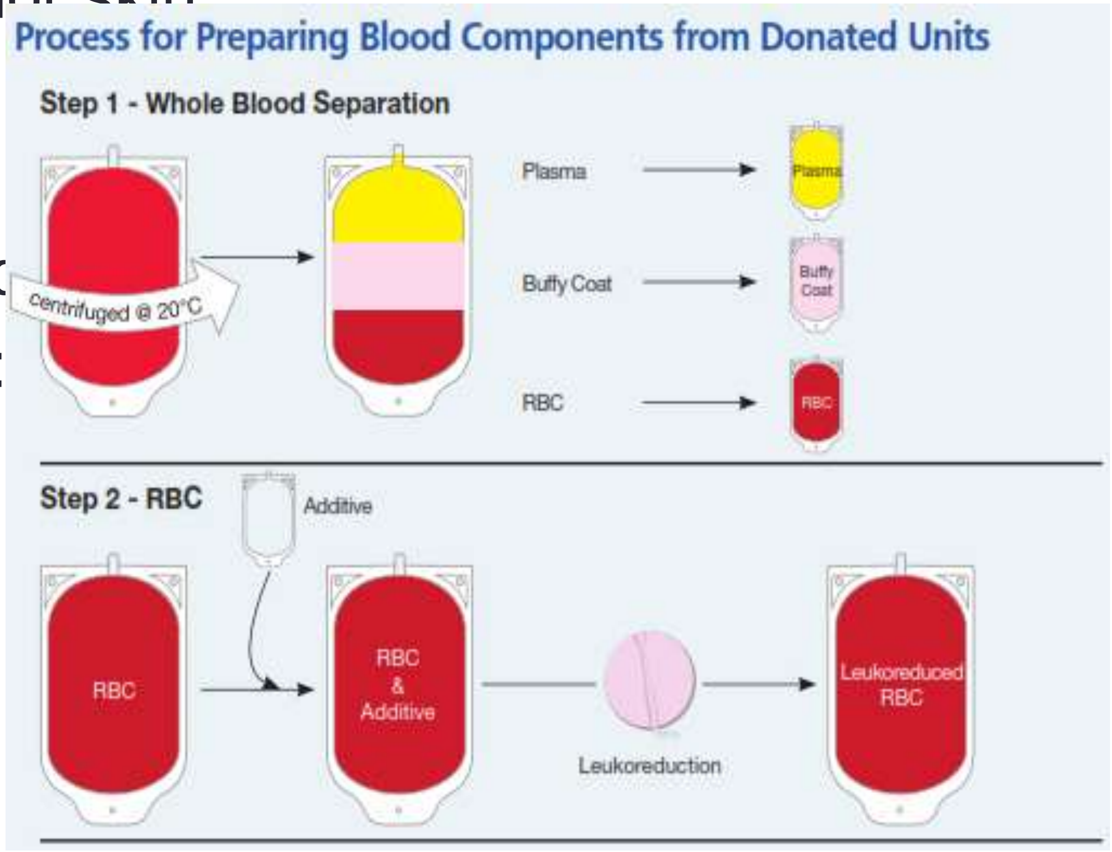
BLOOD BANK PRACTICES

Preparation of Blood Components

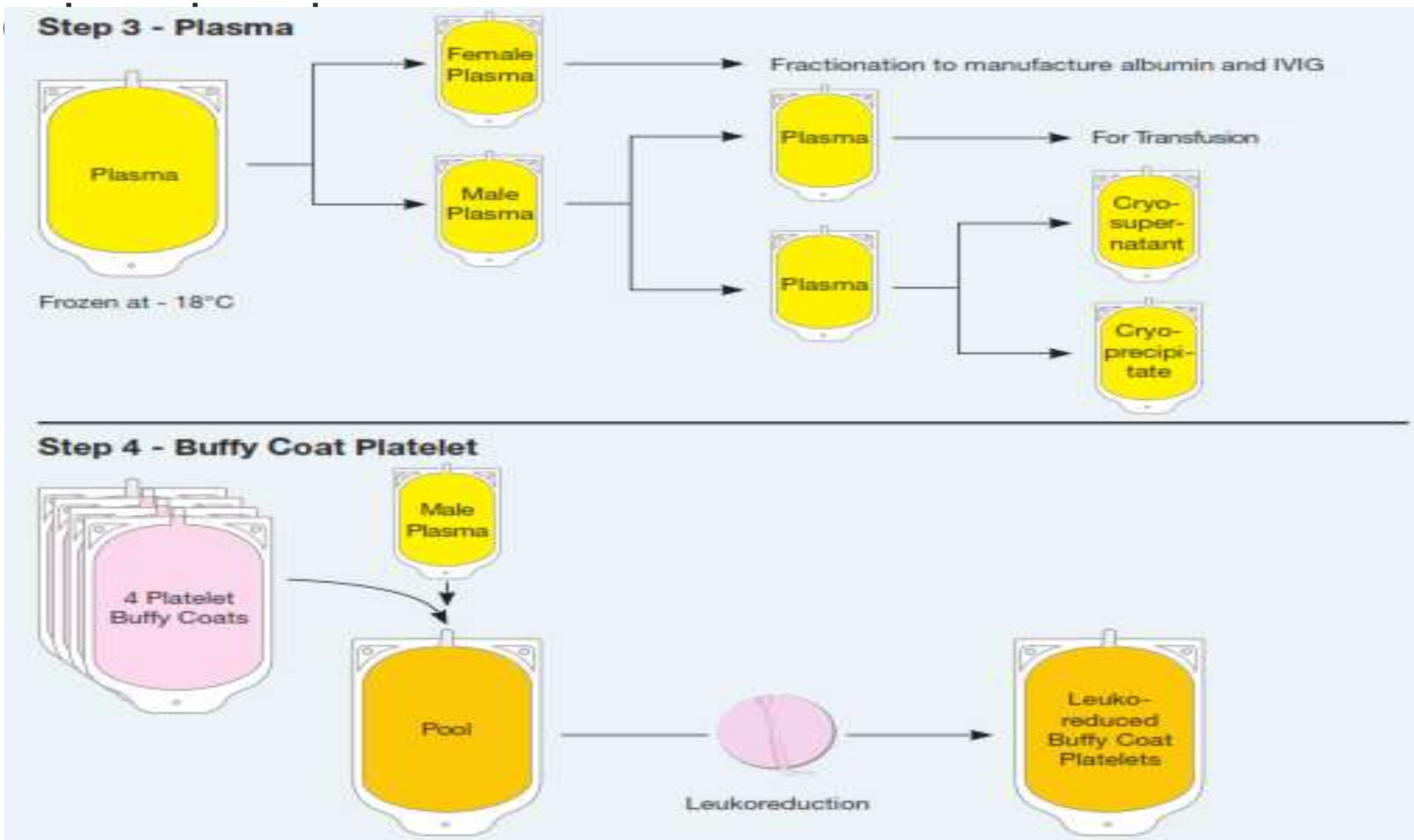
- Blood donors:
  - Approximately 17 million units of blood are donated in Europe each year.
  - Each donor is interviewed for medical history of known infectious diseases
  - Each unit is screened for antibodies to:
  - Syphilis
  - Hepatitis B and C
  - HIV 1 and 2
  - +/- CMV

Centrifugation

- Collect 500 mL whole blood
- Divert the first 40 mL to reduce risk of bacterial contamination from donor skin
- The 40 mL are used for donor unit testing
- Blood is centrifuged and separated into 3 parts:
- ◆ Red Blood Cells
- ◆ Plasma
- ◆ Buffy coat



- The Buffy coat units from four donors are further processed to separate the platelets
- The red blood cell and platelet components are



- Separated of blood components by 1 unit of **Whole blood**:

- **PRBCS**(hematocrit 70%):
  - 250 mL+saline preservative=350 mL.
  - 1–6°C.
  - May be frozen in a hypertonic glycerol solution for up to 10 years(rare phenotypes)

- A preservative–anticoagulant solution is added. The most commonly used solution is **CPDA**-1:
- **C**itrate as an anticoagulant (by binding calcium)
- **P**hosphate as a buffer
- **D**extrose as a RC energy source
- **A**denosine as a precursor for ATP synthesis.
- 35 days
- AS-1 (Adsol) or AS-3 (Nutrice) extends the shelf-life to 6 weeks.
- ADSOL (Adenine, glucose, mannitol and sodium chloride)
- NUTRICE (Adenine, glucose, citrate, phosphate and NaCl)

- **Platelet:**
  - 50–70 mL.
  - 20–24°C for 5 days.

- **Plasma:**
- The remaining plasma supernatant is further processed and frozen to yield fresh frozen plasma; rapid freezing helps prevent inactivation of labile coagulation factors (V and VIII). Slow thawing of fresh frozen plasma yields a gelatinous precipitate (cryoprecipitate) that contains high concentrations of Factor VIII and fibrinogen.
- 200 mL.
- Once thawed it must be transfused within 24 h.

BUT BEFORE EVERYTHING THE BLOOD BANK HAS TESTS TO COMPARE THE BLOOD OF THE DONOR TO THE BLOOD OF THE RECIPIENT

So you must know the blood groups

Blood Groups

- At least 20 separate blood group antigen systems are known; fortunately, only the ABO and the Rh systems are important in the majority of blood transfusions.

The ABO System

- Simply speaking, the chromosomal locus for this system produces two alleles: A and B. Each represents an enzyme that modifies a cell

Incidence	Naturally Occurring Antibodies in Serum	Type
45%	Anti-B	A
8%	Anti-A	B
4%	—	AB (Universal recipient)
43%	Anti-A, anti-B	O (Universal donor)

COMPATIBILITY TESTING

Intra-operative Transfusion Practices

Packed Red Blood Cells

- Ideal for patients requiring RCs but not volume replacement (eg, anemia pt in compensated CHF).
- Hgb 7-8 g/dL (<6, most people require blood >10 most people do not)
- Each unit raise Hgb by 1g/dl
- 170-µm filter to trap any clots or debris.
- Warming to 37°C during infusion.
- Hypothermia and low levels of 2,3-diphosphoglycerate (2,3-DPG) in stored blood can cause a marked leftward shift of the hemoglobin–oxygen dissociation curve
- ABO-compatible units are mandatory.

Fresh Frozen Plasma

- FFP contains all plasma proteins, including all clotting factors.
- Indications:
  - Isolated factor deficiencies.
  - Reversal of warfarin therapy.
  - Coagulopathy associated with liver disease
  - CABG,bleeding+NL ACT.
  - Massive blood transfusions.
  - Antithrombin III def.

- The initial therapeutic dose is usually 10–15 mL/kg
- ABO-compatible units are mandatory.
- Coagulation factors INR 1.4-1.6 (INR>1.6, most people require FFP transfusion for major surgery; INR<1.4, most people do not require)

Platelets

- Thrombocytopenia or dysfunctional platelets .
- Surgery or invasive procedures: 70,000 x 10^9
- Vaginal delivery and minor surgical procedures: 50,000 x 10^9/L.
- Each unit expected to increase the count by 10,000–20,000 x 10^9/L.
- ABO-compatible platelet transfusions are desirable but not necessary

Cryoprecipitate

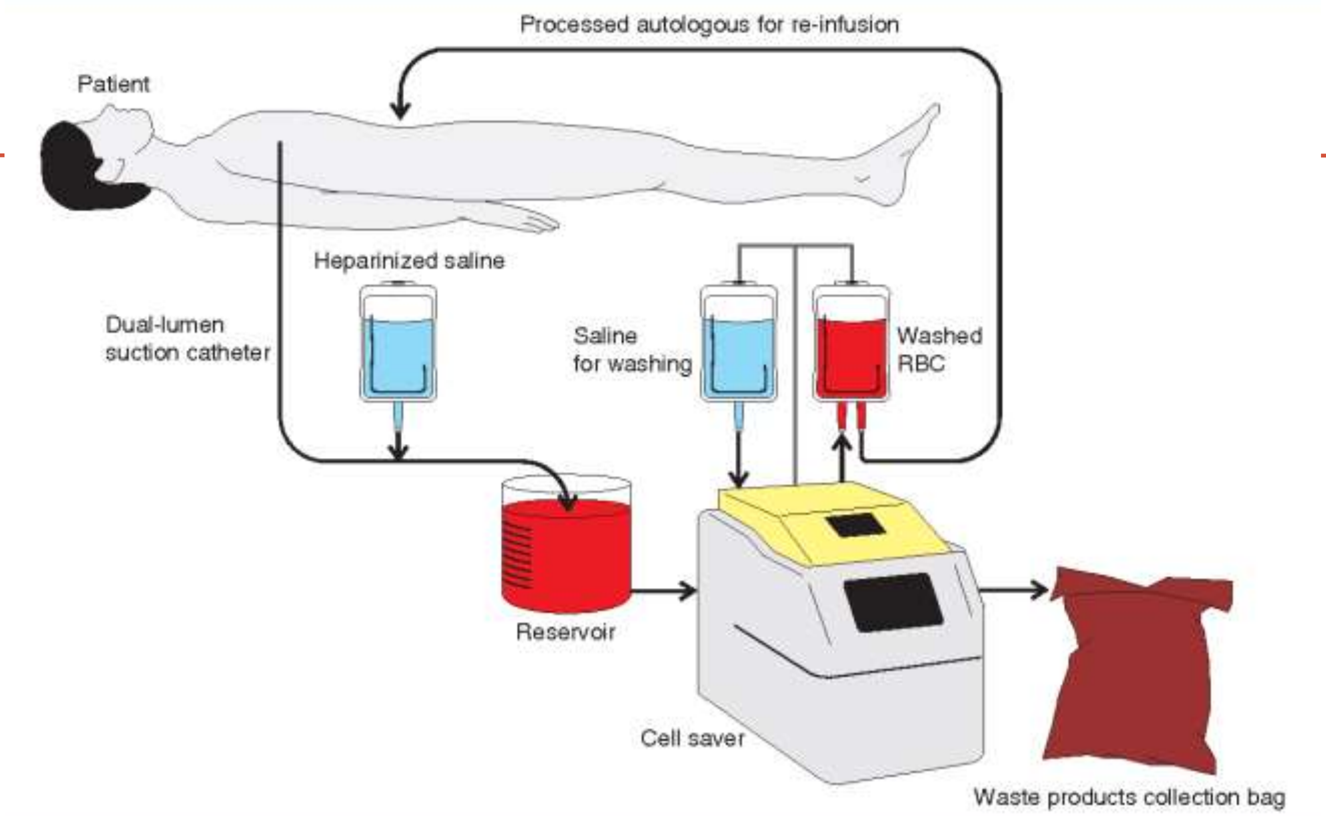
- Each unit (15 ml) contains fibrinogen 150 mg, factor VIII 100 units, von Willebrand factor (vWF) (100 units)

- DIC, hemophilia A, von Willebrand disease, quick reversal of thrombolytic therapy

- Fibrinogen (most people require cryoprecipitate for major surgery if fibrinogen < 1 g/dL)

CELL SAVER

CELL SAVER


Processed autologous for re-infusion
Patient
Heparinized saline
Dual-lumen
suction catheter
Saline
for washing
Washed
RBC
Reservoir
Cell saver
Waste products collection bag

LEVEL 1 (A) INFUSION PUMP

Complications of Blood Transfusion

- Hemolytic reactions
  - Acute Vs. Delayed
- Febrile Non hemolytic reactions
- Transfusion Related Acute Lung Injury (TRALI)
- Infectious complications

TRALI

- ARDS following blood transfusion
- High morbidity … mechanical ventilation
- Lung injury is generally transient with PO2 levels returning to pretransfusion levels within 48 -96 hours and CXR returning to normal within 96 hours.
- Mortality rate, often approximated at 5 to 10%
- Treatment as ARDS

APPROACHES TO FLUID MANAGEMENT

The "Classic" Approach

- Step 1: Calculate Ongoing Maintenance Requirements

4/2/1 rule: 4 cc/kg/hr for the first 10 kg, 2 cc/kg/hr for the second 10 kg, and 1 cc/kg/hr for every kg above 20.

Ex. 70kg → 10 * 4 ml = 40 ml

10 * 2 ml = 20 ml

50 * 1 ml = 50 ml

110ml / hour given each hour as oral or enteral intake is stopped

Ex. 15kg → 10 * 4 ml = 40 ml + 5 * 2 ml = 10 ml = 50 ml / hour

- Step 2:Calculate Preoperative Fluid deficit

Maintenance * the time without intake what so ever

Ex. 70kg fasting for 10 hours pre-operatively

M = 110ml/hour * time 10 hour = 1100 ml

- Step 3: Calculate Anticipated Surgical Fluid Losses
- Minimal tissue trauma (ex. herniorrhaphy): 0-2 cc/kg/hr
- Moderate tissue trauma (ex. cholecystectomy): 4-6 cc/kg/hr
- Severe tissue trauma (ex. bowel resection): 8-10 cc/kg/hr

- Ex. 70kg undergoing major laparotomy →

10 ml * 70 kg = 700 ml/hour as long as surgery is going on

- Step 4: Adjust for Blood Losses

- A common recommendation is to give 3-4 cc of crystalloid for every 1 cc of blood loss

- Remember to add up suction volume, lap pads (100-150 cc each if fully soaked) and 4x4 small pads (10 cc each if fully soaked)

Ex. In the 1st hour of laparotomy there was 200ml of pure blood in the suction jar, 2 fully soaked lap pads, and 10 fully soaked small gauses

200 ml + 2 * 150 ml + 10 * 10 ml = 600 ml (in that hour) to be replaced with either 600 * 4 of cryst. or -if indicated- 600 ml of blood

- 1^{st} hour = Maintenance + ½ Deficit + Blood loss + Ongoing loss
- 2^{nd} hour = Maintenance + ¼ Deficit + Blood loss + Ongoing loss
- 3^{rd} hour = Maintenance + ¼ Deficit + Blood loss + Ongoing loss
- Maintenance continued post-operatively as long as fasting
- Blood loss replaced as long as there is bleeding
- Ongoing loss as long as the surgery continues

THANK YOU