Calculations

Agenda

- TBV
- TPV
- BSA
- ECV
- Collection efficiencies
- Total processed volume
- Ratio
- Hb → Hct

Total blood volume

- 5 liter

TBV

- Nadler's formula
- Gilcher's rule of five
- Other calculations

Nadler's Formula

For Males = (0.3669 * Ht^3 in M) + (0.03219 * Wt in kgs) + 0.6041

For Females = (0.3561 * Ht^3 in M) + (0.03308 x Wt in kgs) + 0.1833

Note:
* Ht in M = Height in Meters
* Wt in kgs = Body weight in kilograms

Gilcher's rule of five

Gilcher's Rule of Fives				
	Blood Volume (mL/kg of Body Weight)			
Patient	Obese	Thin	Normal	Muscular
Male	60	65	70	75
Female	55	60	65	70
Infant/Child	-	-	80/70	-

Others

Age group	Approximate blood volume (mL/Kg)
Premature infant, at birth	90-105
Term newborn infant	80-90
Children > 3 months	70-75
Adolescents and adults Male Female	 70 65

Others

	BMI < 18.5	BMI 18.5-24.9	BMI 25-29.9	BMI >30
Blood volume	80 mL/kg	70 mL/kg	65 mL/kg	55 mL/kg

Body Mass Index

$$BMI = \frac{Wt}{H^2}$$

Wt = 75 kg
H = 1.70 m

BMI = 75 / (1.7 * 1.7) = 26 kg/m^2

Body surface area

$$BSA\ (m^2) = \sqrt{\frac{Height\ (cm) \times Weight\ (kg)}{3600}}$$

Wt = 75 kg
H = 1.70 m

BSA = ((170 * 75) / 3600)$^{0.5}$ = 1.88 m^2

ECV

- Maximally 15% of TBV
- Important to know:
  - Volume disposable
  - Volume to collect
  - Tubes collected
  - TBV patient / donor

ECV

- ECV disposable Cobe Spectra 285 mL
- Volume to collect 300 mL
- Total ECV will be 585 mL
- 585 mL of ECV is 15% of 3,900 ml TBV meaning take care of smaller patients

Extra corporeal red cell volume (ECRV)

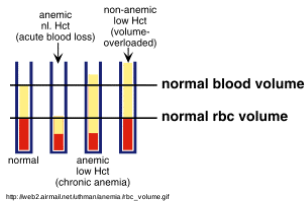
- Advice: maximal 15%
- Content in disposable and (if taken) tubes

- Female patient of 1,50 m and 45 kg, Hct 20% → TBV 2900 mL; RBCvolume 580 mL →ERCV maximal 87 mL
- Female patient of 1,30 m and 20 kg, Hct 20% → TBV 1650 mL; RBCvolume 330 mL →ERCV maximal 50 mL

Total plasma volume

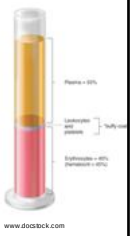
TPV = TBV * (1 – Hct)

$$TPV = \frac{TBV * (100 - Hct)}{100}$$



Hematocrit

- The volume percentage of red blood cells in blood
- Females 0.36 – 0.46 L/L (36 – 46%)
- Males 0.41 – 0.53 L/L (41 – 53%)



Total plasma volume & Hct

TPV = TBV * (1 – Hct)

$$TPV = \frac{TBV * (100 - Hct)}{100}$$

TBV = 5,000 mL

Hct = 50% TPV = 5,000 * 0,5
2,500 mL

Hct = 30% TPV = 5000 * 0.7
3,500 mL

Higher volume for plasma exchange

Relation apheresis & Hct → plasmapheresis

Reservoir for temporarily storage of cells → 200 mL of Hct = 80%
→ In reservoir 160 mL cells

Hct = 50% Processing of 320 mL
→ Collection of 120 mL of plasma

Hct = 40% Processing of 400 mL
→ Collection of 200 mL of plasma

Higher Hct → more donor blood needs to be processed for plasma collection

Hct and apheresis

- High Hct plasma donors
- Low Hct in patients for TPE

- Longer plasmapheresis procedures
- More blood needs to be processed
  - Procedure time ↑
  - Replacement fluids ↑

Weight and volume

You have a bag of plasma weighing 500 gram. What is the volume?

Gram to mL:
Mass (gram) / Density (specific gravity) = Volume (mL)

mL to gram:
Volume (mL) * Density (specific gravity) = Mass (gram)

Blood densities

	Specific gravity	Size
Plasma	1.026	
Platelets	1.040	1-4 µm
Lymphocytes	1.050-1.061	6-10 µm
Monocytes	1.077	10-30 µm
Basophils	1.080	10-15 µm
Eosinophils	1.082	9-15 µm
Neutrophils	1.088	12-15 µm
Erytrocytes	1.100	6-8 µm

Weight and volume

You have a bag of plasma weighing 500 gram. What is the volume?

Gram to mL:
500 gram / 1.026 = 487.3 mL

You have a bag with a volume of 500 mL. What is the weight?

mL to gram:
500 mL * 1.026 = 513 gram

Collection efficiency

How many of the by the machine processed cells are collected in the bag

e.g. platelets

$$\frac{T_{product}}{((T_{pre} + T_{post}) / 2) * (\text{Processed volume} - \text{AC volume})} * 100$$

$$\frac{T_{product}}{T_{pre} * (\text{Processed volume} - \text{AC volume})} * 100$$

Collection efficiency

e.g. platelets

$$\frac{T_{product}}{((T_{pre} + T_{post}) / 2) \times (\text{Processed volume} - \text{AC volume})} \times 100$$

T product 350 x 10^9/unit
T pre 280 x 10^9/L
T post 200 x 10^9/L
PV – AC 2,000 mL

$$CE = \frac{350}{((280+200)/2) \times 2} \times 100 = 72.9\%$$

Collection efficiency

CD34 product 4 x 10^6 / kg of the recipients' body weight

$$\frac{CD34_{product}}{(CD34_{pre}) * (\text{Processed volume} - \text{AC volume})} \times 100$$

Body weight recipient 70 kg → product = 70 x 4 = 280 x 10^6 CD34 collected

We processed 15 L without ACD-A
$CD34_{pre}$ 30 x 10^6/L

$$\text{Therefore } CE = \frac{280}{30 \times 15} \times 100 = 62{,}2\%$$

Calculating TBV to be processed

- Don't process standard volumes e.g. 15 liter or always 3x TBV
- Be aware of CD34 count in donor / patient

Calculating TBV to be processed

- TBV = $\frac{CD34_{needed} \text{ x body weight patient}}{CD34_{donor} \text{ x collection efficiency}}$

$CD34_{donor}$	35 x 10^6/L = 35 / µL
$CD34_{needed}$	3 x 10^6/kg
BW patient	65 kg
Mean Collection efficiency	45%

TBV = $\frac{3 \times 65}{35 \times 0.45}$ = 12.5 Liter ***uncoagulated*** blood

Calculating TBV to be processed

TBV = $\frac{3 \times 65}{35 \times 0.45}$ = 12.5 Liter ***uncoagulated*** blood

In case of AC ratio = 1 : 12

Total processed volume must be at least:

12,500 + (12,500 : 11) = 12,500 + 1,136 = 13,636 mL

Ratio

e.g. AC : WB ratio = 1 : 12

→ 1 mL of AC is added to 12 mL of whole blood

OR

→ Off 12 mL of processed volume 1 mL is AC
so 1 mL AC is added to 11 mL of whole blood

Product yield → 3x TBV processing

$\frac{CD34_{donor} \text{ x } TBV_{donor} \text{ x } 3 \text{ x } CE_{mean}}{1000} = CD34_{product}$

e.g.

$CD34_{donor}$	35 x 10^6/L = 35 / µL
BW donor	80 kg
TBV donor	80 x 70 = 5,600 mL
Mean Collection efficiency	45%

$\frac{35 \times 5600 \times 3 \times 0.45}{1000}$ = 265 x 10^6 / unit

or for patient 65 kg = 265 : 65 = 4 x 10^6 / kg

Calculation Hb g/dL into mmol/L and vv

- 1 g/dL = 0,62 mmol/L
- 1 mmol/L = 1,61 g/dL

Calculation Hb into Hct

Note: Hb and Hct are two different things
- Hct is percentage of RBCs in blood
- 97% of RBC content is Hb

- g/dL → Hct is roughly 3x Hb
- mmol/L → ((Hb x 10) :2) -2

Calculation Hb into Hct

- g/dL → Hct is roughly 3x Hb
- mmol/L → ((Hb x 10) :2) -2

Hb = 16.1 g/dL = 10 mmol/L

- g/dL → Hct = 3 x 16.1 = 48%
- mmol/L → Hct = ((10 x 10) :2) -2 = 48%

In summary

- TBV
- TPV
- BSA
- ECV
- Collection efficiencies
- Total processed volume
- Ratio
- Hb → Hct