# Blood composition, function and viscosity

DR. ARWA RAWASHDEH

# Blood

- Plasma and cells

Function:

Transport

Defense

Hemostasis

Homeostasis

Plasma : water and protein 55%

Cells: 45%

# Blood composition

TBW= 60% of TBW
ECF 1/3 of TBW
Plasma ¼ of ECF
Plasma 3L of plasma
90% water
Inorganic sub 0.9%
cation : Na+
Anion : CL-
Organic substance 9.1%

plasma protein : albumin and globulin
lipids and protein: lipoprotein
Plasma lipids: cholesterol,Triglycerides, phospholipids
Miscellaneous : glucose and vitamins
Gases

Albumin
, Globulin,
Fibrinogen,
Prothrombin
In the liver
Albumin/Globulin 4 g/dl/ 2.5 g/dl 1.2 – 1.6 normal
lower cirrhosis and nephrosis
Except: gamma globulin plasma cells, B lymphocytes, Bone marrow and lymphoid organs

Globulins
Apha 1 anti trypsin
Alpha2 Angiotensinogen
B coagulation factors transferrin
Coagulation factor number 4 is calcium
Gamma anti bodies MAGED

Hypoprotinemia , Nephrotic syndrome

Malnutrition

Kwashiorkor syndrome

Not making protein

Cirrhosis

losing protein

Kidney: Nephrotic syndrome

Stool: Malabsorption syndrome or menetrier syndrome ; gastropathy

Plasma protein function

Amino acids source

Buffering

Blood viscosity 1.5 times than water resistance

Coagulation ( 2 hemostasis)

Capillary function: permeability

Defense mechanisms; immunoglobulins

Oncotic pressure

:push hydrostatic

pulls oncotic

Transport: albumin ca

globulins : Thyroid, cortisol, estrogen, testosterone

# Resistance

- *How to relate TPR to blood pressure*
- $\boldsymbol{F = \Delta P / R}$
- $\boldsymbol{CO = \Delta P / TPR}$
- $\boldsymbol{R = 8nl/\pi r4}$ $Poiseuille's\ law$
- $\boldsymbol{n\ \alpha\ R}$
- $\boldsymbol{n =\ viscosity}$

*Polycythemia (high Hct)*$\alpha\ n$*; a lot of friction between the layers, because whenever blood is flowing it flows in layers when there is a lot of friction rubbing up against between those layers because increase in viscosity and slow the flow down*

*Anemia* $\frac{1}{\alpha} n$

$\boldsymbol{L\ \alpha\ R}$

*Increase in Weight and height increases in L*

$\boldsymbol{r = 1/\alpha\ R}$ ***the most important factor that affecting the R because it is raised to power 4***

*Vasodilation increase in r*

*Vasoconstriction decrease in r*

- Blood volume = The blood cells 3% of body weight + blood plasma 5% of body weight =8% of our body weight expressed in kg
- 8% × 70kg = to 5.6L = 5.6 kg
- Total Blood Volume (TBV) = Plasma Volume / 1- Hematocrit (PCV)
- Total Blood Volume (TBV)= 2.8 / 1- 45%= 5.6L
- One pint (blood unit)= 500ml or half a court ( one quart = 2 pints)
- In this example you got 10pints in your blood . So when you donate 1 pint you giving less than 1/10 of your blood body.
- If you gave twice that you will lose a litre of blood, half a court of blood then you need a medical attention.
- So the person who less than 100 bound doesn't give blood. In other word when you donate blood you given 10% or less
- Blood Plasma =55% × 5.6L
- Blood cell =45% × 5.6L

# RBCS

- Biconcave
- Non nucleated
- 120days

Hgb A,C  blood sugar over 3 to 4 months

High EPO
Neonates
Athletes
High altitudes

RBCS  Hg  heme and globulins  Heme:  iron and protoporphyrin
protoporphyrin:  biliverdin
biliverdin: unconjugated  bilirubin
liver: conjugated

# Pluripotent

Stem cells in the bone marrow

- Multipotent stem: produce different cells Myeloid and lymphoid
- Myeloid: proerythroblast ( RBCS), myeloblast ( WBCS) granulocytes, monoblast Agranulocyte cells, megakaryoblast platelets

Lymphoid: B and T

Hematopoiesis: yolk sac 3-8 wk , 6w liver, 8w spleen, 18w Bone marrow

Erythropoietin EPO

Normal cell: interstitial cells of the peritubular capillary bed in the cortex

Androgen and estrogen: androgen more effect

Cancer cell: Renal cell and hepatocellular carcinoma newplastic syndrome

hypoxemia and anemia

O2 content=sat+PaO2

Hypoxmia frees oxygen

decrease O2 sat

high altitude

left shift

Except polycythemia vera low EPO

Artificial EPO (epoeitin) to increase energy

# Erythrocyte indices

RBCS count No of tubes

- Male 4.5-6 million M/L
- Female 4-5 million M/L

Hgb Conc weight of air in tubes

Hgb Conc amount/ volume g/dl

Male 14- 17 15

Female 12-15 13

Hematocrit (Hct)

Vol of RBCS/ Volume of blood volume of tube per volume of water

Male 45%

Female 40%

Mean corpuscular volume ( MCV) size of tube

Small cells low MCV mic

Large cells High MCV mac

Normal 80-100 fl

Mean corpuscular hemoglobin ( MCH) average weight in every tube

Average content of Hgb per red cells

MCH= Hb g/dl mass / RBC conut /ML X 10 picograms

Male: 30 picograms

Mean corpuscular hgb conc .(MCHC) average density

average content of Hb per unit volume of RBCS mass/volume density

MCHC= Hb/ Hct X100 Male: 33 g/dl

Red blood cells distribution width (RDW)

variation in diameter Anisocytosis (RDW)

11.5-14.5%

Significant if it elevated

Normocytic to

Microcytic iron deficiency anemia

Macrocytic anemia V B12

RDW in nutritional anemia not genetic like thalassemia

# Reticulocytes

( proerythroblast, normoblast, reticulocytes, eryrthrocytes)

Network and cells Large cells with bluish cytoplasm

Normally < 3%

Everyday 1-2%

Splenic macrophage Maturation 24hrs

Anemia increase the number of retic ( good response or effective erythropoiesis)

Corrected reticulocyte count (CRC) = HCT/Normal hematocrit X reticulocyte count

Additional correction of polychromasia ( baby retics) 2-3 days RBCS

CRC/2

- Retics index=3% HCT= 15% Normal= 45% 1%
- 1/2.5= 0.4 reticulocyte production index
- The bone marrow is not putting enough retics

- Retics index=18% HCT=15% Normal=45% 6%
- 6/2.5 =2.4 the bone marrow is putting enough retics

# Anemia

- Decreased O2 carrying capacity of blood

Oxygen content will decrease due to Hb concentration

SaO2 bound saturation  normal

PaO2 free  partial pressure  normal

- Decreased total RBCs mass
- Decreased  Hgb, RBCs or Hct  indicators

RBCS nuclear scan to measure mass literally

Signs ( doc discover during exam) and symptoms ( patient complain)

Tired and pale

Dizziness

Dyspnea

Flow murmur  low viscosity and flow fast

# Causes of Anemia

- Production defect

Bone marrow or kidney damage ( EPO) hypothyroidism ( hypometabolic)  low retic

- Maturation defects

cytoplasmic : Hgb: Iron , globin, DNA

nuclear: B12 and folate deficiency

- Survival defects

Intrinsic defect

Membrane  Spherocytosis

Enzyme  G6PD deficiency

Glycolysis ; phosph to pyruvate 2ATP , 2,3BPG increase right shift

NADPH reduced glutathione reduced $H_2O_2$

Fenton reaction

converting met fe+3 into Fe +2 and convert oxygen into superoxide

Hgb  sickle disease

Extrinsic attack RBCs

- Sequestration ( hypersplenism) portal hypertension
- Blood loss acute loss  peptic ulcer disease , hemorrhagic shock
- The most common cause of anemia in US is iron deficiency anemia