Blood composition, function and viscosity

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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 O2 CO2

Plasma proteins

- Albumin 3.5 -5 g//dl
- Globulin 2.5
- Fibrinogen, 0.4
- Prothrombin 0.01
- 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
- Beta coagulation factors transferrin
- Coagulation factor number 4 is calcium
- Gamma anti bodies MAGED

Hypoproteinemia

- Malnutrition

  Kwashiorkor syndrome

- Not making protein

  Cirrhosis

- losing protein

  Kidney: Nephrotic syndrome

  Stool: Malabsorption syndrome or menetrier’s syndrome ; gastropathy

Plasma protein function

- Amino acids source
- Buffering
- Blood viscosity 1.5 times than water resistance
- Coagulation (2 hemostasis) ; Coagulation factors
- 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

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 Hb+PaO2

Hypoxemia frees oxygen

decrease O2 sat

high altitude

left shift

Except polycythemia vera low EPO

Artificial EPO (epoetin) to increase energy

Erythrocyte indices

RBCS count No. of tubes

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

Mean corpuscular hemoglobin (MCH) average weight of air in every tube

Average content of Hgb per red cells

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

Male: 30 picograms

Hgb Conc weight of air in tubes

Hgb Conc amount/ volume g/dl

Male 14- 17 15

Female 12-15 13

Mean corpuscular hgb conc .(MCHC) average density of air in every test tube

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

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

Hematocrit (Hct)

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

Male 45%

Female 40%

Red blood cells distribution width (RDW)

Mean corpuscular volume (MCV) size of tube

Small cells low MCV mic

Large cells High MCV mac

Normal 80-100 fl

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, globin

  nuclear: B12 and folate deficiency

- Survival defects

Intrinsic defect

- Membrane Spherocytosis

Enzyme G6PD deficiency

Glycolysis :phosphoenol pyruvate to pyruvate 2ATP 2,3BPG increase right shift pyruvate kinase

redox metabolism: glucose 6 p 6 phosphogluconate G6PD NADPH reduced glutathione reduced H2O2

Fenton reaction: FE +2 oxidized converting fe+3 is reduced into Fe +2

hydrogen peroxide hydroxyl radical

- 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