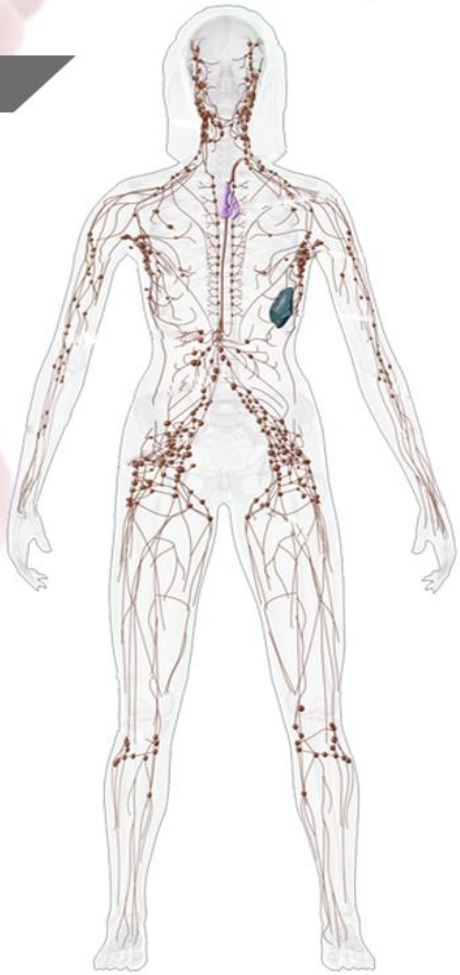
Sheet 5

Hematology and Lymphatic system

Subject | Physiology



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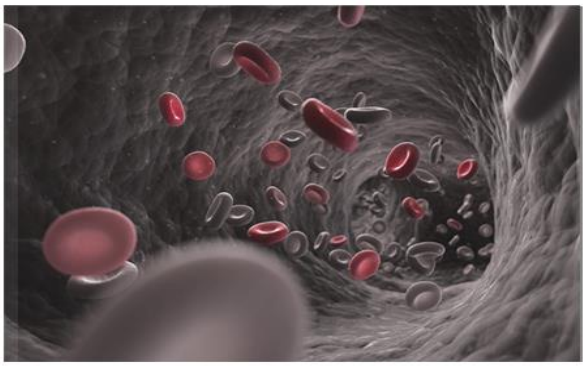

Anemia (Erythrocytopenia)

Anemia is a name given for a group of disorders that develops when your blood **lacks** enough healthy **red blood cells** or **hemoglobin**, i.e. it is either characterized by **low RBCs** or **low hemoglobin**.

Generally, anemia is due to either **increased blood loss**, **decreased blood production** or **high RBCs destruction** (rupture).

Classification of Anemia

Based on Morphology:

1- **Normocytic Normochromic**: The **size** and **hemoglobin** content of the RBCs are within **normal limits**, but their **number isn't enough**.

2- **Microcytic Hypochromic**: RBCs' **size** is **smaller** than usual, with **decreased hemoglobin** content.

3- **Macrocytic Hypochromic**: Unusually **large RBCs**, with **decreased hemoglobin** content.

4- **Normocytic Hypochromic.**

5- **Micro-spherocytic**: A hereditary rare disorder where RBCs look like **spheres**, leading to premature breakdown of red blood cells.

Based on Etiology:

1- **Increased blood loss, which could be caused by:**

   a- **Acute or chronic hemorrhage**

   b- **Hemolysis**, a problem which can be:

      Corpuscular: The problem is either **in the cell itself** or its **membrane**. Like a deficiency of some enzymes such as **G6PD** (Glucose-6-phosphate dehydrogenase) or **pyruvate kinase**.

      Extra corpuscular: The problem is **outside the cells**, in the **plasma** for example because of **toxins** or **infections** like malaria.

2- **Decreased blood production:**

   a- **Nutritional**: Inadequate dietary intake of some essential substances for erythropoiesis such as deficiency in vitamin B12, folic acid, pyridoxine (vitamin B6), ascorbic acid or proteins.

   b- **A problem in the bone marrow** (bone marrow failure), as the bone marrow is the place where erythropoiesis takes place.

Effects of anemia:

1. **Blood Viscosity decreases**; because of the **low number of RBCs**.

   The main factor affecting blood viscosity is RBCs concentration, therefore, when the RBCs number becomes **low** → viscosity **decreases** → resistance to blood flow in blood vessels **decreases** → the blood flow increases → **increased** amounts of blood return to the heart → **increased cardiac output**.

   Moreover, **Hypoxia** leads to **vasodilatation** of peripheral tissue blood vessels, causing a further **increase** in the amount of blood returned to the heart and **cardiac output.**

2. **The heart rate increase.**

   ⇨ The effects of anemia on the heart are **increased cardiac output** and **increased heart rates**.

Polycythemia (Erythrocytosis)

Polycythemia is defined as an **increase** in the number of the RBCs in the circulation; unlike anemia.

Forget what was here :)

Sorry for the inconvenience, but we are suffering with a 'fluctuating' source of information.

Classification of Polycythemia (erythrocytosis):

1. **Relative erythrocytosis**:

   Results from **dehydration**, in which the **plasma** volume **decreases** so the total volume of blood decreases, while the RBCs number is still the same. As a result, the RBCs concentration increases **relatively** to the volume of the blood. This case usually occurs during **fasting**.

2. **True erythrocytosis**, which is further divided into:

   a- **With increased erythropoietin**: physiologically due to **high altitude** or substances such as **Cobalt** and **androgens**. *'Erythrocytosis as mentioned in the extra note'*

   b- **With low or normal erythropoietin**: because of **cancer**. *'Polycythemia with the problem being in the bone marrow'*

Effects of Polycythemia:

As a result of **increased RBCs**, viscosity **increases** → this leads to an **increase** in the **resistance** to blood flow in blood vessels → the blood flow will **decrease** → the pumping workload on the heart **increases** (the heart pumps hardly).

When the viscosity is **high**, the venous return relatively **decreases** but the **blood volume** is **high**, due to **increased** number of RBCs. Therefore, the **amount of blood return** will be **very high** (because of increased volume), **increasing the load** on the heart.

- ⇨ In both cases, **anemia** and **polycythemia**, the **heart work** is **increased** but due to different causes, and this may lead to **heart failure**. In **polycythemia**, **increased blood volume** causes increased venous return and heart load, whereas in **anemia**, **decreased resistance** due to **decreased RBCs** and **vasodilation**, is what increases the venous return.

Leukocytes

Classification

The white blood cells (also known as leukocytes) are divided into 5 groups: lymphocytes, monocytes, neutrophils, basophils and eosinophils. WBCs are often classified into two classes:

1- **Granular**: Neutrophils, eosinophils and basophils.
2- **Agranular**: Lymphocytes and monocytes.

Count

- The normal total white blood cells count ranges from 5,000-10,000/mm³ or 4,000-11,000/mm³.
- Healthy individuals might still have a count that is slightly out of the normal range (whether higher or lower).
- A **low WBC** count is referred to as **leukopenia** while a **high count** is referred to as **leukocytosis**.
- **Gender** has **no effect** on the WBC count, but even in the same individual the count **changes** physiologically, for example:

  1- WBCs count is **high** in the **evening** and **low** in the **morning**.
  2- It increases **after meals, exercises, excitement** and during **pregnancy**.

- WBCs are **nucleated** and are **larger** in size than RBCs.
- WBCs move *(amoeboid movement)* from capillaries to tissues to perform their functions.
- WBCs have short half-lives ranging from **hours** (6 hours for neutrophils) to a **year** (for some monocytes).
- **Average WBC count/mm³:**

Neutrophils: 5,400 (60%)	Eosinophils: 275 (3%)	Basophils: 35 (1%)
Lymphocytes: 1000-4800 (30%)	Monocytes: 540 (4%)	

  ⇨ Neutrophils are the most abundant followed by Lymphocytes then monocytes, eosinophils and finally basophils.

- The lymphocytes we count make up only **50%** of the total number of lymphocytes as the remainder adhere to the **inner surfaces** of the blood vessels. These adhering lymphocytes are referred to as the **marginal pool** and they are only released in some conditions like **hemorrhage**.

Leukopoiesis

- Leukopoiesis is the production of white blood cells.
- The duration required for the production of WBCs via leukopoiesis is **6 days**, which is the same amount of time taken for the production of RBCs, but WBCs remain in the **bone marrow** for **6 more** days, after they are produced before being released to the circulation, to mature and activate.
- **All WBCs** are only produced in the **bone marrow** only, except the **lymphocytes,** which are produced in both the **bone marrow** and **thymus**.
  - ⇨ *'this is what is required'*

Extra Note: Lymphocytes develop from bone marrow stem cells and mature in the generative lymphoid organs *(**Bone marrow**: for B cells, **Thymus**: for T cells).*

Fully mature T lymphocytes leave the thymus to reside in secondary lymphoid organs, where they might also get activated. Whereas B lymphocytes leave the bone and undergo a minor final stage of differentiation in the secondary lymphoid organs *(spleen, lymph nodes, etc.)*

In conclusion: both the **bone marrow** and the **thymus** are sites of **Lymphopoiesis**. Other secondary lymphoid organs have a **minor** role in the formation of **B lymphocytes** only which we are not required to know in details.

'Sorry for the inconvenience as I had to reach dr. Hiba for the final say'

Good Luck