HEMATOLOGICAL AND BLOOD DISORDERS

(CHAPTERS 21 AND 23)

QUESTION 1

Describe the composition of blood. What is the difference between plasma and serum? What is the difference between collecting blood in green- and red-topped tubes?

About half of the volume of blood (55%) is **blood plasma**, a dilute solution of plasma proteins in water.

The other half (45%) is composed of **formed elements**, almost all of which is **red blood cells**.

Blood **plasma** is the entire fluid-and-solute portion of blood **without** formed elements (so no RBCs, WBCs, or platelets.)

Plasma samples are formed by fractionating whole blood in a centrifuge, then removing the heavier formed elements.

Blood **serum** is very similar to blood plasma, but has also been stripped of **fibrinogen** and other clotting factors.

Whole blood is encouraged to clot and **then** centrifuged, and the clotted material removed along with the formed elements.

Green blood collection tubes **prevent** clotting with heparin for tests that can be run with **plasma** with clotting factors present.

Red tubes **encourage** clotting with tiny glass or silica particles for tests that require blood **serum**.

QUESTION 2

What components are seen in the plasma fraction?

Blood plasma is mostly **water**, with most of the rest being made up of **plasma proteins** in solution:

- 92% water
- 4% albumin
- 3% other plasma proteins

  (immunoglobulins, fibrinogen, etc.)
- 1% "other stuff"

PART 1, QUESTION 3

Why would a patient who has nephrotic syndrome be more susceptible to infection? Why would liver disease lead to bleeding?

We talked about **nephrotic syndrome** before during the Fluid & Electrolytes unit—increased permeability of the renal glomeruli allows proteins to leak into the urine.

This affects all plasma proteins, including **immunoglobulins**, which play a crucial role in immune defense.

Decreased level of immunoglobulins in the blood results in an impaired immune response and greater risk of infection.

Remember that the liver plays a crucial role in **fat absorption** in the small intestine through the production of bile.

Decreased liver function impairs absorption of fats, and by association, absorption of fat-soluble vitamins.

Vitamin K deficiency is a common consequence of liver disease, leading to impaired synthesis of clotting factors.

(In fact, many clotting factors are also **produced** in the liver.)

QUESTION 4

Why is hemoglobin A1c a good indicator of glucose control over a 4 month period?

Glycated hemoglobin (HbA1c) is hemoglobin that has been **chemically bound** to glucose in the bloodstream.

This process is **irreversible** and, once it occurs, will be present for the entire lifetime of the RBC—about 4 months.

The more glucose is present in the blood, the more often this reaction occurs, and the higher the HbA1c level will be.

Unlike direct measurement of blood glucose, HbA1c doesn't fluctuate. If your glucose is fine today, but has been high for the past few months, your HbA1C will be high, too.

QUESTION 5

Compare petechiae and purpura.

Petechiae, **purpura**, and **ecchymosis** (bruising) are three categories of **hematoma**—localized bleeding under the skin.

All of these can be caused by coagulative and vascular disorders, or by trauma.

The three terms are differentiated on the basis of **size**.

petechiae – tiny "pin-prick" spots less than 2–3 mm in size

purpura – medium-sized spots larger than petechiae but smaller than 1 cm

ecchymosis – general term for any bruising larger than purpura

QUESTION 6

What vitamins and nutrients are needed for red blood cell (RBC) production?

The main three: **iron**, **folate** (vitamin B_9,) and **vitamin B_{12}**.

Iron is a component of **hemoglobin**, and B-vitamins play an important role in the proper **maturation** of RBCs.

QUESTION 7

What is intrinsic factor? Where is it produced and what does it do? Why do bariatric surgery and kidney disease lead to anemia?

Intrinsic factor is a protein produced by the **parietal cells** of the stomach, which aids the absorption of vitamin B_{12} in the ileum.

Gastric bypass surgery "skips over" part of the stomach, **reducing** the amount of intrinsic factor entering the ileum and impairing B_{12} absorption.

This leads to **pernicious** (vitamin B_{12} deficiency) anemia.

The kidneys are responsible for the production of **erythropoietin**, a hormone that triggers the production of red blood cells in the bone marrow.

Chronic kidney disease can lead to a deficit of erythropoietin, causing an underproduction of red blood cells—**not** pernicious!

QUESTION 8

Why do dark urine and light feces signal liver disease?
Which form of bilirubin is excreted in bile?

Let's review the unit on liver disease—unconjugated **bilirubin** is produced as a byproduct of hemolysis during the recycling of old RBCs.

Unconjugated bilirubin is combined with acid to produce **conjugated** bilirubin, which is then normally excreted into the bile.

In liver disease, bilirubin either **fails to be conjugated** due to hepatocyte damage, or **fails to be excreted** due to cholestasis. This results in an increase in bilirubin **in the blood**, which can cause jaundice.

Decreased levels of bilirubin in the intestines and increased levels in the blood (excreted in the kidneys) lead to lighter stool and darker urine.

QUESTION 9

What factors lead to platelet disintegration?

The protein **plasminogen**, produced in the liver, plays an important role in the breakdown of blood clots.

It is an **inactive form** of the enzyme **plasmin**, which breaks down the **fibrin** that holds clots together.

Plasminogen naturally "sticks" to the fibrin and integrates itself into the clot, but has no effect its inactive form.

Over time, it becomes converted to **plasmin** and begins to cleave the fibrin molecules, slowly breaking down the clot over the course of several days.

QUESTION 10

What is plasmin? What is tPA, and what is its medical use?

tPA (tissue plasminogen activator) is a naturally-occuring enzyme that is **slowly** released by damaged cells, **activating** the plasminogen contained in clots by converting it to **plasmin**.

This slow release of endogenous tPA is responsible for demolishing clots as the natural healing process of the underlying tissue progresses.

alteplase (Activase) is a synthetic form of tPA, used as a "clot buster" for STEMI, pulmonary embolism, ischemic stroke, etc.

It tends to be used only in extreme circumstances due to risk of **uncontrolled bleeding**.

QUESTION 11

Why is tPA better than streptokinase?

tPA and **streptokinase** are both thrombolytic drugs, but tPA is **fibrin-specific** meaning that it acts **only** on fibrin and not on clotting factors.

Combined with its short half-life, this makes tPA great for treating acute blood clots without causing sustained systemic thrombolysis.

In contrast, streptokinase is **fibrin non-specific**, meaning it also breaks down **fibrinogen**, causing systemic suppression of **new** clots and increasing the risk of bleeding.

QUESTION 12

What is the consequence of anemia?

Generally speaking, anemia results in a systemic decrease in the **oxygenation** of tissues.

Decrease in number of RBCs or their hemoglobin content decreases the "carrying capacity" of the blood, lowering the effectiveness of the circulatory system at conducting gas exchange.

QUESTION 13

What conditions can contribute to anemia?

- Chronic kidney disease (CKD)
- Nutritional deficiencies: B_{12}, folate, iron
- Thalassemia (genetic disorder of increased hemolysis)
- Misshapen RBCs: sickle cell disease, spherocytosis
- Hemolytic disease of the newborn (HDN)

QUESTION 14

Describe some common signs and symptoms of anemia.

- **fatigue** and **weakness**
- **tachycardia**, **chest pain**, **shortness of breath**
- **pallor** (pale or yellowish skin)
- **neurological symptoms**: headache, tinnitus, lightheadedness
- **nail "spooning"** (primarily in iron-deficiency anemia)

QUESTION 15

What are the body's compensatory mechanisms for anemia?

Two of the most noticeable compensations are **tachycardia** and **tachypnea** as the body attempts to increase oxygen supply to the tissues.

As the blood gets thinner, systemic vascular resistance naturally decreases, which also has the effect of increasing cardiac output.

The body may also shunt blood towards more important areas such as the heart and brain.

QUESTION 16

Why is sickle cell disorder considered an anemia?

Sickle cell anemia is a recessive genetic defect in the DNA coding for hemoglobin, resulting in RBCs that collapse into a "moon" or "sickle" shape when they become deoxygenated. It occurs almost exclusively in **black patients**.

These malformed cells can become tangled with each other and stuck in the arteries, leading to sudden episodes of pain referred to as **sickle cell crisis**.

Once they malfunction, these RBCs are targeted for hemolysis and broken down, resulting in a **hemolytic** anemia.

QUESTION 17

What are nutritional anemia and aplastic anemia?

Nutritional anemia is linked to a **deficit of nutrients** required for proper RBC synthesis (iron, B_{12}, folate.)

Aplastic anemia is a **very rare** form of anemia characterized by the **underproduction** of many types of blood cells, including RBCs. It is potentially fatal and is treated with bone marrow transplant.