ANEMIA OF DECREASED PRODUCTION

1. IRON DEFICIENCY ANEMIA

- RBCS are microcytic (low MCV)
- hypochromic.
- low serum ferritin (sensitive to IDA)
- low iron levels
- low transferrin saturation
- low hepcidin
- increased total serum iron- binding capacity
- increased RDW
- platelet count often is elevated
- Erythropoietin levels are elevated but RBC count is low

2. ANEMIA OF CHRONIC INFLAMMATION/CHRONIC DISEASE

- elevated hepcidin
- IL-6
- decreases ferroportin
- low serum iron levels
- RBCs slightly hypochromic and microcytic
- storage iron in the bone marrow increased
- serum ferritin increased
- total iron-binding capacity is reduced

3. MEGALOBLASTIC ANEMIA

- large erythroid precursor cells
- nuclear-cytoplasmic asynchrony (immature nuclei but normal cytoplasm)
- hypersegmented neutrophils (nuclei with more than 4 segments)
- abnormally shaped platelets

pancytopenia

- RBCs are usually oval shaped and markedly macrocytic

3A. Folate deficiency

- smears of peripheral blood and bone marrow (shows megaloblastic characteristics)
- low serum and RBC folate

3B. Vitamin B12 deficiency

- low serum vitamin B_{12} level
- normal or elevated serum folate level
- megaloblastic characteristics
- a dramatic reticulocytic response to administration of vit B_{12}
- Pernicious anemia has additional serum antibodies to intrinsic factor.

4. ANEMIA OF CHRONIC LIVER DISEASE

spur cells (or acanthocytes).

5. **ANEMIA OF CHRONIC RENAL DISEASE**

ecchinocytes (also known as Burr cells)

6. APLASTIC ANEMIA

- pancytopenia (anemia, neutropenia, and thrombocytopenia)
- no splenomegaly or gallbladder stones

BM with adipose tissue, no hematopoietic cells

7. **MYELOPHTHISIC ANEMIA**

- anemia and thrombocytopenia
- mild leukocytosis
- Characteristically misshapen red cells (teardrops)
- Immature granulocytic and erythrocytic precursors *(leukoerythroblastosis)*

ANEMIA OF PERIPHERAL REMOVAL

1.ANEMIA OF BLOOD LOSS

- Increased Erythropoietin level
- Increased reticulocyte count
- Leukocytosis but after recovery thrombocytosis
- Normocytic normochromic anemia or slightly macrocytic due to reticulocytes

2. Anemia of Hemolysis

- Increase destruction of RBCs
- Elevated erythropoietin levels
- Accumulation of hemoglobin degradation products, bilirubin and iron.
- Erythroid precursor hyperplasia in the bone marrow
- high reticulocyte counts in the blood.

Both intra and extra vascular hemolysis share these clinical manifestations:

- Low haptoglobin
- High LDH (lactate dehydrogenase) - very nonspecific finding.
- Splenomegaly
- Jaundice

The difference between them:
Extravascular - No hemoglobinuria and no hemoglobinemia
Intravascular - there is hemoglobinemia and hemogloburia and Schistoyctes

EXTRINSIC HEMOLYSIS

A) Immune hemolytic anemia

coombs test

A1) Warm antibodies (IgG)
mild anemia with splenomegaly.

A2) Cold antibodies (IgM)
ischemia in the periphery.

B) Hemolysis of mechanical trauma

Schistocytes

C) Infection

- brown pigmentation of the spleen, liver and bone marrow
- Massive splenomegaly and occasional hepatomegaly
- Schistocytes

INTRINSIC HEMOLYSIS

A) Hereditary spherocytosis

osmotic fragility test

- Anemia
- jaundice
- gallbladder stones
- splenomegaly
- only anemia with high MCHC

B1) Sickle Cell anemia:

- Chronic hemolytic anemia.
- Fatty change in the heart, liver and renal tubules.
- Reticulocytosis and erythroid hyperplasia in bone marrow.
- Bone changes, prominent cheekbones and crew-cut skull
- Extramedullary hematopoiesis in liver and spleen (splenomegaly at first) but eventually we will have autosplenectomy. so no gallbladder stones or splenomegaly.

Diagnosis:

- Hemoglobin electrophoresis to demonstrate HbS
- Fetal DNA via amniocentesis or chorionic villi biopsy

B2) Thalassemia:

- Heinz bodies and “bite cells” or “blister cells”
- tissue hypoxia, and red cell hemolysis
- Low hemoglobin 3-6g/dL
- very low MCV (micro)
- normal to low RDW
- target cells
- skeletal deformities - crew-cut
- Elevated HbF and HbA2 (sensitive for beta thalassemia)

Beta thalassemia minor:

- Increased erythropoietin and RBCs
- Bone marrow erythropoiesis progenitor hyperplasia
- Normal Hb
- Low MCV
- RDW is normal
- Elevated HbA2

C) Enzymopathies - G6PD deficiency

- Heinz bodies and bite cells
- features related to chronic hemolysis (splenomegaly and gallbladder stones) are typically absent

Acquired hemolytic anemia of Intrinsic causes - Paroxysmal nocturnal hemoglobinuria (PNH)

- Low level chronic hemolytic anemia.
- has some association with aplastic anemia and thrombosis
- High incidence of bone marrow disorders like myelodysplastic syndrome and leukemia

Polycythemia

high RBC count and elevated hemoglobin level

Relative Polycythemia
decrease in plasma volume with no change in the total RBC mass

Absolute Polycythemia
here there is an actual increase of RBC count

In **secondary -** elevated erythropoietin

Primary - low erythropoietin levels

polycythemia vera (PCV)

- increased marrow production of red cells, granulocytes, and platelets (panmyelosis)
- increased red cell volume or Hb
- mild splenomegaly at first but then becomes more severe
- hypercellular bone marrow
- bone marrow fibrosis and significant organomegaly
- 2% risk for transforming to acute myeloid leukemia.
- Pruritis.
- Headache; dizziness.
- Hyperuricemia and gout
- Increased risk of both major bleeding and thrombotic episodes (fatal) includes: DVT, stroke, MI, Bowel infarction, Budd-Chiari syndrome, Epistaxis and bleeding gums.