CBC | APPROACH TO ANEMIA

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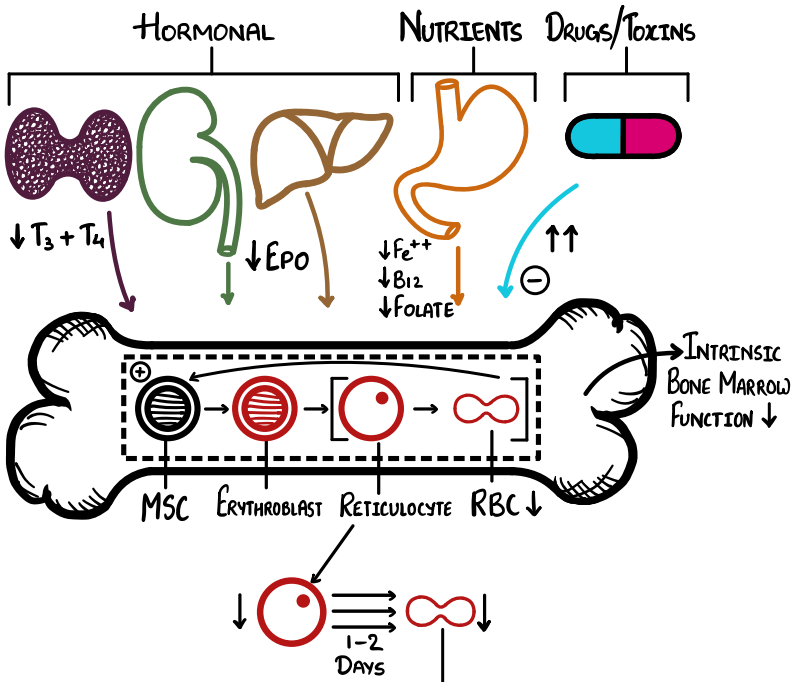
OUTLINE

I) RED BLOOD CELLS (RBC)

- Red blood cells are also known as **erythrocytes**
- Red blood cell production occurs in the **red bone marrow**
- **Myeloid Stem Cell**
  - Progenitor for red blood cells, platelets, and granulocytes (e.g. neutrophil, basophil, eosinophil)
  - Receives stimuli which direct it to form red blood cells



(A) STIMULI

- **Erythropoiesis** refers to the process of red blood cell production
- There are different factors which influence production:
  - **Hormones** – stimulates production
  - **Nutrients** – stimulates production
  - **Drug/Toxins** – inhibits production
  - **Intrinsic Bone Marrow Function**

(1) Hormones

- Thyroid Hormones (T_3 and T_4)
- Erythropoietin
  - Produced by the liver and kidney
  - Stimulates the bone marrow to produce RBCs

(2) Nutrients

- Iron
- Vitamin B12 / Cobalamin
- Vitamin B9 / Folate

(3) Drugs/Toxins

- Suppress RBC production in the bone marrow
- Example: Alcohol

(B) LIFE CYCLE

- **RBC Development**
  - Myeloid Stem Cell
    → Erythroblast
    → Reticulocyte
    → Red Blood Cell / Erythrocyte

(C) RETICULOCYTES

- Reticulocytes are immature/developing red blood cells
- It takes 1-2 days for a reticulocyte to develop into an RBC

II) ANEMIA

- **Anemia** refers to a <u>decreased red blood cell mass</u>, manifested as:
  - Decrease in Hemoglobin (Hgb)
  - Decrease in Hematocrit (Hct)
  - Decrease in RBCs
- Anemia can be due to either:
  - External stimuli
  - Poor bone marrow function
  - Bleeding / Increased blood loss
  - Increased destruction of RBCs

(A) CAUSES OF ANEMIA

- To determine the cause of anemia, a **comprehensive history** and **laboratory tests** (e.g., complete blood count, iron studies, peripheral blood smear, etc) are needed.

(1) External Stimuli

- There are different stimuli/factors which influence red blood cell mass
  - **Hormones**
  - **Nutrients**
  - **Drugs/Toxins**
- Reticulocyte index is low (<u>less than 2%</u>)

(2) Poor Bone Marrow Function

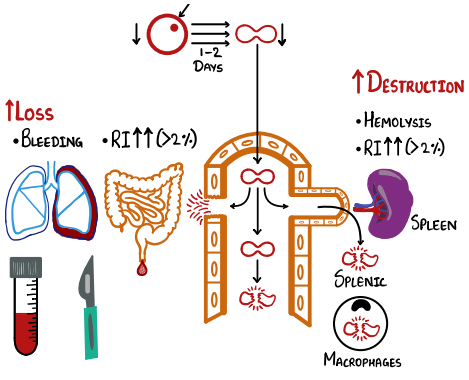
- Bone marrow function is affected when:
  - Exposure to **chemoradiation** destroys the structure of the bone marrow
  - There is a **neoplasm/cancer** of the bone marrow
- Reticulocyte index is low (<u>less than 2%</u>)

(3) Bleeding / Increased Blood Loss

- When there is active bleeding or increased blood loss, the RBC count may decrease
- Since bone marrow function is normal, the decreased RBC count triggers a compensatory mechanism which <u>increases erythropoiesis and subsequently increases the reticulocyte index</u>
- Examples:
  - GI bleed
  - Frequent blood withdrawals (e.g. in the ICU)
  - Surgery
- <u>Reticulocyte index will increase</u> as a compensatory mechanism

(4) Increased Destruction of RBCs / Hemolysis

- RBCs may be destroyed or lysed within the vasculature or the spleen
  - **Intravascular Hemolysis** – destroyed within the vasculature
  - **Extravascular Hemolysis** – destroyed within the splenic macrophages of the spleen
- <u>Reticulocyte index will increase</u> as a compensatory mechanism



(B) CLASSIFICATION OF ANEMIA

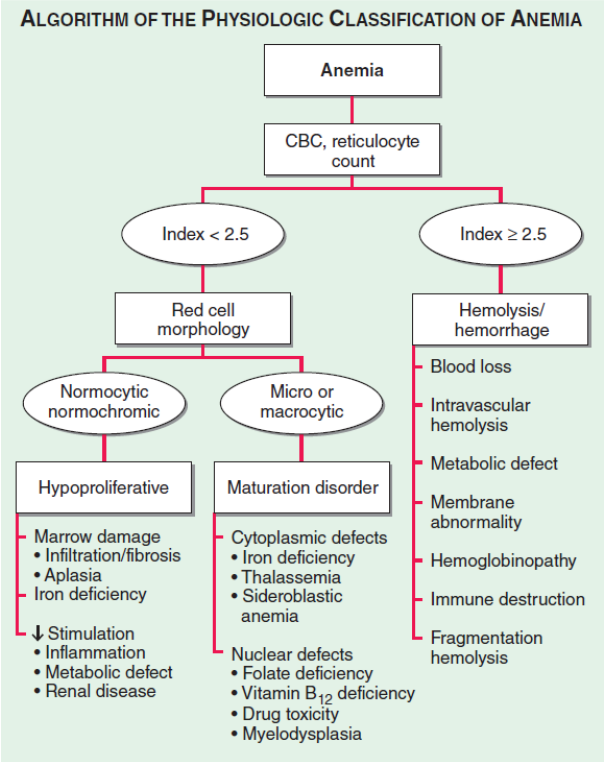


Figure 1. Physiologic Classification of Anemia [Harrison's Principles of Internal Medicine 20th Edition]

- Anemia may be classified based on the **reticulocyte index**
- The **reticulocyte index (RI)** is a good indicator of bone marrow function
  - **RI <2 %** - decreased RBC production (due to decreased stimuli or <u>bone marrow dysfunction</u>)
  - **RI >2%** - increased destruction or loss of RBC; <u>bone marrow is functioning</u>
  - The **reticulocyte count** shown in the diagnostic results is NOT the reticulocyte index

This value should be inputted in a reticulocyte index calculator

- Diagnostic tests are often necessary – on top of a comprehensive history and physical examination – to determine the cause of anemia
- The following are the most common diagnostic tests ordered for anemia:
  - **RDW** – measures the variation in size of RBCs
  - **RBC count**
  - **Menser's Index (MI)**
    - Computed as MVC / RBC
  - **Iron Studies**
    - **Fe^{++}**
    - **Ferritin** – protein which binds to irons inside the cells; reflects iron reserves
    - **Total Iron Binding Capacity (TIBC)**
    - **Transferrin Saturation %**
      - Computed as Fe/TIBC
  - **Peripheral Blood Smear (PBS)**

III) RETICULOCYTE INDEX < 2%

- Disorders with a reticulocyte index < 2% may be further classified based on the RBC morphology
- The **mean corpuscular volume (MCV)** determines the size of the red blood cells
  - Normal Value: 80 – 100 femtoliters (fl)
- The types of anemia based on MCV value are:
  - Microcytic Anemia: < 80 fl
  - Normocytic Anemia: 80 – 100 fl
  - Macrocytic Anemia: > 100 fl

(A) MICROCYTIC ANEMIAS

- **MCV: < 80 fl**
- **Differentials**
  - Iron Deficiency Anemia
  - Anemia of Chronic Disease
  - Thalassemia
  - Sideroblastic Anemia
- **Diagnostic Tests**
  - RDW
  - RBC
  - MI
  - Iron Studies
  - Peripheral Blood Smear (PBS)

(1) Iron Deficiency Anemia

- ↑ RDW
- ↓ RBC
- MI > 13%
- ↓ Ferritin
- ↓ Transferrin Sat %
- PBS is not helpful

(2) Anemia of Chronic Disease

- History is the most important factor; look for symptoms and signs of chronic disease
- ↔ RDW
- ↓ RBC
- MI is not helpful
- ↑↑ Ferritin
  - Ferritin is an acute phase reactant; it may be elevated when there is an active inflammatory process such as in chronic diseases
- Transferrin Sat % is variable

(3) Thalassemia

- ↔ or ↑ RDW
- ↔ RBC
- MI < 13%
  - ↓↓↓ MCV / RBC
- Iron studies are not helpful
- PBS: may show **basophilic stippling**
  - Correlate with history findings (e.g. family history of thalassemia, Mediterranean ancestry)
- Hemoglobin Electrophoresis
  - Will clinch the diagnosis of thalassemia

(4) Sideroblastic Anemia

- History: Look for exposure to lead, alcohol use, medication use
- Causes: lead poisoning, toxins
- ↑ RDW
- ↓ RBCs
- Iron studies are not helpful
- PBS
  - Shows **basophilic stippling**
    - Check lead (Pb) levels
  - Shows **sideroblasts**
    - Get a bone marrow biopsy to confirm

∞ Microcytic Anemias (↓MCV)

↓↓↓MCV/RBC - MI

RDW/RBC's/MI/Iron Studies/PBS + Hx

IDA
- ↑RDW
- ↓RBC's
- MI > 13%
- ↓Ferritin
- ↓Trans. Sat%

ACD
- ↔RDW
- ↓ RBC's
- ×
- ↑↑Ferritin
- History

Thalassemia
- ↔/↑RDW
- ↔ RBC's
- ↓↓↓MCV/RBC<13% (RAI)
- PBS- Basophillic Stipplings
- Hx ⊕
- Hb Electrophoresis ⊕

Sideroblastic Anemia
- ↑RDW
- ↓RBC's
- PBS — Basophillic Stipplings → pb Levels; Sideroblasts ⊕ → BM Bx To Confirm
- Hx ⊕

Iron Studies
- -Fe^{++}
- -Ferritin
- -TIBC
- -Trans Sat%
- ↓Fe^{++}/TIBC↑
- <↓ %

(B) NORMOCYTIC ANEMIA

- **MCV: 80-100 fl**
- **Differentials**
  - Early Iron Deficiency Anemia
  - Early B_{12} deficiency
  - Early Folate deficiency
  - Thyroid Disease
  - Liver Disease
  - Kidney Disease
  - Hemolysis
- **Diagnostics**
  - Iron Studies
  - B_{12} Levels
  - Folate Levels
  - Thyroid Function Tests
  - Liver Function Tests
  - BMP (kidney function)
  - Hemolytic Labs
  - Bone Marrow Biopsy

(1) Early Iron Deficiency Anemia

- ↓ Ferritin /
- ↓ Transferrin Sat %

(2) Anemia of Chronic Disease

- ↑↑ Ferritin

(3) B_{12} and Folate Deficiency

- ↓ B_{12} levels
- ↓ Folate levels
- If the levels are borderline, measure the **methylmalonic acid (MMA)** and **homocysteine** (HC) levels
  - **B_{12} Deficiency** = ↑ MMA, ↑ HC
  - **Folate Deficiency** = ↔ MMA, ↑ HC

(4) Hypothyroidism

- ↓ T_3, T_4

(5) Liver Failure

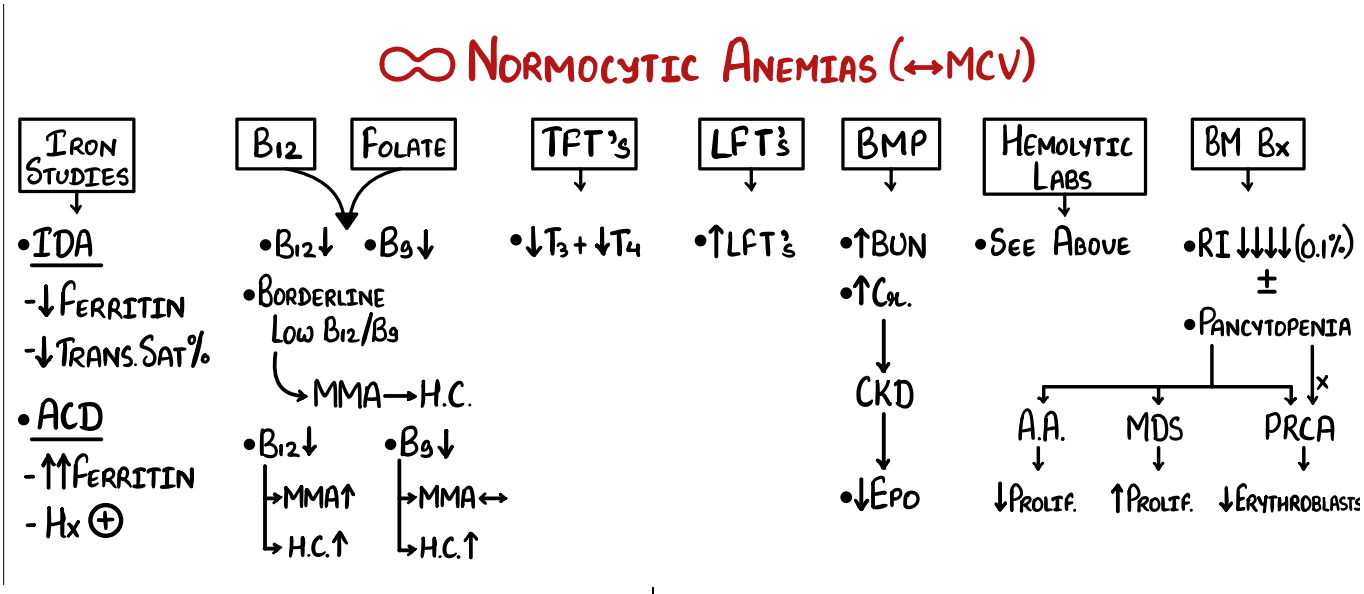
- ↑ AST, ALT (liver enzymes)
- ↓ Albumin
- ↑ INR

(6) Chronic Kidney Disease

- ↑ BUN
- ↑ Creatinine
- ↓ Erythropoietin (EPO)
  - The kidney fails to produce EPO

(7) Intrinsic Bone Marrow Problem

- ↓↓↓ Reticulocyte Index (0.1%)
- Pancytopenia
  - ↓ RBC
  - ↓ WBC
  - ↓ Platelets
- **Bone Marrow Biopsy**
  - **Aplastic Anemia** – low proliferative bone marrow biopsy
  - **Myelodysplastic Syndrome (MDS)**
    - hyperproliferative bone marrow due to overproduction of blast cells
  - **Pure Red Cell Aplasia (PRCA)**
    - low erythroblasts
    - no pancytopenia because only the red blood cell line is affected



(C) MACROCYTIC ANEMIA

- **MCV: > 100 fl**
- **Differentials**
  - B_{12} Deficiency
  - Folate Deficiency
  - Hypothyroidism
  - Drug-induced
  - Alcohol Abuse
  - Myelodysplastic Disorder (MDS)
- **Diagnostics**
  - B_{12} / Folate levels
  - Thyroid Function Tests
  - Liver Function Tests
  - Look at medication use
  - Blood Alcohol Concentration
  - Peripheral Blood Smear
  - Bone Marrow Biopsy

(1) B_{12} and Folate Deficiency

- ↓ B_{12} levels
- ↓ Folate levels
- If the levels are borderline, measure the **methylmalonic acid (MMA)** and **homocysteine** (HC) levels
  - B_{12} Deficiency = ↑ MMA, ↑ HC
  - Folate Deficiency = ↔ MMA, ↑ HC
- **Peripheral Blood Smear**: megaloblastic anemia
  - Shows **megaloblasts** (neutrophils with >5 lobes/segments)

(2) Hypothyroidism

- History: hypothyroid symptoms
- ↓ T_3, T_4

(3) Liver Failure

- History: cirrhosis, alcohol abuse
- ↑ AST, ALT (liver enzymes)
- ↓ Albumin
- ↑ INR

(4) Drug-induced

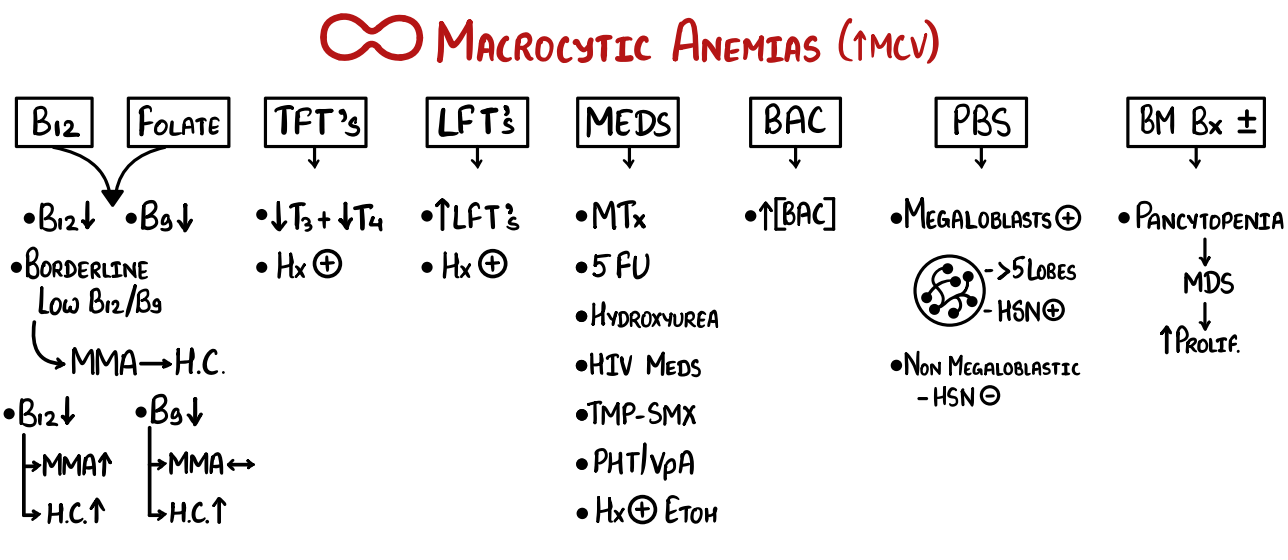
- Drugs which can cause macrocytic anemia include:
  - **Chemotherapeutic agents**
    - Methotrexate
    - Fluorouracil (5FU)
    - Hydroxyurea
  - **HIV Medications**
    - Zidovudine
  - **Antibiotics**
    - Trimethoprim Sulfamethoxazole (TMP-SMX)
  - **Anti-seizure Medications**
    - Phenytoin
    - Valproic Acid
- **Peripheral Blood Smear**: megaloblastic anemia
  - Shows **megaloblasts** (neutrophils with >5 lobes/segments)

(5) Alcohol

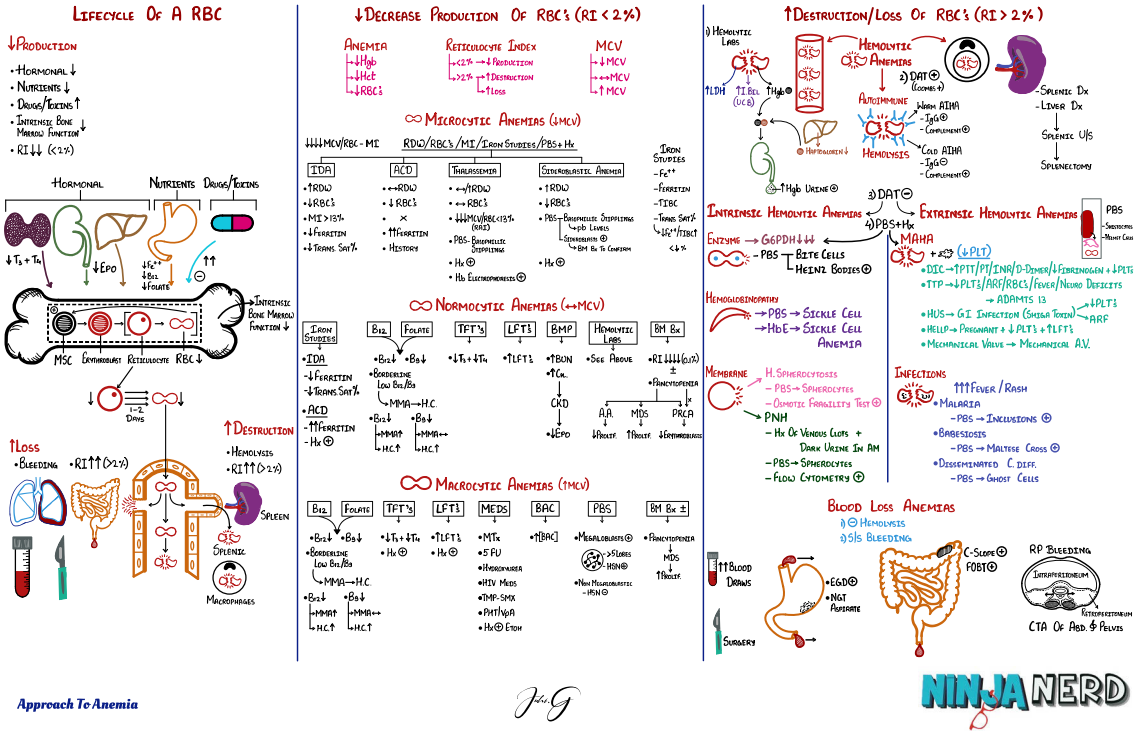
- History: heavy alcohol use
- ↑ Blood alcohol concentration
- **Peripheral Blood Smear**: megaloblastic anemia
  - Shows **megaloblasts** (neutrophils with >5 lobes/segments)

(6) Myelodysplastic Disorder

- Peripheral Blood Smear: non-megaloblastic anemia
  - No megaloblasts / hyper-segmented neutrophils
  - Suggestive of a thyroid, liver, or bone marrow issue
- Bone Marrow Biopsy
  - Consider in patients with pancytopenia
  - Shows <u>hyperproliferative</u> bone marrow



IV) APPENDIX



V) REVIEW QUESTIONS

1) Which of the following parameters reflects bone marrow function?
a) Mean Corpuscular Volume
b) Reticulocyte Index
c) Total Iron Binding Capacity
d) INR

2) If the reticulocyte index is 0.9%, which of the following is the LEAST LIKELY differential?
a) B_{12} Deficiency
b) Myelodysplastic Syndrome
c) G6PD Deficiency
d) Hypothyroidism

3) A 31-year-old female patient's CBC results showed the following:

Hgb 10.3 g/dL

Hct 30.3 %

MCV 121
a) Iron Deficiency
b) Folate Deficiency

d) Thalassemia

4) Which of the following is CORRECTLY paired?
a) MCV < 80 : Normocytic Anemia
b) MI < 13% : Iron Deficiency Anemia
c) ↔ MMA, ↑ HC : Folate Deficiency Anemia
d) RI < 0.8% : Hemolytic Anemia

5) Reticulocyte index > 2% in anemia cases indicates
a) Functional bone marrow → compensates for blood loss
b) Aplastic anemia → unable to compensate for blood loss
c) Anemia caused by nutrient deficiencies
d) Anemia induced by drugs with bone marrow suppression effect

6) What clinical result that is always present and unique to microangiopathic hemolytic anemia?
a) High platelet count
b) Low platelet count
c) Warm AIHA
d) Cold AIHA

7) Osmotic fragility test is commonly used to diagnose which type of anemia?
a) Hereditary spherocytosis
b) Paroxysmal nocturnal hemoglobinuria
c) Thalassemia
d) G6PDH deficiency

VI) REFRENCES

- Harrison, T. R., & Kasper, D. L. (2015). *Harrison's principles of Internal Medicine*. McGraw-Hill Medical Publ. Division.

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CBC I APPROACH TO POLYCYTHEMIA

CBC | Aproach to Polycythemia

Medical Editor: Sarah Abimhamed

OUTLINE

I) LIFE CYCLE

- The red bone marrow forms myeloid stem cells and the following cells are as follows:
  - Myeloid Stem Cell
    - → Erythroblast
    - → Reticulocyte
    - → RBC
- The mature RBCs are released into the circulation and distribute oxygen to the tissues and gas exchange functions in the lung, etc.
- After 120 days, the red blood cells undergo destruction in the spleen.

WHAT STIMULATES THE RBC PRODUCTION?

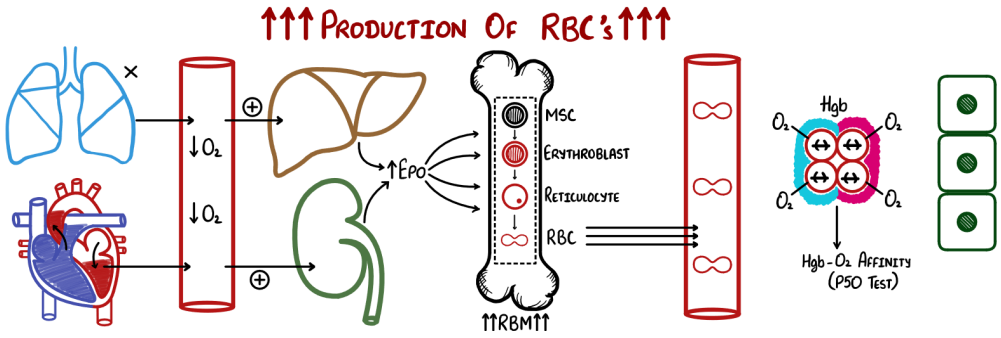
- The kidney (primarily) and the liver produce specific hormones called **erythropoietin (EPO).**
- This hormone stimulates the myeloid stem cells and erythroblast to drive the RBC production.

Factors that increase EPO:

1) **Low oxygen** delivery to the tissues
   - This is detected by the kidneys and liver
     - → stimulates the organs to produce EPO
     - → ↑↑ RBC production
     - As this process can ↑ O_2 to the tissues via the RBCs
   - Some causes of low O_2:
     - **Pulmonary:**
       - COPD, high altitudes, interstitial lung diseases
     - **Cardiac:**
       - Right-to-Left shunting (e.g. in cyanotic heart diseases, Eisenmenger syndrome, congenital diseases)
     - **Hemoglobinopathies / Gas poisoning**
       - Rare cause that could hinder the binding of oxygen to hemoglobin causing ↓ O_2 levels
         - *To check this, a P50 test can be done to see the Hb-O_2 affinity*

2) **Pathologies in the kidney**
   - For example some cancers or tumors in the kidney could cause the release ↑↑↑ EPO

3) **Pathology in the red bone marrow**
   - This could be stimulating myeloid stem cells or erythroblast to produce ↑↑↑ RBCs (e.g. cancer)



II) TO CHECK FOR POLYCYTHEMIA - STEP BY STEP

1. Check the triad

- Polycythemia has:
  - ↑↑↑ Hb
  - ↑↑↑ Hct
  - ↑↑↑ RBCs

2. Check RBC mass

- This is a radionuclide test to measure the RBC mass
  - Determines if it is a ***relative erythrocytosis*** (e.g. caused by dehydration) or polycythemia
  - This test can be unnecessary sometimes
- If the RBC mass is ↑↑↑

3.Check if it is Primary or Secondary Polycythemia

- Primary polycythemia:
  - caused by the red bone marrow
- Secondary polycythemia:
  - problem in the kidneys, lungs or the other organs

4. Check EPO levels

- If **EPO is** ↑↑↑ → Secondary Polycythemia
  - Check if it is *Appropriate or Inappropriate* Absolute Increase in RBC
    - Appropriate: Check history and O_2 saturation
    - Inappropriate: Preform CT scan
- If **EPO is normal or** ↓ → Primary Polycythemia

III) RELATIVE ERYTHROCYTOSIS

- If the RBC mass is normal
  - ***Take history*** to determine if there has been significant fluid loss (dehydration)
    - This is called **hemoconcentration,** when there is ↓↓↓ of fluid, there is a loss of fluid in RBC and hemoglobin appear concentrated hence ↑↑↑ RBC mass

Possible causes:

- Vomiting, diarrhea, diuretics, inadequate PO

Cause of elevated hematocrit

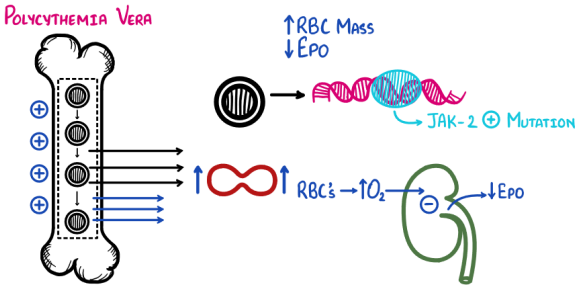
- ↓ **plasma** volume due to fluid loss gives the appearance of ↑ **hemoglobin** hematocrit

IV) PRIMARY OR SECONDARY?

- If the RBC mass is increased, now we have to determine if it is primary polycythemia (bone marrow) or secondary polycythemia (other organs).
  - **EPO** is the determining factor.
    - If **EPO is** ↑↑↑ → Secondary Polycythemia
    - If **EPO is normal or** ↓ → Primary Polycythemia
      - Low EPO is due to a negative feedback mechanism, which causes the kidneys to decrease EPO secretion.

(A) PRIMARY POLYCYTHEMIA

- This is also called **Polycythemia Vera (PV).**
- In this case, the red bone marrow is hyper stimulated due to a pathology (e.g. cancer) which is releasing ↑↑↑ RBC.
- This is caused by a **JAK-2 mutation** in the erythroblastic cells.



To Confirm PV:

- Check RBC mass: ↑↑↑
- EPO: normal or ↓
  - It can be ↓ as ↑↑↑ RBC from the bone marrow
    - This means that there is ↑↑↑ O_2 carrying capacity which ↑↑↑ O_2 delivery to the tissues
    - The kidneys and liver will not be stimulated to increase EPO

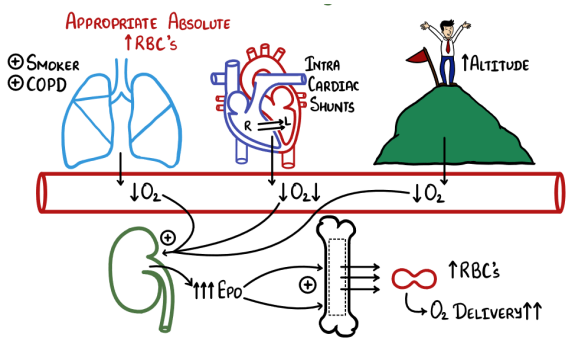
  REMEMBER: a trigger of EPO secretion is low O_2
- Check for JAK-2 mutation

(B) SECONDARY POLYCYTHEMIA

- In this case, EPO is ↑↑↑, there are 2 types:
  1. Appropriate Absolute Increase in RBC
  2. Inappropriate Absolute Increase in RBC

(1) To confirm Appropriate Absolute Increase in RBC:

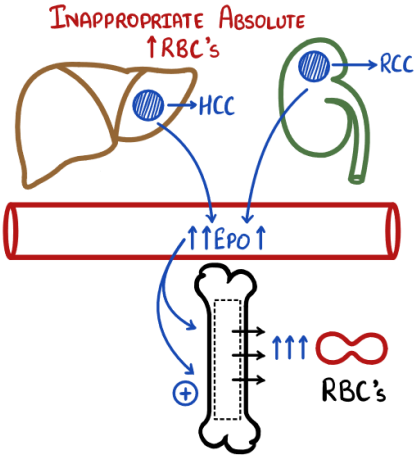
- Check history
  - Smoking, COPD, chronic lung disease, etc.
- Check O_2 saturation
  - Can be low in high altitudes
- Check for congenital heart diseases (e.g. intracardiac shunt or Eisenmenger Syndrome)
  - Especially in pediatric patients
    - Signs: cyanotic (blue) discoloration
- **All of these ↓ O_2 carrying capacity → ↑↑↑ EPO release**



- If there is normal history and O_2 saturation levels this could be **Inappropriate Absolute Increase in RBC.**
  - The EPO source can be from the kidney or the liver
  - This is most likely due to a tumor

(2) To Confirm Inappropriate Absolute Increase in RBC

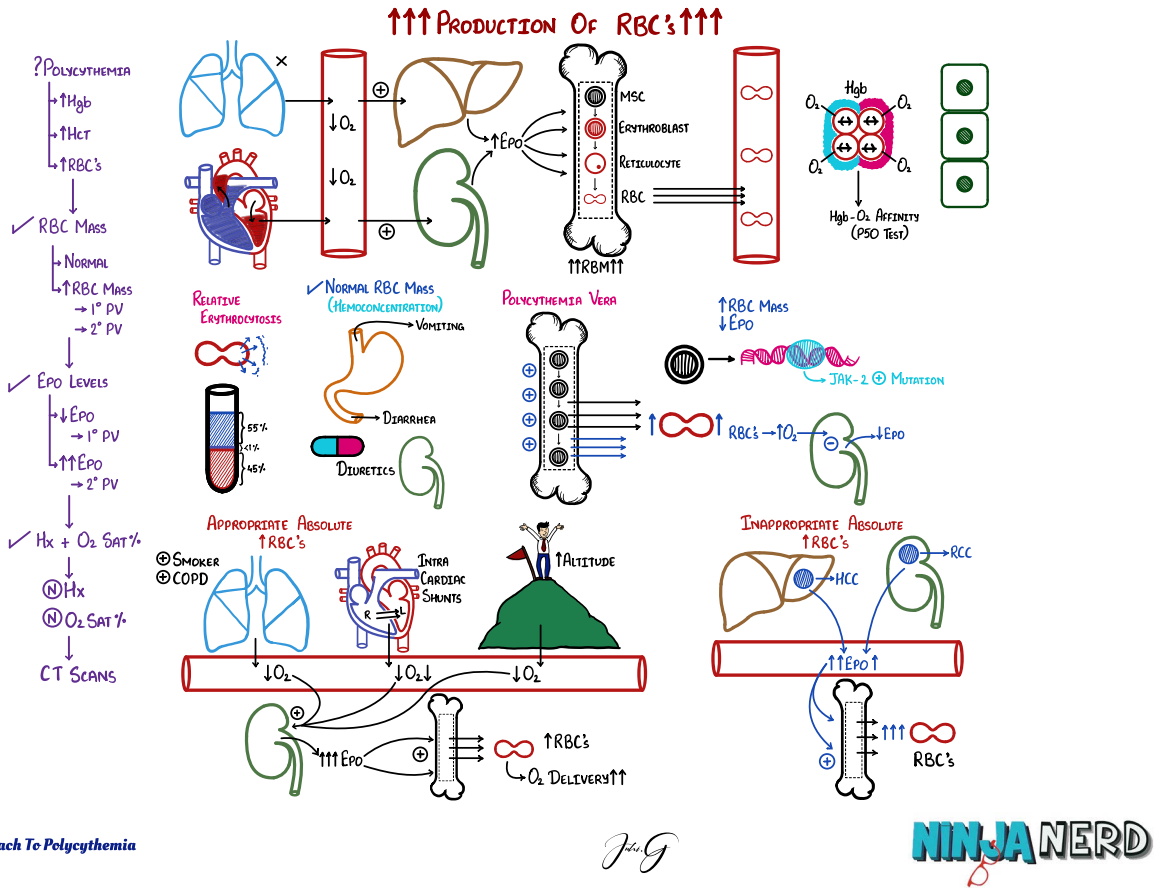
- Preform **CT scans**
  - Tumors that produce EPO
    - Abdomen → Renal Cell Carcinoma (RCC) and Hepatocellular Carcinoma (HCC)
    - These are the most common
      - RCC and HCC secrete EPO uncontrollably
        → stimulates red bone marrow to produce RBC
        → ↑↑↑ RBC
    - Pelvis → Leiomyoma
    - Head → Hemangioma



V) APPENDIX

ypes		Cause	Lab Values	Next Approach
Primary Polycythemia		JAK-2 Mutation	● EPO: normal or ↓	● Check for JAK-2 mutation
Secondary Polycythemia	**Appropriate Absolute Increase in RBC**	Any pathology causing hypoxemia	● EPO is ↑↑↑ ● History of smoking, COPD, etc.	● Check history ● Check O_2 saturation ● Check for congenital heart diseases
	Inappropriate Absolute Increase in RBC	Tumor	● EPO is ↑↑↑ ● Normal history and O_2 saturation	● Preform **CT scans**
Relative Erythrocytosis		Fluid Loss	● **Normal** RBC mass	● Correct fluid levels

● Steps	● Findings
1. Check the triad	● ↑↑↑ Hb ● ↑↑↑ Hct ● ↑↑↑ RBCs
2. Check RBC mass	● Normal → relative erythrocytosis ● ↑↑↑ → Polycythemia
3. Check if it is Primary or Secondary Polycythemia	● Primary polycythemia: ○ due to red bone marrow ● Secondary polycythemia: ○ other organs
4. Check EPO levels	● If EPO is ↑↑↑ → Secondary Polycythemia
	● If EPO is normal or ↓ → Primary Polycythemia
5. If EPO ↑↑↑, Check if it is *Appropriate or Inappropriate* Absolute Increase in RBC	● Appropriate: ○ History of a disease causing hypoxemia ● Inappropriate: ○ Tumor



VI) REVIEW QUESTIONS

1) Relative Erythrocytosis can be treated by:

a) Chemotherapy
b) JAK 2 Inhibitors
c) IV Fluids
d) Diuretics

2) The CT scan of a patient with polycythemia showed a mass in the pelvis, Tumor pathology will most likely find:

a) Hemangioma
b) Leiomyoma
c) Renal Cell Carcinoma (RCC)
d) Hepatocellular Carcinoma (HCC)

3) The findings that suggest Polycythemia vera:

a) ↑ RBC mass (RCM), ↑ EPO
b) ↑ RBC mass (RCM), ↓ EPO
c) ↓ RBC mass (RCM), ↑ EPO
d) ↓ RBC mass (RCM), ↓ EPO

4) A patient with a ventricular septal defect with secondary polycythemia is considered

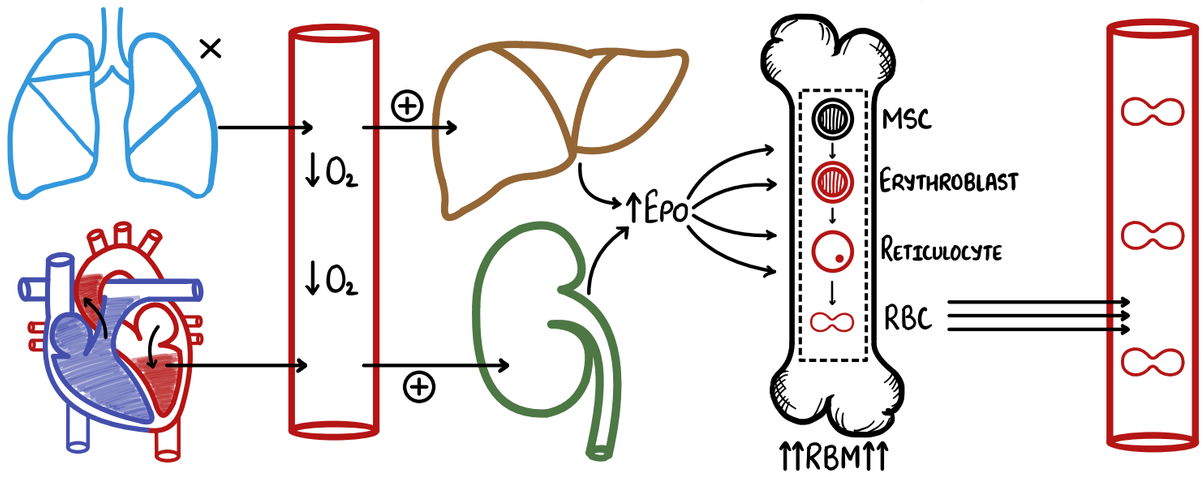
a) Appropriate absolute increase in RBC
b) Inappropriate absolute increase in RBC

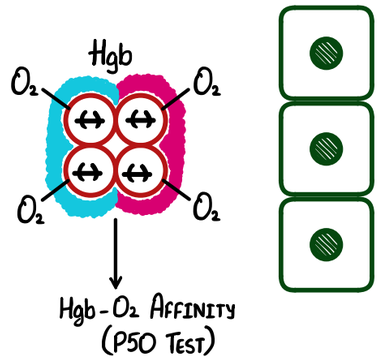
VII) REFRENCES

- Harrison, T. R., & Kasper, D. L. (2015). *Harrison's principles of Internal Medicine*. McGraw-Hill Medical Publ. Division.

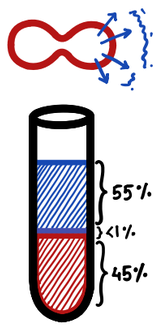
↑↑↑ Production Of RBC's ↑↑↑

- ? Polycythemia
  - → ↑Hgb
  - → ↑Hct
  - → ↑RBC's
    - ↓
- ✓ RBC Mass
  - → Normal
  - → ↑RBC Mass
    - → 1° PV
    - → 2° PV
      - ↓
- ✓ Epo Levels
  - → ↓Epo
    - → 1° PV
  - → ↑↑Epo
    - → 2° PV
      - ↓
- ✓ Hx + O_2 Sat%
  - ↓
- Ⓝ Hx
- Ⓝ O_2 Sat%
  - ↓
- CT Scans

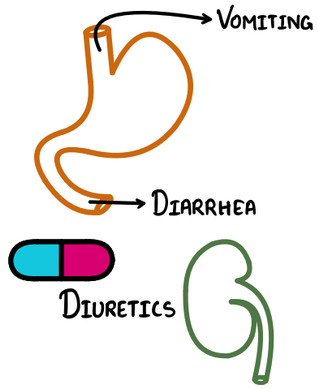




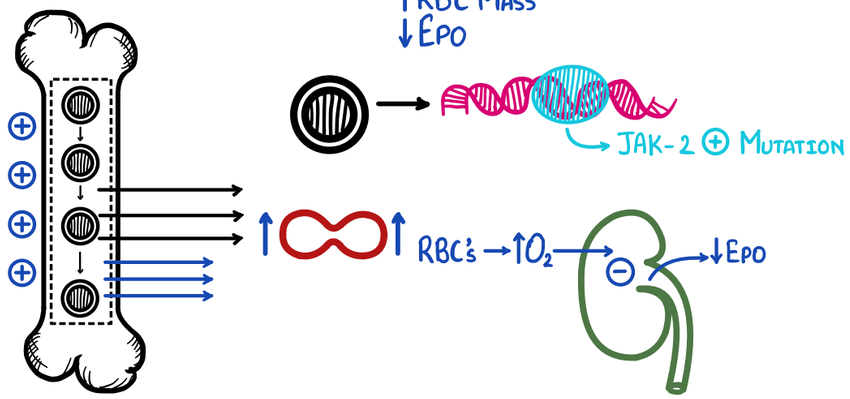
Relative Erythrocytosis



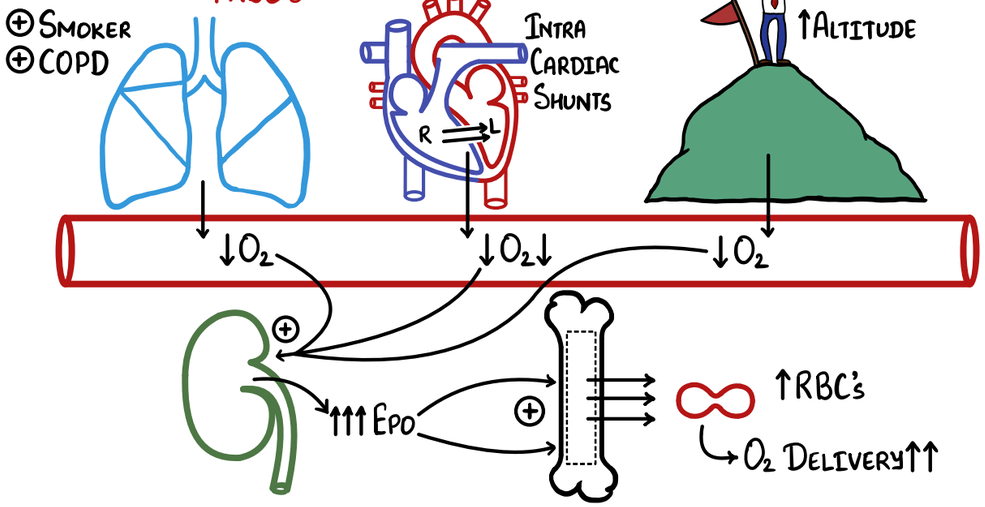
✓ Normal RBC Mass (Hemoconcentration)



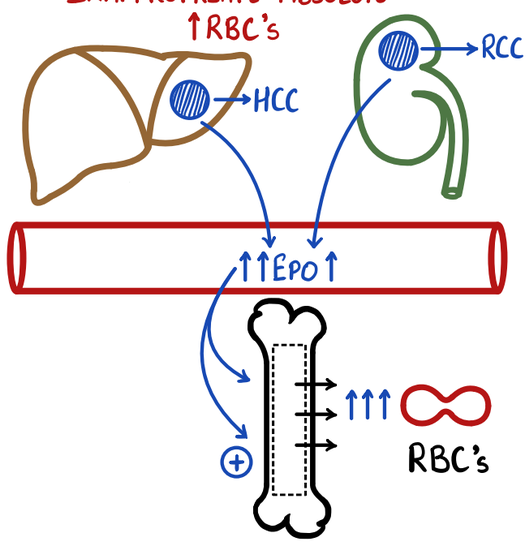
Polycythemia Vera



Appropriate Absolute ↑RBC's



Inappropriate Absolute ↑RBC's



Approach To Polycythemia

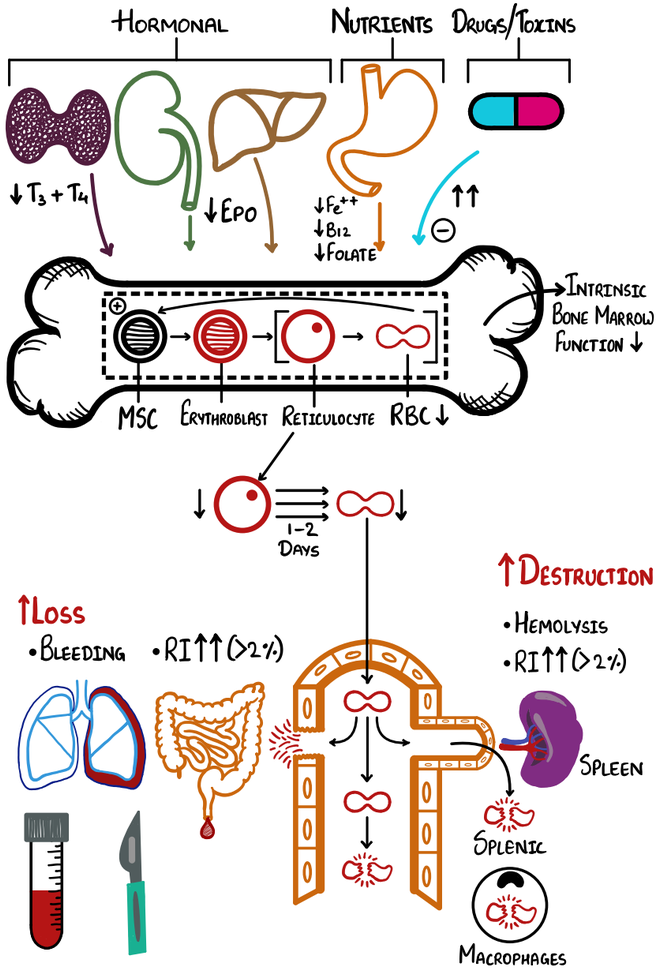
Jabr. G

NINJA NERD

Lifecycle Of A RBC

↓Production

- Hormonal ↓
- Nutrients ↓
- Drugs/Toxins ↑
- Intrinsic Bone Marrow Function ↓
- RI ↓↓ (<2%)



↓Decrease Production Of RBC's (RI < 2%)

Anemia
- ↓Hgb
- ↓Hct
- ↓RBC's

Reticulocyte Index
- <2% → ↓Production
- >2% → ↑Destruction / ↑Loss

MCV
- ↓MCV
- ↔MCV
- ↑MCV

∞ Microcytic Anemias (↓MCV)

↓↓↓↓MCV/RBC - MI

RDW/RBC's/MI/Iron Studies/PBS + Hx

IDA
- ↑RDW
- ↓RBC's
- MI > 13%
- ↓Ferritin
- ↓Trans. Sat%

ACD
- ↔RDW
- ↓ RBC's
- ×
- ↑↑Ferritin
- History

Thalassemia
- ↔/↑RDW
- ↔ RBC's
- ↓↓↓MCV/RBC<13% (RAI)
- PBS - Basophilic Stippling
- Hx ⊕
- Hb Electrophoresis ⊕

Sideroblastic Anemia
- ↑RDW
- ↓RBC's
- PBS → Basophillic Stipplings → pb Levels; Sideroblasts ⊕ → BM Bx To Confirm
- Hx ⊕

Iron Studies
- Fe^{++}
- Ferritin
- TIBC
- Trans Sat% ↓Fe^{++}/TIBC↑ <↓%

∞ Normocytic Anemias (↔MCV)

Iron Studies
- IDA
  - -↓Ferritin
  - -↓Trans. Sat%
- ACD
  - -↑↑Ferritin
  - - Hx ⊕

B12 / Folate
- •B12↓ •B9↓
- •Borderline Low B12/B9 → MMA → H.C.
- •B12↓ → MMA↑ → H.C.↑
- •B9↓ → MMA↔ → H.C.↑

TFT's
- •↓T3 + ↓T4

LFT's
- •↑LFT's

BMP
- •↑BUN
- •↑Cr. → CKD → •↓Epo

Hemolytic Labs
- •See Above

BM Bx
- •RI↓↓↓↓(0.1%) ±
- •Pancytopenia → A.A. (↓Prolif.); MDS (↑Prolif.); PRCA (↓Erythroblasts)

∞ Macrocytic Anemias (↑MCV)

B12 / Folate
- •B12↓ •B9↓
- •Borderline Low B12/B9 → MMA → H.C.
- •B12↓ → MMA↑ → H.C.↑
- •B9↓ → MMA↔ → H.C.↑

TFT's
- •↓T3 + ↓T4
- • Hx ⊕

LFT's
- •↑LFT's
- • Hx ⊕

MEDS
- •MTx
- •5 FU
- •Hydroxyurea
- •HIV Meds
- •TMP-SMX
- •PHT/VpA
- • Hx ⊕ Etoh

BAC
- •↑[BAC]

PBS
- •Megaloblasts ⊕ → >5 Lobes; HSN ⊕
- •Non Megaloblastic - HSN ⊖

BM Bx ±
- •Pancytopenia → MDS (↑Prolif.)

↑Destruction/Loss Of RBC's (RI > 2%)

1) Hemolytic Labs

↑LDH ↑I.Bil (UCB) ↑Hgb

↑Hgb Urine ⊕

Haptoglobin ↓

Hemolytic Anemias

2) DAT ⊕ (Coombs +)

Autoimmune Hemolysis
- Warm AIHA
  - -IgG ⊕
  - -Complement ⊕
- Cold AIHA
  - -IgG ⊖
  - -Complement ⊕

Splenic Dx
- -Splenic Dx
- -Liver Dx
- → Splenic U/S
- → Splenectomy

3) DAT ⊖

Intrinsic Hemolytic Anemias

4) PBS + Hx

Enzyme → G6PDH↓↓↓
- PBS → Bite Cells; Heinz Bodies ⊕

Hemoglobinopathy
- → PBS → Sickle Cell
- → HbE → Sickle Cell Anemia

Membrane
- H. Spherocytosis
  - – PBS → Spherocytes
  - – Osmotic Fragility Test ⊕
- PNH
  - – Hx Of Venous Clots + Dark Urine In AM
  - – PBS → Spherocytes
  - – Flow Cytometry ⊕

Extrinsic Hemolytic Anemias

MAHA + (↓PLT)
- •DIC → ↑PTT/PT/INR/D-Dimer/↓Fibrinogen + ↓PLT's
- •TTP → ↓PLT's/ARF/RBC's/Fever/Neuro Deficits → ADAMTS 13
- •HUS → GI Infection (Shiga Toxin) → ↓PLT's; ARF
- •HELLP → Pregnant + ↓PLT's + ↑LFT's
- •Mechanical Valve → Mechanical A.V.

PBS
- -Shistocytes
- -Helmet Cells

Infections

↑↑↑Fever / Rash
- •Malaria
  - -PBS → Inclusions ⊕
- •Babesiosis
  - -PBS → Maltese Cross ⊕
- •Disseminated C. diff.
  - -PBS → Ghost Cells

Blood Loss Anemias

1) ⊖ Hemolysis
2) S/S Bleeding

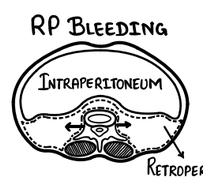
↑↑Blood Draws

Surgery

•EGD ⊕
•NGT Aspirate

C-Slope ⊕
FOBT ⊕

RP Bleeding



CTA Of Abd. & Pelvis

Approach To Anemia

Jul. G

NINJA NERD