Lab 05: Red Cell Indices

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The calculation of the size and haemoglobin content of the red cells from the Hb, PCV and red cell count, have been widely used in the classification of anemia. The three most common indices are the MCV, the MCH.

The MCV is the average volume of a single red cell expressed in femtoliters (fl) or 10^{-15} L. It helps in determining the size of the RBC. The PCV and red cell volume are used in its calculation.
Mean Corpuscular Volume (MCV)

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Hct(L/L) x 1000
• MCV = -------------------------
        RBC count ( x 10^{12}/L)
• Normocytic: 80-100 fL
• Microcytic: Red cells < (100 fL)
• Macrocytic: Red cells > (100 fL)
• The MCV is increased in macrocytic anemias (e.g. megaloblastic anemia) and decreased in microcytic anemias (e.g. iron deficiency, thalassemia)
• Example:
  • PCV = 0.45 L/L (45%), RBC = 5 x 10^{12}/L
  • MCV = \frac{PCV \times 10}{RBC} = \frac{45(\%)}{5} = 90 \text{ fL}
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Microcytic
MEAN CELL HEMOGLOBIN CONCENTRATION

- The **MCHC** is the **concentration of haemoglobin per unit volume of red blood cells** expressed as a percentage, g/dl or g/l. Hemoglobin and PCV are required to calculate MCHC. It is the ratio of hemoglobin mass to volume in which it is contained.

  - MCHC = \( \frac{\text{Hb}(\text{g/dl})}{\text{PCV} \%} \times 100 \)

- Normochromic: 32-36g/dl
- Hypochromic: 36g/dl
- Hyperchromic: >36g/dl

- Example:
  - If one liter of blood contains 0.45 liters of packed cells and 150g of Hb (150g Hb are contained in 0.45 liters of RBCs). What is the Hb concentration?
  - \( \text{Hb} = 15 \text{ g/dl} \) (150 g/l), \( \text{PCV} = 45\% \) (0.45 l/l)
  - MCHC = \( \frac{\text{Hb} \text{ (g/dl)}}{\text{PCV} \%} \times 100 = \frac{15}{45} \times 100 = 33.3\% \) or 33.3 g/dl = 333.3 g/l
MEAN CELL HEMOGLOBIN CONCENTRATION

• **Hypochromic**: If the area of central pallor is >1/3rd of the cell size

• **Hyperchromic**: The only erythrocyte that is hyperchromic with an MCHC of > 36g/dl is the spherocyte

• **Apparent hyperchromasia** (high MCHC) is usually due to an artifactual increase in the haemoglobin result, due to haemolysis, lipaemia, or large numbers of Heinz bodies

• **Low MCHC** values are found in **iron deficiency anemia** and other conditions in which the red cells are microcytic and hypochromic.

• An **increased MCHC** can occur in marked **spherocytosis**.
MEAN CELL HEMOGLOBIN

• **MCH** is the **average weight in picograms of Hb in one red cell**. The Hb level and the RBC count are used for calculation.

• **MCH** = \( \frac{\text{Hb} (g/dl) \times 10 \times \text{RBC} (\times 10^{12}/L)}{10} \)

**MCH** varies in **direct linear** relationship with the **MCV**. **Cells with less volume contain less Hb and vice versa**

Normal value for the MCH: **28 to 34 pg**
MEAN CELL HEMOGLOBIN

MCH Increase
• B12 deficiency
• Folic acid deficiency
• Reticulocyte
• Hemolytic anemia
• Alcoholism

MCH Decrease
• Iron deficiency anemia
• Thalassemia
• Anemia of chronic disorder
Hypochromic microcytic anemia of iron deficiency (peripheral blood smear)

Hyperchromic RBCs
<table>
<thead>
<tr>
<th>Value</th>
<th>Formula</th>
<th>Normal Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCV (fl)</td>
<td>( \frac{\text{PCV} \times 10}{\text{RBC} \text{ (millions / mm}^3)} )</td>
<td>(80-100)76 – 96 fl</td>
</tr>
<tr>
<td>MCH (pg)</td>
<td>( \frac{\text{Hb} \text{ (g/100ml)} \times 10}{\text{RBC} \text{ (millions / mm}^3)} )</td>
<td>27 – 32 pg</td>
</tr>
<tr>
<td>MCHC (x 100%w/v)</td>
<td>( \frac{\text{Hb} \text{ (g/100ml)} \times 100}{\text{PCV} \text{ (%)}} )</td>
<td>32 – 36%</td>
</tr>
</tbody>
</table>
RED CELL DISTRIBUTION WIDTH

• **RDW** is used because MCV is less reliable in describing the erythrocyte population when considerable variation in erythrocyte size occurs.

• **RDW** is a coefficient of variation in size distribution of RBCs

• Measured as: \( \text{RDW} = \frac{\text{Standard deviation of MCV}}{\text{MCV}} \times 100 \)

• Normal value: 11.5-14.5%

• Increased value indicates **ANISOCYTOSIS**
• RDW is **increased** in **Iron deficiency anemia**.
• While RDW is **normal** in **Thalassaemia minor**.
• **Combination of low MCV and high RDW** is one of the best screening test for the **Iron deficiency anemia**.
differential diagnosis anaemia depend on MCV RDW

<table>
<thead>
<tr>
<th>Condition</th>
<th>RDW</th>
<th>MCV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutritional deficiencies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron deficiency</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Folic acid deficiency</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Vitamin B deficiency</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>β-thalassemia</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Hemolytic anemias</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immune hemolytic anemia</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Hereditary spherocytosis</td>
<td>N/↑</td>
<td>N/↓</td>
</tr>
<tr>
<td>Anemic hemoglobinopathies (i.e., SS, SC)</td>
<td>↑</td>
<td>N</td>
</tr>
<tr>
<td>Sickle cell trait</td>
<td>N</td>
<td>↓</td>
</tr>
<tr>
<td>Chronic disorders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronic diseases anemia</td>
<td>N</td>
<td>↓</td>
</tr>
<tr>
<td>Chronic liver disease</td>
<td>↑</td>
<td>N/↑</td>
</tr>
<tr>
<td>Hematologic disorders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aplastic anemia</td>
<td>N</td>
<td>↑</td>
</tr>
<tr>
<td>Chronic leukemias</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Myelodysplastic syndrome</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Other thalassemias</td>
<td>N</td>
<td>↓</td>
</tr>
<tr>
<td>Acute hemorrhages</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

↑, increased; N, normal; ↓, decreased. RDW, red blood cell distribution width; MCV, mean corpuscular volume.
- 25 yr old Patient with history of fatigue
- RBC: 3.0 x 10⁶ /μl
- Hb: 8.0 g/dl
- MCV: 62 fl
- MCH: 19.0 pg
- MCHC: 30 g/dl
- WBC: 5.3 x 10⁹/l
- Platelets: 400 x 10⁹/l
- Impression:
  - MICROCYTIC HYPOCHROMIC ANEMIA
- Differential diagnosis?
26 yr, Patient of low socio economic status comes with history of weakness since 6 months, history of chronic abuse of PPI.

- RBC: 3.0 x 10⁶ /μl
- Hb: 11.0 g/dl
- MCV: 75 fl
- MCH: 24.0 pg
- MCHC: 29 g/dl
- WBC: 5.3 x 10⁹/l
- Platelets: 400 x 10⁹/l
- RDW: 17%

Interpretation?

- Microcytic hypochromic anemia
- Is Vit B12 def possible in this patient?
- A case of dimorphic anemia or combine anemia.

If yes - explain MCV?