HEMOGLOBIN & HEMATOCRIT

TERM DEFINITION

Hemoglobin (Hb) is the concentration of Hb in whole blood. Hematocrit (Hct) is the fractional volume of blood composed of red blood cells.

Hb expressed as g/dL	Hct expressed as %

RELATIONSHIP

MCHC = Hb/Hct

CLINICAL PEARLS

3:1 RULE

The ratio between Hct and Hb is normally 3:1; if the ratio is significantly higher, the patient likely has iron deficiency anemia

Hct depends on the presence of cells, not hemoglobin. In theory the Hct may be normal with Hb=0

Hb carries oxygen, Hct does not

Oxygen delivery = cardiac output x oxygen content of blood

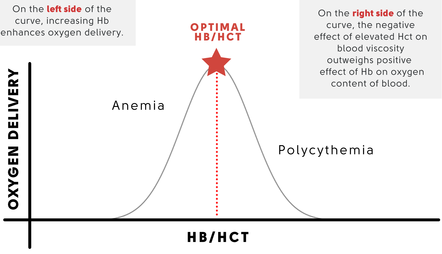
Oxygen content of blood (ml/dL) = 1.34 ml/ml x **Hb (g/dL)** x oxygen saturation (%)

Cardiac output = mean arterial pressure/total peripheral resistance
Total peripheral resistance correlates positively with viscosity
Hct (%) is primary determinant of viscosity

OPTIMAL HCT/HB

On the **left side** of the curve, increasing Hb enhances oxygen delivery.

On the **right side** of the curve, the negative effect of elevated Hct on blood viscosity outweighs positive effect of Hb on oxygen content of blood.



LEFT SIDE OF CURVE

- Patients have anemia
- Hb is limiting
- Goal is to climb the curve towards the apex (top of the mountain)
- That's why we speak of Hb when discussing patients with anemia

RIGHT SIDE OF CURVE

- Patients have polycythemia
- Hct is limiting
- Goal is to backtrack towards the apex of the curve
- That's why we speak of Hct when discussing patients with polycythemia

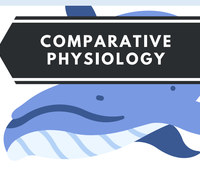
THERAPEUTIC PRINCIPLES

For those on the left side of the curve, treatment may include replacement of iron or vitamin B12, treatment of underlying condition causing anemia, or blood transfusion.

For those on the right side of the curve, phlebotomy (short term) or hydroxyurea (in cases of polycythemia vera) may decrease Hct and provide symptomatic relief.

COMPARATIVE PHYSIOLOGY

The optimal Hb/Hct is highly conserved across mammals. It varies between **40-45%**, though this number is achieved by many different combinations of MCV and RCB count (Hct = MCV x RBC count). An exception are marine mammals, which operate at an optimal Hct of **50-55%** or even higher, presumably related to their diving behavior.



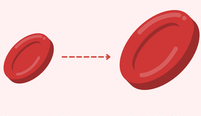
PROXIMATE MECHANISMS

The oxygen sensor in the **kidney** is attuned to oxygen delivery, which is positively influenced by the Hb and negatively influenced by the Hct. It is impervious to the MCV or or red cell number.

Hb increases the oxygen content of blood. Hct increases the viscosity of blood, which in turn leads to increased total peripheral resistance and decreased cardiac output. So from the standpoint of oxygen delivery, these two parameters are at odds with each other. From an evolutionary standpoint, this may represent a cost of packaging our respiratory pigment inside red cells.

EVOLUTIONARY MECHANISMS

Evolution has selected for an optimal Hb and Hct to deliver oxygen to tissues. As discussed above, animals can arrive at an optimal Hb/Hct by many different permutations of MCV and RBC count (Hct = MCV x RBC count).



How one achieves an optimal Hb/Hct, whether through the over-production of tiny RBCs or the underproduction of large RBCs, seems to be less important than meeting the Hb/Hct goal itself.

Patients with thalassemia minor have unusually small red cells. To make up for the small size, they adjust their output of red cells to reach a normal Hb/Hct.

HISTORY OF MEDICINE

When clinicians started to develop markers for anemia in the late 1800s, they began with RBC counts because the **hemocytometer** was invented before the Hb or Hct assay. The invention of the Hb assay transformed the field of hematology, as it provided a more reliable, quantitative assay for diagnosing anemia. Finally, the invention of the Hct was heralded as a replacement for the laborious red cell count. It soon became apparent that Hb/Hct could give information about the MCHC (called saturation index back then) and that Hct/RBC count could provide a volume index (now referred to as the MCV).

NOTES

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The Blood Project
ENCYCLOPEDIA OF BLOOD