Lecture Notes

UJ | SCHOOL OF MED

PHYSIOLOGY

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019

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Physiology of the blood

- We said that the hemoglobin concentration in males is 15g/100ml of blood and in females it is 14g/100ml.
- Usually 1g of hemoglobin carries 1.34 ml of O2, therefore in 100ml of blood it carries 20 ml of oxygen. Even in plasma, there is a small amount of oxygen, about 0.3 ml.
- The hemoglobin molecule is formed by 4 subunits, 2 alpha subunits and 2 beta subunits, each subunit contains one heme molecule. A heme molecule is a protoporphyrin IX with an iron atom. In one hemoglobin molecule there are four iron atoms, and each one of them carries one oxygen molecule. In one RBC there are millions of hemoglobin molecules which in turn carry a large amount of oxygen (300 millions to be exact)
- What we mentioned applies for the adult hemoglobin, there are other hemoglobin types

Table 4-4. Normal Human Hemoglobins—Genetic Variants

Name	Designation	Molecular Structure	Proportion in Adults	Proportion in Newborns
Adult hemoglobin	A	$\alpha_2\beta_2$	97%	20%
Hemoglobin A_2	A_2	$\alpha_2\delta_2$	2.5%	0.5%
Fetal hemoglobin	F	$\alpha_2\gamma_2$	<1%	80%
Portland		$\zeta_2\gamma_2$	0	0
Gower I		$\zeta_2\epsilon_2$	0	0
Gower II		$\alpha_2\epsilon_2$	0	0

- There are six types of hemoglobin in the human being. Three of them are present in the adult as well as the newborn.
- There are other embryonic hemoglobin molecules, Portland, Gower I and Gower II. They are present only in the embryo, they cannot be found in the adult or newborn.

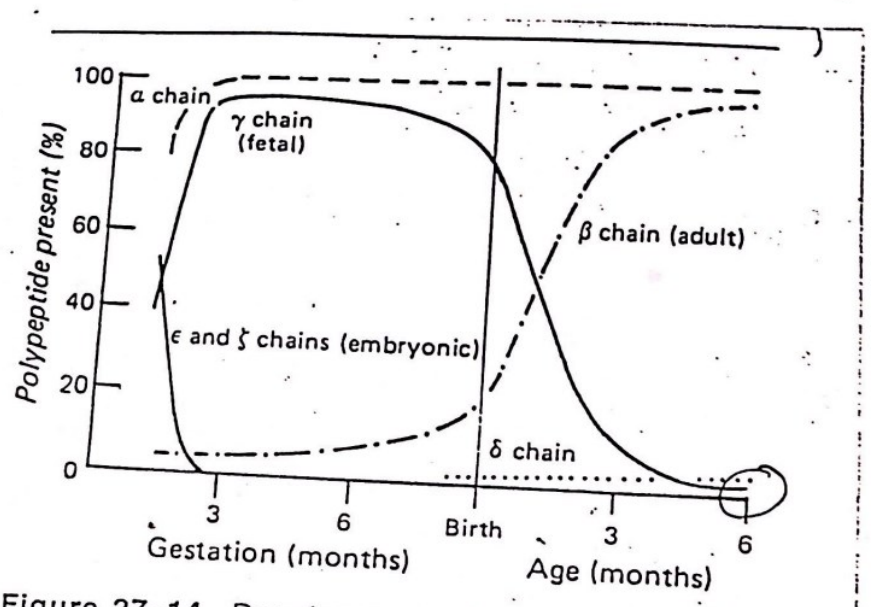
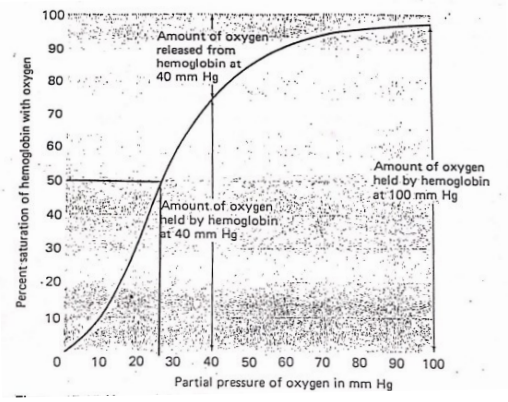
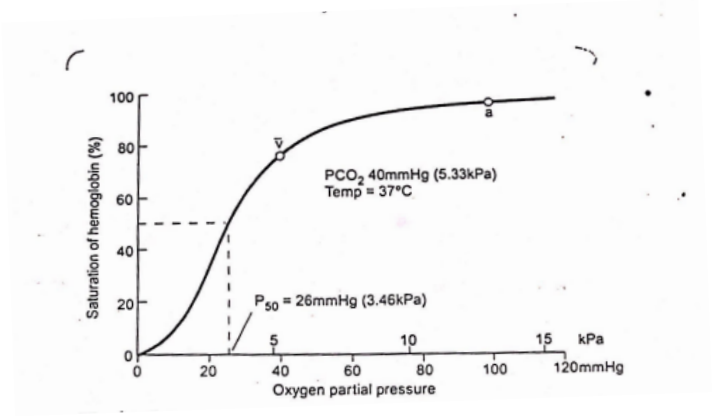


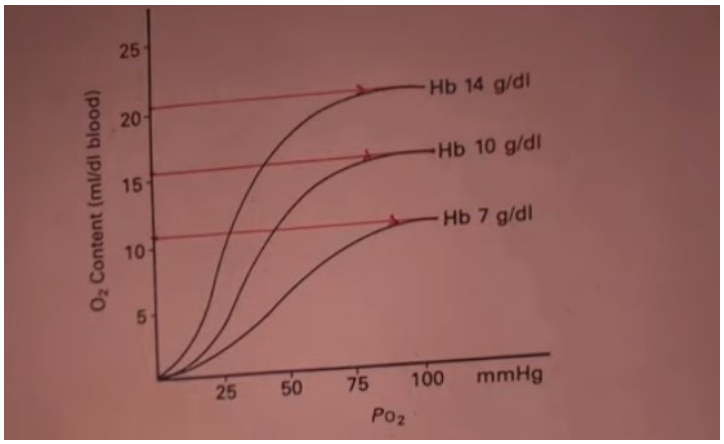
Figure 27–14. Development of human hemoglobin chains.

- Fetal hemoglobin is replaced almost completely by adult hemoglobin after the end of the 6th month after birth.
- Myoglobin is an oxygen binding pigment found in the RBCs. There is also another type of binding globin which is found in the brain, called neuroglobin. These proteins bind oxygen.





- This curve is called the hemoglobin-oxygen dissociation curve.
- There are 3 assets we must know in this figure:
  1. When pO2 in the lungs is about 100mm Hg, only about 90% of the hemoglobin becomes saturated (not all of it as you might think) + (97% is a more accurate percentage)
  2. At the level of tissues when pO2 is 40mm Hg, only about 25% of O2 is released (not all of it)
  3. When 50% of the hemoglobin becomes saturated with the hemoglobin the pO2 is about 26mm Hg (P50).
- This hemoglobin-oxygen dissociation curve does not change from person to person whatever the hemoglobin concentration is, we will always get this curve, but when we put pO2 and oxygen content in the blood on the axies of the graph, we will get different curves depending on the hemoglobin content for this person, as seen in the graph below.



- It is evident that the quantity of oxygen carried in a volume of blood is dependent on pO2 as well as the hemoglobin concentration.
- The percentage saturation of hemoglobin with oxygen is dependent on pO2 and totally independent of hemoglobin concentration.
- If oxygen content (instead of percentage of saturation of hemoglobin with oxygen) is plotted against pO2, the level of the curve will be dependent on the hemoglobin concentration of the sample of blood.
  But when plotting percentage saturation against pO2, as is usually done, the curve will always be the same, whatever the hemoglobin concentration, if other factors remain the same.

$$Hb_4 + O_2 \rightleftarrows Hb_4O_2$$
$$Hb_4O_2 + O_2 \rightleftarrows Hb_4O_4$$
$$Hb_4O_4 + O_2 \rightleftarrows Hb_4O_6$$
$$Hb_4O_6 + O_2 \rightleftarrows Hb_4O_8$$

- Not all heme molecules bind oxygen at the same time, they bind one by one.
- Combination of the first heme in the Hb molecule with O2 increases the affinity of the second heme for O2, and oxygenation of the second increases the affinity of the third etc., so that the affinity of Hb for the fourth O2 molecules is many times that for the first.

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