Peripheral oxygen delivery

Definition

Components of Oxygen in Blood

Oxygen delivery to the periphery depends on the oxygen content of blood and tissue blood flow. The oxygen content of blood has two components: oxygen bound to hemoglobin and oxygen dissolved in plasma. Oxygen bound to hemoglobin is generally the much greater contributor to oxygen content. (One notable exception when oxygen dissolved in plasma is a major contributor is carbon monoxide poisoning: hemoglobin has 230 times greater affinity for carbon monoxide than oxygen.) Tissue blood flow is equal to cardiac output.

Oxygen Delivery(DO2)

Therefore, oxygen delivery can be calculated:

DO_2 = Oxygen content (CaO_2) x Cardiac Output (CO)

(CaO_2) = (1.39 x Hb x O_2Sat/100) + (0.003 x PO_2)

Oxygen Consumption

Oxygen consumption can be calculated by the Fick principle as the difference between arterial and venous oxygen content: $VO_2 = CO \times (CaO_2 - CvO_2)$

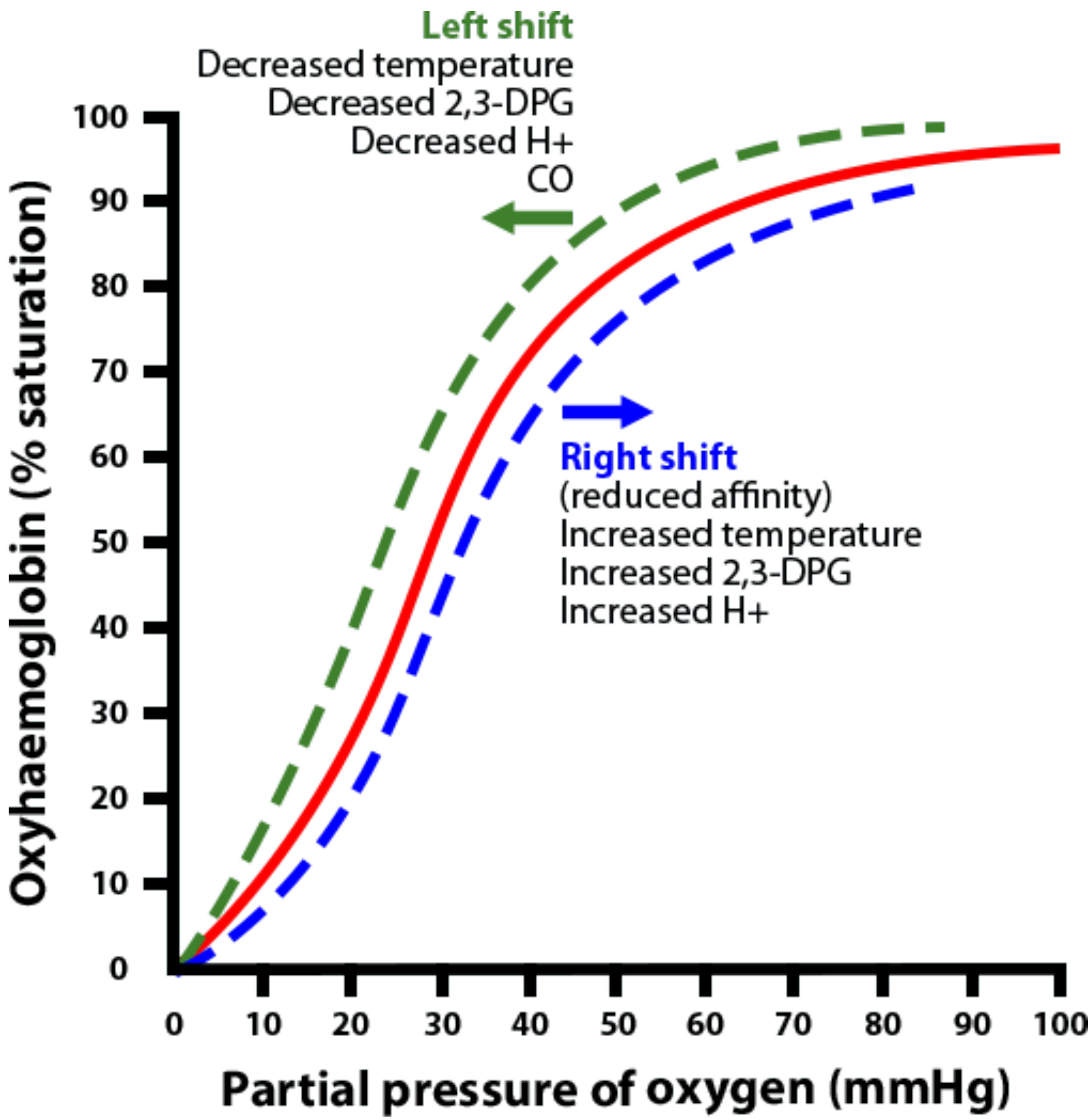
Oxygen Dissociation

The oxyhemoglobin dissociation curve relates oxygen saturation at varying oxygen tensions. The oxyhemoglobin dissociation curve is S shaped, reflecting subunit cooperativity. Using the dissociation curve and the equations above it is possible to calculate oxygen delivery and consumption.

Under normal conditions, the oxygen tension of arterial blood is 95 mmHg (oxygen tension at the pulmonary capillaries is 104 mmHg, but pulmonary capillary blood then mixes with bronchial blood to reach an arterial oxygen tension of 95 mmHg), and is fully saturated. Using the oxygen content equation and a hemoglobin concentration of 15 g/dL the amount of oxygen this blood caries is 21.14 mL/dL. If cardiac output is 5 L/min, then total oxygen delivery is 1057 mL/min. This blood then travels to the periphery where the PO_2 is 40 mmHg. From the oxyhemoglobin dissociation curve, it is evident that a PO2 of 40 is equal to an oxygen saturation of 75%. Using the equation for oxygen content again, the amount of oxygen in venous blood is 15.76 mL/dL. Using the Fick principle, oxygen consumption is calculated as 269 mL/min

The S shape of the oxyhemoglobin dissociation curve allows blood to unload oxygen where it is needed most, thus in the periphery small changes in the partial pressure of O2 lead to large changes in the % saturation.

The portion contributed by dissolved O_2 [PaO2 x 0.003] is usually negligible except in cases of extreme anemia (i.e. Hgb 5) or carbon monoxide poisoning.


Left shift
Decreased temperature
Decreased 2,3-DPG
Decreased H+
CO
Right shift
(reduced affinity)
Increased temperature
Increased 2,3-DPG
Increased H+
Oxyhaemoglobin (% saturation)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Partial pressure of oxygen (mmHg)

Shifts in the Dissociation Curve

Factors that affect the oxyhemoglobin dissociation curve will also affect oxygen delivery:

The P50 is the oxygen tension at which hemoglobin is 50% saturated. The normal P50 is 26.7 mm Hg.

- **Left shifts of the oxyhemoglobin dissociation curve** (Hgb holds onto O2 more):

HbF, alkalosis, hypocarbia, decreased temperature, carbon monoxide, methemoglobin, hypophosphatemia (critical care patients

- **Right shifts** (Hgb unloads more O_2):

CADET right face!

CO_2 [Bohr effect: hypercarbia causes drop in pH, decreases affinity for oxygen (right shift) at tissues and facilitates unloading of O_2.]

Acidemia:

2,3-**D**PG

Exercise

Temperature: hyperthermia causes a rightward shift