OXYGEN TRANSPORT STUDIES

A. Total Oxygen Delivery
   1. the total amount of oxygen delivered to the peripheral tissues is dependent on:
      a. the body's ability to oxygenate blood
      b. the hemoglobin concentration
      c. cardiac output
   2. $D_{O_2} = \dot{Q}_T \times (Ca_{O_2} \times 10)$
      a. calculate the oxygen delivery if cardiac output is 5 l/min. and Ca_{O_2} is 20 vol%.
   3. oxygen delivery decreases when:
      a. blood oxygenation decreases
      b. hemoglobin concentration decreases
      c. cardiac output decreases

B. Arterial-venous Oxygen Content Difference
   1. $C(a-\bar{v})_{O_2} = Ca_{O_2} - C\bar{v}_{O_2}$
   2. $Ca_{O_2} = (Hb \times 1.34 \times SaO_2) + (PaO_2 \times 0.003)$
      a. normally Ca_{O_2} is 20 vol%
   3 $C\bar{v}_{O_2} = (Hb \times 1.34 \times S\bar{v}O_2) + (P\bar{v}O_2 \times 0.003)$
      a. normally $C\bar{v}_{O_2}$ is 15 vol%
   4. factors that increase $C(a-\bar{v})_{O_2}$
      a. decreased cardiac output
      b. periods of increased oxygen consumption
         1) exercise
         2) seizures
         3) shivering in a postoperative patient
   5. factors that decrease $C(a-\bar{v})_{O_2}$
      a. increased cardiac output
      b. skeletal relaxation -
      c. peripheral shunting -
      d. poisons -
      e. hypothermia

C. Oxygen Consumption
   1. the amount of oxygen extracted by the peripheral tissue in one minute
   2. $\dot{V}_{O_2} = \dot{Q}_T[C(a-\bar{v})_{O_2} \times 10]$
   3. $\dot{V}_{O_2}$ is a component of the respiratory exchange ratio
      a. $R = \dfrac{\dot{V}_{CO_2}}{\dot{V}_{O_2}}$
   4. factors that increase oxygen consumption
      a. exercise
      b. seizures
      c. shivering in postoperative patients
      d. hyperthermia
   5. factors that decrease oxygen consumption
      a. skeletal relaxation -
      b. peripheral shunting -
      c. poisons -

d. hypothermia

6. clinically oxygen consumption is indexed by a patient's body surface area (BSA)
   a. oxygen consumption index = $\dfrac{\dot{V}_{O_2}}{BSA}$
   b. oxygen consumption index ranges - 125 to 165 ml O_2/m^2

D. Oxygen Extraction Ratio
1. this is the amount of oxygen extracted by the peripheral tissues divided by the amount of oxygen delivered to the peripheral cells.
2. O_2ER is also known as the oxygen coefficient ratio or the oxygen utilization ratio
3. $O_2ER = \dfrac{Ca_{O_2} - C\bar{v}_{O_2}}{Ca_{O_2}}$
4. normal O_2ER is o.25
5. factors that increase O_2ER
   a. decreased cardiac output
   b. periods of increased oxygen consumption
      1) exercise
      2) seizures
      3) shivering in postoperative patient
      4) hyperthermia
   c. anemia
   d. decreased arterial oxygenation
6. factors that decrease O_2ER
   a. increased cardiac output
   b. skeletal relaxation -
   c. peripheral shunting -
   d. poisons -
   e. hypothermia -
   f. increased hemoglobin concentrations
   g. increased arterial oxygenation

E. Mixed Venous Oxygen Saturation
1. normal $S\bar{v}_{O_2}$ is about 75%
2. clinically an $S\bar{v}_{O_2}$ of 65% is acceptable
3. factors that decrease the $S\bar{v}_{O_2}$
   a. decreased cardiac output
   b. periods of increased oxygen consumption
      1) exercise
      2) seizures
      3) shivering in postoperative patient
      4) hyperthermia
4. factors that increase the $S\bar{v}_{O_2}$
   a. increased cardiac output
   b. skeletal relaxation -
   c. peripheral shunting -
   d. poisons -
   e. hypothermia -

F. Shunt Equation
1. pulmonary shunting occurs when a portion of cardiac output enters the left side of the heart without exchanging gas with alveolar gas (true shunt) or

2. pulmonary shunting occurs when blood gases exchange with alveolar gas but does not obtain a PO_2 that equals that of a normal alveolus (shunt-like effect)
3. $\frac{\dot{Q}_S}{\dot{Q}_T} = \frac{Cc_{O_2} - Ca_{O_2}}{Cc_{O_2} - C\bar{v}_{O_2}}$ or $\frac{QS}{QT} = \frac{(PA_{O_2} - Pa_{O_2}) \times 0.003}{[(PA_{O_2} - Pa_{O_2}) \times 0.003] + C(a - \bar{v})_{O_2}}$
   a. $Cc_{O_2} = (Hb \times 1.34 \times 1^*) + (PA_{O_2} \times 0.003)$
      *if $PA_{O_2} > 150$ use 1.0
      *if $PA_{O_2} \leq 150$ but > 125 use 0.99
      *if $PA_{O_2} \leq 125$ but > 100 use 0.98
      * if $PA_{O_2} \leq 100$ but > 75 use 0.97
4. clinical significance of pulmonary shunting
   a. < 10% describes a normal lung
   b. 10-20% indicates an intrapulmonary abnormality) rarely significant
   c. 20-30% is significant intrapulmonary disease, may be life threatening
   d. > 30 is potentially life-threatening, aggressive cardiopulmonary support measures are required
5. calculating the degree of pulmonary shunting is not reliable in patients demonstrating:
   a. questionable perfusion status
   b. decreased myocardial reserve
   c. unstable oxygen consumption demand

G. OXYGEN TRANSPORT STUDIES

CLINICAL FACTORS	DO_2 (1000 ml O2/min)	$\dot{V}O_2$ (250 ml O2/min)	$C(a - \bar{v})O_2$ (5 vol%)	O_2ER (25%)	$S\bar{v}O_2$ (75%)
↑ O2 Consumption	Same	↑	↑	↑	↓
↓ O2 Consumption	Same	↓	↓	↓	↑
↓ Cardiac Output	↓	Same	↑	↑	↓
↑ Cardiac Output	↑	Same	↓	↓	↑
↓ PaO2	↓	Same	Same	↑	↓
↑ PaO2	↑	Same	Same	↓	↑
↓ Hb	↓	Same	Same	↑	↓
↑ Hb	↑	Same	Same	↓	↑
Peripheral Shunting	Same	↓	↓	↓	↑