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ScVO2

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- Hypoxia is typically pretty easy to fix with supplemental oxygen
- What is more important is understanding oxygen delivery and consumption

The Oxygen content of blood = CaO2 = 1.34 x Hg x SaO2 + .003 x PaO2

- Once Hg is fully saturated, PaO2 does very little to support oxygen delivery
- With a Hg of 15, typical CaO2 is around 20 ccO2/dl blood
- e.g. If you increase FiO2 to 500 on the ventilator, CaO2 will only increase by 1.2 ccO2/dl blood
- Keeping the PaO2 above what is necessary to adequately saturate Hg does very little for you and likely exposes patients to oxygen toxicity
- <u>RULE 1: Oxygen saturation (SaO2) is much more important than PaO2</u>

Now that your blood is loaded with oxygen, you need to get it to the tissues. Delivery of oxygen = DO2 = CO x CaO2 x 10 (to get it into mL as opposed to dL)

- The major factors that make up oxygen delivery are CO, Hg and SaO2
- CO has the greatest impact on DO2
- Hg the second greatest
- Hypoxia has the least impact
- <u>RULE 2: Increasing CO or improving anemia can offset hypoxemia in terms of oxygen delivery</u>

Once oxygen gets delivered to the tissues, it is consumed. VO2 = oxygen consumption.

- During exercise or critical illness, VO2 can increase by 30-50%
- We can measure VO2 by looking at ScVO2 (or mixed venous if you have a swan)

- By knowing the venous oxygen saturation, we can calculate the Venous Oxygen Content = $CvO2 = 1.34 \times Hg \times SvO2 + .003 \times PvO2$
- The VO2 is then the arterial-venous oxygen difference x CO
    - $VO2 = CO \times (CaO2 - CvO2) \times 10$
    - $VO2 = CO \times [(1.34 \times Hg \times SaO2) - (1.34 \times Hg \times SvO2)] \times 10$
    - $VO2 = CO \times 1.34 \times Hg (SaO2 - SvO2) \times 10$

Knowing either the DO2 or the VO2 is unhelpful. What we really want to know is whether the DO2 is adequate for the VO2

- During both rest and exercise, the DO2:VO2 ratio is maintained at ~4:1 or 5:1
- This is done by changes/adjustments in CO
- This allows the body a reserve. It would be pretty dumb if the body only delivered just enough oxygen for it's demand. The minute something stressful happened, you would die.
- If the DO2 does decline, eventually it will reach a point at which further drops in delivery lead to declines in consumption — or consumption becomes delivery-dependent
    - This is called the Anaerobic threshold.
    - You would expect this to be when DO2:VO2 ratio is 1, however it actually occurs closer to 2:1 ratio
    - <u>RULE 3: DO2:VO2 ratio is typically 4:1 or 5:1, once it reaches close to 2:1, the patient is nearing anaerobic threshold</u>

ScVO2 can be used as surrogate to the DO2:VO2 ratio

- *The ScVO2 can be used to identify when a patient has insufficient oxygen delivery to meet the body's demand (when patients are nearing anaerobic threshold)*
- How can the ScVO2 act as a surrogate?
    - DO2/VO2 ratio = $(CO \times 1.34 \times SaO2 \times 10) / [CO \times 1.34 \times Hg \times (SaO2 - SvO2) \times 10]$

- Cancel everything out and you are left with:
    - DO2:VO2 = SaO2/(SaO2 - SvO2)
    - If you assume the SaO2 is 100%, then the SvO2 correlates the DO2:VO2 ratio:
        - 5:1 = 80%
        - **4:1 = 75%**
        - 3:1 = 67%
        - **2:1 = 50%**

Inadequate oxygen delivery for consumption demands can only be due to three things:

- Low CO
- Anemia
- Hypoxemia
    - CO has the GREATEST IMPACT ON THIS
        - *We always tend to think of heart failure when ScVO2 is low, but anything that reduces CO will decrease ScVO2:*
            - Hypovolemia
            - Hemorrhagic shock
            - Cardiac Tamponade, etc
    - <u>RULE 4: ScVO2 is low in LOW FLOW STATES</u>

In critical patients in which hypoxemia is difficult to correct, your ScVO2 will go down with each reduction in SaO2 (if DO2:VO2 otherwise stays the same)

- Calculating the oxygen extraction ratio is a quick way to estimate the balance between oxygen delivery and consumption, even when SaO2 is low
- O2ER = (SaO2 - SvO2)/SaO2
- A normal O2ER is 20-25%

- An O2ER >30% should warrant evaluation
- An O2ER >40% means the patient is rapidly nearing anaerobic threshold!
- RULE 5: If SaO2 is low, you can use the O2ER to evaluate delivery versus demand accurately (basically, if the SaO2 is low and you want to know if that's the reason why oxygen delivery is poor, or if it is due to CO or anemia)