HK*4550 Human Cardio-respiratory Physiology Midterm II Answer Key (F13)

1.

a) Respiratory failure
- Inability to sustain an expected level of pressure/force production
- aka. pump failure
- Sometimes evident as apnea

b) Dead space
- Where gas exchange does not occur in airways
- Trachea, bronchioles

c) Emphysema
- Anatomic alteration of lung characterized by enlargement of air spaces distal to terminal bronchioles
- Destruction of alveolar walls

d) Z-line streaming
- In normal muscle, z-lines are vertical; with damage, cause changes in the angle of the z-line
- Z-lines no longer parallel
- Evidence of fatigue or injury; ultrastructural

e) Exacerbation
- To make worse; flare up
- E.g. asthma patient has asthma attack, COPD patient has pneumonia

f) Ubiquitin
- ATP-dependent regulatory protein involved in protein degradation
- Once activated, ubiquitin binds to oxidized/damaged proteins and directs them to proteasomes for degradation into amino acids
- The more ubiquitin that binds to a protein, the more likely it will be degraded

g) Atrophy
- Reduction in cross-sectional area
- Wasting of muscle as the result of disease, injury and/or disuse

h) PAH
- Pulmonary arterial hypertension
- As pulmonary vascular resistance increases we must also increase pressure to maintain blood flow through pulmonary circulation
- Prolonged elevation of blood pressure leads to right ventricular hypertrophy and eventually cor pulmonale

2.
- Patient may have early stages of COPD in which O2 uptake is impaired due to alterations in surface area/thickness of the alveolar tissue (e.g., emphysema) however CO2 uptake is not yet affected.
- Patient may be at altitude in which there is a decrease in atmospheric pressure resulting in decreased PO2 levels whereas CO2 levels remains unchanged.

3.

- Pulmonary – low pressure, low resistance, all blood goes to the lung, little directionality (low smooth muscle content), hypertension treated with PDE-5 inhibitors, prostaglandins, endothelin receptor antagonists etc.
- Systemic – high pressure, high resistance, blood goes to multiple capillary beds, directionality in order to shunt blood (high smooth muscle content), hypertension treated with ACE inhibitors, B-blockers, angiotensin II inhibitors etc.

4. Force production is determined by muscle length, which is determined by lung volume. In order to make comparisons between individuals, we measure at FRC to normalize for these differences in lung volumes and inspiratory muscle lengths.

5.

a) Record measurement of diaphragm function before and after insult. Failure if reductions in force/pressure are a result of insult and recoverable by rest. Valid tests include, but not limited to, force (or pressure)-frequency curve, force (or pressure)-velocity curve, MIP, Pdi/Phr etc.

b)

- Expensive
- No baseline
- Invasive
- Requires specialized equipment/training
- Time consuming

c) Decrease in force and/or pressure generation as a result of work/load (exercise) that is reversible with rest.

d)

- Decreased force production of diaphragm (proportional to time on mechanical ventilation)
- Diaphragm atrophy (decreased cross sectional area)
- Myofibril damage (e.g., swollen mitochondria, increased intermyofibril lipid droplets, decreased lipid uptake by mitochondria, disrupted myofibrils, z-line streaming)
- Increased oxidative stress (loss of biological function)
- Increased proteolysis

6.

- Every lab uses a different animal model and different models exist for the different contributions of respiratory muscle dysfunction
- Mechanism in humans is unknown
- No agreement on the contributions of peripheral failure, central failure and neuromuscular transmission failure

7. CO_2 is perfusion limited. Plot PCO_2 (mmHg) vs. Time (seconds). Graph should illustrate an exponential decline from 0 – ~0.125 (< 0.25) seconds as CO_2 pressure decreases from ~45mmHg – ~40mmHg during offloading. After ~0.125 seconds, graph should level off at

40mmHg to ~ 0.75 seconds. Even though the pressure gradient for CO2 is small (~5mmHg), CO2 is very soluble (↑ solubility coefficient) allowing for rapid diffusion. P1 = P2 reaches equilibrium quickly (~0.125 seconds) and thus is perfusion limited.

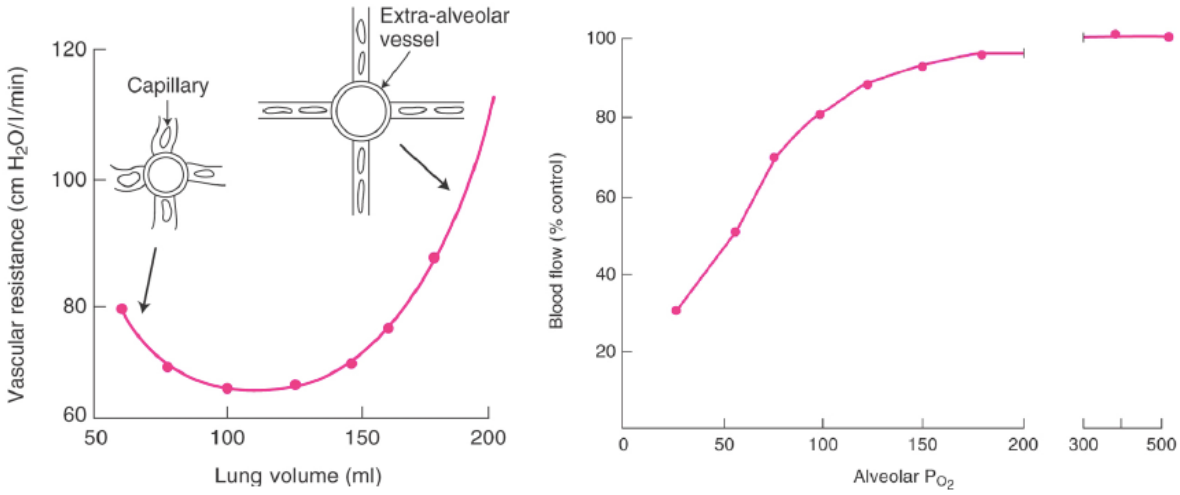
8. Lack of a specific and sensitive marker for peripheral fatigue and central failure that is clinically useful. This is made worse by an overall lack of funding in the field.

9. a) Resistance and pressure

b) There is a linear relationship between blood flow (%) and position in lung (top → bottom). Blood flow is highest at the bottom of the lung as more work is required to pump blood higher resulting in a loss of blood pressure, reducing flow. At the top of the lung – $P_A > P_a > P_v$; at the bottom of the lung – $P_a > P_v > P_A$.

10. Helium dilution technique – subject is connected to a spirometer with a known volume containing a known concentration of helium gas, virtually insoluble in blood. Valve is released and subject is allowed to breathe normally until the helium concentration in the machine equilibrates with the lung. Using C1V1 = C2V2 we can find V2 (volume of machine + total volume of lung). Solve for total lung volume and subtract vital capacity (tidal volume + IRV + ERV) to find residual volume.

11. a)



During COPD, total lung volume increases due to air trapping. As lung volume increases, the extra-alveolar vessels become distended while capillaries become over-stretched increasing resistance and decreasing blood flow.

Acute hypoxic vasoconstriction. Local mechanism within the lung that detects decreases in alveolar PO2 and feeds back to the supplying arteries signaling vasoconstriction. This allows for blood flow to be rerouted to areas in the lung that have normal P_AO2 and prevents blood from being sent to hypoxic areas of the lung. This mechanism is ideal for healthy individuals however the mechanism exacerbates problems with COPD as whole lung is hypoxic resulting in increased vascular resistance.

b) Right ventricular hypertrophy leading to cor pulmonale.