Lung Mechanics

What factors are responsible for the magnitude of the:

- functional residual volume?
- total lung capacity?
- residual volume?
- vital capacity?
- tidal volume?

For reasons that remain not well understood, the changes in pleural pressure from apex to base in the upright lung are less than one would predict from the action of gravity on a simple column of liquid. In an individual with a 30 cm long lung, the pleural pressure measured at end-expiration at the apex is -12 cm H₂O and at the base is -2 H₂O. How would this influence regional lung volume? regional ventilation?

Airway Dynamics

In both the airways during increased expiratory efforts and in the pulmonary circulation at specific sites in the lung an unusual flow pattern known as flow limitation occurs. In certain patients with sleep-disordered breathing, flow limitation can occur with inspiration. These patients are characterized as having markedly compliant oropharyngeal structures and decreased muscle tone in the skeletal muscles of the oropharynx and cervical region.

A) In each of these three situations, what are the usual pressure gradients generating flow and what is the nature of the additional pressure influencing flow when flow limitation occurs?
B) Under conditions of maximal expiratory airflow, derive an expression that predicts flow based on the bag-in-the-box model.

Analysis of the relation between pleural pressure and lung volume change during spontaneous breathing allow us to estimate the work done on the lung during a respiratory cycle. In a patient undergoing elective surgery under anesthesia and paralysis, you have obtained informed consent to determine the work done on the lung, on the chest wall, and on the entire respiratory system during inspiration. You can use a standard ventilator that inflates the lungs with positive pressure during inspiration and an esophageal balloon to measure pleural pressure. How would you proceed? Why are the shapes and magnitudes of the pressure volume relations different? The dashed line is the actual pressure tracing during inflation.
Gas Exchange

Consider a 3-component lung model (UL, ML, LL). Ventilation is 6 L/min and initially equally distributed to each region as is perfusion (cardiac output is 6 L/min). Subsequently UL is not ventilated because of development of lobar pneumonia (fluid and inflammatory cells filling the alveoli).

What is the PO\textsubscript{2} in capillary blood leaving UL?
What is the ventilation/perfusion ratio in ML?
Measurement of blood flow to UL reveals a value of 1 L/min. What process is responsible for this change in local pulmonary blood flow?

Gas Transport

High concentrations of urea in blood produce an increase in hemoglobin oxygen affinity by maintaining hemoglobin in its relaxed oxy conformation. This has led to attempts to administer intravenous urea to patients with sickle cell anemia to prevent or reduce the duration of painful crises by preventing sickle cell formation and disturbances in microcirculatory flow. What are some of the problems associated with increases in red cell oxygen affinity on oxygen delivery at the tissue level. Under what conditions would an increase in red cell oxygen affinity be important in oxygen uptake in the lung.
Additional Respiratory Questions

1. A large blood clot lodges in the left pulmonary artery completely blocking blood flow to the left lung. What happens to dead space ventilation, shunt, PaO2, PCO2? How might the body compensate for these changes?

2. Carbon monoxide binds avidly with Hg and thus displaces O2 from its binding sites. One treatment for carbon monoxide poisoning is placing the patient in a hyperbaric chamber. How high would atmospheric pressure need to be to meet the metabolic demands of the body with solely the dissolved component of O2 in blood?

3. A patient unable to breathe on his own, is on assisted ventilation. During inspiration, air is forced into his lungs by a ventilator connected to his airway. With respect to alveolar pressure, how is this situation different from normal breathing? What happens to lung blood flow under these conditions?

4. If you suddenly increase the plasma protein osmotic pressure by 30%, would the lung water content decrease? If so, why? What would happen to the water content if you know increased left atrial pressure by 20 cm H2O?