Pathophysiology - Some items to consider

Blood

- An adult has ~70mL of blood per kilogram.(1 kg equals 2.2 pounds; 1 lb is equal to ~0.45kg)

Heart rate

- Cardiac output = heart rate x stroke volume
- Cardiac output for an adult at rest is ~5 liters/minute (full blood volume)
- A decrease in heart rate will decrease cardiac output
- An increase in heart rate, if not excessive, will increase cardiac output
- Preload is the pressure generated in the left ventricle at the end of diastole
- Afterload is the resistance in the aorta that must be overcome by ventricle contraction
- A decrease in blood volume will decrease preload, stroke volume, and cardiac output
- An increase in blood volume will increase preload, stroke volume, and cardiac output
- A decrease in myocardial contractility will decrease stroke and cardiac output
- An increase in myocardial contractility will increase stroke volume and cardiac output
- Neural stimulation from sympathetic nervous system will increase heart rate, myocardial contractility, and cardiac output
- Neural stimulation from the parasympathetic nervous system will decrease heart rate, myocardial contractility and cardiac output
- $Beta_1$ stimulation from epinephrine will increase heart rate, myocardial contractility and cardiac output
- An extremely high diastolic blood pressure will increase the pressure in the aorta, requiring a more forceful contraction to overcome the aortic pressure and a higher myocardial workload and may weaken the heart and decrease the cardiac output over time
- A reduction in the diastolic blood pressure will decrease the pressure in the aorta, require a less forceful contraction to overcome aortic pressure, and reduce the myocardial workload, which may improve the cardiac output in a weakened heart

Blood Pressure

- An increase in cardiac output will increase blood pressure
- A decrease in cardiac output will decrease the blood pressure
- An increase in the heart rate will increase the cardiac output, which will increase the blood pressure
- A decrease in the heart rate will decrease the cardiac output, which will decrease the blood pressure
- An increase in the stroke volume will increase the cardiac output, which will increase the blood pressure
- A decrease in the stroke volume will decrease the cardiac output, which will decrease the blood pressure
- An increase in systemic vascular resistance will increase the diastolic blood pressure
- A decrease in systemic vascular resistance will decrease the diastolic blood-pressure
- An increase in blood pressure will increase cellular perfusion
- A decrease in blood pressure will decrease cellular perfusion
- An abnormally high diastolic blood pressure is not a desirable condition. The higher the diastolic blood pressure, the greater the resistance to blood being ejected from the left ventricle, meaning the left ventricle has to work harder to pump blood.

Hydrostatic pressure, Oncotic pressure (Pressure within blood vessels)

- A high hydrostatic pressure will push fluid out of a capillary and promote edema
- A low hydrostatic pressure will push less fluid out of the vessel
- A high oncotic pressure will draw excessive amounts of fluid into the vessel or capillary and promote blood volume overload
- A low oncotic pressure will not exert an adequate pull effect to counteract the push of hydrostatic pressure and will therefore promote loss of vascular volume and promote edema

Pulse Pressure

- (Systolic BP) - (Diastolic BP)
- Narrow (low) if less than 25% of the systolic value (Ex: 108/88 = 20 (25% of 108 = 27))
- Measured in millimeters of mercury: Ex: 120/80 = Pulse Pressure of 40 mmHg
- Resting, Healthy adults, Sitting position: 30-40 mmHg.
- Increases with exercise due to increased stroke volume
- If blood or fluid loss a narrow pulse pressure is a significant sign. (blood loss reduces venous volume, which reduces preload, which reduces stroke volume which reduces cardiac output)

Systemic Vascular Resistance

- Resistance to blood flow through a vessel
- Vasodilation: Increases vessel size; Decreases resistance; Decreases blood pressure.
- Vasoconstriction: Decreases vessel size; Increases resistance; Increases blood pressure.
- Sympathetic nervous system stimulation causes vasoconstriction, increasing systemic vascular resistance.
- Parasympathetic nervous system stimulation causes vasodilation, decreasing systemic vascular resistance.
- $Alpha_1$ properties in epinephrine and norepinephrine, cause vasoconstriction, and increases systemic vascular resistance

Chemoreceptors/Baroreceptors (Respiratory and Blood Pressure)

- Chemoreceptors (Sense changes in blood - controls breathing and BP)
  - Central in the medulla (Hypercapnic/hypercarbic Drive)
  - Peripheral In the aortic arch and the carotid bodies (Hypoxic Drive)
- Baroreceptors in aortic arch and carotid sinuses - stretch-sensitive receptors (Sense BP)

Boyles Law

- An increase in pressure will decrease the volume of a gas
- A decrease in pressure will increase the volume of a gas

Breathing

- Compliance: Measure of ability of the chest wall and lungs to stretch, distend, and expand.
- Airway resistance: The ease of air flow down the airway structures to the alveoli.
- Lung Receptors: Irritant, Stretch, J receptors
- Respirator Centers in the brainstem
  - Dorsal respiratory group (DRG): facilitates inhalation
  - Ventral respiratory group (VRG): active when increased in ventilatory effort is needed
  - Apneustic center: provides stimulation to the DRG and VRG to intensify inhalation
  - Pneumotaxic center: sends impulses to turn off inhalation before lungs are too full
- Ventilation / Perfusion (V/Q) Ratio: under normal conditions, V/Q <1

Minute ventilation

- Minute ventilation = tidal volume x frequency of ventilation
- In an average adult, tidal volume is ~ 500 mL; Rate 12bpm; Minute Ventilation ~6 Lpm
- A decrease in tidal volume will decrease in minute ventilation
- A decrease in frequency of ventilation will decrease the minute ventilation
- A decrease in minute ventilation will reduce the amount of air available for gas exchange in the alveoli
- A decrease in minute ventilation can lead to cellular hypoxia
- To ensure adequate ventilation, the patient must have both an adequate tidal volume and an adequate rate of ventilation

Alveolar ventilation.

- Alveolar ventilation = (tidal volume - dead air space) x Frequency of ventilation/minute
- Dead air space = approximately 150 mL; Alveolar Ventilation = ~4.2 Lpm
- Rapid breathing, may not equal more oxygen in the alveoli
- Dead air space will fill first (providing O_2 may not improve hypoxia)