Teaching Model for Ventilation and Perfusion Mismatching

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Function:

Ventilation and perfusion mismatching is the most predominant cause of hypoxemia. However, medical students often have a very difficult time understanding this concept. Other than a textbook diagram by John West in his text *Respiratory Physiology* [1], there are no relevant representations of ventilation/perfusion mismatching. Our goal is to improve a prototype completed by previous UW Madison students to create an effective teaching model of ventilation/ perfusion mismatching to be studied by medical students for a deeper understanding of hypoxemia.

Client requirements:

- Sliding knobs for changing the V/Q ratio to represent different levels of mismatching
- Output that shows oxygenation (client will help with calculations)
- A digital display of some sort for the values (or displayed on computer screen)
- Able to be showed in lecture hall under document camera
- Not necessarily realistic, but good representation of what happens in the body at different V/Q levels leading to hypoxemia

Design requirements:

1. **Physical and Operational Characteristics**
    a. Performance requirements:
        i. A physical model to represent the concept of ventilation/perfusion mismatching and how it leads to hypoxemia
        ii. Used in a classroom setting
        iii. Ability to change ventilation/perfusion ratio

    b. Safety:
        i. No danger of electrocution (no loose wires)
        ii. Shell has no sharp corners

    c. Accuracy and Reliability:

i. All coding should be free of error and reproducible/stored where it can be retrieved easily
ii. This will be further analyzed after our testing phase

d. Life in Service:
    i. Arduino Uno may need to be replaced after approximately one year depending on the conditions under which it is stored
    ii. Under good conditions for electrical components, expected life in service should be at least 5 years
    iii. As a teaching model, device should last throughout lectures and hands on learning

e. Shelf Life:
    i. The product should be able to withstand storage for long periods of time. (At least five years under good condition of electronic components)
    ii. The product needs to be reusable and could be set up easily
    iii. The product will be placed in a sealed container in order to maintain a low moisture level
    iv. Ideal storage temperature is in the range of 10-27℃ [2] (50-80 ℉)

f. Operating Environment:
    i. Classroom setting, not exposed to harsh elements
    ii. Slight risk of damage due to mishandling between transition from classroom to storage

g. Ergonomics:
    i. Very light and portable
    ii. Be able to be displayed in a lecture hall using a document camera, or seen in a small-group setting (within 3 meters of the device)

h. Size:
    i. Roughly 1 ft x 1 ft

i. Weight:
    i. Easily movable and carryable, no more than 15 lbs

j. Materials:
    i. 3D printed base because it is lightweight and cost effective
    ii. LED lights to represent V/Q ratios because they are energy efficient

k. Aesthetics, Appearance, and Finish:
    i. No specific color
    ii. Dinner-plate sized
    iii. No loose wires or sharp corners
    iv. Digital display of some kind for relevant values
    v. Computer program for inputting different V/Q ratios and visualizing effects on the human body if possible

2. Production Characteristics

a. Quantity: number of units needed
    i. 4 units
        1. 3D printed base to hold all components together
        2. LED lights connected to create a string of illumination
        3. Arduino to connect the LEDs and program the model
        4. Sliders/ buttons to change the ventilation/perfusion mismatching ratios

b. Target Product Cost:
    i. To be determined once production phase begins
    ii. Similar cost to previous semster's prototype (about $140)

3. Miscellaneous

a. Standards and Specifications:
    i. No applicable at this time

b. Customer:
    i. Medical students and educators would be the customers
    ii. Should be an effective teaching model, with interactive learning aspects for medical students to understand the complex topic

c. Patient-related concerns:
    i. Device will need to be carefully stored in order to prevent deterioration of electrical components

d. Competition:
    i. Currently, there are no effective teaching models on the market

Citation

[1] West, J. B., & Luks, A. (2021). *West's respiratory physiology: The essentials*. Wolters Kluwer.

[2] *Storing electronics in a storage unit: Storing electronics in heat + cold*. EZ Storage. (2019, October 22). Retrieved September 24, 2021, from https://www.ezstoragenow.com/blog/delicate-balance-properly-storing-electronics-heat-cold/#:~:text=The%20trick%20to%20properly%20storing,between%2050%20and%2080%20degrees.