**Engineering Analysis of a Model Lung / Capillary Bed for ECMO Device Development**

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Abstract

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1. Background and Motivation

The human respiratory system plays a crucial role in sustaining like, primarily by facilitating gas exchange in the lungs. This process involves the intake of oxygen (O2) from the atmosphere and release of carbon dioxide (CO2) as a waste product of cellular respiration. In certain medical conditions, the lungs’ natural ability to perform gas exchange is compromised, leading to life-threatening situations. Extracorporeal membrane oxygenation (ECMO) is a last-resort therapy designed to support or temporarily replace the function of the lungs in patients suffering from severe respiratory diseases(1).

Despite its potential to save lives, ECMO therapy is associated with survival rates of only around 60% (Gravlee et al., 2007). Given the significant need for improvement in ECMO devices, our employer has identified this as a potentially life-saving and lucrative opportunity. To initiate the development of a novel ECMO device, we must first establish a thorough understanding of gas transport and exchange in normal adult human lungs.

Our team aims to develop a comprehensive physiological model of gas exchange in the lungs and the capillary bed supporting the alveoli. By applying engineering principles and processes, we will model the lungs as a multi-unit system to capture the complex processes involved in respiration. This model will incorporate the primary chemical constitutes, such as O2 and CO2, as well as the physical processes occurring in the lungs, including mixing and diffusion. Furthermore, the model will address the dynamic nature of breathing, taking into account unsteady-state pressures and compositions.

The development of this physiologically realistic model will lay the foundation for subsequent design of an improved ECMO device. The model will provide insights into the critical functions of the lungs, enabling the identification of key areas where current ECMO devices can be enhanced. By quantitatively analyzing the concentrations, pressures, volumes, and rates in the model, we will generate valuable data to guide the engineering of the next generation of ECMO devices.

In summary, the motivation for our task is threefold: 1) to develop a thorough understanding of gas transport and exchange in normal adult human lungs, 2) to create a solid foundation for the design of an improved ECMO device, and 3) to ultimately contribute to saving lives by enhancing the efficacy and reliability of EMO therapy for patients with several respiratory diseases.

2. Model

1.1 Subsection heading

The idea behind the creation of this model was to start it as a simple unit, and advance towards a more complex iteration each attempt. To start, the team first gathered the necessary equations needed to relate the exchange of gases between alveolus and capillary beds.

The idea was to first begin constructing a model using Fick's first law of diffusion. The gas exchange between the capillary beds and the alveolus occurs due to diffusion (2), so the use of Fick’s first law was the starting point.

Acknowledgements

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