Internship proposal:

Numerical modeling of lung biomechanics and gas exchange during mechanical ventilation of Acute Respiratory Distress Syndrome patients

Host structure

The Laboratoire de Biomécanique Appliquée (LBA) is a joint Gustave Eiffel University/Aix-Marseille University research unit. Located at the heart of the Faculty of Medicine, on the Campus Hospitalo-Universitaire Nord, the Laboratoire de Biomécanique Appliquée is unique in that it focuses on the Virtual Human to understand trauma, prevent and repair it, and provide better care for the human body. This scientific positioning in the fields of health, transport and sport is thus likely to support the scientific strategy of the two supervisory institutions. It opens up two complementary fields of application: “protection and performance” and “technology for health”

Duration: 6 months

Salary: about 600€/month

Introduction

The Acute Respiratory Distress Syndrome (ARDS) is a critical condition with death rate in hospital that can be as high as 40%. Several etiologies were identified for this pathology: uptake of toxic substances, trauma, or infection such as the infamous COVID-19. In case of ARDS, mechanical ventilation (MV) must be used to ensure sufficient oxygenation of the patient. However, since this pathology is very patient-specific, there is not an “one-size-fits-all” approach to determine the most appropriate ventilation strategy. To better understand the physical phenomena underlying the impaired biomechanics of pathological lungs and how they respond to different MV strategies, numerical modeling has proved to be a valid approach.

Context

A numerical model of the ARDS lung mechanics and gas transfer under mechanical ventilation was developed (available in the repository: https://gitlab.univ-eiffel.fr/claire.bruna-rosso/mega). It is a geometrically and conceptually simplified model of the lung. For instance, the trachea-bronchial tree is represented using a resistance network using the analogy air flow – electric current. However, a rather detailed constitutive law was implemented to describe the pressure-volume behavior of the lung parenchyma, which takes into account the pathology distribution inside the lung. This mechanical model is also coupled with a gas-transfer model to study the impact of impaired respiratory biomechanics on the patient blood oxygenation. However, this model is currently pressure driven only, which limits its applicability, since MV can be volume driven, i.e., the intensivist imposes a certain volume of air to be delivered to the patient.

Objectives

The internship aims at developing the set of equations and implement a volume-controlled mechanical model within the existing framework. Together with this development, verification tests have to be implemented. The model obtained will then be put into use to characterize the influence of MV, mechanical and physiological parameters on the patient oxygenation. This study will participate in better understanding how the ARDS deteriorates the lung biomechanics and physiology and in better designing ventilation strategies to ARDS patients.

Student profile

Master student in Applied Mathematics, Mechanical or Biomedical Engineering.

Required skills:

- Numerical modeling
- Programming (Julia is a plus)
- Basic knowledge of continuum mechanics
- Good level of English
- Knowledge in respiratory biomechanics and/or physiology is a plus.

Contact

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