EFFECT OF CANNULA TIP POSITIONS IN PULMONARY ARTERIAL CANNULATION ON BLOOD FLOW AND GAS EXCHANGE USING COMPUTATIONAL FLUID DYNAMICS ANAYLSIS

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Introduction

Pulmonary arterial cannulation presents itself as a viable alternative cannulation strategy for patients at high risk of right ventricular and severe respiratory failure on mechanical circulatory support [1]. However, limited data exists to what effect the position of the cannula tip has on the oxygen perfusion throughout the pulmonary artery (PA). This study aims to evaluate, using computational fluid dynamics, the effect of different cannula tip positions on the oxygenation level in the PA to determine an optimal cannula position.

Methods

The pulmonary artery 3D geometry is a simplified reconstruction using patient CT data as the foundation and Code_Saturne, an open-source software, was used for the computation to simulate the flow field and oxygen concentration distribution. The visualization of the results was performed using ParaView.

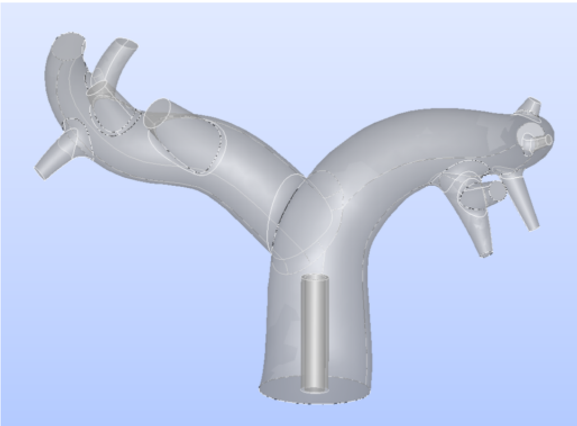

Figure 1: Example of the pulmonary artery 3D geometry with one of the four cannula tip positions

Results

Computational results reveal how the position of the cannula tips affect blood flow patterns and consequently the oxygen perfusion in the pulmonary artery. A slight change in the positioning of the cannula can have drastic outcomes on the overall perfusion, for example, position 3, with the cannula tip directed towards the right pulmonary artery (RPA), for which it could be shown that the RPA was almost exclusively saturated with the oxygenated blood (see Figure 2).

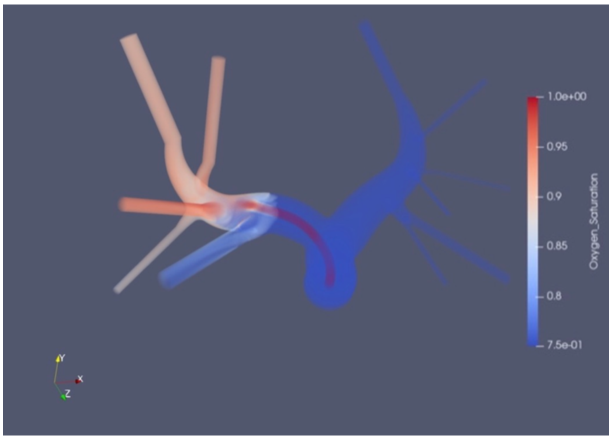

Figure 2: The oxygen saturation distribution in the pulmonary artery with Position 3, the cannula tip positioned directed towards the right pulmonary artery.

Discussion

Results indicate that out of the 4 tested positions, position 2, with the cannula placed at the upper portion of the main PA before the bifurcation, is the most suitable, with both the RPA and LPA achieving adequate mean value and the smallest difference in the concentrations of oxygen. Variations in individual patient geometry is also assumed to have a major impact on the computational results and the modelling accuracy. Furthermore, this computational study used a veno-arterial support level of 50% of the total blood flow rate. Future studies using higher levels of support, such as 75%, can be useful to see whether varying support levels can improve oxygen perfusion and hence contribute to finding the optimal setting for pulmonary artery ECMO support. Finally, the CFD study demonstrated promising results, however more calculations are necessary to determine optimal perfusion parameters to be used for pulmonary arterial cannulation.

References

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