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CFD-Based Risk Assessment in VV-ECMO

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Veno-venous extracorporeal membrane oxygenation (VV-ECMO) is a life-support therapy used for patients with severe respiratory failure, including those affected by COVID-19. In this therapy, gas exchange is partially or fully supported by an extracorporeal circuit, thereby substituting impaired lung function. Despite its clinical effectiveness, the presence of non-physiological flow conditions introduces significant risks of adverse outcomes such as thrombosis (clot formation) and hemolysis (red blood cell damage). This study examines how ECMO flow influences the risk of thrombosis and hemolysis at the patient-specific level.

A patient-specific model of the right atrium and connecting veins was reconstructed from a CT scan. The drainage and return cannulas were positioned 10 cm apart, corresponding to clinical practice. Blood flow was computed by solving the incompressible Navier–Stokes equations at three ECMO flow conditions (2, 4, and 6 L/min). Simulation results were used to evaluate thrombosis risk through endothelial cell activation potential and hemolysis via a cumulative shear-based hemolysis index.

As ECMO flow increased from 2 to 6 L/min, the average thrombotic risk declined by 33%, whereas the risk of hemolysis increased by 319%. Regional analysis revealed that thrombotic risk depends on patient anatomy, with the right atrial appendage demonstrating higher vulnerability. Patient-specific modelling shows promise for individualized risk prediction˜in˜VV-ECMO.

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