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Abstract

TPMS structures delay clotting in extracorporeal blood contactors

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Membrane oxygenators or dialyzers are state of the art blood contacting devices based on hollow fiber membranes. Due to the straight shape of the hollow fibers, boundary layers are formed, which must be intermixed to increase mass transfer.

Recent research focuses on using triply periodic minimal surface (TPMS) structures for the blood phase in extracorporeal circulatory devices. These structures can only be additively manufactured as their geometry is intertwined with undercuts. TPMS structures have continuous, periodic, and tortuous flow channels that introduce radial mixing in the laminar flow regime. [1,2]

This study incorporates TPMS structures into housings utilizing the inlet and outlet regions for fluid distribution and collection for the first time. Three modules are compared: a hollow fiber imitating tubular module (tubular), an isotropic TPMS module (isoTPMS) with unit cells of the same size, and an anisotropic TPMS module (anisoTPMS) that has distorted unit cells, imitating the cardiovascular system and reducing shear rate peaks and leaps. In these modules, the coagulation behavior of human blood was examined by serial experiments, looking at various coagulation parameters and visually inspecting formed clots via computed tomography (CT). These human blood experiments are backed up with experimental residence time distribution (RTD) measurements and simulative data of hydrodynamic investigations.

With these simulations and experiments, we were able to show that TPMS structures delay the coagulation of blood, resulting in less obstructive blood clot formation compared to the tubular structure.

Author's Statement

All authors state no conflict of interest. Informed consent has been obtained from all individuals included in this study. The blood was withdrawn from healthy volunteers after approval from the ethical committee of the University Hospital of the RWTH Aachen University (file no EK22-355) and informed consent.

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