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Abstract

Pressure profile measurements in cranial aneurysm models

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Cranial aneurysms pose significant risks to patient health, possibly leading to subarachnoid haemorrhage, when the aneurysm wall becomes too thin as the aneurysm grows and subsequently cannot sustain the blood pressure inside the aneurysm sack, leading to rupture [1]. They are typically treated by implantation of different types of devices (coils or flow diverters) [2] to lower the pressure and the shear stress applied to the wall [3].

This study presents an experimental setup utilizing a cranial aneurysm model connected to a controlled pump system to simulate blood flow conditions typically observed in cranial arteries. The primary objective of this experiment is to investigate the pressure dynamics at the distal wall of an aneurysm, particularly focusing on the variations induced by the presence of an intravascular implant.

The aneurysm model, 3D printed with a Form 4 (Formlabs, Somerville, USA) using Clear resin, reflects cerebral aneurysm anatomy, as it was segmented from a patient CT scan using 3D Slicer software. The pump system is set to replicate physiological flow rates and pressures. A high-sensitivity pressure sensor PHE121 (EFE, Ivry-la-Bataille, France) is positioned to monitor the intra-aneurysmal pressure acting on the wall, providing critical data on how the wall's integrity is affected by both flow dynamics and the presence of implants (a coil and a WEB device in this study).

The results indicate how the introduction of an implant within the aneurysm changes the pressure profile, allowing for selection of treatment strategies. These findings contribute to a deeper understanding of the biomechanical environment of cranial aneurysms and the effectiveness of various intervention methods including novel ones.

In conclusion, this experimental model serves as a vital tool for investigating aneurysm behaviour under simulated physiological conditions, providing data that may guide clinical decision-making and improve aneurysm treatment outcomes. Additionally, the sensor integration in vascular models can enhance the training experience if such models are used for education of interventionists. Further research is planned to explore new implant designs and their influence on pressure dynamics, with the aim of improving patient outcomes.

Author's statement

Authors state no conflict of interest. In accordance with ethical standards, we confirm that we have obtained ethical approval for the use of the medical data included in this study.The authors would like to thank D. Wendt and T. Gartmann for their contribution to the construction and production of parts. The presented work was supported by the EU (EFRE) and the State of Schleswig-Holstein, Germany (Project: Diagnostic and therapy methods for Individualized Medical Technology (IMTE) – Grant: 124 20 002 / LPW-E1.1.1/1536) and by the Fraunhofer Internal Programs under Grant No. SME 40-08039

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