FEASIBILITY OF DETECTING THROMBOTIC DEPOSITS IN MEMBRANE OXYGENATORS USING MICRO COMPUTED TOMOGRAPHY

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Introduction

Despite major improvements, coagulative disorders and clotting in membrane oxygenators (MO) are still considerable complications in extra corporeal life support, which is an increasingly used rescue therapy in patients with severe respiratory failure or cardiac arrest [1]. For both, evaluation of therapeutic decisions and fundamental research on clotting, direct visualisation and analysis of thrombotic loading in MOs is a matter of interest. So far, these measurements are performed using clinical multidetector computed tomography (MDCT) [2], which is limited in spatial resolution. Here, an imaging method, using micro computed tomography (µCT), circumventing the limitations of MDCT and additionally providing the opportunity for accurate geometry extraction of thrombotic deposits in used MOs is presented.

Methods

Three clinically used Quadrox PLS MOs, and a new MO in order to measure the actual void volume, were included. The MOs were imaged and analysed for thrombotic loading in terms of relative occluded volume, using µCT and standard MDCT for comparison. Standard MDCT was performed according to [2]. µCT imaging was performed using a v|tome|x s (General Electric), with imaging parameters aiming for a compromise between spatial resolution and contrast. Segmentation and analysis was performed with VGStudioMax3.1 (Volume Graphics) based on a combined threshold criterion (local Otsu method) and a dynamic region growing method. From µCT findings and histogram analysis, a revised window centre of -280HU (instead of -80HU) for MDCT is suggested, which is referred to as revised MDCT. Window width remained at 560HU as in [2]. Results are compared in terms of occluded volume and local distribution of deposits inside the MO.

Results

Standard MDCT results in occluded volumes of 13%, 0%, and 1% (revised MDCT: 39%, 6%, 9%), whereas µCT gives 50%, 21%, and 24%, respectively (Figure 1). Figure 2 depicts a representative cross section of MO 1 with segmented deposits. Std. MDCT shows clotted material on the inlet (left) side of the fibre package only, whereas µCT and rev. MDCT detects a more distinct clot structure, which propagates through the entire fibre bundle.

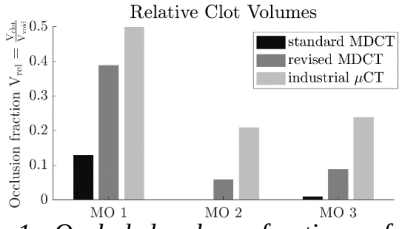

Figure 1: Occluded volume fractions of used MOs, results comparison of std. MDCT, rev. MDCT and µCT.

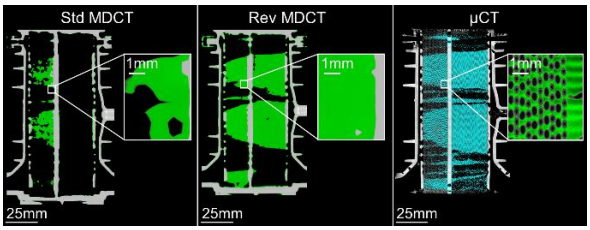

Figure 2: Representative cross section (std. MDCT, rev. MDCT and µCT) of MO 1 with segmented deposits.

Discussion

Using MDCT (std. and red.), absolute and relative (occlusion fraction) clot volumes are systematically underestimated, compared to µCT. The considerably different clot volumes might be related to the significant smaller spatial resolution of MDCT compared to µCT (factor of 15). The ability to resolve the individual structures inside the MO (membranes, chaining threads) overcomes the issue of integrating attenuation properties of air, fibre material and clot, which ignores smaller deposits in std. MDCT. Due to different materials present in the inlet part (heat exchanger), MDCT is likely to show more clots there, compared to outlet part. To circumvent this, the thresholds might be adjusted (rev. MDCT). This results in more reasonable contours of strongly clotted areas, but, since fibres are not resolved, also in mostly imprecise volume measures.

References

1. Lubnow et al, PloS one, 9,2014.
2. Dornia et al, ASAIO J, 60:652-656, 2014.

Acknowledgements

This project is supported by the German Research Foundation (DFG), funding number INST 102/11 – 1 FUGG.
This work is supported by the Bavarian State Ministry of Science and the Arts in the framework of the Centre Digitisation.Bavaria (ZD.B) and the Bavarian Academic Forum (BayWISS) – Doctoral Consortium "Health Research".