ANALYZING ABDOMINAL AORTIC ANEURYSM VESSEL, LUMEN AND THROMBUS GROWTH USING 3D+T ULTRASOUND

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Introduction

An abdominal aortic aneurysm (AAA) is a localized dilatation of the aorta, which in case of rupture has a mortality rate of 80%. Current clinical guidelines of intervention are based on AAA diameter. However, biomechanical models can improve the prediction of rupture risk in a more patient-specific way, using e.g. CT, MRI or ultrasound (US) imaging [1, 2]. CT requires the use of X-ray and nephrotoxic contrast agents and MRI involves long scan times and high costs. US is safe, cheap, and adds temporal information for mechanical characterization of the AAA, therefore US is the preferred modality for clinical acceptance and longitudinal studies. However US has a low contrast, and limited field of view making it challenging to determine the entire geometry of the AAA. Intraluminal thrombus (ILT) is present in 75% of all aneurysms [3], and it is hypothesized that it reduces the wall stress, therefore decreasing the rupture risk [4]. However, on the other hand ILT reduces wall strength, affecting growth. The effect of ILT size on growth rate was analyzed in a CT-based study by Zhu et al., and they found that both cross-sectional aneurysm diameter and the presence of ILT are independent predictors of AAA growth [5]. However, no studies exist, analyzing ILT growth using 3D+t US. Therefore this study aims to use 3D+t US to analyze lumen, ILT, and vessel volume growth. To give more insights in the contradictory effects of ILT on AAA rupture risk.

Methods

Two patients were included with a clear thrombus on the US images, and having more than 3 follow-ups. To overcome the limited field of view, if available, multiple US acquisitions were registered using phase-only correlation, and fused using wavelet decomposition. A semi-automatic segmentation algorithm was used to determine the lumen, ILT and vessel geometry.

The geometries on multiple moments in time were matched using an iterative closest point (ICP) algorithm. The lumen, ILT, and vessel volume were determined in the overlapping region, and growth was analyzed.

Results

In Figure 1 an example of the aligned US images, and corresponding lumen/vessel segmentations are given. Figure 2 shows that the lumen volume is remaining more constant, compared to the thrombus/vessel volume. This figure also shows that Patient 1 has a lower growth rate (7 ml/year) compared to patient 2 (11 ml/year).

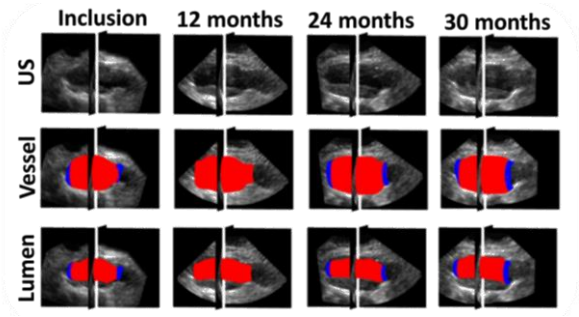

Figure 1: US images of one patient, and both vessel and lumen segmentations over time (segmentations in overlapping regions indicated in red)

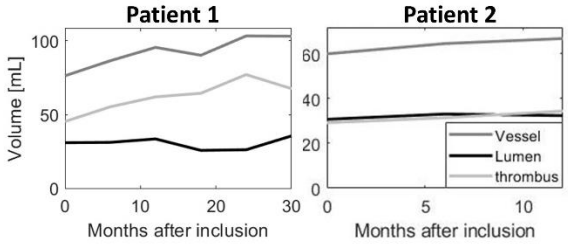

Figure 2: Vessel, lumen and thrombus volume over time of two patients

Discussion

In the proposed framework, the vessel, lumen and thrombus volume were analyzed over time. Those preliminary results show, that the lumen volume remains more constant, compared to the vessel volume, due to the increase in ILT size. Future work will focus on including more patients, to obtain a higher statistical power. Besides this framework could be used to analyze the effect of ILT on local vessel growth, and do wall stress-analysis including ILT, to give more insights in the contradictory effects of ILT on AAA rupture risk.

References

1. Van Disseldorp et al, Eur J Vasc Endovasc Surg, 59: 81-91, 2020
2. Kok et al, J Vasc Surg 61: 1175-1185, 2015
3. Tong et al. Ann Biomed Eng. 2015;43:1488–501.
4. Vorp et al. J Vasc Surg. 2001;34:291–9.
5. Zhu et al. Radiology 2020; 294:707–713

Acknowledgements

This work was supported by e/MTIC, Medtech solutions for Earlier Detection of CArdiovascular Disease (MEDICAID) project.