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Simultaneous pressure and volume measurements to assess mechanical properties of AAA

Marcel van 't Veer^{a,c}, Maarten Merckx^{a,c}, Jaap Buth^b, Nico Pijls^{a,c}

^aEindhoven University of Technology, Department of Biomedical Engineering

^bCatharina Hospital Eindhoven, Department of Vascular Surgery

^cCatharina Hospital Eindhoven, Department of Cardiology

Introduction

The rupture rate associated with abdominal aortic aneurysms (AAA) smaller than 5.5 cm has been shown to be 1% per year [1]. It has been reported that 5-10% of the ruptured aneurysms is below this diameter criterion. Moreover two out of three aneurysms will never rupture [2]. In an effort to develop methods to better predict the risk of rupture, bio-mechanical parameters have been investigated.

Objective

The objective of the current study is to assess pressure volume relations and the compliance of an AAA as a bio-mechanical marker. Compliance is estimated from simultaneously measured intra-aneurysmal pressure and volume changes of the AAA. For comparison with literature also elastic modulus (E_p) and stiffness (β) will be calculated.

Methods

- After giving written informed consent, 10 patients with an infra-renal AAA ≥ 5.5 cm were included in the study
- Each patient underwent a dynamic MRI enabling assessment of the AAA during multiple phases throughout the cardiac cycle (12-15 phases)
- Intra-aneurysmal pressure was continuously measured during the MRI scan using a fluid filled catheter
- Contours were drawn manually in diastole and propagated automatically through the remaining phases using Cardiac MRI software (Philips Medical Systems). Volume changes were calculated offline using interpolation of the propagated slice contours.
- Compliance was estimated from the pressure volume relation of the AAA
- Elastic modulus (E_p) and stiffness (β) were calculated as:

$$C = \frac{\Delta V}{\Delta P} \quad (1)$$

$$E_p = \frac{(P_s - P_d)D_d}{(D_s - D_d)} \quad (2)$$

$$\beta = \frac{\ln(P_s - P_d)D_d}{(D_s - D_d)} \quad (3)$$

where P_s and P_d represent the intra-aneurysmal blood pressure in systole and diastole and D_s and D_d represent the maximum vessel diameters in systole and diastole respectively.

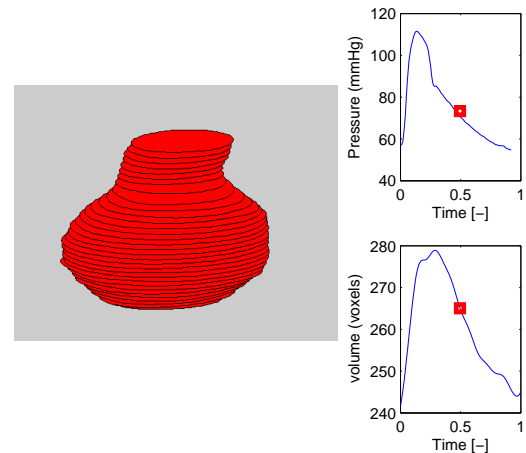


Figure 1: Preliminary result of the simultaneously recorded pressure (top right) and volume change (top left) of a patient with an AAA.

Results

- None of the patients experienced any adverse events
- Average phasic blood pressure was calculated throughout the cardiac cycle (see figure 1, top right)
- Contours were drawn for all patients and propagated through the heart cycle. Volume change was calculated (see figure 1, bottom right).

This is the first time that volume change of an abdominal aortic aneurysm is measured simultaneously with intra-aneurysmal pressure.

Future work

- A first estimate for the compliance (eq.1) of the AAA will be calculated for each patient using the pressure volume relation
- For comparison with values from literature, elastic modulus (E_p) and stiffness (β) will be calculated according to equations 2 and 3

References:

- [1] THE UNITED KINGDOM SMALL ANEURYSM TRAIL PARTICIPANTS: *N Engl J Med* 2002;346:1445-1452
- [2] DARLING, S.C., MESSINA C.R., BREWSTER, D.C., ET AL.: *Circulation* 1977;56:161-164