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INFLUENCE OF ILT MECHANICAL BEHAVIOR IN ABDOMINAL AORTIC ANEURYSMS PASSIVE MECHANICS

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Background:

AAA rupture is the tenth leading cause of death in America causing more than 15000 deaths in US and more than 8000 deaths in UK[1]. Most AAAs remain asymptomatic until rupture occurs. The indications for aneurysm repair (either surgical or endovascular) are largely based upon the presence of symptoms, aneurysm size, and the rate of expansion. Biomechanical studies suggest that one determinant of abdominal aortic aneurysm (AAA) rupture is related to the stress in the wall. Accurate stress analysis depends on using appropriate tissue material models along with accurate geometries and realistic boundary conditions for the AAA. In this regard, intraluminal thrombus (ILT) is found in most AAAs of clinically relevant size. Some authors have suggested that ILT mechanical characteristics may be related to AAA risk of rupture, even though there is still great controversy on this regard. In relation to the mechanical behavior of ILT, several authors found it to be isotropic an inhomogeneous with two main distinct types of ILT morphologies[2]: i) Type I stiff multilayered fibrotic ILT, and ii) Type II singled layered ILT with significant lower stiffness than the fibrotic ILT. This work studies the effect of the ILT mechanical properties on the rupture risk of AAA. In addition, since patient-specific AAA geometric models are usually generated from gated medical images in which the artery is under pressure and therefore does not correspond to an adequate reference configuration, the zero pressure configuration of the AAA is accounted for the stress analysis.

Methods:

Twenty patient specific AAAs of similar maximum diameter (4.8-5.2cm) and ILT volume ranging from 3 to 66 cm^3, and different ILT topology are considered. The arterial wall is assumed as an anisotropic hyperelastic material, whereas the ILT is assumed isotropic hyperleastic. Two different material models for the ILT are considered; representing Type I and Type II ILT respectively. In addition, a novel iterative algorithm is used to determine the zero pressure configuration of the model[3].

Results and conclusions:

Results on 20 AAA geometric models indicate that the peak wall stress (PWS) is always higher for the Type II ILT, with an average increment in the PWS of 24% (SD 21%) (see

Figure 1). A two-sided signed rank statistical test indicates that, AAA of similar geometries presenting a Type II ILT will have a larger PWS than if a Type I ILT will be present (p=0.005). However, the location of the PWS was found to be the same for both ILT models.

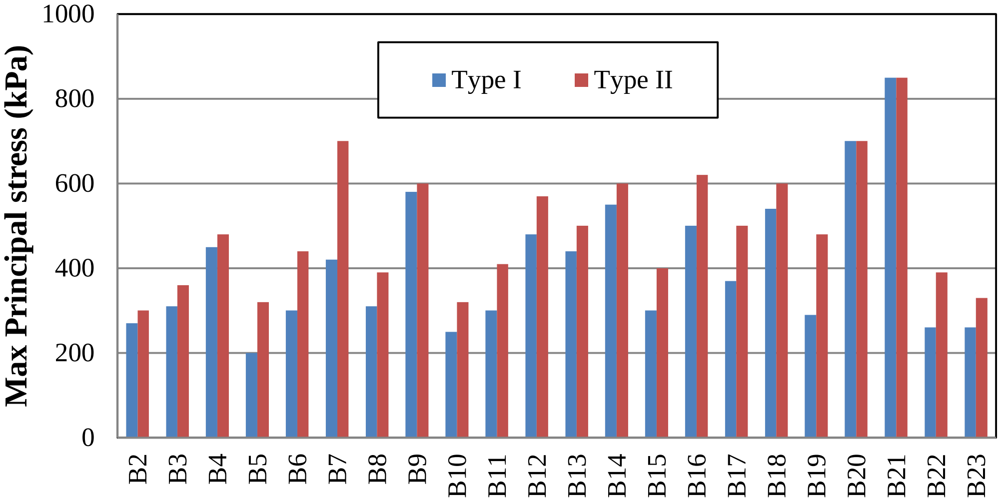

Figure 1. Maximum principal stresses (kPa) for AAA models with Type I and Type II ILT.

The PWS obtained for either ILT type did not show strong correlation with maximum AAA diameter. The same was found for the ILT volume, even though the ILT volume varies more than 20 folds on the analyzed ILT models. Results also suggest that the geometrical configuration of the ILT relative to the arterial wall may be an influential factor not only on the ensuing peak wall stress, but also on its location within the lesion. This study suggests a strong influence of the ILT mechanical properties on the PWS, but also that, it is not only the symmetry, or the curvature, but the topology of the ILT what plays a rather influential roll on the PWS of AAA.

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