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The Role of the Intra-luminal Thrombus in Abdominal Aortic Aneurysm Rupture

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ABSTRACT

An Intra-Luminal Thrombus (ILT) is found in nearly all AAAs of clinically relevant size, i.e. those indicating risk of rupture. ILT is a pathological entity and effects the underlying vessel wall from biomechanical and biochemical points of view. Although it has been shown that ILT has a significant impact on the biomechanics of AAAs and influences both the magnitude and the distribution of AAA wall stress, its relation to AAA rupture is not very well understood.

This paper investigates the hypothesis that failure of ILT tissue might be critical to AAA rupture in general, as it has been indicated by clinical studies and case reports [1]. To this end, a total number of 20 three-dimensional Finite Element (FE) models of the patient-specific ruptured and non-ruptured AAAs were developed and investigated. According to the recent literature [2], the aneurysm wall and the ILT were considered, where their inhomogeneous constitutions were modeled particularly. The involved biological tissues were assumed to be incompressible and mean population data, as it is known from in-vitro experiments, characterized their elastic properties. To quantify the mechanical loading states of the formations, a rupture risk index (RRI) , simply by relating the predicted von Mises stress to the estimated strength from in-vitro experiments [3, 4], was introduced.

Figure 1 presents the distribution of the RRI for the wall and the ILT of a particular patient-specific AAA. The comparison clearly shows that the RRI is significant lower in the aneurysm wall than in the ILT, where, in this particular case, it approaches even 1.0. This finding is consistent for the investigated aneurysm and might explain that the majority of AAA failure occurs in the wall underlying the ILT or in the immediate vicinity of it, as it has been found from evaluation of signs of rupture from CT data [1].

The predicted stress fields suggest that ILT failure might start at the luminal side and could propagate towards the aneurysm wall. Since the aneurysm wall behind a thick ILT thrombus is known to be weaker, the stress concentration induced by ILT failure could finally be responsible for AAA rupture.

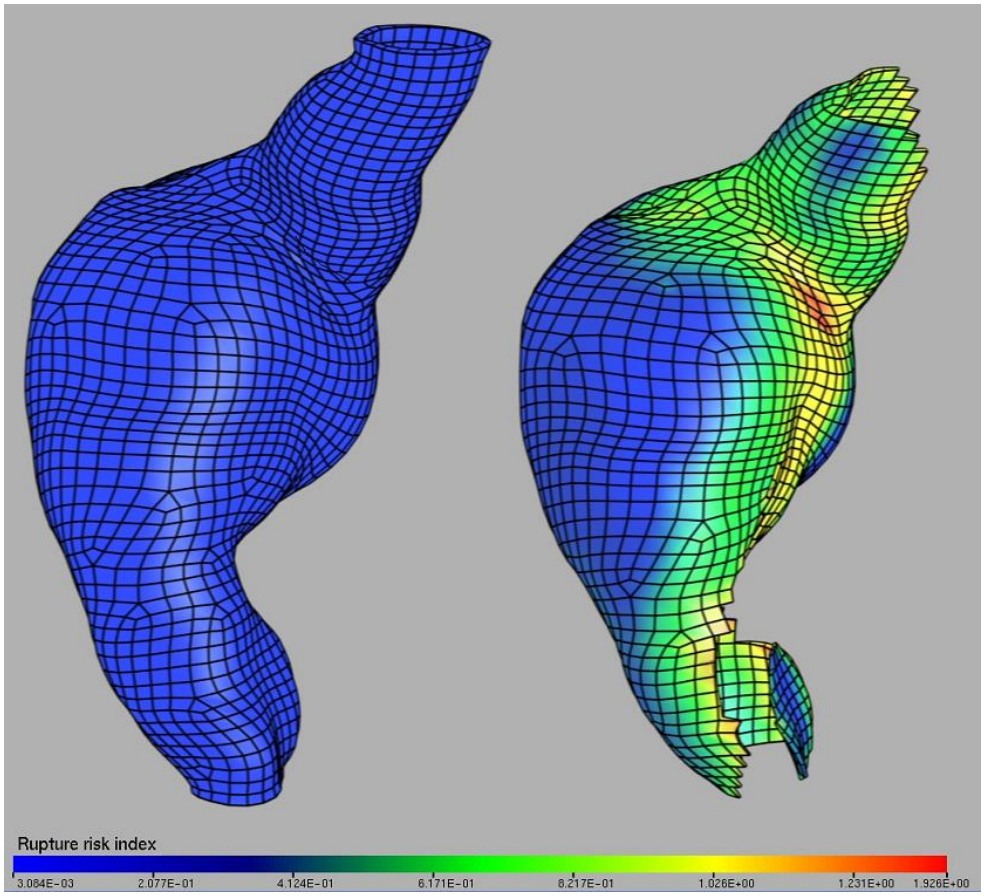

Figure 1: Rupture Risk Index (RRI) predicted in (a) the AAA Wall and (b) the ILT.

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