How to predict TAA rupture risk

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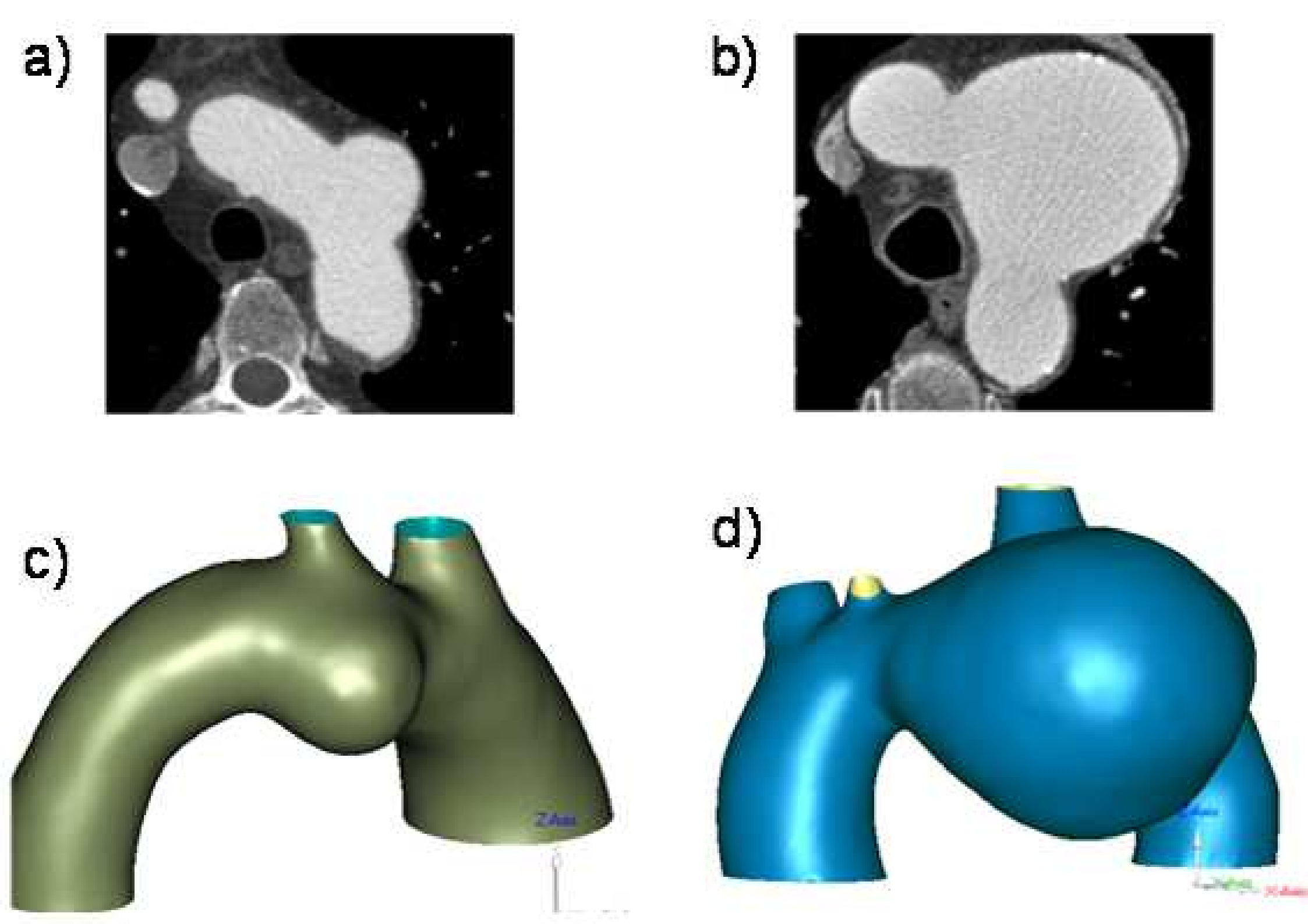
Aim. In clinical practice, the maximum diameter (D_{max}) is used as criterion to estimate the aneurysm rupture risk. Unfortunately this criterion is only a general rule and not a reliable indicator since also small aneurysm can rupture. In addition the measure of the D_{max} becomes difficult when applied to the thoracic segment, in particular, due to the geometrical complexity. From the biomechanical perspective, the rupture event occurs when the mechanical wall stress exceeds the tensile strength of the tissue, consequently, the peak wall stress can be investigated as a more reliable value to predict the rupture risk.
The aim of this study is to identify the morphological parameters that mainly influence the peak wall stress and that can be used as a reliable predictor of rupture. In addition a new method based on accurate patient-specific models is also presented.

Methods. The analysis of aortic wall stress distribution has been investigate by using Finite Element (FE) analyses. CT images from our patient database have been analysed and the main morphological features of thoracic aortic arc diseases have been identified, figure 1. A virtual library of TAA models were developed (up to 200 models) and sensitivity analyses were performed by using a probabilistic approach implemented in a FE code. The correlation between the morphological features and the stress state has been collected and analysed.

Results. The sensitivity analysis shows that the mean value of the maximum stress is about 0.48 MPa (sd 0.047 MPa), figure 2a. For diameters less that 50 mm the peak stress is primarily affected by eccentricity (*ecc*) of the bulge (C.C.=0.88), while for diameters in the range of 50-60 mm the C.C. is 0.35 for the *ecc* and 0.67 for the *Dmax*, figure 2b.

Conclusions. Simulations show that the maximum diameter can not be considered as a unique criterion to estimate the aneurysm rupture risk and that for small aneurysm, the *ecc* plays the main role. Moreover, this study points out the capability of our approach to investigate patient-specific TAA by means of computational simulations in preoperative estimation of aneurysm rupture risk.


a)
b)
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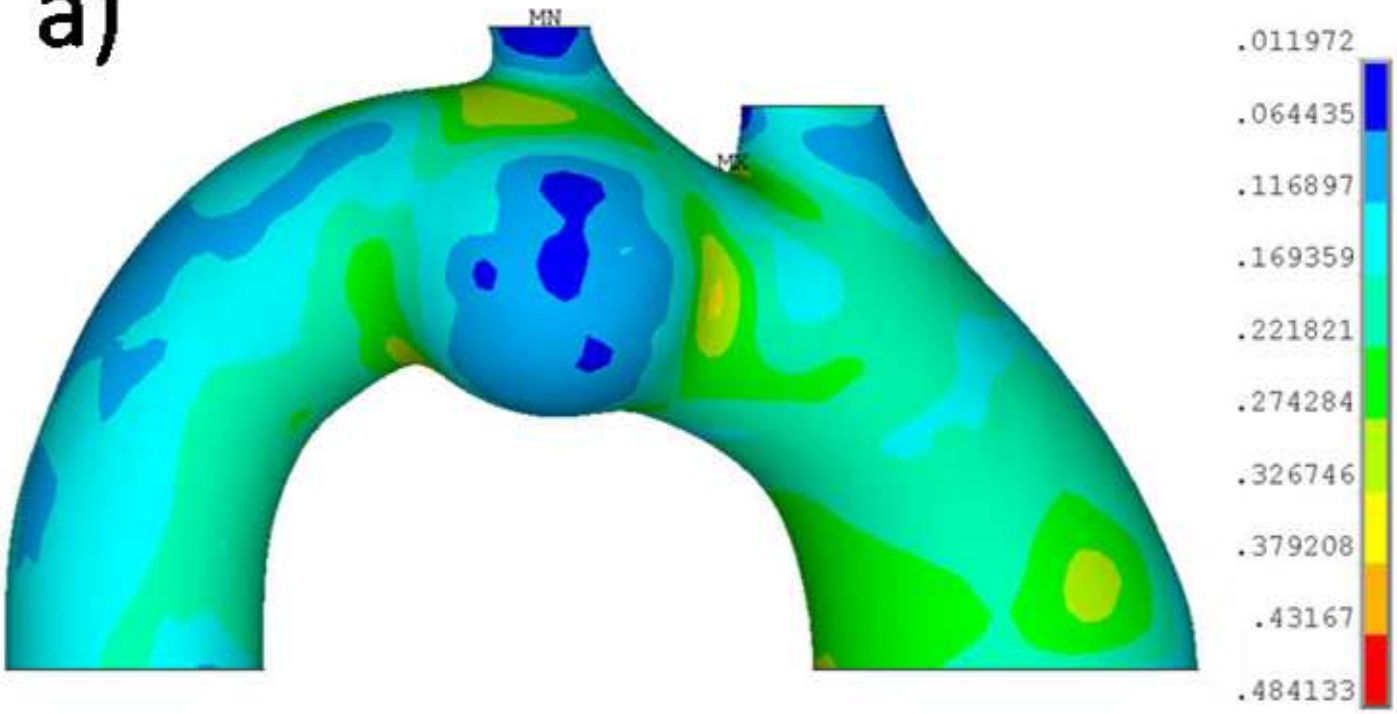
d)

a)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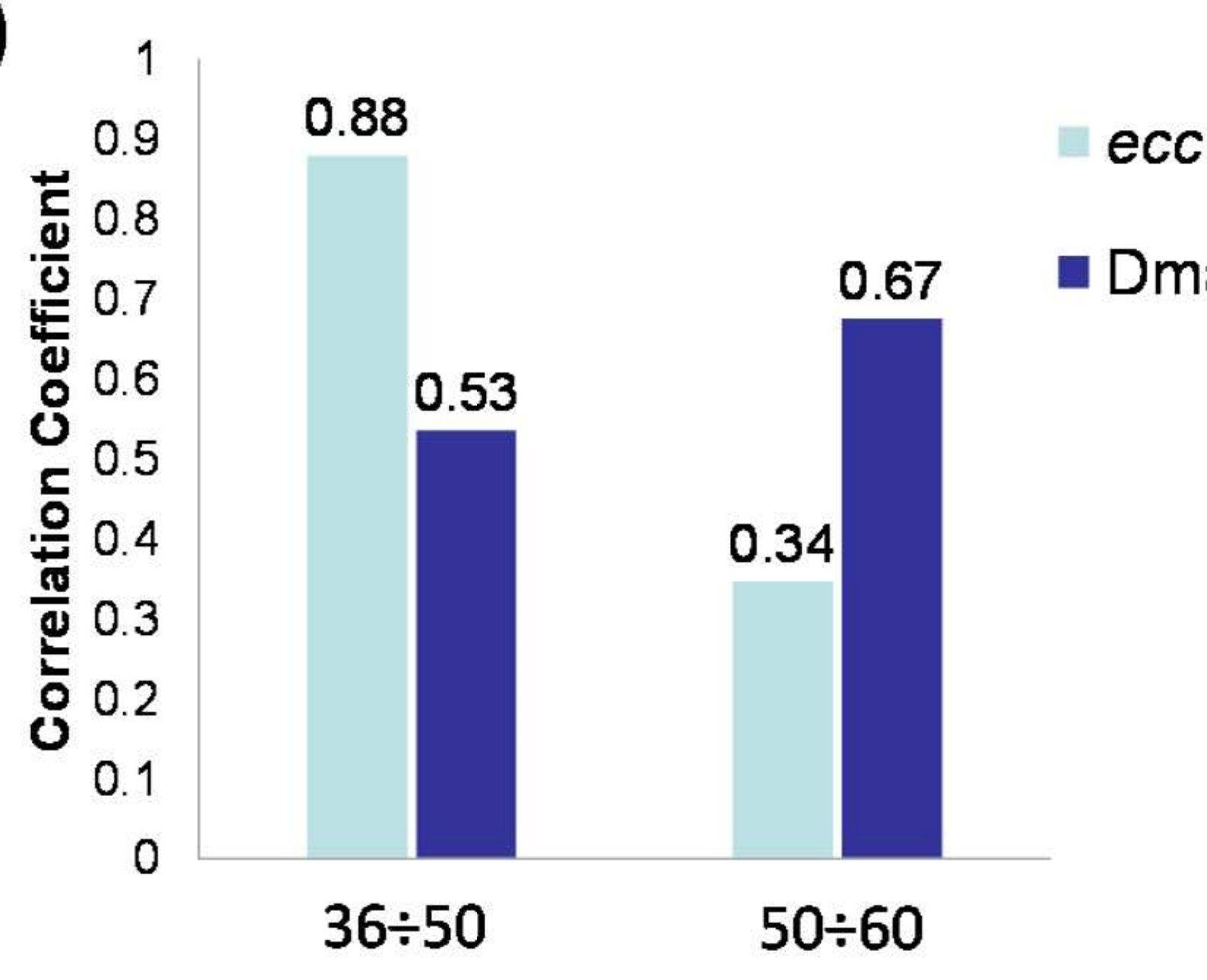
Correlation Coefficient
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0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.88
0.53
0.34
0.67
36÷50
50÷60
ecc
Dm