How calcifications can impact TEVAR procedures: insights from computational analyses

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Abstract:
Thoracic endovascular aneurism repair (TEVAR) is a mini-invasive technique used to treat the pathological tract of the aorta. TEVAR guidelines discourage the procedure when high calcified aortas are present, in particular in the landing zone regions, due to the possibility of developing endoleak; however, clinicians, sometimes, proceed with the operation off-label despite these recommendations. This study analyzes, in-silico, the effects of the calcification on a patient-specific anatomy after a TEVAR procedure, testing different idealized and patient-specific calcification geometries and mechanical properties.

A patient-specific anatomy without calcification from Professor Hejimen of Radboud University Medical Center, Netherlands, was taken into consideration for this study. Four different idealized calcification models and three different elastic modules of the calcification were tested: 2.75 MPa, 50 MPa and 20 GPa. A total of thirteen simulations of the TEVAR procedure were performed, following the â€˜tracking method.

Comparing the models from a qualitative point of view, the stent-graft apposition looked the same for all the models, suggesting a good stent-graft apposition even in the presence of calcifications. Relevant results were also achieved with the analysis of the von Mises stresses calculated on aorta and calcification: as the Young modulus of the calcification was reduced from 20 GPa to 2.75 MPa, the stresses on the calcification post-TEVAR implant were highly reduced.

From this analysis the calcifications appeared to function as load-bearing structures, reducing stress on the aorta while increasing stress on calcifications. This was a significant finding, as an increase in wall stress on the aorta was associated with a higher risk of aneurysm rupture. In this case, however, calcifications helped reduce the average von Mises stresses on the aorta, potentially lowering the likelihood of aneurysm rupture. This study suggests that TEVAR could still be feasible, at least from the perspectives of stress analysis and qualitative device comparison.