MECHANICAL PERFORMANCES OF STENT-GRAFTS WITHIN TORTUOUS ABDOMINAL AORTIC ANEURYSMS

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Introduction

Endovascular aneurysm repair (EVAR) is an established alternative to abdominal aortic aneurysms (AAA) surgery. It consists in excluding the aneurysm sac from the blood flow by inserting a stent-graft (SG). However, secondary interventions after EVAR are frequent, mainly due to SG flexibility issues, especially when the device is deployed in a tortuous AAA. To avoid these complications, a new generation of more flexible SGs has been developed [Weale, 2010]. However, design strategies remain empirical. The aim of this study was to compare the mechanical performances of two multi-material models of first (FG) and last generation (LG) SGs by simulating their deployment within a tortuous AAA.

Methods

Two SG limbs with several Z-stents were modeled using finite element analyses (Abaqus, *Simulia*): Zenith (Ze-SG) *(Cook Medical)* of FG and Endurant (En-SG) *(Medtronic)* of LG. The mechanical properties of each component material were obtained from literature, manufacturers' data and in-house mechanical tests. The simulations involved four steps: (i) SG crimping inside the sheath, (ii) insertion within a 60°-angulated AAA, (iii) SG deployment and (iv) pressurization. Mechanical performances of both SGs were assessed through global and local criteria: the maximal reduction of SG lumen (LR_{max}) and the maximal Von Mises stress in the metallic stents (σ_S^{max}).

Results

In this 60°-angulated AAA, LR_{max} reached a value around 25 % for Ze-SG, while the lumen of En-SG was only reduced by 15 %. Moreover, σ_S^{max} was twice as much with Ze-SG stents compared to En-SG stents (205 MPa *vs.* 100 MPa, respectively). Furthermore, from a qualitative point of view, the simulations showed that the SG of LG (En-SG) was better affixed against the proximal and distal aortic necks than Ze-SG.

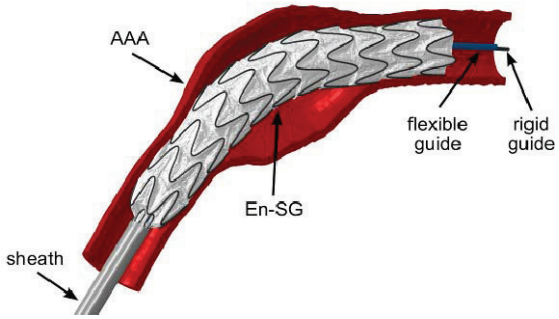

Figure 1: En-SG deployment within an idealized 60°-angulated AAA.

Discussion

These results are in agreement with previous studies on the bending behaviour of SGs [Demanget, 2011] and confirm the trend that last generation SGs have overall better mechanical performances than earlier generation SGs. LR_{max} and σ_S^{max} values obtained for En-SG are comparable to other LG devices. This present study is the first report of SG behavior within a tortuous AAA with unprecedented precision level. Previous studies only considered homogeneous isotropic SGs and did not investigate SG deployment [Li, 2006].
In clinical practice, the use of more flexible SGs may decrease the incidence of complications, such as endoleaks (better affixing against the aortic neck), stenosis or thrombosis (better flexibility) of the SG and stent fracture, in the setting of tortuous AAAs. Furthermore, this new numerical approach could be implemented as an aid in surgical decision or used at the design stage of new SGs.

References

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