Comparing hemodynamic and geometric profiles of commercial devices for endovascular AAA repair

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1. Introduction

Abdominal aortic aneurysm (AAA) is a vascular disease characterized by an expansion of the abdominal aorta lumen. In recent years, endovascular aortic repair (EVAR) technique has been massively applied to treat AAA, as alternative to classical open-chest surgery. The advantages of the endovascular approach are mitigated by the fact that EVAR implantation leads to (1) the redirection of blood through the deployed endograft, and (2) iliac bifurcation reshaping, thus altering the local hemodynamics [1]. In this study, the impact that the design features of two different commercial endovascular graft (EG) have on hemodynamics and iliac bifurcation geometry is evaluated by applying image-based computational hemodynamics to EVAR-treated patients after a month from the implantation, and compared to healthy subjects. The aim is to identify hemodynamic alterations between installed EG devices and physiological infrarenal abdominal aortic structures.

2. Methods

Healthy subjects (N=10), and patients treated with Endurant® (Medtronic, CA, USA) (N=10) and with Excluder® (Gore Medical, AZ, USA) (N=10) devices, underwent CT angiography. DICOM images of all subjects were segmented to obtain the 3D models [1]. A centerline-based geometrical analysis was carried out evaluating curvature, torsion, normalized cross-sectional area and its variation [2]. The reconstructed 3D geometries were meshed with tetrahedral elements and the governing equations of blood motion were solved by applying the finite volume-based method [1]. Conditions at boundaries were based on flow and pressure measurements [1]. Near-wall hemodynamics and intravascular flow structures were described, respectively, in terms of time-average wall shear stress (TAWSS), helical flow, and blood recirculation volume (RV).

3. Results

In terms of geometry, no significant differences were observed between groups. As for hemodynamics, overall, statistically significant correlation was observed between the average TAWSS and helicity intensity (ρ=0.887; $p_{value}=3.67\cdot10^{-7}$) and between the cross-sectional area variation and the percentage of the recirculation volume (ρ=0.447 /p_{value}=0.014). Interestingly, the cohort treated with the Endurant presented the lowest average TAWSS and helicity intensity values, and the highest RV percentage values.

4. Discussion

No significant differences were observed between reshaped iliac bifurcations and healthy subjects. The hemodynamics in the patient group treated with the Endurant was observed to be slightly more prone to thrombosis than the group treated with the Excluder. The observed relationship between TAWSS and helicity intensity confirms the beneficial role of helical flow [3] in suppressing low velocity/stagnation regions, susceptible to thrombus formation. The observed relationship between cross-sectional area variation and the amount of recirculation volume could represent a parameter for EGs design optimization.

References

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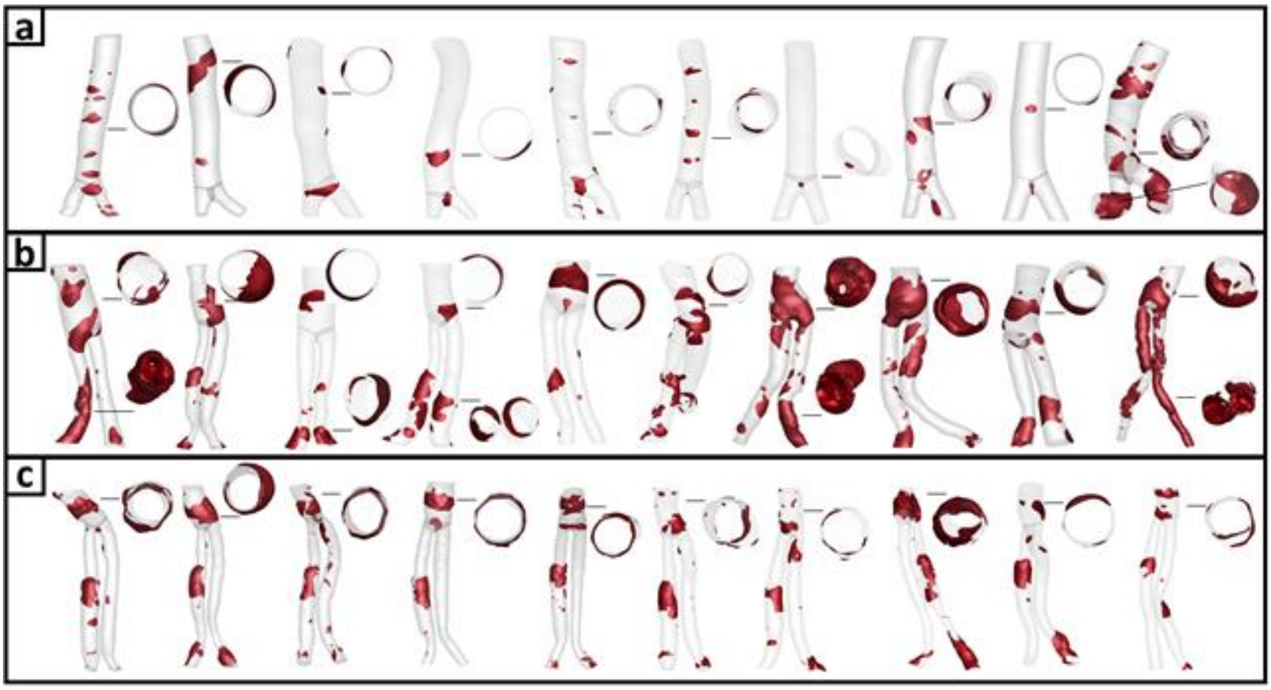

Figure 1: Recirculation volume for (a) healthy subjects, (b) Endurant models and (c) Excluder cases