A NEW 3D-DERIVED INDEX TO PREDICT THE DEFORMATIONAL BEHAVIOR OF AORTA IN FENESTRATED EVAR

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Background

The introduction of fenestrated endografts (fEVAR) enabled endovascular treatment of short-necked, juxtarenal, and suprarenal abdominal aortic aneurysm (AAAs) [1]. Endograft implantation in the target visceral vessels (TVVs) influences arterial angle and curvature after fenestrated EVAR positioning [2]. This altered anatomy could potentially kink the stented target vessel and strain the endograft, thus leading to post-operative complications that require reinterventions [3]. The exact influence of endograft implantation on aortic anatomy and the endograft changes after complex endovascular treatments remain unknown [4].

The aim of the study is to analyze the morphological changes of the aortic and TVVs anatomy after fEVAR endografting, using three-dimensional (3D) virtual modeling and a novel index computed on 3D anatomical reconstructions.

Materials and Methods

For the study, a total of 11 patients who underwent fEVAR at IRCCS Azienda Ospedaliero-Universitaria di Bologna were selected. The cases were divided into: "Instability" group (n=6): patients presenting post-EVAR type III endoleak verified at follow-up imaging; "Control" group (n=5): patients free from type III endoleak at follow-up.

Computed Tomography Angiography (CTA) scans of the patients were digitally processed to generate 3D reconstructions of the aortic anatomy using D2P® software (Oqton, San Francisco, California, US). For both groups, the 3D model was reconstructed at the pre-operative stage (T_{-1}), at the immediate post-operative stage (T_0), and at 3-12 months follow-up (T_1). The central lumen line (CLL) for the aorta (AO) and the TTVs were automatically extracted from the 3D model (Figure 1).

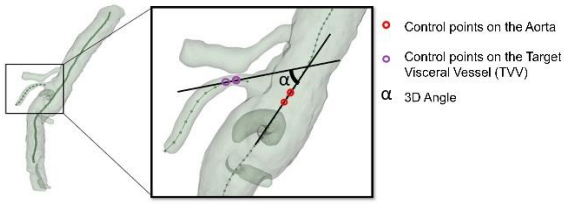

Figure 1: 3D model reconstruction with extracted CLL for AO and TTVs, and the calculated AO-TVV angle.

Then, each CLL was sampled via control points, identified with *x,y,z* spatial coordinates. All automatic processing was implemented in 3DSlicer software. The angle between the AO and the TVV of interest (AO-TVV angle, α) was calculated between two straight lines passing through two selected control points of the AO and TVV (Figure 1), for all 11 patients at T_{-1}, T_0, T_1.

Results

The endograft implantation introduces a variation in the amplitude of the AO-TVV angle. In the Control group, an increase in amplitude from the pre-operative (T_{-1}) to the immediate post-operative stage (T_0) is always followed by a further increase in amplitude at follow-up (T_1). Similarly, a decrease at T_0 always corresponds to a further decrease at T_1 (Figure 2a). Conversely, in the Instability group, a variation in AO-TVV angle amplitude from T_{-1} to T_0 is always followed by a variation in the opposite direction at T_1 (Figure 2b).

The percentage variations of the AO-TVV angle obtained for all patients in the two groups are reported in Figure 2.

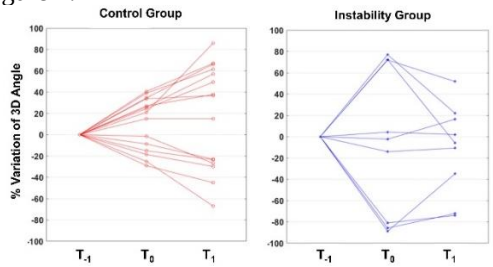

Figure 2: Percentage variations of the AO-TVV angle from T_{-1} (reference) to T_0 and T_1.

Discussion

This work has defined a new method of evaluating the deformational behavior of the aortic anatomy after fEVAR. We have introduced the automatic calculation of the angle between the AO and TVVs starting from 3D reconstructions obtained from patient imaging. The new 3D-derived angle is attributable to a clearly different behavior for the two groups: a monotonous ascending or descending trend for the Control group, and an inverting trend over time for the Instability group. These findings suggest the role that the AO-TVV angle may have in predicting instability, therefore in optimizing patient surveillance protocols. As major limitations: the study report results from a small sample size; only one type of fEVAR endograft was considered; and time for follow-up CTA is not standardized for all patients.

References

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