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Risk Factor Analysis of Bird Beak Occurrence after Thoracic Endovascular Aortic Repair

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WHAT THIS PAPER ADDS

The present study is focused on the risk of stent graft malapposition after thoracic endovascular repair through an objective and accurate assessment of proximal landing zone anatomy with particular reference to aortic angulation.

Objectives: The aim was to analyze the role played by anatomy and stent graft in the incidence of incomplete apposition to aortic arch.

Methods: Between 2007 and 2014 data including available and suitable computed tomographic angiography (CTA) imaging of patients who had undergone thoracic endovascular aortic repair were reviewed. The study included 80 patients (65 men, 54 ± 21 years) treated for traumatic aortic rupture ($n = 27$), thoracic aortic aneurysm ($n = 15$), type B aortic dissection ($n = 24$), penetrating aortic ulcer ($n = 5$), intramural hematoma ($n = 2$), aorto-oesophageal fistula ($n = 2$), and aortic mural thrombus ($n = 5$). Pre- and post-operative CTA images were analyzed to characterize bird beak in terms of length and angle, and to calculate aortic angulation within a 30 mm range at the proximal deployment zone.

Results: Bird beak configuration was detected in 46 patients (57%): mean stent protrusion length was 16 mm (range: 8—29 mm) and mean bird beak angle was 20° (range: 7—40°). The bird beak effect was significantly more frequent after traumatic aortic rupture treatment ($p = .05$) and in landing zone 2 ($p = .01$). No influence of either stent graft type or generation, or degree of oversizing was observed ($p = .29$, $p = .28$, $p = .81$ respectively). However, the mean aortic angle of patients with bird beak was higher in the Pro-form group than that in the Zenith TX2 group (62° vs. 48°, $p = .13$). Multivariate analysis identified the aortic angle of the deployment zone as the unique independent risk factor of malapposition (HR = 1.05, 95% CI 1—1.10, $p = .005$). The cutoff value of 51° was found to be predictive of bird beak occurrence with a sensitivity of 58% and a specificity of 85%.

Conclusions: Assessment of proximal landing zone morphology to avoid deployment zones generating an aortic angle of over 50° can be recommended to improve aortic curvature apposition with the current available devices.

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INTRODUCTION

During the last decade, the indications for endovascular thoracic aortic repair have been extended to different pathologies and landing zones (LZs) along the aortic arch or even in the ascending aorta. This raises new issues relating to the optimal LZ, whose quality and stability largely determines the technical success of the procedure.[1] These developments have led to the concept of conformability, which implies adequacy of contact between material and LZ, independently of anatomic characteristics, taking into account that LZ length can vary from brand to brand (15 to 20 mm). However, clinical experience has shown that in terms of conformability the material has certain limits when morphology is defined as complex.

One of the manifestations of incompatibility between stent graft and aorta is the bird beak (BB) effect, which can

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be defined as a gap between the aortic wall and the stent, with stent protrusion into the aortic lumen of more than 5 mm.[2] This configuration may lead to severe hemodynamic disturbances and lack of sealing, resulting in a risk of migration, endoleak or stent graft collapse.[3–6]

Different hypotheses have been formulated regarding the causes of BB, incriminating stiffness of stent and/or accentuated arch curvature.[7] However, these factors have not yet been analyzed objectively.

The present study aims to analyze the different factors favoring the occurrence of BB and in particular the relationship between this phenomenon and aortic anatomy.

MATERIALS AND METHODS

Between January 2007 and November 2014 all patients admitted for thoracic aortic pathology and treated with stent graft were reviewed retrospectively. Data relating to patient demographics, indication for repair, operative reports, and outcomes were collected. Pre- and post-operative computed tomographic angiography (CTA) images were re-evaluated according to the protocol outlined below. Patients with unavailable and/or unsuitable post-operative CTA, as well as those with follow up imaging performed at other sites, were excluded.

All data and CT imaging were anonymized. Because of the retrospective design and according to French law it is neither necessary nor possible to obtain approval of an ethical committee (in French CPP, for Comité de Protection des Personnes) for this type of non-interventional study. Moreover CPPs are not entitled to issue waivers of approval for this type of study.

Imaging technique and analysis

All patients underwent CTA with a multidetector CT scanner (Siemens Sensation 64 cardioscanner, Erlangen, Germany). Axial image data were transferred to a workstation and analyzed with dedicated vascular software (Endosize, Therenva, Rennes-France).

A three dimensional (3D) aortic lumen centerline (CL) was extracted automatically from the ascending aorta to the celiac trunk and divided into four anatomical zones according to the Ishimaru classification.[8] Matlab scripts were developed to extract 3D coordinates (x, y, z) of each point generated at 1 mm increments along the CL and to calculate the aortic angle α at the proximal deployment zone. Beforehand, three reference planes (A, B, C) were defined. All of them were perpendicular to the CL at different levels: plane B to the cross section view showing the stent totally apposed to the wall, and planes A and C to the cross section views located 15 mm along CL above and below plane B respectively. The aortic angle α corresponds to the angle between planes A and C within a 30 mm range (Fig. 1).

The pre-operative aortic angle was calculated after locating the tip of the stent in relation to a fixed anatomical landmark on the post-operative CTA. This made it possible to measure the proximal deployment zone angle at exactly the same location pre- and post-operatively and thus to obtain a comparison.

The importance of BB was characterized by length (L) and angle (θ). Whether covered or bare, L represented the

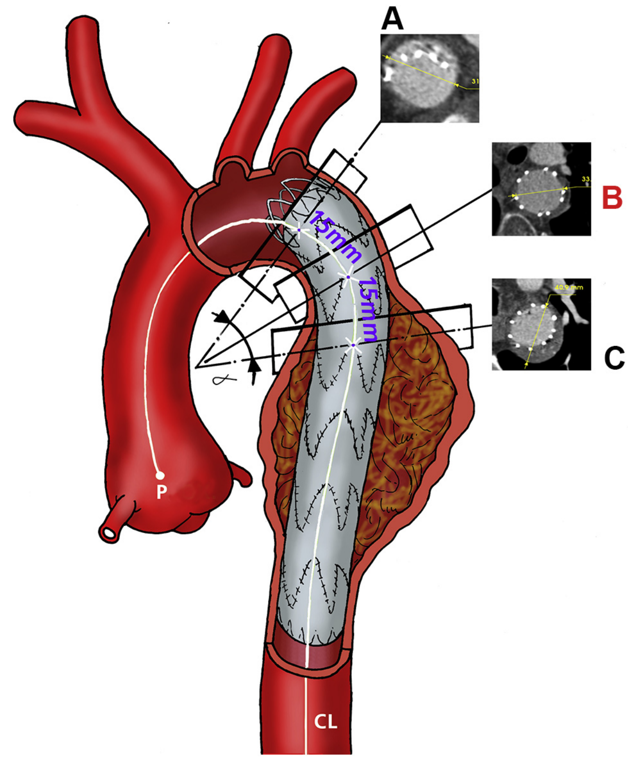

Figure 1. Schematic representation of aortic angle α calculation within a 30-mm range at the proximal deployment zone. (A) Cross-section view of the aorta located 15 mm along the centerline above plane B. (B) Cross-section view showing the stent totally apposed to the wall. (C) Cross-section view of the aorta located 15 mm along centerline below plane B.

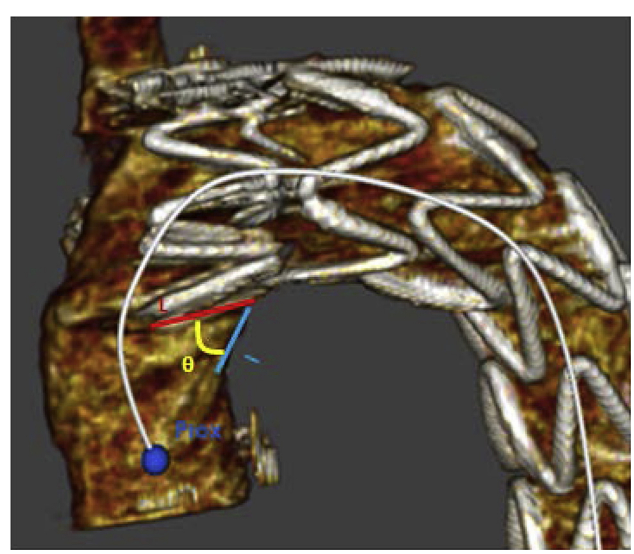

Figure 2. Illustration of bird beak angulation θ calculation on three-dimensional reconstruction image. L = the length of stent-graft protrusion, l = the longitudinal distance between the cross-section view of the stent tip and the cross-section view of the entire stent circumference apposed to the aortic wall.