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Aortic Arch Morphology and Aortic Length in Patients with Dissection, Traumatic, and Aneurysmal Disease

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WHAT THIS PAPER ADDS

The results of this study are unique because of its large, multicenter sample size, from varying patient populations. This makes the results more generalizable to the broader patient population than those of previous studies. In effect, the application of the results is more substantial and is beneficial for device designs and patient selection, which plays a critical role in patient outcomes.

Objectives: To assess aortic arch morphology and aortic length in patients with dissection, traumatic injury, and aneurysm undergoing TEVAR, and to identify characteristics specific to different pathologies.

Method: This was a retrospective analysis of the aortic arch morphology and aortic length of dissection, traumatic injury, and aneurysmal patients. Computed tomography imaging was evaluated of 210 patients (49 dissection, 99 traumatic injury, 62 aneurysm) enrolled in three trials that received the conformable GORE TAG thoracic endoprosthesis. The mean age of trauma patients was 43 ± 19.6 years, 57 ± 11.7 years for dissection and 72 ± 9.6 years for aneurysm patients. A standardized protocol was used to measure aortic arch diameter, length, and take-off angle and clockface orientation of branch vessels. Differences in arch anatomy and length were assessed using ANOVA and independent *t* tests.

Results: Of the 210 arches evaluated, 22% had arch vessel common trunk configurations. The aortic diameter and the distance from the left main coronary (LMC) to the left common carotid (LCC) were greater in dissection patients than in trauma or aneurysm patients ($p < .001$). Aortic diameter in aneurysm patients was greater compared with trauma patients ($p < .05$). The distances from the branch vessels to the celiac artery (CA) were greater in dissection and aneurysm patients than in trauma patients ($p < .001$). The take-off angle of the innominate (I), LCCA, and left subclavian (LS) were greater, between 19% and 36%, in trauma patients than in dissection and aneurysm patients ($p < .001$). Clockface orientation of the arch vessels varies between pathologies.

Conclusions: Arch anatomy has significant morphologic differences when comparing aortic pathologies. Describing these differences in a large sample of patients is beneficial for device designs and patient selection.

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INTRODUCTION

Thoracic endovascular aortic repair (TEVAR) has proven to be successful in treating patients with dissection, traumatic injury, and aneurysm in the descending thoracic aorta.[1—5] In comparison with open surgical repair, patients undergoing TEVAR for these conditions have shown lower morbidity and mortality.[6—11] The application of stent-graft technology within the aortic arch, however, introduces challenges not encountered in the descending aorta. Noted complications have included stent-graft collapse, endoleak, and stroke.[12,13] It is recognized that an important factor in TEVAR success, specifically in the ascending aorta, is dependent on aortic arch morphology and the ability of the endograft to seal off the area of disease or injury by

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appropriate fixation at the proximal and distal landing zones in the normal aorta.[14] Defining the aortic morphology differences between various patient population groups is therefore important in the considerations for the device choice and sizing, as well as the introduction of new stent-graft technology. This study hypothesizes that there are inherent differences in the aortic arch morphology and aortic length between patients with dissection, traumatic injury, and aneurysm. The null hypothesis is that there are no differences between the three patient populations. The purpose of this study was to assess the aortic arch morphology and aortic length in patients with dissection, traumatic injury, and aneurysm undergoing TEVAR and identify characteristics specific to the different pathologies.

MATERIALS AND METHODS

A retrospective analysis of the aortic arch morphology and the aortic length was completed on patients enrolled between October 2009 and November 2013 in three multi-site trials that received the GORE Conformable TAG (CTAG) thoracic device (manufactured by W.L Gore and Associates, Flagstaff, AZ). Inclusion criteria for the studies required: the presence of an acute complicated type B aortic dissection, a descending thoracic aorta (DTA) aneurysm, or traumatic injury of the DTA; a proximal and distal landing zone length $\geq$ 2.0 cm; and proximal and distal landing zone inner diameters between 16 and 42 mm. All three studies excluded patients with known connective tissue disorders and those patients with aneurysmal, dissected, heavily calcified, or heavily thrombosed landing zones. Approximately 71% (n = 120) of dissection patients screened for eligibility in the CTAG trial were excluded from study participation, with 29% (n = 33) of aneurysm patients and 40% (n = 40) of trauma patients being screen failures.

For this study, patients were excluded from the analysis if they were screen failures for the CTAG trial, did not have pre-treatment imaging, and/or had incomplete imaging that did not include the visceral arteries. A total of 210 patients (99 traumatic injury, 49 dissection, 62 aneurysm) were included in this study. The mean age of trauma patients was 43 $\pm$ 19.6 years, 57 $\pm$ 11.7 years for dissection and 72 $\pm$ 9.6 years for aneurysm patients.

A series of measurements were completed on each subject to effectively establish an average morphology among the patient populations and to identify morphologic features that differed significantly among the pathologies. Each measurement was completed according to a standardized measurement technique and dual reads were completed to ensure inter-observer agreement was within 15%. TeraRecon Aquarius iNtuition (TeraRecon, Inc., Foster City, CA) was used to complete all measurements. Using TeraRecon toolboxes, the aorta was segmented, surrounding tissues were excluded, and a center lumen line was introduced into the aorta and great vessels and a greater curve into the aortic arch.

Aortic diameters were measured outer edge to outer edge, perpendicular to the center lumen line at distances 20 mm and 40 mm distal to the left main coronary artery (LMC), and 30 mm distal to the left subclavian artery (LSA) (measurement 1–3, Fig. 1A). Additional diameter

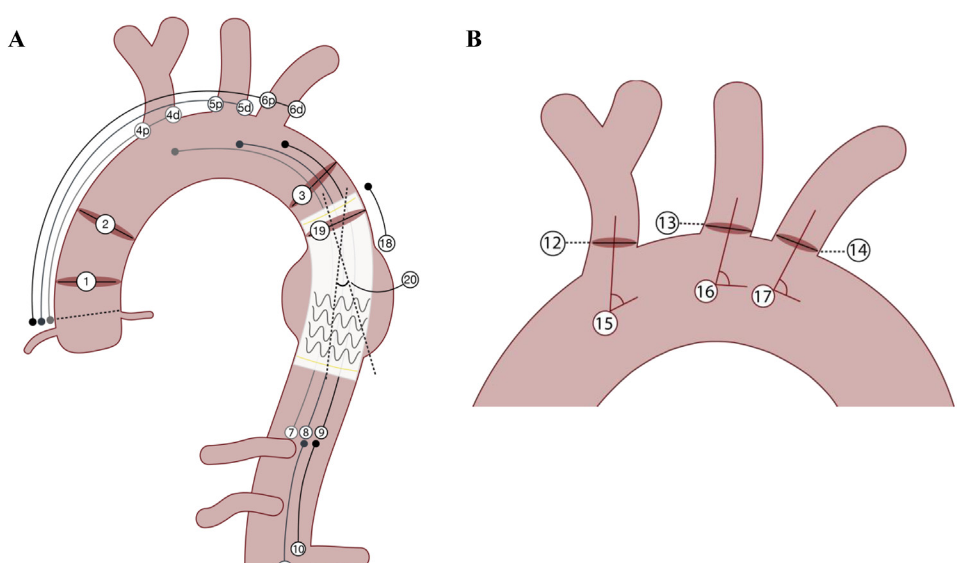

Figure 1. Diagram of measurements completed on each subject using both centerline and greater curve. (A) (1) Maximum diameter 20 mm distal to LMC; (2) Maximum diameter 40 mm distal to LMC; (3) Maximum diameter 30 mm distal to LSA; (4p and 4d) Length from LMC to proximal and distal IA; (5p and 5d) Length from LMC to proximal and distal LMC; (6p and 6d) Length from LMC to proximal and distal LSA; (7) Length from IA to CA; (8) Length from LCC to CA; (9) Length from LSA to CA; (10) CA to upper renal; (11) CA to lower renal. (B) (12) Maximum diameter IA; (13) Maximum diameter LCC; (14) Maximum diameter LSA; (15) TOA of IA; (16) TOA of LCC; (17) TOA of LSA; (18) Length of proximal sealing zone; (19) Maximum diameter of proximal sealing zone; (20) Neck angle of proximal sealing zone.