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Comparison of Volumetric and Diametric Analysis in Endovascular Repair of Descending Thoracic Aortic Aneurysm

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WHAT THIS PAPER ADDS

Aneurysm volumetric analysis has been reported for the evaluation of the outcome of endovascular repair for abdominal aortic aneurysm (AAA) and for aortic dissection. However, volumetric analysis after thoracic endovascular aortic repair (TEVAR) for descending thoracic aortic aneurysm has never been reported. Volumetric analysis after TEVAR was able to predict the presence of endoleak, especially high pressure endoleak, and was more favorable than diametric analysis A smaller pre-operative thrombus ratio (<11.3%) was associated with a higher risk of Type II endoleak after TEVAR. An increased aneurysm volume (>11.6%), compared with the baseline CT scan, was associated with a greater probability of high pressure endoleak.

Objectives: The aim was to evaluate computed tomography angiography (CTA) volumetric and diametric analysis after endovascular repair of descending thoracic aortic aneurysms (DTAAs) and its correlation with and applicability for clinical follow up.

Methods: Fifty-four consecutive endovascular repairs for DTAA were retrospectively evaluated from 2008 to 2014. All patients underwent pre-operative CTA and at least one post-operative CTA at 6 months. Fifty-four pre-operative and 137 post-operative CTAs were evaluated (using the Ziosoft 2 software) to analyze the aneurysm and thrombus volume, the maximum aneurysm diameter, and their changes at the last follow up CTA (mean 30.5 months; range 6.5—66.4 months). A statistical analysis was performed to assess the correlation between diameter and volume changes, as well as association with endoleaks. The cut off point to predict endoleaks was determined using a receiver operating characteristic (ROC) curve. The predictive accuracy of volume change versus diameter change for Type I endoleak was analyzed.

Results: The mean pre-operative aneurysm diameter, aneurysm volume, and thrombus volume were 56.7 ± 11.7 mm, 145.8 ± 120.0 mL, and 48.8 ± 54.8 mL, respectively. Within the observational period, a mean decrease of $-27.9 \pm 30.5\%$ in the aortic volume and $-15.9 \pm 15.4\%$ in diameter was observed. Correlation between aneurysm diameter and volume changes was good ($r = 0.854$). Volume and diameter changes were significantly different between groups with and without endoleaks (volume change $16.9 \pm 38.8\%$ vs. $-35.6 \pm 23.1\%$, $p < .001$; diameter change $8.0 \pm 12.1\%$ vs. $-18.8 \pm 14.3\%$, $p < .001$). A pre-operative thrombus volume percentage of <11.3% and increase in aneurysm volume +11.6% were predictive factors for Type II and Type I endoleak, respectively. The accuracy of a >10% volume increase in predicting a Type I endoleak was higher (accuracy 96.3%, sensitivity 75%, and specificity 98%) than a >5 mm diameter increase (accuracy 92.6%, sensitivity 25%, and specificity 98%).

Conclusions: CT volumetric analysis is a more reliable modality for predicting endoleaks after endovascular repair for DTAA than diameter analysis.

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INTRODUCTION

The first successful thoracic endovascular aortic repair (TEVAR) for descending thoracic aortic aneurysm (DTAA) was reported by Dake et al. in 1994.[1] This technique has become more popular due to the benefits associated with minimally invasive therapy. In 2005, a phase II multicenter trial of the GORE TAG thoracic endoprosthesis showed good results with low mortality and morbidity, and excellent 2

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year freedom from aneurysm related death.[2] Five year results of the Zenith TX2 showed all cause mortality and aneurysm related mortality similar to open repair, and also a reduction of severe complications with TEVAR.[3] However aneurysm expansion, endoleaks, and stent graft migration still occurred during the follow up period.

The indications for TEVAR, follow up of morphological changes of the aneurysm, and detection of stent graft related complications can be accurately provided by computed tomography (CT). Most previous reports have described the morphological changes of aneurysms based only on maximum diameter measured from the axial and/or longitudinal view. This measurement reflects only linear changes of a single cross sectional area and may be subjective. Volumetric analysis, which reflects three dimensional (3D) morphologic changes of the aneurysm either by CT or 3D ultrasound, has been proposed to be more appropriate, accurate, and reliable for follow up surveillance after endovascular abdominal aortic aneurysm repair (EVAR).[4] However, this imaging method is complex and requires a dedicated workstation and experienced operator. While volumetric analysis following EVAR focuses on the region between the renal arteries and the iliac bifurcation, no specific area is targeted following TEVAR, as the aneurysmal region can be at various points along the descending thoracic aorta. Studies of volumetric analysis following TEVAR are limited and have been conducted mostly in the field of thoracic aortic dissection.[5,6] The aim of this study was to investigate the utility of pre- and post-operative volumetric and diametric analysis of the aneurysm sac and thrombus, and to determine their correlation with and applicability to clinical follow up, especially to predict endoleaks as a surrogate endpoint for poor long-term clinical outcomes.

MATERIALS AND METHODS

Patient selection

From July 2008 to April 2014, 118 patients underwent TEVAR using commercially available stent grafts. The inclusion criteria included all consecutive patients with DTAA treated by TEVAR who had undergone follow up CT for at least 6 months after the treatment. Patients with dissecting and mycotic aneurysms and those undergoing bridging TEVAR were excluded. This study included 54 DTAA (28 saccular, 26 fusiform type) patients (40 male, 14 female) with a mean age of 76.2 $\pm$ 7.9 years (age range 60–92 years) who had undergone successful TEVAR. Three types of commercially available stent graft were used: 43 (79.6%) TAG (W. L. Gore and Associates, Inc., Flagstaff, AZ, USA); 7 (13.0%) Zenith TX2 (Cook Medical, Inc., Bloomington, IN, USA); and 4 (7.4%) Valiant (Medtronic, Inc., Santa Rosa, CA, USA). The choice of endograft was based on aneurysm anatomy and the criteria of endograft selection as follows: cases with poor iliac and/or tortuous aortic access were treated using Valiant; cases with proximal or distal landing zone close to neck and/or abdominal branch were treated using Zenith TX2, because accurate positioning was necessary; TAG endograft was chosen for other cases. All patients provided written informed consent prior to TEVAR. TEVAR was performed in the operating room under local or general anesthesia. In the hospital, approval from the institutional ethics committee for retrospective study was not necessary.

Computed tomography

Biphasic images (non-contrast and contrast enhanced images) were obtained using a 64 slice CT scanner (Aquilion, Toshiba Medical Systems, Japan). The scanning parameters used were automatic tube current range 120 kV; pitch 1.00 mm/0.8 mm; interval 0.84/1 mm; and rotation time 500 ms. Pre-contrast and post-contrast acquisitions were obtained with Omnipaque 300 solution at a dose of 400 mg iodine/kg body weight (Iohexol, concentration 300 mg iodine/mL, Daiichi Sankyo, Inc., Japan) injected intravenously using an automatic injection driver system (Dual Shot GX, Nemoto Kyorindo Co., Ltd., Tokyo, Japan) at a flow rate of 3 mL/s at 300 psi. The late phase images were acquired 35 s after the early phase images.

The raw scanned images were then reconstructed to 1 mm thick slices. Aneurysm and thrombus volumetric analysis was performed retrospectively using Ziosoft 2 software (Ziosoft, Inc., Tokyo, Japan) in a blinded fashion by a surgeon (Y.N.) and a radiologist (T.O.). The aneurysm volume was obtained by performing manual line encircling to the segment of the aortic aneurysm in 1 mm slice axial images and was calculated automatically using the Ziosoft 2 software. The thrombus volume was calculated to obtain an unenhanced scan of a segment of the aneurysm from preoperative images in a similar manner. The stent graft was included in the aneurysm volume measurement during the post-operative and follow up periods (Fig. 1). The maximum diameter of the aneurysm was measured from adventitia to adventitia on axial image sections perpendicular to the dominant axis of flow in the aortic segment. Fifty-four preoperative and 137 post-operative CT images (obtained at 6 months after the intervention, and annually thereafter) were analyzed. Volume changes are expressed as percentages using the following formula: $[(V_x - V_1)/V_1] \times 100\%$, in which V_1 indicates volume measured at pre-operative CT, and V_x indicates volume measured at the final follow up CT. Therefore, a negative value indicates aneurysm shrinkage, whereas a positive value indicates aneurysm enlargement. The analogue formula was used to assess maximum diameter changes. Significant sac enlargement was defined as diameter increase of $>$5 mm.

Statistical analysis

The data were acquired and analyzed using SPSS ver. 22.0 for Windows (IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated for patient and aneurysm characteristics and numeric continuous data. The measured clinical outcomes were endoleaks and sac changes. The association between patient and aneurysm characteristics, diametric, and volumetric variables with clinical outcome