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Measurements After Image Post-processing Are More Precise in the Morphometric Assessment of Thoracic Aortic Aneurysms: An Intermodal and Intra-observer Evaluation

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WHAT THIS STUDY ADDS

There is still an ongoing debate whether pre-operative morphometric assessments of thoracic aortic aneurysms, prior to endovascular repair, require expensive post-processing software or whether measurements using conventional MPRs are sufficient. This study shows that less intermodal and intra-observer variability can be achieved by using curved MPRs created by image post-processing software. In addition, greater distances are measured with curved MPRs. This result corresponds more to the clinical experience, where the actual size of aortic pathologies are often underestimated.

Objectives: Precise pre-procedural anatomical analysis of aneurysmal anatomy is essential for successful thoracic endovascular aortic repair (TEVAR). Since surgeons and radiologists have to perform multiple measurements in the same patient, high intra-observer reliability of any imaging method is mandatory. Commercially available three dimensional (3D) post-processing techniques are expected to be superior to conventional two dimensional multiplanar reconstructions (MPRs) derived from computed tomography angiograms (CTAs). However, few data exist to support this view. This study aims to evaluate the intermodal and intra-observer differences using 3D software (3surgery) in descending thoracic aortic aneurysms (dTAAs).

Methods: Pre-operative CTAs (performed between 2004 and 2010) of 30 dTAAs (mean maximum diameter 61.4 $\pm$ 13 mm) were assessed by three independent investigators with different experience in the measurement of aortic pathologies. Intra-observer reliability and intermodal differences (3D vs. 2D) were investigated using pre-specified measurement points (distances of total length, maximum diameter, proximal and distal landing zones). Statistical analyses were performed using the Bland—Altman method and a mixed regression model.

Results: Intermodal comparison showed that 2D measurements significantly underestimate the measured distances (maximum diameter 3.7 mm [95% CI −5.3 to −2.1] and landing zone maximum 1.4 mm [95% CI −2.0 to −0.2] shorter with 2D, $p < .05$). In almost all 3D measurements, all investigators showed lower variability comparing the intra-observer differences, most notably in the measuring point total length (reduction of the SD up to 7.9 mm).

Conclusions: These data show that both techniques led to significant measurement disparity. This occurs especially at the point of indication (maximum diameter) and the total length of the aneurysm (important for correct stent graft selection). But overall the variability is reduced with the 3D technique, which also tends to measure greater distances. The use of post-processing software therefore leads to more precise device selection for TEVAR in TAA.

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INTRODUCTION

Successful thoracic endovascular aortic repair (TEVAR) for descending thoracic aortic aneurysms (dTAAs) requires precise sizing of the landing zones and consideration of the length of the aneurysm itself, otherwise procedural complications such as endoleaks (especially type IA/IB), aortic

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wall trauma, increase in aortic diameter, stent graft collapse or dislocation, and spinal ischemia might occur.[1–5]

The current gold standard uses multiplanar reconstructions (MPRs) from computed tomography angiograms (CTAs), reconstructed from raw data (axial, sagittal, and coronal planes). These conventional two-dimensional (2D) MPRs run the risk of erroneous dimension measurements, whereas new reconstruction methods, for example curved MPRs (3D), reduce the impact of aortic kinking and promise more precise measurements.

By direct comparison of 2D versus 3D measurement techniques of abdominal aortic aneurysms, previous studies have shown good agreement between both methods with a tilt towards the 3D technique, but the latter should be reserved for difficult anatomies (highly curved).[6] The latest study, however, suggested a negative correlation, with lower variability in the centerline analysis (3D).

Compared with these non-congruent results in the area of the abdominal aorta, the results of three studies were consistent for dTAAs: measurements corrected to a centerline are the least variable and most reliable method for planning a TEVAR.[5,7,8] These studies investigated only differences between the measuring techniques on the basis of inter-observer variability (all 3 studies), and additionally in Rudarakanchana et al.[8] the intra-observer variability.

Currently there are no data in the literature comparing measurement methods of standardized reconstructions, 2D, vs. image post-processing, 3D, examining intermodal and intra-observer differences in different medical disciplines when planning TEVAR for dTAA. The aim of this study was therefore to detect intermodal differences and the intra-observer reliability of commercially available image post-processing software (3Mensio, Medical Imaging BV, Bilthoven, The Netherlands; semi-automatic centerline analysis) compared with measurements derived from conventional MPRs.

PATIENTS AND METHODS

This retrospective study included 30 degenerative TAAs, limited to the descending thoracic aorta, in 28 patients, which were treated between 2004 and 2010. Two patients presented with two independent dTAAs and these were reported independently in the analysis. The mean maximum diameter was 61.4 $\pm$ 13 mm.

Exclusion criteria were aneurysms affecting the aortic arch, a proximal landing zone (distance between the origin of the left subclavian artery) less than 20 mm, ruptured dTAA, aneurysm secondary to aortic dissections, and a distal landing zone (distance between the celiac trunk and the distal end of the dTAA) less than 20 mm.

Data acquisition

CT data were acquired from images produced both externally and internally. The majority of CTAs (18 out of 28) were generated in the Radiology Department in the hospital using a multi-detector CT Somatom Sensation Cardiac 64 (Siemens Medical Systems, Erlangen, Germany). A standard aortic protocol for CTAs was used (120-kV tube current modulation and 120 mAs), which covers the whole aorta (including the aortic valve to the femoral arteries). A 0.6 mm slab thickness was reconstructed axially to 3 mm. The in-plane resolution was 0.6—0.8 lp/mm. An 80 ml bolus of Iomeprol 400 with a 30 ml bolus of NaCl (injection rate of 4 mL/second) was used as contrast agent. Ten CTAs were acquired externally and were reconstructed with an axial slab thickness of 3—5 mm. No further information could be obtained from the externally acquired images. However, further scanning within the department was not carried out in these cases because the quality was sufficient for pre-operative planning. Therefore, further radiation exposure was not warranted.

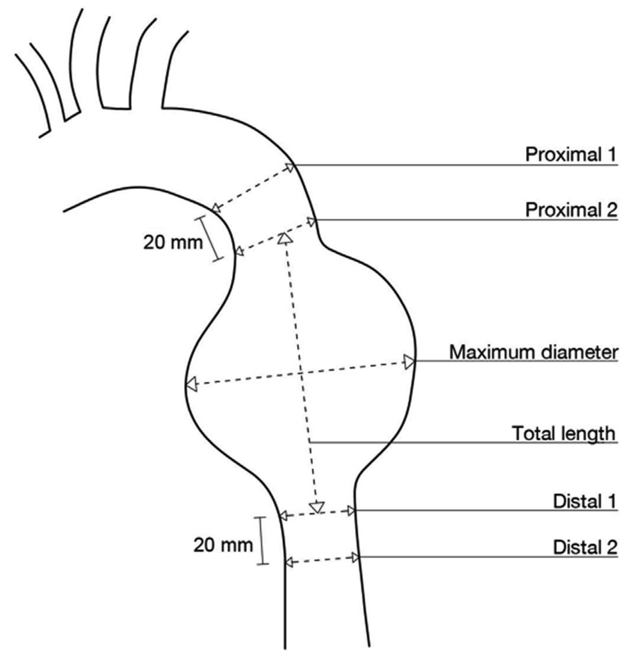

Figure 1. Definition of measuring points.

Software

3surgery, Version 4.0 (3Mensio Medical Imaging BV) was used for image post-processing. This program offers the possibility to present CT data sets both in two dimensions (MPRs) and three dimensions (curved MPR) to perform precise measurement based reconstructions.

Definition of the measurement points

Six measurement points were defined (Fig. 1): two for the proximal landing zone (Proximal 1 and 2), two for the distal landing zone (Distal 1 and 2), maximum diameter, and total length. The distance between the two proximal or distal measuring distances was 20 mm or greater. Ideally the landing zones had a cylindrical shape (conical shapes were avoided). Another measuring point was the maximum diameter of the aortic aneurysm. The outer wall was used as the landmark for measuring the diameter (adventitia to adventitia, excluding adherent structures). The total length was measured from Proximal 2 to Distal 1 along the central axis (centerline). All distance measurements were recorded in millimeters (mm) to one decimal place.