Eur J Vasc Endovasc Surg (2010) 40, 326—331

Pulsatile Distension of the Proximal Aneurysm Neck is Larger in Patients with Stent Graft Migration

J.W. van Keulen [a], F.L. Moll [a], G.K. Barwegen [a], E.P.A. Vonken [b], J.A. van Herwaarden [a,*]

[a] Department of Vascular Surgery, University Medical Center Utrecht, Utrecht, The Netherlands
[b] Department of Radiology, University Medical Center Utrecht, Utrecht, The Netherlands

Submitted 15 April 2010; accepted 18 May 2010
Available online 18 June 2010

KEYWORDS
Abdominal aortic aneurysm;
Stent graft;
Migration;
Aortic distension

Abstract *Purpose:* The proximal abdominal aortic aneurysm (AAA) neck expands significantly during the cardiac cycle, both before and after endovascular aneurysm repair (EVAR). Clinical consequences of this pulsatility were anticipated but have never been reported. This study investigated whether there is a relation between stent graft migration and preoperatively measured pulsatility of the proximal aneurysm neck.
Methods: EVAR patients with a preoperative dynamic computed tomography angiography (CTA), an immediate postoperative, and a CTA at 3 years after EVAR were included. The preoperative dynamic CTAs consisted of eight images per heartbeat. Aortic diameter and area changes per heartbeat were measured at two levels: (A) 3 cm above and (B) 1 cm below the most distal renal artery. Postoperatively, the distance between the most distal renal artery and the most proximal stent graft ring was measured. Two patient groups were distinguished according to whether migration during follow-up occurred (group 1) or had not occurred (group 2). The aneurysm neck dynamics of the two groups were compared by using the *t*-test for unpaired data and multivariable logistic regression analyses were performed. Mean values are presented with the standard deviation.
Results: Included were 26 patients (19 Talent, 6 Excluder and 1 Lifepath). Stent graft migration of $\geq$5 mm occurred in 11 patients (group 1). The pulsatility of the AAA neck in these patients was compared with the pulsatility in 15 patients with no graft migration (group 2). There were no significant differences in aortic neck characteristics (angulation, length and diameter) or degree of stent graft oversizing between the two groups. At level A in group 1 versus group 2, the diameter increase during the cardiac cycle was 2.0 $\pm$ 0.3 versus 1.7 $\pm$ 0.3 mm and the aortic area increase was 49 $\pm$ 15 versus 33 $\pm$ 12 mm^2. At level B in group 1 versus group 2, the diameter increase per heartbeat was 1.8 $\pm$ 0.3 versus 1.6 $\pm$ 0.4 mm, and the area increase was 37 $\pm$ 10 versus 25 $\pm$ 15 mm^2. The heartbeat-dependent diameter and area changes at both levels were significantly higher in group 1 compared with group 2. Multivariate

* Corresponding author at: Department of Vascular Surgery, Room G.04.129, University Medical Center, PO Box 85500, 3508GA Utrecht, The Netherlands. Tel.: +31 887556965; fax: +31 887555017.
E-mail address: J.A.vanherwaarden@umcutrecht.nl (J.A. van Herwaarden).

doi:10.1016/j.ejvs.2010.05.009

regression analysis showed suprarenal aortic pulsatility was a significant predictor for stent graft migration after 3 years.
Conclusion: The preoperative heartbeat-dependent aneurysm neck distension is significantly associated with stent graft migration after 3 years. The aortic pulsatility in patients with stent graft migration is significantly higher than the pulsatility in patients without stent graft migration.

Adequate fixation and complete sealing of a stent graft in an abdominal aortic aneurysm (AAA) neck is considered one of the most crucial aspects of endovascular aneurysm repair (EVAR).[1] Inadequate proximal fixation or sealing might lead to stent graft migration, thereby compromising the results of EVAR.[1,2] Several morphologic features of the proximal aneurysm neck, including neck length, diameter and angulation, are related to stent graft sealing and fixation-related complications.[3–6]

The proximal sealing and fixation zone of a stent graft in the aneurysm neck expands significantly per heartbeat, both preoperatively and postoperatively.[7,8] Preoperatively, this aortic pulsatility could complicate the process of stent graft selection and sizing, which is most commonly based on static computed tomography angiography (CTA) images. Postoperatively, stent grafts should be able to withstand and adapt to millions of repetitive heartbeat-dependent aortic wall movements to prevent stent graft migration.

The diameter variation of the proximal aneurysm neck of individual patients ranges from less than 1 mm to up to 4 mm or more during the cardiac cycle.[8] More severe pulsatility in the aneurysm neck is likely to increase the demand on the fixation and sealing zone of the stent graft. Patients with more aneurysm neck pulsatility are therefore probably more prone to stent graft sealing and fixation-related complications after EVAR than patients with less pulsatility. Although aneurysm neck pulsatility has been studied before, to our knowledge, the relation between aneurysm neck pulsatility and EVAR outcome has never been studied.

It is, therefore, the purpose of this study to investigate whether there is a relation between the preoperative aneurysm neck pulsatility and stent graft migration. Our hypothesis is that heartbeat-dependent aneurysm neck distension is larger in patients with stent graft migration than in patients without stent graft migration.

Methods

Patients

From our prospectively collected AAA database, we selected all AAA patients with a preoperative dynamic CTA, an immediate postoperative ($\leq$7 days after EVAR) and a CTA at 3 years after EVAR. These three CTA scans were available for 26 AAA patients (21 men, median age 73 years, range, 50–82 years). The stent graft characteristics and clinical course of these patients during follow-up were investigated.

Imaging

The dynamic preoperative and static postoperative CTA scans were performed on a 64-slice or 256-slice CT scanner (Philips Medical Systems, Best, The Netherlands; values for the 265-slice scanner stated between parentheses) with a standardised acquisition protocol. Scan parameters were: slice thickness, 0.9 mm (0.9 mm); increment, 0.7 mm (0.7 mm); collimation, 64 $\times$ 0.625 mm (128 $\times$ 0.625 mm); and pitch 0.25 (0.2). Field of view was 250 $\times$ 250 mm (250 $\times$ 250 mm), and the reconstructed matrix size was 512 $\times$ 512 (512 $\times$ 512), resulting in a voxel size of 0.5 $\times$ 0.5 $\times$ 0.9 mm (0.5 $\times$ 0.5 $\times$ 0.9 mm). Radiation exposure parameters were 120 kVp (120 kVp) and 300 mAs (250 mAs), resulting in a CT dose index ($CTDI_{vol}$) of 17.6 mGy (16.5 mGy). Intravenous nonionic contrast (120 ml; Iopromide, Schering, Berlin, Germany), followed by a 60-ml saline chaser bolus, was injected at a rate of 6 ml s^{-1}. The scan was started using bolus-triggering software with a threshold of 100 HU over baseline. Retrospectively, electrocardiogram-gated reconstructions were made at eight equidistant time points covering the cardiac cycle on the (preoperative) CTAs. All scans were acquired during a single breath-hold.

All preoperative and postoperative CTA data sets were transferred to a 3 Surgery 4.0 workstation (3Mensio Medical Imaging B.V., Bilthoven, The Netherlands) for analysis. The dynamic images were analysed using a custom-made dynamic extension tool for this software.

Preoperative dynamic CTA analysis

An aortic centre lumen line (CLL) was automatically constructed by placement of a proximal start and distal end point in the aortic lumen. Aortic CLL spline points were thereafter manually checked and corrected, if necessary.

Multiplanar reconstructions of the eight images per cardiac cycle were made perpendicular to the aortic CLL at two levels: 3 cm above the most distal renal artery (level A) and 1 cm below the most distal renal artery (level B).

A semi-automatic segmentation of the aortic lumen of the eight images per cardiac cycle was performed at those levels. A seeding point was placed manually inside the aortic lumen, and a region-growing algorithm was applied thereafter to automatically segment the aorta. The segmentations were reviewed and minor corrections were made manually, if necessary.

After segmentation of the aortic lumen, areas and minimum/maximum diameters were calculated. Diameter measurements were performed through the centre of mass