Dynamic behavior of the aortic arch before and after branched TEVAR

Jaimy A. Simmering; on behalf of the ADEAR study group

Departments of Vascular and Cardio-Thoracic Surgery, (Thorax Centrum Twente), Medisch Spectrum Twente, Enschede, the Netherlands
Multimodality Medical Imaging Group, Technical Medical Centre, University of Twente, Enschede, the Netherlands.
Departments of Vascular and Cardio-Thoracic Surgery, University Medical Center Groningen, University of Groningen, Groningen, the Netherlands.
Cardio-Thoracic Surgery, St. Antonius Hospital, Nieuwegein, The Netherlands
Department of Vascular Surgery, Erasmus University Medical Center, Rotterdam, the Netherlands

Correspondence: j.a.simmering@utwente.nl

Published as: Simmering JA, Leeuwerke SJG, Meerwaldt R, Zeebregts CJ, Slump CH, Geelkerken RH. In Vivo Quantification of Cardiac-Pulsatility-Induced Motion Before and After Double-Branched Endovascular Aortic Arch Repair. Journal of Endovascular Therapy. 2022;0(0). doi:10.1177/15266028221086474

BACKGROUND

Despite the technical and short term clinical succes[1] of branched thoracic endovascular aortic repair (**bTEVAR**), ongoing thrombo-embolic events remain a serious, poorly understood challenge to long term durability with incidence of 15-40%.[1,2]. Electrocardiogram (ECG)-gated computed tomography (CT) analysis allows for detailed quantification of aortic and stent-graft deformation during the cardiac cycle and follow-up[3–5].

CASE

A 62-year-old male with a growing, asymptomatic saccular aortic arch aneurysm of 55mm and substantial comorbidity contraindicating open repair successfully underwent **bTEVAR** with the Relay®Branch stent-graft (Terumo Aortic, Sunrise, FL, USA) preceded by a left common carotid artery-left subclavian artery bypass. Completion angiography confirmed proper positioning of the bTEVAR without signs of complications. During follow-up, the patient developed three **events of embolic thrombosis** of the right axillary, brachial and radial artery. No signs of potential thrombogenicity, cardiac or bTEVAR causes were found on the eight follow-up CT scans. The patient died of **hemorrhagic stroke** 22 months after bTEVAR.

METHODS

Contrast enhanced **ECG-gated CTs** were made preoperatively, 11 days and 5.5 months postoperatively and analyzed with a registration algorithm[6].

- Cardiac-pulsatility-induced **motion** was quantified in x-(lateral), y-(ventral-dorsal) and z-(caudal-cranial) direction (Figure 1).
- Geometrical parameters included **length, tortuosity index (TI) and curvature** of aortic arch and branches were calculated over centerlines of the brachiocephalic trunk (BCT), left common carotid artery (LCCA) and the aortic arch (Figure 2).
- Aortic arch **diameters** were calculated in two directions perpendicular to the centerline, every 1 cm along the centerline (Figure 3A).

RESULTS

- **Motion** in z-direction increased after bTEVAR, especially for the distal ends of branch-stents, while the downstream first native artery-bifurcation-pathlengths changed negligible (Figure 1C).
- **Curvature** decreased from pre- to post-bTEVAR and remained constant during follow-up (Figure 2).
- The static aortic arch **diameter** remained stable (Figure 3B), but the dynamic diameter change reduced after bTEVAR (Figure 3C).

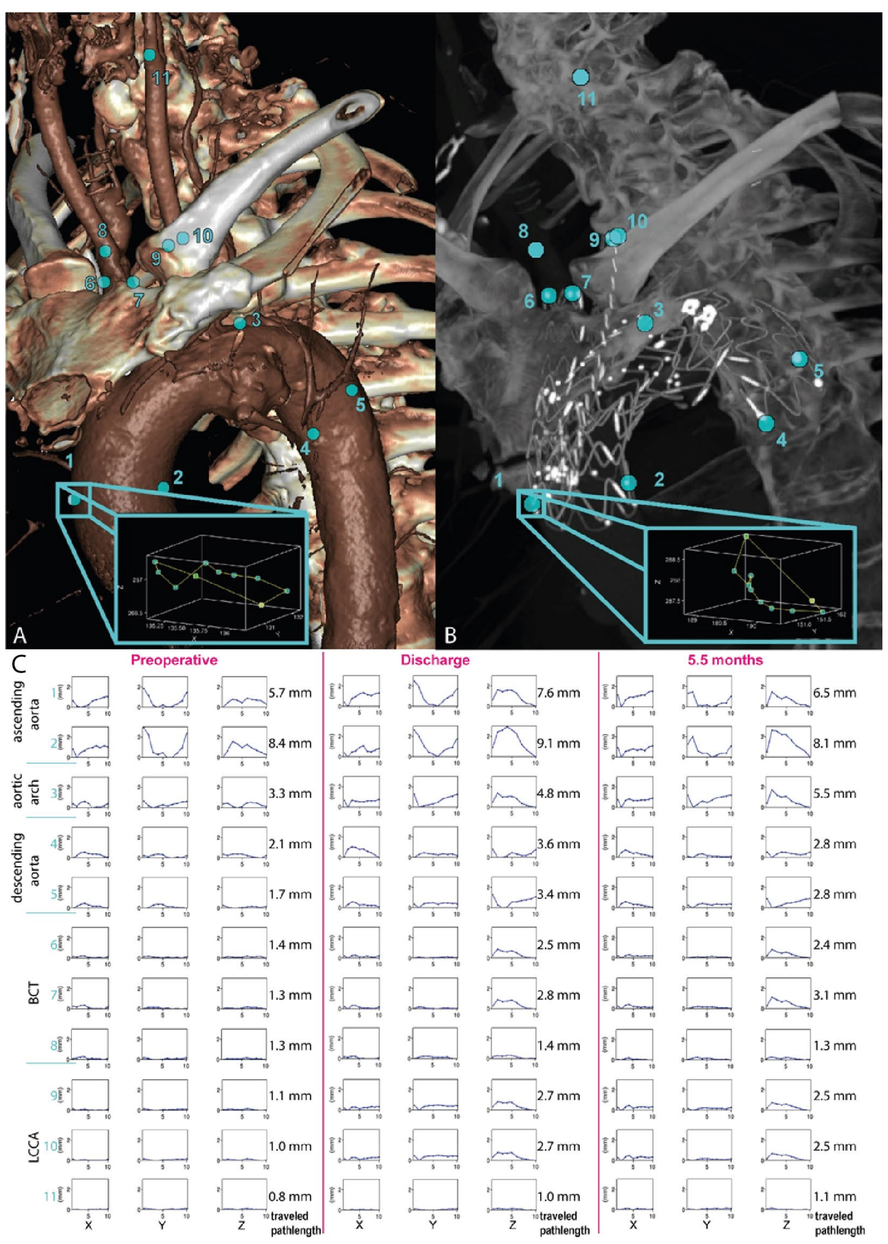

Figure 1. (A) preoperatively and (B) postoperatively selected points for motion analysis. (C) the x, y and z motion patterns at the 3 scan moments.

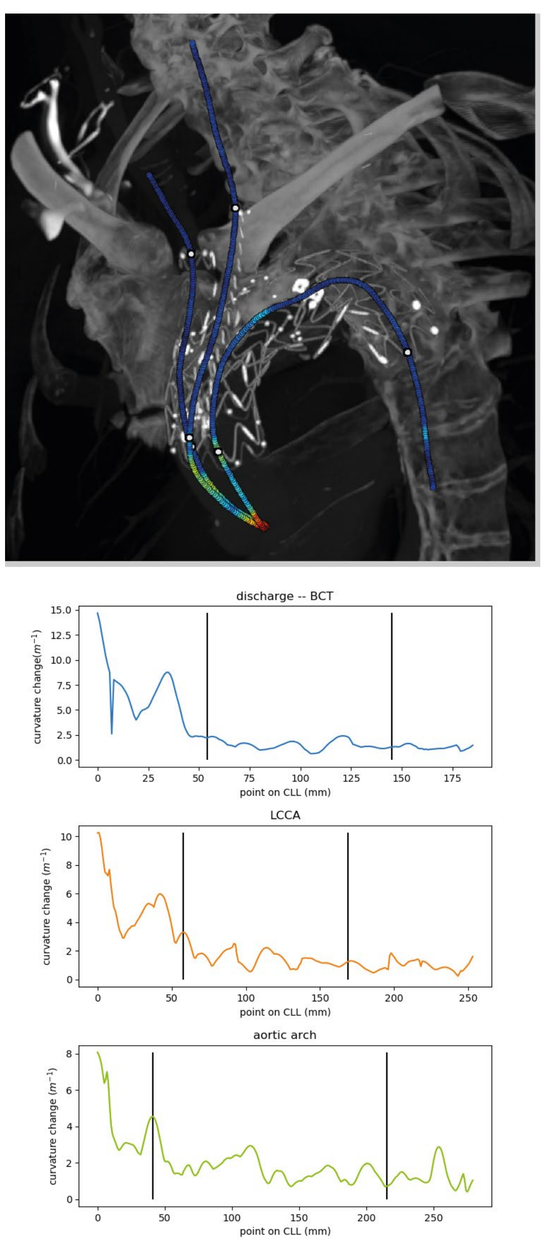

Figure 2. Curvature of the BCT, LCCA and aortic arch.

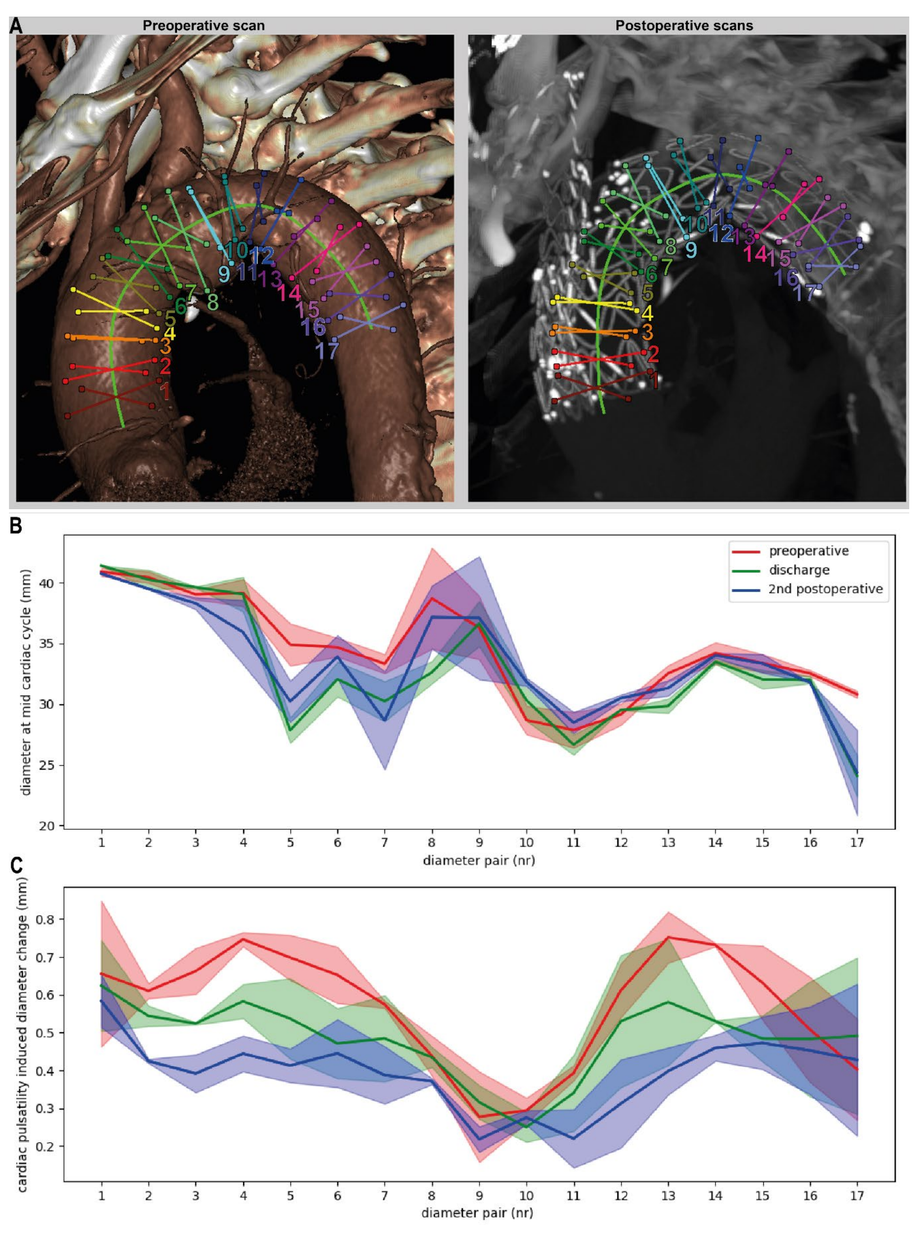

Figure 3. (A) preoperatively and postoperatively calculated aortic arch diameters. (B) static diameters and (C) dynamic diameter change during cardiac cycle of the 3 scan moments.

CONCLUSION

Dynamic CT scanning analyzed with a sophisticated algorithm has the potential to quantify aorta dynamics. If the increased motion of the post-bTEVAR branch transition zone between stent and native artery, the stiffening of the aorta and the probably related change in wall shear stress are the source of ongoing micro-embolisms is subject of further research (Trialregister.nl NL8401).

References
1. van Bakel et al. Ann Cardiothorac Surg 2018;
2. van der Weijde et al. Ann Thorac Surg 2020;
3. Koenrades et al. Eur J Vasc Endovasc Surg 2019;
4. Koenrades et al. J Vasc Surg 2020;
5. Koenrades et al. Eur J Vasc Endovasc Surg 2019;
6. Klein et al. Med Imaging 2011.

MST Medisch Spectrum Twente een santeon ziekenhuis
ChirCON
Multi-Modality M3i Medical Imaging
UNIVERSITY OF TWENTE. | TECHMED CENTRE