Functional Analysis of Thoracic Stent Grafts after Thoracic Endovascular Aortic Repair (TEVAR)

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Introduction: Thoracic Endovascular Aortic Repair (TEVAR) of various aortic pathologies has turned out as attractive therapeutic alternative to conventional surgical approaches. TEVAR may be associated with graft related complications such as endoleaks, kinking, infolding, and stentgraft migration, disconformability and especially disattachment phenomena. Therefore a better understanding of the functional impact of the implanted stent appears important to get a better understanding of the related complications.

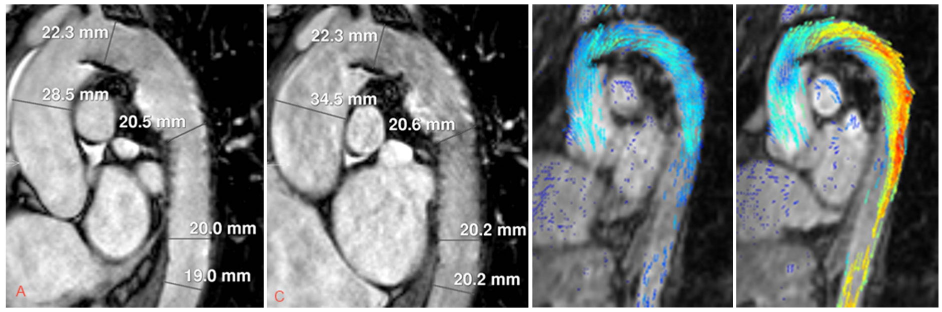

Figure 1: Diameter and velocities during end-diastole (a,c) and end-systole (b,d)

The objective of this work was to investigate MRI for the assessment of the impact of the stent graft on the flow pattern and vascular compliance.

Methods and Materials: 20 consecutive patients (6 female, 14 male; mean age 34.7 +/- 16.9) were enrolled in this study. All patients presented with an aortic rupture at the transition zone of the arch and descending segment of the thoracic aorta and were treated with endovascular stent graft (11 Gore TAG, 9 Medtronic Valiant, 20% oversized to enable normal compliance). All patients underwent an investigational MRI protocol, comprising a three-dimensional angiogram of the aorta, a cardiac phase resolved quantitative 3D flow measurement, and a cine acquisition proximal and distal to the stent and at its proximal, central and distal location.

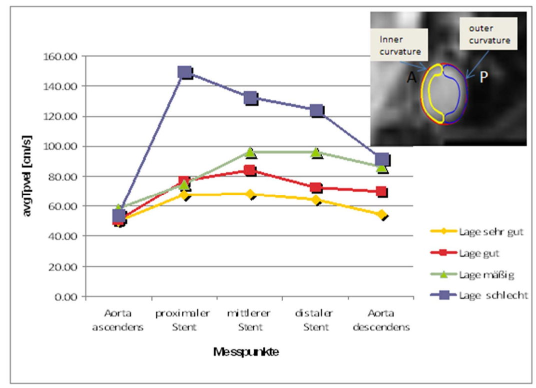

Fig 2: Average outer curvature velocity

3D Flow: TE/TR = 3.1/5.3ms, Δx = 2.5x2.5x3mm³, respiratory navigator, α = 15°, v_{enc} = 200cm/s along AP, RL and FH direction, 40 cardiac phases. **Cine:** TE/TR = 1.7/3.4ms, Δx = 1.2x1.2x6mm³, breathhold, α = 60°, 40 cardiac phases. Flow images where analyzed with GTFlow (Gyrotools Ltd), compliance measurements on an extended workstation (Philips Healthcare).

Results: Stent graft geometry, vessel compliance, and 3D+t flow data was obtained with sufficient quality (Tacq = 52 +/- 12 min) in all patients. Vessel compliance and blood flow was clearly impacted within the stent (Fig. 1). Depending on the disattachement, increasing average velocities of up to 150cm/s were observed in the outer curvature (Fig. 2). Long term follow-up revealed a correlation between developing hypertension and high systolic velocities.

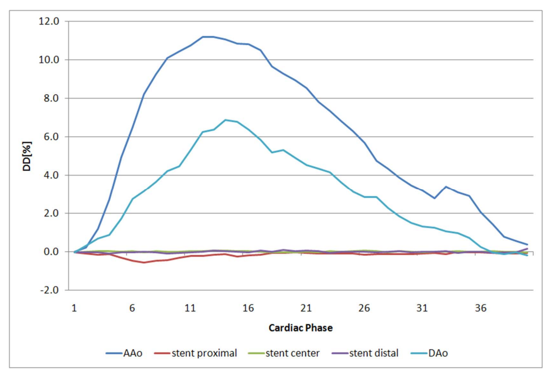

Fig. 3: In-stent vessel compliance

A small but highly significant ($p < 0.01$, paired student's t-test) reduction of the proximal stent diameter (Fig 3, red curve) was observed during systole in the proximal area of the stent. The diameter reduction scales with the velocity and ranged between 0% (excellent attachment) and 4.2% (poor attachment). In the central and distal segment of the stent, no diameter variations were observed, where the measurement proximal and distal to the stent showed normal changes.

Discussion: MRI enables the assessment of stent related flow and compliance changes. With the correlation between blood velocity and long-term outcome, MRI may have some predictive value. The reduced compliance along the stent indicates that oversizing of the stent may not be needed. The observed reduction of the stent diameter may be some first hints to better understand the kinking of the stent, observed in a minority of patients.