CT-based morphometry of endovascular graft position after TEVAR

Poster No.: C-2273
Congress: ECR 2014
Type: Scientific Exhibit
Authors: H. von Tengg-Kobligk\textsuperscript{1}, C. Brenke\textsuperscript{2}, D. Kotelis\textsuperscript{2}, F. Rengier\textsuperscript{2}, S. Wörz\textsuperscript{2}, D. Böckler\textsuperscript{2}, H. U. Kauczor\textsuperscript{2}; \textsuperscript{1}Berne/CH, \textsuperscript{2}Heidelberg/DE
Keywords: Cardiovascular system, Arteries / Aorta, CT-Angiography, Surgery
DOI: 10.1594/ecr2014/C-2273

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR’s endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Aims and objectives

Many comparative studies looking at elective open surgery vs. thoracic endovascular aortic repair (TEVAR) of different aortic pathologies could show that TEVAR is associated with a lower intraoperative risk. [1]

Moreover, TEVAR has the advantage of smaller surgical trauma followed by a faster convalescence and consequently a shorter stay in hospital. Thus, the choice of the surgical method is also a question of cost. [2]

Although the 30-day-mortality can be reduced by TEVAR [3], in the first five years after intervention quite often complications such as endoleaks, migration or collapse of endovascular graft (EVG), thrombosis or infection do occur (10-25 %). [4, 5]

Previous scientific studies mainly illustrated the success rate and complications of TEVAR vs. open surgery or investigated how complications could be managed.

Aim of our study is to assess to what extent the success of TEVAR depends on a more advanced preoperative evaluation of aortic morphology. Furthermore, we investigated if the success of TEVAR could be optimized by a more comprehensive preoperative planning regarding nature and dimensions of proximal landing zone and implanted EVG. [6]

Based on different parameters as aortic arch morphometry, localization and geometry of the proximal (PLZ) and distal landing zone (DLZ) as well as dimensions of the implanted endograft success of TEVAR was investigated with respect to observed complications such as endoleaks. Bird beak configuration (incomplete apposition of EVG to the aortic arch) was assessed as a result of increased potential risk to develop a type Ia endoleak. [7]

Methods and materials

Included were 57 patients (40 male, 17 female; mean age 66.1 years) with a vascular disease of the aortic arch treated with endovascular reconstruction of the aorta with an endoluminal graft performed at University Hospital Heidelberg during 2001-2010.

Vascular pathologies: 34 thoracic aortic aneurysms (TAA), 19 thoraco-abdominal aortic aneurysms (TAAA), 3 penetrating aortic ulcers (PAU) and one aortic arch transection loco typico.
The following EVG of the first and second generation were used during intervention:

TAG®, W.L. Gore and Associates, Flagstaff, Arizona, USA; Talent®, Medtronic Vascular, Santa Rosa, California, USA; Zenith®, Cook Inc., Bloomington, Indiana, USA; Valiant®, Medtronic Vascular, Santa Rosa, California, USA. [8]

In each case pre- and post-operative Multislice-CTA was used for segmentation with a specialized commercial software and an in-house designed 3D-intensity-model.

First part of analysis was performed with the TeraRecon Aquarius® 3D- Workstation [9] (TeraRecon Inc., San Mateo, California, USA, Software-Version 4.4.3.23.573) and included various measurements:

1) Various distance measurements along the centerline in postoperative CT-dataset (fig. 1)

2) Various diameter measurements (of aortic lumen) in preoperative CT-dataset (fig. 2)

To analyse if severe aortic conicity is present in the region of the landing zones we defined the maximal aortic lumen diameter at three positions: 1. at the postoperative position of proximal / distal EVG marker (transposed from the postoperative to the preoperative dataset); 2. 1 cm proximal as well as distal to the future position of the respective markers.

The results of these measurements were first compared within several subgroups. Then the following calculations were performed:

- Conicity of aorta at PLZ and DLZ (fig. 3, fig. 4)

- Oversizing of EVG in relation to the aortic diameter at PLZ / DLZ

Further analysis looked at possible geometric configurations in the pre- and/or postoperative aortic geometry that might lead more frequently to an endoleak type Ia or Ib, respectively.

To analyse aortic arch curvature and its correlation to complications such as endoleaks we used a three-dimensional intensity model developed by the Biomedical Computer Vision Group (BMCV) of the Theoretical Bioinformatics department (iBioS) at the German Cancer Research Center (dkfz).
This model is based on the intensity profile of an ideal 3D-cylinder which is smoothed by a 3D Gaussian filter to model the image blur that is generated during CT imaging. [10] Similarly the centerline of the vessel was investigated with regard to its bending in three-dimensional space. This was done by a stepwise technique that adapted different 3D-curves to the particular centerline position. [11]

By this model the curvature at a particular position of the aorta could be quantified by the radius of curvature of the corresponding 3D-curve.

Statistical analysis and graphic representation were performed with SigmaPlot 12.5 (Systat Software, Inc.). For statistical evaluation Fisher’s exact test and the non parametric Mann-Whitney U-Test (rank sum test) were used. The significance level was 0.05.

Images for this section:
Fig. 4
Results

Endoleak type Ia

The mean oversizing at the position of the proximal EVG marker was 4.7% in the endoleak group (n=7), slightly less than 9.7% in the control group (n=50), (rank sum test p-value=0.402), (fig. 5).

In 6 / 7 patients (85.7%) with an endoleak type Ia the LSA was overstented. This was in just 38% of the group without endoleak Ia the case (Fisher’s exact test p-value=0.036).

This led to the question whether the reason for frequent occurrence of an endoleak was primarily due to overstenting the LSA-origin or a shortened distance of the proximal EVG-marker to the LSA-origin. Distance between proximal EVG marker and LSA-origin revealed 17 mm for the overstented group with type Ia endoleak (n=6) and 25 mm in the group without endoleak (n=17), (p=0.151), (fig. 6).

Maximum aortic diameter at position of proximal marker on average 38.1 ± 11.3 mm in the group of patients with an endoleak type Ia was higher than in the control group (32.7 ± 6.7 mm), (p=0.096).

Absolute differences of the two maximum diameters that were measured 1 cm proximal and 1 cm distal the postoperative position of the proximal EVG marker revealed in patients with a type Ia endoleak an absolute difference of 5.9 mm, in patients within the control group only 2.6 mm (p=0.016), (fig. 7).

In the endoleak-group the average radius of curvature was 54.1 ± 20.8 mm vs. 59.6 ± 47.2 mm in the control group (p=0.554).

6 / 7 patients with endoleak type Ia (85.7 %) underwent re-intervention during follow-up-time, in patients without such an endoleak only 24 % (n=12), (p=0.003).

Endoleak type Ib

Oversizing: In the group with type Ib endoleak mean oversizing was only 0.2 % compared to the control group (20.1%), (p=0.014), (fig. 5). In 4 patients with type Ib endoleak one patient (25%) showed overstretching of celiac trunc during TEVAR vs. 9 patients within the control group (18%), (p=0.571).
We compared the following two groups: patients with an endoleak Ib but without overstented celiac trunc vs. the patients without endoleak and no overstented celiac trunc.

In the first group, mean distance of distal EVG marker to origin of celiac trunc was 14.2 ± 17.2 mm vs. 81.9 ± 60.5 mm in the second group. Despite the relatively large standard deviation p-value was 0.063 (fig. 8).

Mean maximum vessel diameter at postoperative position of distal marker was 35.9 ± 7.0 mm in patients with an endoleak type Ib vs. 28.9 ± 6.2 mm in the control group (p=0.038). 1 cm proximal and distal to this position proportions were similar (39.4 mm vs. 30.7 mm and 31.1 mm vs. 29.2 mm, respectively).

We defined the absolute difference of the maximum vessel diameter 1 cm proximal and 1 cm distal to the postoperative position of distal EVG marker. In patients with a type Ib endoleak mean difference was 8.3 mm vs. only 2.6 mm in the control group (p=0.006) indicating an increased risk for the development of type Ib endoleak if the aortic vessel diameter has a strong conicity in the distal landing zone (fig. 9).

There was the need for reintervention in all 4 patients with an endoleak type Ib (100%) whereas among the patients without such leakage 14 of 53 patients (26.4%) underwent reoperation (p=0.008).

**Bird beak configuration**

Among 57 patients 16 patients (28.1%) presented bird beak configuration after TEVAR.

Average oversizing of EVG-diameter in relation to maximum aortic diameter at postoperative position of the proximal EVG marker was 6.9% in patients with bird beak vs. 10.0% in the control group (p=0.729).

Among 16 patients with a bird beak configuration 3 patients (18.8%) were found with endoleak Ia, among the control group in just 9.8% (p=0.388).

Mean radius of aortic curvature at position of proximal EVG marker was 41.5 ± 19.4 mm among patients with a bird beak configuration. In the control group (n=41) aortic radius of curvature was 65.5 ± 49.6 mm. Thus, an aorta with an implanted EVG that formed a bird beak configuration was significantly stronger curved at the position of the proximal EVG marker (p=0.049), (fig. 10).
If the LSA was not overstented mean distance from proximal EVG marker to LSA was 13.3 ± 12.6 mm in patients with bird beak configuration vs. 49.6 ± 43.0 mm in the control group without bird beak. A significant p-value of 0.036 suggests that a shortened distance from LSA-origin to EVG offers an increased risk of bird beak development.

Images for this section:

Fig. 5
Fig. 6

[Box plot of distance along centerline vs. endoleak status]

- Median
- Mean

- endoleak IA
- + overstented LSA
- no endoleak IA
- + overstented LSA

[n=6] [n=17]

[Box plot of difference max. aortic diameter vs. endoleak status]

- Median
- Mean

- endoleak IA [n=7]
- no endoleak IA [n=50]
Fig. 7

![Box plot showing difference max. aortic diameter vs. endoleak status.]

Fig. 8

![Box plot showing difference max. aortic diameter vs. endoleak status.]

- median
- mean
Conclusion

Advanced aortic morphometry helps identifying risk factors for post-TEVAR related complications like type Ia and Ib endoleaks. In the presented patient study it could not be shown that bird beak configurations lead automatically to a type Ia endoleak during our follow-up time of 24 months.

This study aims to contribute to the improvement of preoperative TEVAR planning in order to help further reducing well known complications. Our results could become even more meaningful if further studies are conducted with a larger number of patients.

Personal information

The study was performed in Heidelberg. All patients were referred from the medical center of the University Hospitals (Department of Vascular and Endovascular Surgery). Study design and commercial software were developed in cooperation with the German Cancer Research Center (dkfz). Meanwhile Hendrik von Tengg, MD moved to Bern, where he can be reached via eMail: hendrik.vonTengg@insel.ch.

References


