Eur J Vasc Endovasc Surg (2017) ■, 1–6

Aortic Elongation and Stanford B Dissection: The Tübingen Aortic Pathoanatomy (TAIPAN) Project

M. Lescan [a,*], K. Veseli [a], A. Oikonomou [a], T. Walker [a], H. Lausberg [a], G. Blumenstock [b], F. Bamberg [c], C. Schlensak [a], T. Krüger [a]

[a] Department of Thoracic and Cardiovascular Surgery, University Medical Centre Tübingen, Tübingen, Germany
[b] Institute for Clinical Epidemiology and Applied Biometry, Eberhard Karls University of Tübingen, Tübingen, Germany
[c] Department of Diagnostic and Interventional Radiology, University Medical Centre Tübingen, Tübingen, Germany

WHAT THIS PAPER ADDS

Aortic elongation has not yet been considered a potential risk factor for type B dissections (TBD). Herein, a significant elongation and dilatation in the non-dissected aortic arch of patients with TBD is demonstrated for the first time. The question of risk stratification on the basis of these parameters is raised and the draft of a predictive score for TBD presented.

Objective/Background: Aortic elongation has not yet been considered as a potential risk factor for Stanford type B dissection (TBD). The role of both aortic elongation and dilatation in patients with TBD was evaluated.
Methods: The aortic morphology of a healthy control group ($n = 236$) and patients with TBD ($n = 96$) was retrospectively examined using three dimensional computed tomography imaging. Curved multiplanar reformats were used to examine aortic diameters at defined landmarks and aortic segment lengths.
Results: Diameters at all landmarks were significantly larger in the TBD group. The greatest diameter difference (56%) was measured in dissected descending aortas ($p < .001$). The segment with the most considerable difference between the study groups with regard to elongation was the non-dissected aortic arch of patients with TBD (36%; $p < .001$). Elongation in the aortic arch was accompanied by a diameter increase of 21% ($p < .001$). In receiver–operating curve analysis, the area under the curve was .85 for the diameter and .86 for the length of the aortic arch.
Conclusions: In addition to dilatation, aortic arch elongation is associated with the development of TBD. The diameter and length of the non-dissected aortic arch may be predictive for TBD and may possibly be used for risk assessment in the future. This study provides the basis for further prospective evaluation of these parameters.

Article history: Received 15 February 2017, Accepted 28 May 2017, Available online XXX
Keywords: Aneurysm, Aorta, Aortic dissection, Aortic elongation, Computed tomography

INTRODUCTION

Genetic predisposition, inflammatory aortic disease, hypertension, age $\geq$ 60 years, and male sex are well established risk factors for Stanford type B aortic dissection (TBD).[1,2] Aortic dilatation is the only established morphological risk factor, and prophylactic intervention on the ascending and descending aorta is recommended at a diameter of 55 mm.[3,4] However, most aortic dissections occur at lesser diameters.[5,6] Therefore, the currently published European Society for Vascular Surgery (ESVS) guidelines for management of descending thoracic aorta diseases state that the aortic diameter is not closely related to the occurrence of the TBD.[7] Thus, the identification of further morphological risk factors may help to better identify patients at risk for TBD.

Under physiological conditions, the aortic "Windkessel effect" functions in both the longitudinal and circumferential directions.[8,9] Aortic elongation, analogously to dilatation, probably leads to a sustained loss of elastic fibres and, consequently, to inelastic wall properties.[10] Longitudinal wall stress and failure of longitudinal wall properties result in a circumferential laceration, as observed in dissections. Recently, it was shown that the ascending aortas of patients before Stanford type A aortic dissection are significantly elongated.[5,6] Hence, it was hypothesized that the incidence of TBD is increased among patients with an elongated aortic arch and descending aorta.

The aim of this study was to compare the three dimensional (3D) morphology of TBD and healthy control aortas and, specifically, to evaluate the role of aortic elongation in TBD.

* Corresponding author. Department of Thoracic and Cardiovascular Surgery, University Medical Centre Tübingen, Tübingen, Germany.
E-mail address: mario.lescan@med.uni-tuebingen.de (M. Lescan).

http://dx.doi.org/10.1016/j.ejvs.2017.05.017

Please cite this article in press as: Lescan M, et al., Aortic Elongation and Stanford B Dissection: The Tübingen Aortic Pathoanatomy (TAIPAN) Project, European Journal of Vascular and Endovascular Surgery (2017), http://dx.doi.org/10.1016/j.ejvs.2017.05.017

MATERIALS AND METHODS

Study design

In this retrospective observational cross sectional study, all patients diagnosed with an acute TBD at University Medical Centre Tübingen between 2002 and 2016 were analysed. All patients with known connective tissue disorders, iatrogenic dissections, and those who had previously undergone surgery on the aorta were excluded. Importantly, all TBD with significant retrograde involvement of the aortic arch (other than minimal wall haematoma) were excluded. Finally, 96 patients were included in the TBD group. The control group consisted of patients who received computed tomography angiography (CTA) for a non-vascular emergency at University Medical Centre Tübingen's emergency department between 2014 and 2015. Because the youngest patient in the TBD group was 22 years old, only patients $\geq$ 22 years of age were included in the control group (age homogenisation). Demographic data, including age, sex, body height, and weight on admission, were collected. This study was approved by the local ethics committee (no. 076/2015R). Obtaining written informed consent was not necessary because of the retrospective, observational nature of the study.

CTA scans

CTA scans were carried out at University Medical Centre Tübingen's emergency department using a second generation dual source CT scanner (Somatom Definition Flash; Siemens Healthcare, Erlangen, Germany), with a high iodinated contrast bolus of 100 mL (400 mg/mL iodine). The bolus was injected at a rate of 4–5 mL/s and was chased by saline. CTA images with a maximum slice thickness of 3 mm were accepted for further processing.

Image processing

CTA datasets were processed using OSIRIX MD (Pixmeo, Bernex, Switzerland) software.[11] Three dimensional modeling of the aorta with the centreline tool was used to obtain reliable measurements, and curved multiplanar reformats from the aortic valve annulus to the aortic bifurcation were prepared.[12] The aortic perimeter was delineated using the pencil tool in the short axis view at defined landmarks, and the optimised aortic diameter was calculated to minimise errors due to elliptical shaped aortas. The true lumen, false lumen, and thrombus (if present) were included in the diameter measurement. Having identified the defined aortic landmarks, aortic segment lengths were measured in the curved multiplanar reformats along the centreline.

Aortic landmarks

Guideline consistent aortic landmarks were applied (Fig. 1).[4] Because it was challenging to reproduce the diaphragm as a landmark for measurements, it was replaced by the orifice of the coeliac trunk. The following landmarks were applied for assessment of aortic diameters: D1 (aortic valve annulus); D2 (sinus of Valsalva [halfway between D1 and D3]); D3 (sinotubular junction); D4 (mid-ascending aorta [halfway between D3 and D5]); D5 (orifice of the brachiocephalic trunk); D6 (mid-aortic arch [halfway between D5 and D7]); D7 (distal aortic arch [directly downstream of the left subclavian artery]); D8 (descending aorta [at the level of the pulmonary artery bifurcation]); D9 (thoraco-abdominal [orifice of the coeliac trunk]); D10 (mid-abdominal [halfway between D9 and D11]); D11 (distal abdominal [distally bounded by the aortic bifurcation]).

The aortic segments for length measurement were defined as follows: L1 (aortic root [D1–D3]); L2 (ascending aorta [D3–D5]); L3 (aortic arch [D5–D7]); L4 (distal aortic arch [D7–D8]); L5 (descending aorta [D8–D9]); L6 (abdominal aorta [D9–D11]).

Statistical analysis

Statistical analysis was performed using SPSS 23.0 software (IBM, Armonk, NY, USA). Because criteria for normality were not fulfilled in all cases in the Shapiro–Wilk test, continuous data are described as the medians with interquartile

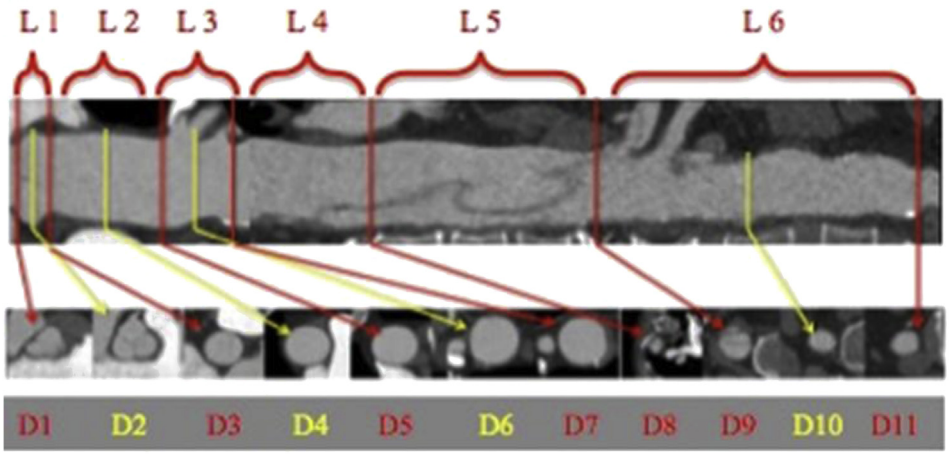

Figure 1. Curved multiplanar reformat, aortic landmarks. Centreline of the entire aorta with short-axis view at landmarks D1–D11 used for diameter assessment. *Note*. L1–L6 = aortic segments for length measurement.

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