Number of Entry Tears Is Associated With Aortic Growth in Type B Dissections

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Background. Aortic growth rate in acute type B aortic dissection (ABAD) is a significant predictor for aortic complications and death. To improve the overall outcome, radiologic predictors might stratify patients who benefit from successful medical management vs those who require intervention. This study investigated whether the number of identifiable entry tears in ABAD patients is associated with aortic growth.

Methods. ABAD patients with uncomplicated clinical conditions and therefore treated with medical therapy were evaluated. Those with a computed tomography angiography (CTA) obtained at clinical presentation and a subsequent CTA obtained at least 90 days after medical treatment were included (2005 to 2010). The CTAs were investigated for the number of entry tears between the true and false lumen. Diameters of the dissected aortas were measured at five levels on the baseline and on the last available follow-up CTA, and annual aortic growth rates were calculated. The number of entry tears in these patients and the location in the aorta were compared with the aortic growth rate.

Results. Included were 60 patients who presented with 243 dissected segments. Mean growth rates during follow-up (median, 23.2; range, 3 to 132 months) were significantly higher in patients with 1 entry tear (5.6 ± 8.9 mm) than in those with 2 (2.1 ± 1.7 mm; p = 0.001) and 3 entry tears (mean 2.2 ± 4.1; p = 0.010). The distance of the primary entry tear from the left subclavian artery did not have an effect on the aortic growth rate (median, 38; interquartile range, 24 to 137 mm; p = 0.434).

Conclusions. The number of entry tears in ABAD patients detected on the first CTA after clinical presentation is a significant predictor for aortic growth. Patients with 1 entry tear at presentation show a higher growth rate than other patients and might benefit from more strict surveillance or early prophylactic intervention.

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Patients and Methods

The independent medical ethics committees of the hospitals that participated in this study approved the study.

Patients

We retrospectively analyzed all computed tomographic angiography (CTA) data of ABAD patients who were...
medically treated in 4 referral centers between 2005 and 2010. For all ABAD patients included in this study, a CTA was obtained within 7 days of the initial diagnosis (baseline CTA) and a second CTA (follow-up CTA) was obtained at least 3 months after the baseline CTA and before any possible intervention. Patients with a complete false lumen thrombosis at presentation were excluded. If more than 1 follow-up CTA was available, the most recent examination was selected for analysis.

**Imaging**

All CTA images were acquired on multislice CT-scanners with 16-slice or 64-slice detector configuration. Non-contrast images were obtained first, followed by acquisition of 2.5-mm axial images from the top of the aortic arch to the bifurcation of the abdominal aorta after a 50 mL intravenous injection of nonionic contrast. Biphasic protocols were used, with the acquisition of an arterial and venous phase. The arterial phase was started by a bolus-tracking technique in the descending aorta. The acquisition was started 7 seconds after a region of interest had reached 100 HU. The venous phase was scanned for 60 seconds after the start of the contrast medium injection. The acquired CTA data sets were transferred to a 3Mensio Vascular 4.2 workstation (3Mensio Medical Imaging B.V., Bilthoven, The Netherlands) for analysis.

**Analysis**

All baseline CTA images were investigated by 2 investigators for the presence and number of entry tears between the true and false lumen over the entire length of the aorta. An entry tear was defined as a discontinuity of the aortic flap with a clear flow of contrast between the true and false lumen on at least 2 different views (transversal, coronal, sagittal, or center vessel reconstruction; Fig 1). Multiplanar reconstructions were made perpendicular to the center lumen line of the aorta. Semiautomatic segmentation of the aortic lumen was performed, which were reviewed, and minor corrections were made manually, if necessary. After segmentation of the aortic lumen, minimum and maximum diameters were calculated. Diameter measurements were performed from the outer to the outer vessel wall, through the center of mass of the aortic lumen. Aortic diameters were measured 2 cm below the origin of the left subclavian artery (LSCA), 10 cm below the LSCA, 20 cm below the LSCA, 8 cm below the most distal renal artery, and at the level of the largest point of the descending aorta.

The presence of dissection was identified at the 5 different levels of the aorta because the dissection did not involve the abdominal aorta in all cases. The annual growth rates at each affected level for each patient was calculated by dividing the difference between the diameter on the baseline scan and the diameter on the last available CTA scan by the time interval between the 2 CTAs.

**Statistics**

Statistical analysis of the number of entry tears in the different patient groups was performed with the use of the Kruskal-Wallis test and post hoc with the Mann-Whitney U test. Linear regression was used to analyze the influence of the distance of the proximal entry tear on aortic growth rate. Data are presented as mean ± standard deviation and range. Interobserver and intraobserver reliability was calculated using the multiobserver k statistic. Statistical analysis was performed using SPSS 20.0 software (SPSS Inc, Chicago, IL).

**Results**

The study included 60 ABAD patients (39 male) who were a median age of 59.7 years (range, 37.0 to 82.6 years) at

![Fig 1](image-url) An example of an entry tear (arrow) is shown between the true lumen (TL) and false lumen (FL) in the thoracic aorta on a plane perpendicular to the aorta.

![Fig 2](image-url) Mean aortic growth rate (mm/yr) is shown related to the number of entry tears. The error bars show the standard deviation.
presentation; of these, 20 patients (33.3%) presented with 1 entry tear, 19 (31.6%) with 2, 15 (25%) with 3, 2 (3.3%) with 4 or more entry tears, and 4 (6.7%) presented without any detectable entry tears (Table 1). The last available CTA was obtained after a median of 22 months (range 3 to 130 months). Of the 300 analyzed aortic segments, 243 (81%) were dissected (Table 1). Mean initial diameter was 36.1 ± 9.5 and mean final diameter 40.3 ± 11.2, resulting in a mean aortic growth rate of 3.3 ± 6.3 mm/y. The mean aortic growth rates for the different groups are presented in Figure 2.

Aortic growth rates based on the analysis of the dissected aortic segments were significantly affected by the number of entry tears (p = 0.003). The median aortic growth rate (5.8 mm/y) was significantly higher in patients with 1 visible entry tear than in patients with 2 entry tears (0.98 mm/y; p = 0.01) and in patients with 3 entry tears (1.31 mm/y; p = 0.010). Patients with 4 entry tears (median, 2.50 mm/y; p = 0.992) and without visible entry tears (median, 1.60 mm/y; p = 0.156), in whom the number of segments was relatively low, did not show a significant difference in growth rate compared with patients with 1 entry tear. The median distance between the left subclavian artery (LSCA) and the primary entry tear was 38 mm (interquartile range, 24 to 137) and did not have a significant effect on aortic growth rate (p = 0.434). However, patients with 1 entry tear located within 5 cm of the LSCA showed significant more growth than their counterparts (5.8 ± 7.7 vs 2.5 ± 2.7 mm/y; p = 0.003).

Intraobserver agreement was substantial, at 80% and a κ coefficient of 0.73, as was the interobserver agreement, at 75% and a κ coefficient of 0.65.

Comment

Our study demonstrated that the number of patent entry tears in patients with ABAD, on the baseline CTA scan, is associated with aortic growth. Previous clinical and bioengineering studies showed that in patients with ABAD, an impaired outflow of the false lumen might lead to a significant increase in mean arterial and diastolic pressure. A similar process might result in a decreased blood outflow from the false lumen in patients with a partially thrombosed false lumen [8]. Increased blood pressure in the false lumen is likely to result in a higher growth rate of the false lumen, potentially associated with aortic dilatation and rupture. Although the mortality rate was higher in patients with a partially thrombosed false lumen than in patients with a completely patent false lumen, the peak aortic growth rate of these subsets were comparable [5, 11]. Sueyoshi and colleagues [11] introduced the concept of the “sac formation,” defined as a partially closed false lumen at the reentry site resulting in a blind pouch with a persistent proximal entry tear. This imaging sign was associated with the largest increase in aortic diameter and these findings correlate with our study [11]. Currently, the role of partial false lumen thrombosis as predictor for aortic growth is not completely understood nor is its importance as cause of aortic-related death. In this context, the number of patent entry tears may further clarify this issue, because a limited number of entry tears between the true and false lumen might induce false lumen thrombosis. In presence of 1 entry tear, as we observed in our study, blood outflow is impaired, with persistent pressurization of a “blind sac” false lumen. This condition might lead to thrombosis but might also change the normal laminar blood flow into a turbulent flow, leading to increased wall stress [12]. In combination with reduced vessel wall strength, due to the dissection, this process could favor aortic dilatation.

Endovascular treatment for type B aortic dissection is focused on coverage of the proximal entry tear to reduce the false lumen pressurization, to promote false lumen thrombosis, and to favor aortic remodeling. However, studies have shown that distal entry tears might serve as a renewed entry tear, which is associated with persistent patency of the false lumen and may result eventually in failure of therapy [9, 13, 14]. Our study showed that the location of an entry tear did not influence aortic growth directly, and aortic growth is still prone to develop in patients with an entry tear located more downstream. However, patients with 1 entry tear located within 5 cm of the LSCA tended to have higher aortic growth rates. The false lumen in these patients is probably subjected to higher forces, leading to a higher growth rate. Theoretically, the same mechanism might result in the development of aortic dilatation in patients with 1 residual entry tear after thoracic endovascular aortic repair, justifying closer

### Table 1. Patient Baseline Characteristics

<table>
<thead>
<tr>
<th>Entry Tearsa Patients (No.)</th>
<th>Dissected Levels (No.)</th>
<th>Distance of First Entry Tear From LSCA (mean mm)</th>
<th>Growth Rate (mean mm/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None detectable</td>
<td>4</td>
<td>14</td>
<td>...</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>80</td>
<td>14.5 ± 21.8</td>
</tr>
<tr>
<td>2</td>
<td>19</td>
<td>79</td>
<td>33.3 ± 60.9</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>61</td>
<td>25.2 ± 53.7</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>9</td>
<td>8.0 ± 8.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.6 ± 5.5</td>
</tr>
</tbody>
</table>

a Mean data are presented with the standard deviation.

LSCA = left subclavian artery.
surveillance. Consequently, patients with multiple entry tears might benefit from coverage of all entry tears to initiate the remodeling process of the entire aorta [14].

We observed that the number of entry tears on the presenting CTA might help to identify those patients who are at higher risk for aortic dilatation and might benefit from early intervention. However, imaging in acute dissections may vary significantly, according to the cardiac cycle phase, because the configuration of the aortic lumina and flap change during systole and diastole. In this context, dynamic imaging might give the best representation of the disease. Nevertheless, the standard of care is static CT imaging because dynamic imaging is not routinely used in current clinical practice. Therefore, our study shows a real representation of current clinical practice.

To minimize potential bias related to the reduced detection of entry tears, intraobserver and interobserver variability were conducted, which showed a substantial agreement regarding the identification of the number of entry tears. Therefore, this radiologic sign might be used at the primary risk assessment in uncomplicated ABAD patients, especially with improving imaging modalities.

The analysis of growth rate with regard to the number of entry tears has been based on the evaluation of the dissected aortic segments, using the same methods adopted in previous studies on predictors of aortic growth in ABAD [16, 17]. Because it is uncommon that patients with ABAD present with a false lumen completely thrombosed, partially thrombosed, or with patency of the entire length of the dissection, this method allows the evaluations all the segments that are involved in the dissection, taking into consideration their differences in aortic growth rate.

This study has several limitations. Clinical information of the study population was not available due to the multicenter character of the study. In addition, a certain number of entry tears could have been missed on the baseline CTAs because entry tears could conceivably be smaller than the slice thickness of our CTA scans. However, this would affect most likely all patient groups equally. It is also possible that other imaging predictors, such as the size of the entry tears and other connections between the true and false lumen as visceral vessels and intercostals arteries, might influence the aortic growth. However, previous studies showed CTA is a reliable imaging tool in the detection of dissections and entry tears in ABAD patients [15]. The sensitivity and specificity for the detection of entry tears were 82% and 100% respectively [15]. Figure 1 gives an example of an entry tear as seen on a single CTA slice; however, the use of several subsequent slices for the detection of entry tears is preferable over the use of a single slice.

In conclusion, this study shows that the number of entry tears on a baseline CTA scan influence aortic growth in patients with conservatively treated ABAD. In those with 1 entry tear, an impaired outflow and changed flow pattern might be the cause of higher growth rates.

References