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Axillary Versus Femoral Arterial Cannulation During Repair of Type A Aortic Dissection? An Old Problem Seeking New Solutions

Sotiris C. Stamou, MD, PhD, FACS1*, Derek Gartner, BA1, Nicholas T. Kouchoukos, MD2, Kevin W. Lobdell, MD3, Kamal Khabbaz, MD4, Edward Murphy, MD5, Robert C. Hagberg, MD6

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Abstract
Background: The goal of this study was to compare early postoperative outcomes and actuarial-free survival between patients who underwent repair of acute Type A aortic dissection with axillary or femoral artery cannulation.
Methods: A total of 305 patients from five academic medical centers underwent acute Type A aortic dissection repair via axillary (n = 107) or femoral (n = 198) artery cannulation between January 2000 and December 2010. Major morbidity, operative mortality, and 5-year actuarial survival were compared between groups. Multivariate logistic regression was used to determine predictors of operative mortality, and Cox regression hazard ratios were calculated to determine predictors of long-term mortality.
Results: Operative mortality was not influenced by cannulation site (16% for axillary cannulation vs. 19% for femoral cannulation, p = 0.64). In multivariate logistic regression analysis, hemodynamic instability (p < 0.001) and prolonged cardiopulmonary bypass time (>200 min; p = 0.05) emerged as independent predictors of operative mortality. Stroke rates were comparable between the two techniques (14% for axillary and 17% for femoral cannulation, p = 0.52). Five-year actuarial survival was comparable between the groups (55.1% for axillary and 65.7% for femoral cannulation, p = 0.36). In Cox regression analysis, predictors of long-term mortality were: age (p < 0.001), stroke (p < 0.001), prolonged cardiopulmonary bypass time (p = 0.001), hemodynamic instability (p = 0.002), and renal failure (p = 0.001).
Conclusions: The outcomes of femoral versus axillary arterial cannulation in patients with acute Type A aortic dissection are comparable. The choice of arterial cannulation site should be individualized based on different patient risk profiles.

Key Words
Aortic dissection • Outcomes • Axillary cannulation • Femoral cannulation • Aorta • Dissection

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Introduction

Acute Type A aortic dissection is a cardiovascular emergency with a risk of serious postoperative morbidities and death [1-6]. Surgical repair requires a nondiseased arterial cannulation site for cardiopulmonary bypass (CPB); the most commonly used sites are the right axillary and common femoral arteries [7, 8]. Improvements in surgical technique have led to decreases in operative mortality and adverse clinical outcomes in the modern era, which have been accompanied by a shift in cannulation site from the femoral artery to the axillary artery [1, 9, 10].

There is still considerable debate regarding the optimal cannulation site for maximizing long-term survival [2, 6, 11-15]. It has been hypothesized that cannulation of the femoral artery reverses flow in the thoracoabdominal aorta, which increases the risk of brain or organ malperfusion in those undergoing Type A aortic dissection repair [13, 16]. A recent meta-analysis found central cannulation, including the axillary artery, to be superior to peripheral cannulation of the femoral artery in the short term [17].

Our study sought to evaluate whether patients repaired with axillary artery cannulation have better clinical outcomes and long-term actuarial survival following acute Type A aortic dissection compared to patients repaired with femoral artery cannulation.

Methods

Patients

The Society of Thoracic Surgeons Databases at Beth Israel Deaconess Medical Center, Carolinas Medical Center, Missou- ri Baptist Medical Center, Mejier Heart and Vascular Institute, and University of Iowa Hospitals and Clinics were queried to identify all patients who underwent aortic dissection repair between January 2000 and December 2010. A total of 305 patients underwent repair for acute Type A aortic dissections, of which 107 repair procedures used axillary artery cannulation and 198 used femoral artery cannulation. Patients excluded were those who presented with Type A aortic dissection and did not have surgery, whose dissections were repaired using alternative sites of arterial cannulation, or whose axillary and femoral arteries were both used during repair. No serious complications specific to the femoral or axillary cannulation were reported. No crossover patients who started repair using one mode of cannulation and switched to the other were reported.

A preoperative diagnosis of aortic dissection was accomplished using computed tomography angiography or transesophageal echocardiography (TEE). The diagnosis was later confirmed at the time of operation. A database was created for entry of demographics, preoperative data, procedural data, and postoperative outcomes, which were prospectively entered by dedicated data-coordinating personnel. Long-term survival data were obtained from the Social Security Death Index, prior to censorship (http://www.genealogybank. com/gbnk/ssdi/). Follow-up was 97% complete.

Prior to this analysis, study approval from the Institutional Review Boards of each center was obtained. Consistent with the Health Insurance Portability and Accountability Act of 1996, patient confidentiality was consistently maintained.

Definitions

The Society of Thoracic Surgeons national cardiac surgery database definitions were used for this study. Acute Type A dissection was defined as any dissection that involved the ascending aorta with presentation within 2 weeks of symptom onset. Previous cerebrovascular accident was defined as a history of central neurologic deficit persisting for >24 h. Chronic renal insufficiency was defined as a serum creatinine value >2.0 mg/dL. Diabetes was defined as a history of diabetes mellitus, regardless of disease duration or need for oral agents or insulin. Recent myocardial infarction was defined as myocardial infarction occurring within 7 days. Depressed ejection fraction was defined as ejection fraction <40%. Hemodynamic instability was defined as hypotension (systolic blood pressure <80 mm Hg) or the presence of cardiac tamponade, shock, acute congestive heart failure, myocardial ischemia, and/or infarction. Prolonged ventilatory support was defined as postoperative pulmonary insufficiency requiring ventilatory support >24 h. Postoperative stroke was defined as any new major (Type I) neurologic deficit presenting in-hospital and persisting >72 h. Acute renal failure was defined as one or both of the following: (1) an increase in the serum creatinine to >2.0 mg/dL and/or a >two-fold increase in the most recent preoperative creatinine level or (2) a new requirement for dialysis, postoperatively. Operative mortality includes both (1) all deaths occurring during the hospitalization in which the operation was performed (even if death occurred after 30 days from the operation), and (2) those deaths occurring after discharge but within 30 days of the procedure.

Operative Technique

Intraoperatively, the diagnosis of Type A aortic dissection was confirmed by TEE for all patients. A median sternotomy was performed. CPB was instituted by arterial cannulation of the femoral or right axillary artery and venous cannulation of the right atrium. The axillary artery was cannulated by suturing an 8- or 10-mm graft whereas the femoral artery (with a good pulse) was accessed by cutdown and direct cannulation. The decision whether to clamp the ascending aorta was based on the individual surgeon's decision. Cold blood cardioplegia administration was performed through an antegrade approach via the ostia of the coronary arteries and/or a retrograde approach through the coronary sinus, to ensure myocardial protection. The right superior pulmonary vein provided access for vent placement in the left ventricle. Restoration of the aortic root was accomplished by resection of the intimal tear followed by repair or resuspension of the aortic
valve and replacement of the ascending aorta. After reaching the temperature range of 10°C to 20°C for deep hypothermic circulatory arrest or 21°C to 28°C for moderate hypothermic circulatory arrest, the aortic clamp was removed, and the aortic arch was examined. The distal anastomosis was then completed either using a hemiarch or clamp-on technique. Antegrade aortic perfusion was established. If the aortic valve and sinuses were normal, resuspension of the aortic valve was performed by placing three polypropylene pledgeted sutures at the three valve commissures along with replacement of the ascending aorta with a straight tube graft. If the aortic valve was structurally abnormal but the sinuses were normal, we performed aortic valve replacement with mechanical or tissue prosthesis and supracoronary aortic grafting. If the aortic valve and sinuses were abnormal due to dilation (>5 cm) or extension of the intimal tear to the valve, aortic root replacement (modified Bentall operation) with a tissue or mechanical valve-conduit was used. Teflon (polytetrafluoroethylene) strips were used to reinforce the proximal and distal anastomoses. In some patients, biological glue (BioGlue® surgical adhesive, Cryolife, Kennesaw, GA, USA) was used to better re-approximate the dissected layers.

**Univariate Analysis**

Univariate comparisons of preoperative, operative, and postoperative variables were performed between patients repaired with axillary artery cannulation (n = 107) and those repaired with femoral artery cannulation (n = 198). Normal distributions of continuous variables were assessed using Kolmogrov-Smirnov tests. Continuous variables were tested using either Student’s t tests or Mann-Whitney tests, while categorical variables were assessed by chi-square or Fisher exact tests, depending on the data distribution. All tests were two-sided, and p < 0.05 was considered statistically significant.

**Multivariate Analysis**

A multivariable, stepwise, forward logistic regression analysis was conducted to determine independent predictors of operative mortality. The criterion for a variable entry into the logistic model was a univariate probability level of p < 0.1. The quality of the fit of the logistic model was tested with the Hosmer-Lemeshow goodness-of-fit test.

**Survival Analysis**

Kaplan-Meier univariate unadjusted survival estimates were calculated and compared using a log-rank test for patients repaired with axillary artery cannulation versus patients repaired with femoral artery cannulation. Cox regression hazard ratios were calculated to determine the predictors of long-term mortality. All analyses were conducted using SPSS statistical software Version 21 (IBM Corp, Armonk, NY, USA).

**Results**

**Preoperative Characteristics**

Preoperative characteristics are summarized in Table 1. The axillary cannulation group was more likely to undergo repair in the modern surgical era compared to the femoral cannulation group (p < 0.001) and had a lower number of patients with instability compared to the femoral cannulation group (p = 0.009). There was also a difference in the New York Heart Association class distribution (p < 0.001). There was no other significant difference between patients repaired with axillary or femoral artery cannulation.

**Operative Characteristics**

Operative characteristics of patients who underwent repair for acute Type A aortic dissection with axillary cannulation or femoral cannulation are presented in Table 2. Patients in the axillary cannulation group more frequently had a prolonged CPB time, defined as >200 min, compared to the femoral cannulation group (p = 0.002). The type of cerebral perfusion used also differed between the groups, with antegrade cerebral perfusion used more commonly in axillary cannulation patients (p < 0.001). The hemi-arch technique was used less frequently in patients with axillary cannulation compared to patients with femoral cannulation (p = 0.004).

**Postoperative Characteristics**

Postoperative characteristics are depicted in Table 3. Hemorrhage-related re-exploration was more frequent in the femoral cannulation group compared to the axillary cannulation group (p = 0.013).

**Multivariate Analysis**

In multivariate logistic regression analysis, hemodynamic instability (odds ratio [OR] = 23.8, 95% confidence interval [CI] = 0.067-0.316, p < 0.001) and prolonged CPB time (OR = 3.8, 95% CI = 0.261-1.002, p = 0.051) emerged as independent predictors of operative mortality. Cannulation site was not found to be an independent predictor of mortality.

**Survival Analysis**

Actuarial Kaplan-Meier survival estimates are presented in Figure 1. There was no difference in actuarial survival between those with axillary cannulation and femoral cannulation (p = 0.360). Table 4 depicts the Cox regression hazard ratios for the predictors of long-term mortality.
Discussion

Our study compares the early and late postoperative outcomes for patients with axillary and femoral artery cannulation during repair of acute Type A aortic dissection. The axillary cannulation group more often had prolonged CPB time and less frequently used the hemiarch technique compared to the femoral cannulation group. No significant difference in stroke, operative mortality, or long-term survival was noted between the groups. Our results imply the arterial cannulation site for patients undergoing surgical repair of an acute Type A aortic dissection should be chosen on a case-by-case basis.

Principal Findings

Operative Mortality. The preferred arterial cannulation site for CPB during surgical repair of acute Type A aortic dissection has changed in the past few decades, and axillary cannulation has become more frequent [9, 18, 19]. However, which site offers the best operative and postoperative outcomes remains controversial [2, 6, 11-15]. Our study found no significant difference in operative mortality (p = 0.638) or stroke (p = 0.517) between the axillary artery and femoral artery cannulation groups. Previous studies also reported no significant difference in operative mortality between axillary and femoral cannulation [2, 15]. Specifically, Di Eusanio et al. [15] compared central cannulation and femoral cannulation in 473 patients undergoing aortic arch surgery and found similar rates of in-hospital death and permanent neurological damage between the groups. However, mixed results have generally been observed for operative mortality and neurological deficit based on cannulation strategy [10, 19, 20, 21-23]. Svensson et al. [18] reviewed 1,336 operations for complex cardiac problems that used

Table 1. Preoperative patient characteristics.

<table>
<thead>
<tr>
<th>Variable*</th>
<th>Axillary Cannulation (n = 107)</th>
<th>Femoral Cannulation (n = 198)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>58 (23-87)</td>
<td>61 (19-83)</td>
<td>0.951</td>
</tr>
<tr>
<td>Modern surgical era (2006–2010)</td>
<td>81 (75.7%)</td>
<td>95 (48.0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diabetes</td>
<td>7 (6.5%)</td>
<td>17 (8.6%)</td>
<td>0.658</td>
</tr>
<tr>
<td>Hypertension</td>
<td>86 (80.4%)</td>
<td>146 (73.7%)</td>
<td>0.209</td>
</tr>
<tr>
<td>Ejection fraction</td>
<td>60 (15-75)</td>
<td>60 (25-80)</td>
<td>0.883</td>
</tr>
<tr>
<td>COPD</td>
<td>8 (7.5%)</td>
<td>17 (8.6%)</td>
<td>0.717</td>
</tr>
<tr>
<td>Creatinine</td>
<td>1.1 (0.5-3.1)</td>
<td>1.1 (4-12.5)</td>
<td>0.265</td>
</tr>
<tr>
<td>Female gender</td>
<td>34 (31.8%)</td>
<td>61 (30.8%)</td>
<td>0.897</td>
</tr>
<tr>
<td>Arrhythmias</td>
<td>7 (6.5%)</td>
<td>23 (11.6%)</td>
<td>0.226</td>
</tr>
<tr>
<td>NYHA class</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>10 (9.3%)</td>
<td>15 (7.6%)</td>
<td>0.000</td>
</tr>
<tr>
<td>II</td>
<td>48 (44.9%)</td>
<td>42 (21.2%)</td>
<td>0.671</td>
</tr>
<tr>
<td>III</td>
<td>12 (11.2%)</td>
<td>55 (27.8%)</td>
<td>0.999</td>
</tr>
<tr>
<td>IV</td>
<td>37 (34.6%)</td>
<td>86 (43.4%)</td>
<td>0.000</td>
</tr>
<tr>
<td>History of stroke</td>
<td>5 (4.7%)</td>
<td>21 (10.6%)</td>
<td>0.088</td>
</tr>
<tr>
<td>History of cerebrovascular accident</td>
<td>4 (3.7%)</td>
<td>16 (8.1%)</td>
<td>0.224</td>
</tr>
<tr>
<td>Hemodynamic instability</td>
<td>7 (6.5%)</td>
<td>34 (17.2%)</td>
<td>0.009</td>
</tr>
<tr>
<td>EF &lt; 40</td>
<td>4 (3.7%)</td>
<td>9 (4.5%)</td>
<td>1.000</td>
</tr>
</tbody>
</table>

*Continuous data are shown as medians (ranges), and categorical data are shown as percentages. COPD = chronic obstructive pulmonary disease; EF = ejection fraction; NYHA = New York Heart Association.
### Table 2. Operative patient characteristics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Axillary Cannulation</th>
<th>Femoral Cannulation</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPB time &gt; 200 min</td>
<td>60 (56.1%)</td>
<td>74 (37.4%)</td>
<td>0.002</td>
</tr>
<tr>
<td>CPB time, min</td>
<td>218 (5-430)</td>
<td>182 (31-684)</td>
<td>0.098</td>
</tr>
<tr>
<td>Circulatory arrest time, min</td>
<td>22.5 (0-71)</td>
<td>25 (0-146)</td>
<td>0.194</td>
</tr>
<tr>
<td>Cerebral perfusion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>41 (38.3%)</td>
<td>133 (67.2%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Antegrade</td>
<td>55 (51.4%)</td>
<td>23 (11.6%)</td>
<td></td>
</tr>
<tr>
<td>Retrograde</td>
<td>11 (10.3%)</td>
<td>42 (21.2%)</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>18 (10-27)</td>
<td>18 (8-32)</td>
<td>0.552</td>
</tr>
<tr>
<td>Aortic valve procedure</td>
<td></td>
<td></td>
<td>0.083</td>
</tr>
<tr>
<td>Nothing</td>
<td>37 (34.6%)</td>
<td>53 (26.8%)</td>
<td></td>
</tr>
<tr>
<td>Replacement</td>
<td>9 (8.4%)</td>
<td>14 (7.1%)</td>
<td></td>
</tr>
<tr>
<td>Resuspension</td>
<td>35 (32.7%)</td>
<td>95 (48%)</td>
<td></td>
</tr>
<tr>
<td>Bentall</td>
<td>26 (24.3%)</td>
<td>36 (18.2%)</td>
<td></td>
</tr>
<tr>
<td>Hemiarch technique</td>
<td>52 (48.6%)</td>
<td>130 (65.7%)</td>
<td>0.004</td>
</tr>
<tr>
<td>Total arch replacement</td>
<td>14 (13.1%)</td>
<td>14 (7.1%)</td>
<td>0.097</td>
</tr>
<tr>
<td>Bioglu/Felt Strip</td>
<td></td>
<td></td>
<td>0.298</td>
</tr>
<tr>
<td>Bioglu</td>
<td>52 (48.6%)</td>
<td>84 (42.4%)</td>
<td></td>
</tr>
<tr>
<td>Felt strip</td>
<td>28 (26.2%)</td>
<td>69 (34.8%)</td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td>27 (25.2%)</td>
<td>45 (22.7%)</td>
<td></td>
</tr>
</tbody>
</table>

*Continuous data are shown as medians (ranges), and categorical data are shown as percentages.

*CPB = cardiopulmonary bypass.*

### Table 3. Postoperative patient characteristics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Axillary Cannulation</th>
<th>Femoral Cannulation</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prolonged ventilation</td>
<td>51 (47.7%)</td>
<td>87 (43.9%)</td>
<td>0.549</td>
</tr>
<tr>
<td>Acute renal failure</td>
<td>22 (20.6%)</td>
<td>39 (19.7%)</td>
<td>0.881</td>
</tr>
<tr>
<td>Hemodialysis</td>
<td>8 (7.5%)</td>
<td>18 (9.1%)</td>
<td>0.675</td>
</tr>
<tr>
<td>Hemorrhage-related re-exploration</td>
<td>9 (8.4%)</td>
<td>39 (19.7%)</td>
<td>0.013</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>7 (6.5%)</td>
<td>22 (11.1%)</td>
<td>0.225</td>
</tr>
<tr>
<td>Stroke</td>
<td>15 (14%)</td>
<td>34 (17.2%)</td>
<td>0.517</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>22 (20.6%)</td>
<td>42 (21.2%)</td>
<td>1.000</td>
</tr>
<tr>
<td>Hospital length of stay (days)</td>
<td>9 (0-99)</td>
<td>11 (0-86)</td>
<td>0.291</td>
</tr>
<tr>
<td>Operative mortality</td>
<td>17 (16%)</td>
<td>37 (18.7%)</td>
<td>0.638</td>
</tr>
</tbody>
</table>

*Continuous data are shown as medians (ranges), and categorical data are shown as percentages.*
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CPB. Their results favored axillary cannulation due to a significant increased risk of hospital mortality in patients with femoral cannulation. On the other hand, Ayyash et al. [10] and Fusco et al. [20] found femoral cannulation to yield good clinical results with low adverse outcome and death rates. A possible explanation of the disparity in the conclusion of those studies may be the use of axillary cannulation in more recent years when improvements in the surgical technique and postoperative care may account for improved outcomes rather than cannulation site per se. In our study, axillary cannulation was more frequently used in the more recent years compared to the use of femoral arterial cannulation. Further, femoral cannulation patients had a higher risk profile such as higher incidence of hemodynamic instability that affects both the cannulation strategy (femoral cannulation allows for more expedient institution of CPB) and postoperative outcomes. In our study, hemodynamic instability on presentation and prolonged CPB time emerged as independent predictors of operative mortality, as previously reported [24].

Table 4. Predictors of long-term mortality.

<table>
<thead>
<tr>
<th>Variable</th>
<th>HR</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>21</td>
<td>1.024-1.062</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Stroke</td>
<td>15</td>
<td>0.244-0.630</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>CPB &gt; 200 min</td>
<td>11.8</td>
<td>0.315-0.728</td>
<td>0.001</td>
</tr>
<tr>
<td>Hemodynamic instability</td>
<td>9.3</td>
<td>0.266-0.750</td>
<td>0.002</td>
</tr>
<tr>
<td>Renal failure</td>
<td>8.4</td>
<td>0.326-0.806</td>
<td>0.004</td>
</tr>
</tbody>
</table>

CI = confidence interval; CPB = cardiopulmonary bypass; HR = hazard ratio.
Axillary cannulation patients more often had a prolonged CPB time compared to those who had femoral cannulation, possibly related to a higher frequency of complex cases in the axillary cannulation arm (e.g., aortic root replacements and total arch replacements). Fewer patients with axillary cannulation had hemiarch replacement compared to femoral artery patients, possibly because more patients in the axillary cannulation arm underwent creation of distal anastomosis with the cross-clamp on. Moreover, axillary cannulation patients had lower rates of hemodynamic instability and hemiarch replacement and a higher incidence of moderate hypothermia compared to those who had femoral cannulation, resulting in a higher rate of hemorrhage-related re-exploration.

**Actuarial Survival**

Our study is among the few studies comparing actuarial survival for axillary versus femoral artery cannulation in patients undergoing repair for acute Type A aortic dissection. While there was no significant difference in long-term survival, patients who underwent femoral cannulation tended to have lower survival within the early postoperative period. This could be explained by the impact of surgical era and hemodynamic instability on long-term outcomes. Earlier surgical era and hemodynamic instability have been shown to significantly decrease short-term survival following dissection repair, but less so over a longer period of time [9, 25]. In our study, more patients who underwent femoral artery cannulation were repaired in the earlier surgical era and had a higher incidence of hemodynamic instability. This likely contributed to the poorer survival witnessed in the femoral cannulation group over the early postoperative period. Kamiya et al. [11] examined long-term survival in patients with either central or femoral cannulation for repair of acute Type A aortic dissection. Survival for central cannulation was 80 ± 5%, 66 ± 6%, and 40 ± 8% at 1, 5, and 10 years, respectively, and for femoral cannulation it was 73% ± 4%, 64 ± 4%, and 46 ± 5% at 1, 5, and 10 years, respectively [11]. The same trend was seen in our data with axillary cannulation initially having better survival, but after 5 years, the femoral cannulation group had better survival. However, actuarial survival failed to reach significance in either study. Wong et al. [23] also investigated actuarial survival for patients with axillary artery cannulation. At 1 and 3 years, the survival rates were 73 ± 5% and 64 ± 6%, respectively, compared to 81.3% and 77.6% in our patients.

Cox regression analysis identified statistically significant predictors of long-term mortality of age at time of surgery, postoperative stroke, CPB >200 min, hemodynamic instability, and postoperative renal failure (Table 4).

**Clinical Implications**

We conducted a multi-institutional observational study to assess the impact of arterial cannulation site on early and long-term outcomes following repair of acute Type A aortic dissection. We examined an unselected cohort of patients from five academic institutions and compared patients that underwent surgery for acute Type A aortic dissection with either axillary artery or femoral artery cannulation. The differences in operative mortality and stroke rates between the cannulation sites were not statistically significant. Cannulation site selection needs to be individualized. In unstable patients who require expedient institution of CPB, femoral arterial cannulation provides quick access, while axillary cannulation with antegrade cerebral perfusion and moderate hypothermia is more beneficial in stable patients, allowing for a shorter CPB time by decreasing the cooling and rewarming periods. Obesity and at times small axillary artery size may limit its use in a selected set of patients. Involvement of the artery in the dissection, atherosclerosis, and other factors must also be considered when choosing a site [8, 12, 26]. Difficulty advancing the cannula, extreme arterial line pressure, insufficient CPB flow, vessel stenosis, small vessel diameter, and arterial wall damage may require a switch from axillary to femoral cannulation [26]. Iliofemoral disease and the risk of atheroembolism due to retrograde aortic perfusion contraindicate the use of the femoral artery for cannulation [8].

**Study Limitations**

Inherent limitations of a retrospective multi-institution investigation inevitably affected our study. The small sample size did not allow propensity score matching of the two groups to risk adjust for preoperative characteristic imbalances. Bias may have also
been introduced into the analysis since different surgeons from five different institutions performed the procedures. Further study of reoperations on the remaining dissected aorta, the causes of late mortality, and false lumen fate were outside the scope of our analysis. In future studies, these variables should be included to evaluate the long-term outcomes of acute Type A aortic dissection repair.

Conclusions

The arterial cannulation site (i.e., the axillary or femoral artery) was not significantly related to stroke or mortality rates. The arterial cannulation site for CPB during acute Type A aortic dissection repair should be individualized based on the patient’s presentation, anatomic consideration, risk profiles, and surgeon preference.

Conflict of Interest

The authors have no conflict of interest relevant to this publication.

References


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Abstract
Reliable methods for measuring the thoracic aorta are critical for determining treatment strategies in aneurysmal disease. Z-scores are a pragmatic alternative to raw diameter sizes commonly used in adult medicine. They are particularly valuable in the pediatric population, who undergo rapid changes in physical development. The advantage of the Z-score is its inclusion of body surface area (BSA) in determining whether an aorta is within normal size limits. Therefore, Z-scores allow us to determine whether true pathology exists, which can be challenging in growing children. In addition, Z-scores allow for thoughtful interpretation of aortic size in different genders, ethnicities, and geographical regions. Despite the advantages of using Z-scores, there are limitations. These include intra- and inter-observer bias, measurement error, and variations between alternative Z-score nomograms and BSA equations. Furthermore, it is unclear how Z-scores change in the normal population over time, which is essential when interpreting serial values. Guidelines for measuring aortic parameters have been developed by the American Society of Echocardiography Pediatric and Congenital Heart Disease Council, which may reduce measurement bias when calculating Z-scores for the aortic root. In addition, web-based Z-score calculators have been developed to aid in efficient Z-score calculations. Despite these advances, clinicians must be mindful of the limitations of Z-scores, especially when used to demonstrate beneficial treatment effect. This review looks to unravel the mystery of the Z-score, with a focus on the thoracic aorta. Here, we will discuss how Z-scores are calculated and the limitations of their use.

Key Words
Z-score • Pediatrics • Thoracic aorta

Introduction
Z-scores are a means of expressing the deviation of a given anatomic or physical measurement from a size- or age-specific population mean. Z-scores can be applied to echocardiographic measurements, height, weight, and blood pressure, and thus may assist in clinical assessment and decision-making [1].

In diseases that affect the aortic diameter, serial diameter measurements of the aortic root are useful for monitoring disease progression. Z-scores of the aorta diameter are also useful aids in diagnosis and determination of therapeutic effects. The use of Z-scores facilitates the detection of pathological increases in aortic root diameter above that expected due to normal growth, which appears as an increased Z-score over time [2]. We discuss Z-scores in detail in the attached audio-visual presentation.

Centiles (also called percentiles) are a common alternative to Z-scores. They are easy to interpret and have been used to monitor development in pediatrics, including aortic root dilatation. However, centiles...
are less sensitive to changes in the aortic root diameter, particularly at the extremes [2]. For example, if a hypothetical patient (with a body surface area (BSA) of 1.87 m²) has an aortic root that increases from 3.56 to 3.69 cm (1.3 mm difference), the percentile increases from the 99th to 99.7th%. This difference sounds small, but it corresponds to a Z-score increase of +2.33 to +2.75, which is a more visually obvious difference. Z-scores therefore can quantify growth status outside of the percentile ranges [3]. Z-scores also allow: (i) a standardized measure allowing comparison across different ages, genders, and measures and (ii) a continuous variable allowing generation of summary statistics such as mean and SD.

In adult practice, Z-scores are less commonly used. Instead, aortic root diameter is often reported with respect to a single “normal range.” However, this approach is inaccurate in growing children because the normal range of measurements will be impacted by patient size and age. Therefore, the interpretation of these measurements during childhood presents a unique challenge, specifically in determining whether a given measurement is within the expected range. One approach to the description of clinical and echocardiographic variables is to express measurements in terms of Z-scores. In current practice, there is a lack of understanding of how Z-scores are calculated and interpreted. Here, we review the literature on Z-scores, focusing on application in thoracic aortic aneurysms.

**What is a Z-Score?**

The Z-score describes how many standard deviations a given measurement lies above or below a size- or age-specific population mean (Figure 1) [2]. Z-scores are calculated as follows:

\[
Z = \frac{(\chi - \mu)}{\sigma}
\]

where \(\chi\) = the observed measurement, \(\mu\) = the expected measurement (population mean), and \(\sigma\) = the population standard deviation (adapted from [2]).

A Z-score above the population mean will have a positive value, whereas a Z-score below the population mean will have a negative value. The greater the deviation of the Z-score from zero (in a positive or negative direction), the greater the magnitude of deviation from the mean [2]. A value that is 2 standard deviations above the mean (the 97.7th percentile) will have a Z-score of +2.0. Z-scores make clinical interpretation simple because of the mean of 0 and normal range of -2.0 to +2.0. A change in Z-score value over time is interpreted as a change in the size of the cardiovascular structure beyond what would be expected from the normal growth of that person [4].

For a Z-score to be calculated, the mean and standard deviation for that body structure (e.g., aortic root diameter) must be determined in the population. The mean and standard deviation have been calculated in many individual studies of varying sample sizes. These are empiric observations that are not “written in stone,” but rather vary somewhat among different studies. The individual studies can be used to generate nomograms [5]. This is achieved by selecting a cohort of individuals and calculating their BSA based on one of the available BSA equations. A parameter of interest (e.g., aortic root diameter) is then recorded for each individual, allowing generation of a scatterplot (Figure 2A) and calculation and plotting of a regression equation and confidence intervals. This scatterplot can then be transformed into a nomogram (Figure 2B), allowing one to determine the Z-score for an individual patient given their BSA and parameter of interest (e.g., aortic root diameter) [5].

---

Figure 1. A schematic diagram depicting the relationship between Z-scores and percentiles, where the parameter is normally distributed. At extreme values, (>3 standard deviations from the mean), the centile remains fairly constant, but the Z-score remains sensitive to changes in measurements. Included with permission from Chubb et al. [2].
Limitations

Z-scores have significant advantages to alternative methods of measuring aortic diameter, especially in the pediatric population. However, sources of limitations include measurement error, validity of nomograms, inconsistent use of BSA equations (at different ages in a child’s development), and our uncertainty of the natural history of Z-scores. These limitations may significantly influence Z-score values and may falsely indicate changes in the size of a structure where true variability does not exist.

There are several formulas available for calculating BSA, which have marked discrepancies in the values they produce and therefore are limited in their accuracy. Furthermore, the validity of the studies used to develop these formulas may be questionable. Often, the studies utilize small sample sizes and do not indicate which patient demographic they represent (see Table 1 for a comparison of the most widely used BSA formulas). In addition, many BSA equations tend to over- or underestimate BSA in certain populations.
### Table 1. List of established formulas for measuring body surface area (BSA).

<table>
<thead>
<tr>
<th>Formula</th>
<th>Equation</th>
<th>Sample Size</th>
<th>Age (Years)</th>
<th>Gender (F:M)</th>
<th>Main Limitation(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banerjee (1955) [16]</td>
<td>$\text{BSA}_\text{cm}^2 = \text{weight}^{0.425} \times \text{height}^{0.725} \times 74.66$</td>
<td>15</td>
<td>18-44</td>
<td>0%</td>
<td>Small sample size. Only relevant to Indian population. Inaccurate in SE Asian population [23].</td>
</tr>
<tr>
<td>Boyd (1935)</td>
<td>$\text{BSA}_\text{cm}^2 = \text{weight}^{0.017827} \times \text{height}^{0.4838}$</td>
<td>197</td>
<td>Unclear*</td>
<td>Unclear*</td>
<td>BSA overestimated if: infant, short, obese. BSA underestimated if: tall, thin [14, 24, 25]. Study demographics unclear.</td>
</tr>
<tr>
<td>Du Bois (1916)</td>
<td>$\text{BSA}_\text{cm}^2 = \text{weight}^{0.725} \times \text{height}^{0.425} \times 71.84$</td>
<td>9</td>
<td>Not stated</td>
<td>Not stated</td>
<td>BSA underestimated if: infant/child, obese [8, 14, 26, 27]. Significant patient heterogeneity. Study demographics unclear. Nutritional status of study sample is unrepresentative.</td>
</tr>
<tr>
<td>Gehan (1970)</td>
<td>$\text{BSA}_\text{cm}^2 = 0.0235 \times \text{height}^{2.35} \times \text{weight}^{0.0235}$</td>
<td>401</td>
<td>Infants-Adults</td>
<td>Not stated</td>
<td>BSA overestimated if: short, obese. BSA underestimated if: tall, thin, increasing body size [14, 24, 26]. Study demographics unclear. Inaccurate in SE Asian population [23].</td>
</tr>
<tr>
<td>Haycock (1978) [7]</td>
<td>$\text{BSA}_\text{cm}^2 = 0.335 + 0.02 \times \text{weight}^{0.02}$</td>
<td>81</td>
<td>ELBW-infants-adults</td>
<td>Not accessible</td>
<td>BSA overestimated if: infant, short, obese. BSA underestimated if: tall, thin, increasing body size [24, 27, 28]. Inaccurate in SE Asian population [23].</td>
</tr>
<tr>
<td>Jones (1994) [29]</td>
<td>$\text{BSA}_\text{cm}^2 = 6.4954 \times (1,000 \times \text{weight}^{0.62} \times \text{height}^{0.08})$</td>
<td>79</td>
<td>11-42 weeks gestation</td>
<td>Not stated</td>
<td>Small sample size. Only pathological human fetuses studied.</td>
</tr>
<tr>
<td>Meban (1983) [30]</td>
<td>$\text{BSA}_\text{cm}^2 = 94.9 \times (\text{weight}^{0.441} \times 0.441) \times (\text{height}^{0.655} \times 0.655)$</td>
<td>42</td>
<td>Not stated</td>
<td>Not stated</td>
<td>Small sample size. Patient demographics unavailable.</td>
</tr>
<tr>
<td>Mosteller (1987) [31]</td>
<td>$\text{BSA} = \sqrt{\left(\text{height}^{0.62} \times \text{weight}^{0.38}\right)} / 3,600$</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>BSA overestimated if: short, obese [26]. BSA underestimated if: infant, tall, thin, low body size [14, 24, 32]. Less accurate simplification of the Gehan equation.</td>
</tr>
<tr>
<td>Shuter (2000) [33]</td>
<td>$\text{BSA}_\text{cm}^2 = \frac{0.015925 \times \text{weight}^{0.5}}{\text{height}^{0.2} \times \text{weight}^{0.5}}$</td>
<td>3951</td>
<td>20-91</td>
<td>54%</td>
<td>No subjects under 20 years of age. Formula only validated in Chinese individuals. Whole body scanning method does not take into account overlapping and shading body parts [23].</td>
</tr>
</tbody>
</table>

*Chapter of book unavailable to determine age range and gender.

**BSA** = body surface area; ELBW = extremely low birth weight; SE = South East.

Therefore, clinicians must be mindful of which BSA formula is used when interpreting Z-scores. Furthermore, it is important to be consistent in the choice of Z-score calculator, while also being aware that the accuracy of the specific BSA equation utilized in each Z-score calculation will be affected by changes in body mass and age. The user must keep in mind these limitations in the evidence base of Z-scores.

Z-scores are usually calculated using BSA; however, a weight-only equation also exists for the calculation of BSA ($\text{BSA} = 0.1023 \times \text{weight}^{0.62}$) [9]. This may be a more convenient tool, but it lacks the valuable adjustment for height in patients, which is a sensitive factor to consider when assessing the aortic diameter.
The introduction of web-based Z-score calculators, such as http://www.parameterz.com, has revolutionized the ease with which we can calculate Z-scores in the clinical environment. However, these Z-score calculating programs stratify their data using geographically-specific nomograms. Such geographical studies are not available worldwide, and therefore care must be taken to ensure the most accurate geographical region is used for analysis. One must also remember that these nomograms do not take ethnic diversity into account. Despite recent efforts to improve the accuracy of nomograms, there are still numerical and interpretative uncertainties [4, 10-13]. Such nomograms may produce widely different Z-score values. This is because many nomograms utilize a small sample size, with an underrepresentation of information across age groups (particularly neonates and premature infants) [14]. There is a lack of complete information on certain cardiovascular structures and racial and gender differences in the literature [14-16]. In addition, the use of formalin-fixed pathological specimens to determine base data for nomograms is limited by their availability and may significantly underestimate the dimensions of cardiac structures in vivo, thus producing inappropriate clinical tools [17, 18].

To maintain statistical confidence in Z-scores with extreme values, nomograms must adequately represent the heteroscedasticity (change in variance) across body sizes of individuals [2]. Inappropriate averaging of variance may lead to under- or overestimation of Z-score values for children at the extremes of body size [2]. In addition, obesity may skew Z-score data and therefore produce measurement bias when interpreting Z-scores. This is a particular problem in patients with cardiovascular disease. Consequently, an obese patient’s Z-score may be an underestimation of the true value. Dallaire et al. [1] explored this problem and suggested that the use of multivariable models with weight and height as independent predictors of Z-scores should be explored to reduce this potential pitfall. Van Kimmenade et al. [19] concluded that, because we are facing an obesity epidemic, the use of Z-scores that correlate with height rather than BSA/weight may be more accurate in evaluating aortic root measurements in those with Marfan Syndrome.

Measurement error can be a significant limiting factor when determining the validity of Z-scores; therefore, technicians must take consistent measurements of the aortic diameter to minimize observer bias. There are clear guidelines from the American Society of Echocardiography Pediatric and Congenital Heart Disease Council regarding accurate measurement of the proximal aorta (Table 2) [8]. While pediatric measurements are made in systole, adult measurements are made in diastole, which can give significantly different measurements. Care must be taken when interpreting Z-scores recorded before the implementation of the 2010 guidelines. Before the advent of these guidelines, discrepancies in inclusion of vessel wall thickness, axis of measurements, and stage of the cardiac cycle provided important sources of marked variability. Furthermore, dilatations of the aorta are not homogeneous, and therefore a single measurement may not represent the true scale of the pathology [20]. These factors may contribute to intra- and inter-observer bias and affect the reliability of earlier studies [14]. Even small changes in aortic diameter can represent significant disease progression in Z-score calculations. Together, these factors may lead to inappropriate treatment strategies such as lifelong medical therapy, which can expose patients to unnecessary side effects and financial burden, or high risk surgical interventions.

Furthermore, data on the non-pathological natural history of Z-scores is limited. Should the aortic Z-score remain identical in a normal or aneurysmal child from infancy to young adulthood? We simply do not know. Currently, randomized controlled trials (RCTs) investigating aneurysmal pathology rely on Z-score changes as a measure of therapeutic efficacy [21, 22]. The natural history of Z-scores in normal and pathological states remains largely unknown.

| Table 2. Guidelines from the American Society of Echocardiography Pediatric and Congenital Heart Disease Council regarding accurate measurement of the aortic root [8]. |
| Guidelines for the Measurement of the Proximal Aorta |
| 1. Measurements are made in systole, at maximum expansion. |
| 2. Measurements are the intraluminal dimension (also known as inner-ed). |
| 3. Vascular measurements are made perpendicular to the long axis of the vessel. |
therefore limiting the meaningful interpretation of Z-scores.

Z-scores are commonly used in pediatric settings to evaluate the diameter of the ascending aorta and aortic root. However, raw values of aortic root sizes are usually calculated in adults. The rationale for this is that height stabilizes in adulthood and is unlikely to change over time. However, this is inaccurate, especially in elderly patients who lose height from their young adult maximum. In addition, there is a huge variability in size among the population, which suggests that gender and height may be significant confounding factors when interpreting aortic root values in these patients.

Knowing these limitations, careful interpretation of Z-scores in relation to patients and recognition of information gaps in the literature are essential to improve the clinical interpretation of Z-scores.

**Conclusion**

In light of the evidence base, Z-scores are a convenient tool for diagnosing and monitoring cardiovascular disease. In addition, they are widely used in RCTs to determine treatment efficacy in aortic aneurysmal disease.

However, there are some notable limitations to the use of Z-scores. All varieties of BSA calculation directly and substantially impact aortic Z-score determination. Some of these limitations can be overcome by calculating Z-scores using consistent and generalizable nomograms. This may require consistent use of specific Z-score nomograms to accurately reflect the structure measured (e.g., aorta) and the gender, race, height, and weight of the patient. Additionally, measurement bias is a contributing factor to inaccuracies when determining aortic root size. To reduce the impact of intra- and inter-observer bias, consistent reporting of aortic root measurements, ideally by experienced technicians, is required, with abnormal measurements reviewed and confirmed by the interpreting cardiologist/cardiothoracic surgeon. As we face an obesity epidemic, it is also important to consider the accuracy of BSA-based Z-score calculations, and whether height-based calculations should be implemented for obese individuals.

We recommend that further investigation be performed into the natural history of Z-scores in non-pathological states, to assure that current interpretations of therapeutic strategies in RCTs are accurate. Specifically, we feel that clear-cut evidence is needed to show that a decreasing Z-score as a pediatric patient ages truly represents a positive therapeutic (pharmacological) effect, and not simply a normal Z-score progression with increasing body size. We have investigations underway on this specific quandary.

**Conflict of Interest**

We have read and understood the AORTA policy on declaration of interests and declare that we have no competing interests.

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Rapidly Expanding Infectious Aortic Aneurysm Caused by Perforated Colon Cancer

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Abstract
A 50-year-old male smoker presented with a perforated colon cancer and underwent an extended right colectomy. Feculent peritonitis was treated with empiric antibiotics. Postoperatively he developed severe back pain and rising leukocytosis. Serial computed tomography revealed a rapidly expanding infrarenal aortic aneurysm. He was urgently treated with extra-anatomic bypasses and aortic resection. No organisms grew from the resected aortic wall. He was discharged in stable condition, and the ileostomy was reversed 9 months later.

Case Presentation
A 50-year-old male smoker presented with acute onset abdominal pain and peritoneal signs. Exploration revealed a perforated transverse colon mass that was treated with an extended right colectomy with mobilization of the splenic flexure and end ileostomy. Pathology of the mass showed medullary colon carcinoma with stage T4b N1a (1 out of 30 positive regional lymph nodes). Postoperatively the patient was started on empiric vancomycin and piperacillin/tazobactam to prevent feculent peritonitis. His postoperative course was complicated by delayed return of bowel function and persistent leukocytosis. Computed tomography (CT) on postoperative day 6 demonstrated evidence of partial bowel obstruction. The patient also complained of progressive back pain that was not controlled with opiates. A second opinion on the CT scan was sought from a cardiovascular radiologist, who noted mild retroperitoneal stranding around the aorta (Figure 1). The patient made a good further recovery but continued to complain of back pain. Repeat CT scan on postoperative day 15 showed new aneurysmal dilation of the infrarenal aorta with a dramatic increase in diameter from 3.3 cm to 5.5 cm since the first CT scan 9 days earlier. Moreover, a sacular contour irregularity at the left posterior aspect of the aneurysm and worsened peri-aortic stranding were noted (Figure 2). These findings were suggestive of an infectious aortic aneurysm with concern for impending rupture, and the patient underwent emergent surgery.

Introduction
The etymology of aneurysm derives from the Greek word for dilation (ἀνεύρυσμα). Aortic aneurysms are full-thickness dilations of the aorta that exceed its normal diameter by 50% [1]. The role of infectious micro-organisms in the development of aortic aneurysms was classically described by Sir William Osler in 1885 [2]. With the advent of antibiotics, infectious aortic aneurysms have become very rare [3, 4]. Here we describe an infectious aortic aneurysm caused by perforated colon cancer.
In the first part of the operation, axillary-to-femoral and femoral-to-femoral polytetrafluoroethylene bypass grafts were constructed in a sterile field. The contaminated abdominal field was addressed in the second half of the surgery. The old laparotomy was re-entered, and dense adhesions were removed. Exposure of the infrarenal aorta revealed a prominent aortic aneurysm with surrounding necrotic and inflamed tissue but no frank purulence. Proximal and distal control were obtained by clamping the infrarenal aorta and common iliac arteries, respectively. The involved aortic segment and both proximal iliac arteries were resected. Bleeding lumbar arteries were oversewn with figure-of-eight polypropylene sutures. The aortic stump was closed with a polypropylene continuous horizontal mattress suture to obtain intimal apposition and a top layer polypropylene whip-stitch to ensure hemostasis. The common iliac stumps were closed in the same fashion. The contaminated field was then debrided and irrigated by pulsed lavage with 3 L normal saline solution containing cefazolin, vancomycin, and gentamycin. The retroperitoneum was closed over the arterial stumps, but no omental pedicle flaps were available for additional coverage. Pathology of the resected aorta showed a polymorphonuclear infiltrate, but no organisms were seen, and culture results were also negative. The patient’s postoperative course was...
unremarkable, and he was discharged on intravenous vancomycin and meropenem to a rehabilitation facility. His ileostomy was removed 9 months later, and he was well at the 1-year postoperative follow-up.

**Discussion**

Infectious aortic aneurysms feature amongst the most challenging problems in vascular surgery because they are rare, difficult to diagnose, difficult to manage, and rapidly fatal. Infectious aortic aneurysms constitute less than 1% of aortic aneurysms [3, 4]. The diagnosis is based on history as well as clinical, laboratory, and radiographic manifestations of the infection and the aortic mass effect. In our patient, empirical antibiotics started at the time of colon cancer perforation masked the stigmata of infection and explain the negative culture results. Expeditious surgical management is critical because over half of infectious aortic aneurysms are already ruptured at the time of surgery [5,6]. In our patient, a saccular protuberance on CT was concerning for an impending rupture, so he was urgently taken for surgery. In such cases, extra-anatomic bypass grafting in a sterile field followed by aortic resection and retroperitoneal debridement achieve the surgical objectives by preventing aortic rupture, controlling sepsis, and reconstructing the vasculature.

This case highlights that a high index of suspicion with active investigation to determine the diagnosis and expeditious surgery are critical for successful management of infectious aortic aneurysms.

**Conflict of Interest**

The authors have no conflict of interest relevant to this publication.

**References**


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Chimney Technique with Nellix EndoVascular Aneurysm Sealing System in a Patient with Single Kidney and Juxtarenal Abdominal Aortic Aneurysm

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Abstract
We present a saccular asymptomatic juxtarenal abdominal aortic aneurysm in a 70-year-old male with a very short left renal artery supplying the only kidney. The case was successfully treated with the Nellix EndoVascular Aneurysm Sealing system combined with a chimney technique.

Key Words
Abdominal aortic aneurysm • Endovascular aortic aneurysm repair • Chimney technique • Single kidney • EVAS

Introduction
Endovascular aneurysm repair (EVAR) has become the method of choice for abdominal aortic aneurysm (AAA) repair, especially in patients deemed intermediate or high risk for open aneurysm repair [1].

The Nellix EndoVascular Aneurysm Sealing (EVAS) System (Endologix, Inc., Irvine, CA, USA) is a relatively new endoluminal device designed to treat infrarenal AAA by obliterating the aneurysm sac, thus eliminating the potential endoleak space while maintaining normal flow to the lower extremities. The endograft blood-flow lumens are supported with balloon-expandable endoframes surrounded by polymer-filled endobags, and do not require proximal and distal fixation [2, 3]. The goal of the EVAS method is to treat AAAs while preserving side branches.

Case Presentation
A 70-year-old male presented with several years of abdominal and back pain associated with a pulsatile abdominal mass. Computed tomography-angiography (CTA) was performed, showing a 4.7 × 2.7-cm pararenal saccular AAA and a very short 0.8-cm left renal artery. Both common iliac arteries were non-aneurysmal (Figure 1). The patient’s comorbid-
ities included right kidney tumor and subsequent right adrenalectomy and nephrectomy three years previously, which may have caused the formation of the pseudoaneurysm in the aorta at the renal artery level. He also had hypertension and was previously a smoker. The patient had also experienced abdominal trauma 15 years previously caused by a falling tree. The other patient history was unremarkable.

The decision to offer an endovascular solution for this patient was based on the risk/benefit assessment of open surgery, which would involve suprarenal clamping and re-implantation of the single left renal artery. A chimney technique was selected to be combined with EVAS, because this method would preserve the single renal artery. The procedure was performed under spinal anesthesia in a hybrid operating theatre.

Percutaneous access was gained via the common femoral artery to introduce the Nellix system. We used two 160-mm Nellix stent endoframes. Devices were introduced into the abdominal aorta above the left renal artery to fully exclude the aneurysm. Renal artery access was gained via a left brachial artery cut-down using a 7 F catheter (Figure 2). A $7 \times 80$-mm percutaneous transluminal angioplasty (PTA) balloon was placed into the left renal artery to preserve a flow channel in this very short vessel during polymer injection into the endobags (Figure 3). Both endoframes were deployed and the endobags were filled with a polymer under pressure guidance. The EVAS procedure was carried out according to standard procedures [2, 3]. After polymer curing and exclusion of the aneurysm, the PTA balloon was removed and the flow channel between the endobags and the aortic

**Figure 1.** Pre-treatment computed tomography-angiography demonstrating a saccular 4.7 × 2.7-cm abdominal aortic aneurysm (arrows), the left solitary kidney, and a short (0.8-cm) left renal artery.

**Figure 2.** Chimney technique used to treat the abdominal aortic aneurysm involving the single left renal artery. Nellix devices were introduced into the aorta, and the left renal artery was cannulated.

**Figure 3.** A percutaneous transluminal angioplasty balloon was expanded in the left renal artery at the time of deployment of the Nellix stents and polymer injection into the endobags.
the femoral arteries were closed using two Proglide vascular closure devices (Abbott Vascular, Santa Clara, CA, USA) and the brachial artery was closed by direct suture.

The patient had recovered fully and was discharged three days after the procedure with dual antiplatelet therapy for one year. No renal complications or deterioration of renal function were observed at the time of discharge or during follow-up at one or six months. One-month follow-up CTA showed fully patent renal arteries without branch artery thrombosis or renal infarctions. Six-month follow-up CTA scans showed full exclusion of the AAA with no change in diameter, and patent left renal artery (Figure 6). Renal function continues to be normal.

Discussion

Successful results have been reported for the chimney technique with EVAR stent grafts [4]. Nevertheless, Type-I endoleaks are frequently seen after treating patients with self-expanding stent grafts. The Nellix EVAS system can be used successfully for the treatment of challenging AAAs involving side

Figure 4. Stent implantation in the renal artery after endovascular aneurysm sealing to support a renal flow channel.

Figure 5. Post-procedural angiogram showing exclusion of the abdominal aortic aneurysm with a patent renal stent.

Figure 6. Six-month follow-up computed tomography-angiography demonstrating full abdominal aortic aneurysm exclusion and a patent renal artery.
branches [5]. This is a promising technology for performing chimney grafts with lower risk for Type-1 endoleaks due to the polymer filling of the space around the stents.

Special difficulties were present in the case described here: the very short side branch posed a potential risk of intra-procedural stent migration from the side branch to the aorta. We present in this report a successful strategy for the creation of a flow channel at the time of EVAS and implantation of a supporting stent graft after the procedure.

This case shows that the Nellix EVAS system combined with a chimney technique can successfully treat AAA and preserve the renal artery, opening new horizons for EVAS in the treatment of juxtarenal aneurysms.

Conflict of Interest
Dainis Krievins and Janis Savlovskis are paid consultants for the Endologix Nellix scientific medical advisory board.

References
Abstract
Acute coronary thrombosis after emergent surgery for acute Type A aortic dissection is a rare event that can remain undiagnosed in absence of typical electrocardiogram readings. We report a case of left anterior descending artery thrombosis without ST-segment elevation three days after surgical repair, which was successfully treated with angioplasty and stenting.

Case Presentation
A 67-year-old female with arterial hypertension presented to the emergency department with severe chest pain radiating to her back. The electrocardiogram was unremarkable and the troponin-C was normal. Trans-thoracic echocardiograms revealed a dissection flap in the ascending aorta with normal left ventricular contractile function. A computed tomography (CT) scan confirmed the diagnosis of AAD with an intimal flap that extended from the ascending aorta to the iliac bifurcation. The dissection involved the innominate artery while the left carotid and left subclavian artery arose from the true lumen. No gross calcifications of the coronary vessels were detected. The patient underwent emergency surgery for AAD. After median sternotomy, femoro-atriocaval cardiopulmonary bypass was instituted and the patient was gradually cooled to 26°C. After aortic cross-clamping, the dissected aorta was opened into the true lumen. Crystalloid cardioplegia was infused selectively into the coronary ostia. The ascending aorta was then replaced with a Gelweave (Vascutek Terumo, Tokyo, Japan) Dacron 30-mm straight prosthesis after fixing of the true and false lumens with resorcin-formaldehyde biological glue sandwiched between external and intra-luminal Teflon strips.

The first two postoperative days were unremarkable, with normal cardiac biomarkers. On the third day, the patient developed new onset chest pain and electrocardiogram changes consistent with acute coronary thrombosis. An emergent angiogram revealed a thrombus in the left anterior descending artery, which was treated with angioplasty and stenting. The patient recovered uneventfully and was discharged from the hospital on postoperative day seven.
postoperative day, sudden hemodynamic instability appeared, with a growing requirement for inotropic drugs to maintain normal systemic pressure. No specific ECG changes were noted (Figure 1), but global left ventricle hypokinesia was noted on echocardiography without any segmental deficits. A sudden and severe rise in cardiac biomarker levels was also evident, forcing us to perform diagnostic coronary angiography. The catheterization was performed using a right brachial approach. The coronary angiogram revealed a thrombotic occlusion of the left anterior descending artery (LAD) (Figure 2). A 0.014” wire was advanced down the LAD and a 3.0x15mm Xience Pro (Abbott, Illinois, USA) was deployed, squeezing the thrombus peripherally (Figure 3). Double antiplatelet therapy with clopidogrel and acetylsalicylic acid was then administered. The remainder of the postoperative course was characterized by difficult weaning from the mechanical ventilation and a temporary tracheostomy. The patient was discharged on the 28th postoperative day in good clinical and hemodynamic condition.

**Discussion**

Several different underlying mechanisms have been reported for coronary malperfusion following AAD. The first is the so-called “intimo-intimal intussusception”: a circumferential intimal flap resulting from a tear near the sino-tubular junction that prolapses into the left ventricle during diastole, causing severe aortic regurgitation and occluding the coronary ostia [1]. Other mechanisms are the proximal extension of the false lumen toward the aortic root with involvement of the coronary ostia [2], which may also extend for several centimeters along the vessel [3], and acute
thrombosis of an atherosclerotic plaque immediately after replacement of the ascending aorta [4]. Embolization of glue fragments into the coronary artery has also been reported as a possible mechanism of coronary thrombosis after surgery for AAD [5]. Finally, late obstruction of the coronary ostia eight months after repair of aortic dissection has also been described, which was attributed to scarring caused by excessive application of formaldehyde glue [6].

In all cases previously reported, the clinical scenario was characterized by the presence of an ST-segment elevation. In our case, the ECG did not show ST-segment elevation, only non-specific repolarization changes. Moreover, the echocardiograph images showed global hypokinesia but no segmental contractile deficit was noted. The only evidence of acute coronary thrombosis was an inexplicable augmentation of the troponin and creatine kinase-MB levels on the third postoperative day. We carefully evaluated the risks and benefits of high-risk arterial catheterization in this patient who had just undergone surgery for AAD and did not have a fully thrombosed false lumen. Nevertheless, we were forced to perform a diagnostic angiography because of the otherwise inexplicable severe trend of the cardiac biomarkers and unstable hemodynamic status.

Another important aspect to consider is the high risk of bleeding related to the mandatory dual antiplatelet therapy after stent deployment in a patient who recently underwent an operation for AAD. A simple balloon angioplasty would have avoided the need for dual antiplatelet therapy.

In our case, the underlying mechanism was not clear, and could have been acute thrombosis of an atherosclerotic plaque or embolization of a fragment of glue into the coronary artery. The absence of gross calcifications of the coronary vessels at the CT scan indicate that the hypothesis of an acute thrombosis of an atherosclerotic plaque is unlikely, but our image of the thrombotic occlusion of the LAD is very different from the one reported by Hoschtitzky et al. [5] in which an embolization of a glue fragment was the underlying mechanism. We speculate that the occlusion of the LAD was caused by an acute thrombosis of an atherosclerotic plaque free of calcific component. A simple balloon angioplasty might not be effective, so we preferred to use a stent for the percutaneous coronary intervention, although this necessitated dual antiplatelet therapy and the consequent high hemorrhagic risk.

The presence of two concomitant conflicting diseases, such as AAD and acute coronary thrombosis, creates a very difficult scenario. The correct diagnosis presented a challenge for our heart team, especially because of the absence of ST-segment elevation, which was surprising considering the angiographic status. Selection of the best therapeutic option in the catheterization laboratory (stent or simple balloon angioplasty) was also difficult, as was the decision to
administer antiplatelet therapy.

In conclusion, acute coronary thrombosis after repair of AAD is a very rare but very serious event. Regardless of the underlying mechanisms of the coronary thrombosis, a coronary angiography must be performed when an acute coronary syndrome is suspected after surgery for AAD.

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Conflict of Interest

The authors have no conflicts of interest to declare.
Abstract

We describe a 74-year-old male patient with an intimal sarcoma of the descending aorta mimicking aortitis. The patient presented with lower back pain, fever, and increased C-reactive protein, erythrocyte sedimentation rate, and immunoglobulin G4 (IgG4) serum levels, together with Staphylococcus epidermidis-positive blood cultures. These findings, together with evidence of a 49-mm pseudoaneurysm of the descending thoracic aorta, caused us to suspect aortitis. However, postoperative histology and immunohistochemistry demonstrated the presence of an intimal aortic sarcoma. At the 8-month follow-up, local recurrence of the neoplasm and lung metastases were noted.

Key Words
Aorta • Aortitis • Aortic tumor

Introduction

Intimal sarcomas are extremely uncommon tumors involving the major vessels, mostly the pulmonary artery and the aorta, with a dismal prognosis [1]. The clinical presentation is usually nonspecific and mostly related to tumor embolism resulting in limb or visceral ischemia [1, 2]. Preoperative diagnosis is difficult and most neoplasms are recognized only upon histological analysis of the surgical specimen. Here, we describe an unusual case of intimal sarcoma of the descending thoracic aorta mimicking aortitis.

Case Report

Intimal Sarcoma of the Descending Aorta Mimicking Aortitis

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A 74-year-old male was admitted to our department complaining of abdominal and lower back pain and fever for a duration of three months. The patient had also previously been diagnosed with hypertension, hypercholesterolemia, stage 3 chronic kidney disease, and monoclonal gammopathy of unknown significance. Laboratory tests revealed increased erythrocyte sedimentation rate and serum levels of C-reactive protein and IgG4 with mild anemia. Blood cultures were positive for Staphylococcus epidermidis. Computed tomography (CT) with contrast-enhanced angiography showed a disruption of the anterior wall of the aorta with a maximum diameter of 49 mm surrounded by contrast enhancing solid tissue at the thoraco-abdominal transition and close to the origin of the celiac trunk, which was interpreted as a pseudoaneurysm (Figure 1A and 1B). To better define the aortic lesion, 18F-fluorodeoxyglucose (FDG) positron emission tomography (PET) was performed, revealing isolated localization of the radionuclide at the level of the pseudoaneurysm (Figure 1C and 1D).

A differential diagnosis between infective aortitis and aortitis associated with IgG4-related sclerosing disease was considered. Accordingly, steroid and antibiotic therapy was started with no clinical improvement or improvement of laboratory test findings after 10 days.

The patient underwent surgical resection of the pseudoaneurysm through a left thoracotomy in the
7th intercostal space combined with a laparotomy and a retroperitoneal approach. The operation was performed with left heart bypass by cannulating the left femoral artery and the left inferior pulmonary vein under moderate hypothermia (32°C). The pseudoaneurysm was isolated and transected and the aorta was reconstructed with the interposition of a 24-mm cryopreserved homograft. The postoperative course was uncomplicated and the patient was discharged home on the 8th postoperative day.

Both histology and microbiological examinations were performed on the resected aortic tissue. By routine histology and immunohistochemistry, an intimal aortic sarcoma was diagnosed (Figure 2). The aortic wall was extensively infiltrated by a poorly-differentiated spindle cell tumor with nuclear pleomorphism, abundant mitoses, and microfoci of necrosis originating from the intimal surface and infiltrating the aortic wall including the resected margins. Immunohistochemistry, performed using an automated immunostainer and specific antibodies (Ventana Medical Systems, Inc., Tucson, AZ, USA), showed diffuse staining for vimentin and focal Mouse double minute 2 homolog (MDM2) positivity. Markers for epithelial cells, smooth and skeletal muscle cells, leukocytes, and melanocytes were otherwise negative.

The patient was treated with a specific protocol of chemotherapy with close clinical follow-up. However, the tumor relapsed soon after surgery with develop-
ment of local recurrence and lung metastases at 8-month follow-up.

Discussion

The present case is, to our knowledge, the first reported aortic intimal sarcoma mimicking aortitis and presenting as a descending aortic pseudoaneurysm. Intimal aortic sarcomas are extremely rare high-grade malignant neoplasms of large blood vessels, sub-classified into intimal tumors characterized mainly by intraluminal growth, mural tumors of medial or adventitial origin, and mixed tumors [3]. Such neoplasms are poorly differentiated and usually have a nonspecific presentation. The differential diagnosis requires histological analysis demonstrating a malignant mesenchymal tumor, and immunohistochemistry revealing immunoreactivity only for vimentin and MDM2. Vimentin is a sensitive marker for many neoplasms, while MDM2 is found in over 70% of intimal sarcomas and is a negative prognostic marker. Indeed, most cases have been diagnosed either at necropsy or at examination of aortic surgical specimens [1, 2]. An intimal sarcoma must be differentiated from a more common angiosarcoma, which shows definite and diffuse endothelial differentiation, and from a ley-

Figure 2. Histologic sections showing the sarcoma originating from the aortic intima, characterized by highly atypical cells with nuclear pleomorphism (asterisk) and mitoses (arrows), and diffuse immunoreactivity for vimentin and focal positivity for mouse double minute 2 homolog (MDM2). Panel A. Haematoxylin and eosin stain, original magnification 2x. Panel B. Haematoxylin and eosin stain, original magnification 20x; Panel C. Immunoperoxidase staining and haematoxylin counterstaining using a specific antibody against Vimentin, original magnification 10x; Panel D. Immunoperoxidase staining and haematoxylin counterstaining using a specific antibody against MDM2, original magnification 20x.
omiosarcoma, which is characterized by smooth muscle marker immunoreactivity [4-6]. The pathogenesis of intimal sarcoma is still unknown, but genetic factors, including changes in the MDM2-p53 pathway, seem to play important roles [7].

Intimal aortic sarcomas are usually localized in the abdominal aorta between the celiac artery and the iliac bifurcation, and in 30% of cases the descending aorta is involved as seen in the present case [1, 2, 4, 6]. The most common clinical presentation is related to tumor embolization with peripheral or mesenteric ischemia and necrotic skin lesions, or to metastasis, which occurs mainly to bones, liver, and lungs. Less common symptoms are secondary to intraluminal occlusion of the aorta, mass effect, or pseudoaneurysm formation with or without secondary aortic rupture [6].

Imaging studies of the aorta, such as a CT scan, can seldom distinguish aortic intimal tumors from advanced atherosclerotic disease. Even 18F-FDG PET may not specifically differentiate a tumor from an infectious aortic lesion as observed in the present case. This has been emphasized by Naughton et al. [6] who reported a patient with an aortic neoplasm presenting as an abdominal aortic rupture with clinical and radiologic findings suggestive of aortitis. In tumors of the pulmonary artery, the presence of intraluminal filling defect enhancement on MRI with gadolinium has been shown to be the most sensitive diagnostic tool to differentiate such tumors from non-neoplastic lesions [8]; it can be speculated that this finding could also be applied to aortic lesions.

Primary malignant tumors of the aorta have a poor prognosis, with a mean survival time of 14 months [6]. The most effective treatment is surgical resection with graft interposition, but radical surgery is often not feasible because of either tumor volume or local extension with adjacent tissue infiltration. In the present case, operation consisted of excision of the pseudoaneurysm and reconstruction of the aorta by interposition of a homograft because of the suspicion of an infective nature of the lesion. Postoperative histological and immunohistochemical analyses ruled out the presence of aortitis, revealing instead a rare malignant neoplasm.

In conclusion, intimal sarcomas of the aorta are rare and aggressive neoplasms which occasionally may mimic aortitis. The preoperative diagnosis appears of utmost importance because an unsuspected malignancy, as in the case herein reported, may lead to incomplete wide margin resection, thus influencing the long-term prognosis. Indeed, our patient has shown tumor recurrence at 8-month follow-up.

Conflict of Interest

The authors have no conflict of interest relevant to this publication.

References


Comment on this Article or Ask a Question

Pucci, A. et al. Aortic Sarcoma
Abstract
This report describes the long-term follow-up of the repair of a giant ascending aneurysm using a composite graft with a mechanical valve.

Key Words
Aneurysm • Aortic • Ascending • Composite root

A 55-year-old male presented with severe cardiac and renal failure ten years ago. Electrocardiogram (ECG) showed aortic root dilatation, severe aortic regurgitation, and left ventricular dysfunction. Chest computed tomography revealed an ascending aortic aneurysm larger than the heart, measuring 13.5 cm in the transverse diameter and 12 cm anteroposteriorly (Figure 1). Aortic root replacement using a size 33 composite graft and coronary reimplantation were performed. Ejection fraction, renal function, and general health gradually improved. This patient was followed-up for 10 years with no complications and has led a normal life. Recent chest computed tomography showed normal aortic root and coronary arteries (Figure 2). Right coronary implantation is shown in a colored three-dimensional image (Figure 3). This case demonstrates excellent longevity and freedom from reoperation in patients who undergo composite root replacement.

Figure 1. Preoperative computed tomography image showing a 13-cm ascending aortic aneurysm involving the sinuses of Valsalva.
Conflict of Interest

The authors have no conflict of interest relevant to this publication.

Cite this article as: Al-Ebrahim KE, Jabbad HH, Alqari AH. Long-Term Survival After Composite Mechanical Aortic Root Replacement. AORTA (Stamford). 2016;4(4):146-147. DOI: http://dx.doi.org/10.12945/j.aorta.2016.15.039

Figure 2. Postoperative computed tomography images obtained 10 years after surgery. Panel A. Sagittal section showing the neo-ascending aorta. Panel B. Coronal section showing the neo-right coronary artery. Panel C. Coronal section showing the neo-left coronary artery.

Figure 3. Postoperative computed tomography image obtained 10 years after surgery showing the ascending aorta and right coronary artery.
The following pages summarize and review this issue’s articles for an audience without a background in medicine or research.

Sotiris C. Stamou et al.: “Axillary Versus Femoral Arterial Cannulation During Repair of Type A Dissection? An Old Problem Seeking New Solutions.”

Patients who undergo surgery for acute type A aortic dissection, a potentially life threatening disruption of the wall layers of the body's main artery, need to be put on cardiopulmonary bypass while the surgeon operates on the heart. During cardiopulmonary bypass, the patient’s circulation is supported by a heart-lung machine, allowing to stop the heart for the procedure. To lead the blood from the heart-lung machine into the body, a large cannula (or tube) has to be inserted into one of the major vessels of the body. In acute type A dissection, the most commonly used vessels are the femoral artery in the groin and the axillary artery close to the axilla. There is an ongoing debate which of these vessels should be preferred, and a variety of previous studies have shown opposing results. Sotiris C. Stamou et al. conducted a study on 305 patients that were operated on for acute type A dissection. They concluded that the choice of vessels does not influence survival of the patient neither in the first days after surgery nor at long-term. The more relevant factors that influenced survival in their study were instability of the patient before surgery, length of the procedure, age and postoperative complications such as stroke. The authors therefore conclude that the vessel for cardiopulmonary bypass should be chosen on an individual basis, depending on surgeon preference, vessel calcifications and other risk factors. As every study, the study has certain limitations. Therefore, further research is necessary to reach a valid answer to the question.

Alexander E. Curtis et al.: “The Mystery of the Z-Score”

“The mystery of the Z-Score” by Curtis et al. is a state of the art review on a measuring method called Z-score, which can be calculated and applied to a variety of measurements. It shows how much a certain measurement deviates from the average of a normal reference population. Z-scores are an alternative to standard diameter measurement e.g. when evaluating the size of the aorta, the body’s main artery. Since the body surface area can be included in the calculation, it is especially useful when evaluating the aorta of children. Children grow quickly, and growth of their aorta needs to be put in relation to their body size. However, the Z-score has limitations as well, including measurement errors, different body surface area formulas and uncertainties regarding the correct normal reference values and their changes with age. Ethnical and geographical differences need to be taken into account as well. Therefore, Z-scores need to be applied with caution to these limitations. Future studies are needed to investigate the abovementioned limitations, especially focusing on the natural history of the Z-score in normal and pathological states to improve its reliability in clinical decision making.
Case Reports

Taufek Konrad Rajab et al.: “Rapidly Expanding Infectious Aortic Aneurysm Caused by Perforated Colon Cancer”

Taufek Konrad Rajab et al. describe a case of a patient with colon cancer, whose cancer had caused rupture of the bowel wall, causing infectious stool to spill into the abdomen and cause infection. The cancerous lesion and the ruptured bowel were surgically removed and the infection was treated with broad spectrum antibiotics. Within two weeks of surgery, the patient developed a dilatation of the abdominal aorta, the part of the body’s main artery that runs through the abdomen. The dilatation (or aneurysm) showed signs of infection and had to be rapidly removed to prevent rupture. Since the surgery discontinued the aorta, blood flow to the legs was restored with a bypass from the axillary artery which usually only provides blood flow to the arm. The patient recovered without further complications. The described case shows how rapidly an infectious aneurysm can evolve, warranting expeditious surgery.


Kaspar Kisis et al. describe a case of a patient with an aneurysm (dilation) of his abdominal aorta, the part of the body’s main artery that runs through the abdomen. The aneurysm was very close to a vessel branch that supplied the patient’s only kidney. Since it was extremely important not to put the patient’s only kidney at risk, a special technique was employed to treat the aneurysm. The device used is called Nellix EndoVascular Aneurysm Sealing System and consists of two tubed prostheses that are inserted into the aorta via a vessel in the groin. The aneurysm sac around these prostheses is obliterated by a special polymer that is filled into a bag surrounding the prostheses. The branch supplying the kidney was stabilized by a “chimney technique”, which consist of another tubed prosthesis inserted alongside the other prostheses into the branch to keep blood flow into the branch open. The patient recovered without. This technique is of interest because a chimney prosthesis often causes blood to leak along the prostheses into the aneurysm sac. The system employed in this case obliterates the aneurysm sac and therefore reduces the risk of leakage.

Davide Carino et al.: “Early Coronary Thrombosis without ST-Segment Elevation Following Repair of Acute Aortic Dissection.”

Davide Carino et al. describe a case of a patient who underwent surgery for acute type A dissection, a potentially life threatening disruption of the wall layers of the body’s main artery. Three days after surgery, her clinical state deteriorated and she was found to have an obstruction of one of the coronary vessels that supply the heart muscle with blood and oxygen. A coronary angiography was performed, a technique in which a contrast medium is injected into the coronary vessels in order to find a potential obstruction. An occlusion was found and treated with a coronary stent, a little tube prosthesis that keeps open the occluded vessel. The complication significantly prolonged the patient’s hospital stay, but she was discharged home in good condition after one month. This case report underlines that an occlusion of a coronary vessel after surgery for acute type A aortic dissection is a serious complication that needs early recognition and expeditious treatment.

Angela Pucci et al.: “Intimal Sarcoma of the Descending Aorta Mimicking Aortitis”

Angela Pucci et al. describe a case of a patient who was thought to have aortitis, a local infection of the aorta, the body’s main artery. His clinical presentation, laboratory test and imaging suggested an infection of the aorta which was surgically removed. However, surgery revealed that he was suffering of a very rare tumor called intimal sarcoma, which originates from cells of the inner layer of the aortic wall. After surgery, the patient was treated with chemotherapy. Initially, he did well, but a few months later the tumor relapsed and was found to have spread to his lungs. Intimal sarcomas are rare and difficult to diagnose. Even though several imaging techniques and special laboratory tests exist, the diagnosis is often made only after surgical resection. Several treatment options including surgery and chemotherapy exists, but usually, survival of patients with intimal sarcoma is limited.

Khaled E. Al-Ebrahim et al.: “Long-Term Survival After Composite Me-
In the category “Images in Cardiac Surgery”, Al-Ebrahim et al. report a case of a patient with a giant ascending aortic aneurysm. An ascending aortic aneurysm is a dilatation of the body’s main artery directly at its origin at the heart. In this patient, it led to a leakage of the aortic valve, the gate between the heart and the aorta, and had already weakened the heart muscle. The aorta was replaced with a “mechanical composite graft”, which consists of a tube prosthesis attached to a mechanical valve prosthesis. The patient recovered without complications and did very well during the following ten years. The authors show computed tomography images (a method to produce 3D X-Ray images of the body) of the patient’s aorta before surgery and after 10 years. This example shows that a mechanical composite graft can be a long-lasting surgical solution in cases of ascending aortic aneurysms.
List of Upcoming Meetings

November 2016

1. EACTS Academy: Aortic Valve Surgery
   November 24-25, 2016
   Nancy, France
   Meeting information available at:
   www.eacts.org/academy/courses/aortic-valve-surgery

December 2016

1. International Conference for Innovations in Cardiovascular Systems
   December 4-6, 2016
   Tel Aviv, Israel
   Meeting information available at:
   2016.icimeeting.com

2. 13th European Cardiology Congress
   December 5-6, 2016
   Madrid, Spain
   Meeting information available at:
   cardiology.conferenceseries.com/europe

January 2017

1. 35th Annual International Symposium: Clinical Update in Anesthesiology, Surgery and Perioperative Medicine
   January 15-20, 2017
   Cancun, Mexico
   Meeting information available at:
   www.clinicalupdateinanesthesiology.org

2. Controversies and Updates in Vascular Surgery
   January 19-21, 2017
   Paris, France
   Meeting information available at:
   cacvs.org

3. 53rd Annual Meeting of the Society of Thoracic Surgeons and STS/AATS
   Tech-Con 2017
   January 21-25, 2017
   Houston, Texas
   Meeting information available at:
   www.sts.org/education-meetings/sts-annual-meeting

4. STS/CTSNet Career Fair at the 53rd Annual Meeting
   January 22-24, 2017
   Houston, Texas
   Meeting information available at:
   www.ctsnet.org/events/2017-sts-and-ctsnet-career-fair