Comparison of Ascending Aorta Versus Femoral Artery Cannulation for Acute Aortic Dissection Type A

Hiroyuki Kamiya, MD; Klaus Kallenbach, MD, PhD; Dominique Halmer; Merve Özsöz; Kathrin Ilg, MD; Artur Lichtenberg, MD, PhD; Matthias Karck, MD, PhD

Background—The site of cannulation for repair of ascending aortic dissection remains controversial. We present our experience with ascending aortic cannulation for acute aortic dissection type A.

Methods and Results—From January 1988 to September 2007, we operated on 242 patients for acute aortic dissection type A. Medical records of 235 patients who received ascending aortic cannulation or femoral cannulation were retrospectively reviewed. Long-term follow-up was complete in 97% of patients. Cannulation was accomplished in 82 patients through the ascending aorta and in 153 patients through the femoral artery. Preoperative patient characteristics were almost comparable between groups. Similarly, there were no differences in preoperative patient characteristics and intraoperative parameters including operation time, bypass time, cross-clamp time, hypothermic circulatory arrest time, and percentage of total arch replacement. The 30-day mortality rate was 14% in the aortic group and 23% in the femoral group ($P=0.07$), and incidence of stroke was 4.9% in the aortic group and 4.5% in the femoral group ($P=0.86$). During follow-up (mean, 5.5 years), survival at 5 years and 10 years was 65% and 41% in the aortic group and 64% and 46% in the femoral group, respectively ($P=0.97$).

Conclusions—The cannulation site should be chosen according to the patient’s pathology and status, and the present study suggests that ascending cannulation in patients with acute aortic dissection type A can be a safe alternative, offering acceptable early and long-term outcomes. (Circulation. 2009;120[suppl 1]:S282–S286.)

Key Words: acute aortic dissection ■ aorta ■ extracorporeal circulation ■ CPB ■ cannulation site ■ surgery

The femoral artery has been the standard cannulation site for cardiopulmonary bypass in treating acute aortic dissection type A (AADA). Using the femoral artery as aortic return, however, possible complications, for example, cerebral embolization and organ malperfusion, could be caused by a retrograde blood flow.1–3 As an alternative cannulation site, the axillary artery has been preferred by many surgeons, but this technique is time-consuming and not always safe or reliable because of possible insufficient caliber for cardiopulmonary bypass and cannulation injury of the axillary artery.4,5 Additionally, retrograde carotid dissection resulting in cerebral malperfusion may occur.6 Recently, direct cannulation on the dissected ascending aorta has been reported by several surgeons.7–9 This technique can be performed rapidly without injury to the peripheral arteries, but there are concerns that it may risk rupture, extension of the dissection, and malperfusion.

Thus, there are advantages and disadvantages in each cannulation technique, and the real benefit of alternative cannulation techniques (axillary and ascending aortic cannulation) even on early outcome in surgical treatment for AADA remains controversial. Moreover, long-term results regarding the cannulation technique are only available in the traditional femoral cannulation technique at present.

Direct cannulation on the dissected ascending aorta has been performed in our institute for more than 20 years. We present our long-term results of ascending aortic cannulation compared with femoral cannulation in AADA.

Methods

Patients
Between January 1988 and July 2007, a total of 242 consecutive patients with AADA were treated surgically in our institute. Medical records of those patients were retrospectively reviewed. In 4 patients, the cannulation site was not clearly documented, and another cannulation site was chosen in 3 patients (the right axillary artery in 2 patients and the innominate artery in 1 patient). Those 7 patients were excluded from this study. Thus the remaining 235 patients including 82 patients with direct ascending cannulation and 153 patients with femoral cannulation were evaluated in this study. After approval of the institutional review board, follow-up was obtained through contact with the local population administration office, home doctor, or with the patient/family directly. Completeness of follow-up was 97%.

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Circulation is available at http://circ.ahajournals.org

DOI: 10.1161/CIRCULATIONAHA.108.844480

S282
Surgical Procedure
Blood pressure was monitored through the right and left radial arteries and 1 of the femoral arteries. All patients were operated through a median sternotomy. The arterial cannulation site was decided individually, according to patient status and, more dominantly, surgeon preference. In cases with aortic cannulation, an undistected site of the lesser curve in the aortic arch was usually chosen for cannulation. If the aorta was circularly dissected and no undisected site could be seen, the anterior wall of the ascending aorta, near the origin of the brachiocephalic artery, was chosen for the cannulation site. A cannulation suture with 3-0 Prolene was applied to the chosen cannulation site. A cannulation suture with 3-0 Prolene was applied to the chosen cannulation site; the aortic wall was cut 1 cm deep with a surgical scalpel, and a cannula was inserted. Puncture technique was not used. After the insertion, position of the cannula was checked by transesophageal echocardiography. The chronological change of the aortic cannulation site is shown in Figure 1. After insertion of the venous cannula into the right atrium, cardiopulmonary bypass was established and systemic cooling was initiated. The left ventricle was vented through the right superior pulmonary vein. The ascending aorta was then cross-clamped and the proximal part of the ascending aorta was opened. When a blood pressure difference among peripheral arteries was observed, the aortic clamp was opened and the dissecting membrane was incised for perfusion of both the true and the false lumens. A crystalloid cardioplegic solution was given selectively through coronary ostia. For repair of the aortic root, supracoronary aortic replacement, composite replacement, or aortic valve-sparing technique was performed according to the extent of the dissection and the status of the aortic valve. When the bladder temperature reached the target level, the repair of the aortic root was interrupted, cardiopulmonary bypass was stopped, and the aortic clamp was opened. After inspection of the aortic arch, antegrade selective cerebral perfusion was induced with 2 cannulas placed into the brachiocephalic artery and the left carotid artery, if needed until September 2006; it was routinely instituted and systemic cooling was initiated. The left ventricle was vented through the right superior pulmonary vein. The ascending aorta was then cross-clamped and the proximal part of the ascending aorta was opened. When a blood pressure difference among peripheral arteries was observed, the aortic clamp was opened and the dissecting membrane was incised for perfusion of both the true and the false lumens. A crystalloid cardioplegic solution was given selectively through coronary ostia. For repair of the aortic root, supracoronary aortic replacement, composite replacement, or aortic valve-sparing technique was performed according to the extent of the dissection and the status of the aortic valve. When the bladder temperature reached the target level, the repair of the aortic root was interrupted, cardiopulmonary bypass was stopped, and the aortic clamp was opened. After inspection of the aortic arch, antegrade selective cerebral perfusion was induced with 2 cannulas placed into the brachiocephalic artery and the left carotid artery, if needed until September 2006; it was routinely performed since October 2006. The cannulation site on the ascending aorta was resited in all cases with direct ascending cannulation. The intimal tear was also resited if it could be seen until the distal aortic arch. According to the location of the entry, the extent of the distal aortic replacement was defined. After finishing the distal anastomosis, the arterial cannula was inserted into the prosthesis if direct ascending cannulation was applied, the prosthesis was clamped, cardiopulmonary bypass was restarted, and the patient was rewarmed. While rearming, the repair of the aortic root was completed, the anastomosis between the proximal and the distal prosthesis was done, and the aortic clamp was removed after careful de-airing.

Table 1. Patient Characteristics in Each Group

<table>
<thead>
<tr>
<th></th>
<th>Aortic Cannulation (n = 82)</th>
<th>Femoral Cannulation (n = 153)</th>
<th>OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>56±14</td>
<td>57±12</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>61 (74)</td>
<td>101 (66)</td>
<td>0.67 (0.37–1.22)</td>
<td>0.19</td>
</tr>
<tr>
<td>DeBakey I</td>
<td>41 (50)</td>
<td>82 (54)</td>
<td>1.14 (0.67–1.95)</td>
<td>0.63</td>
</tr>
<tr>
<td>Aortic valve regurgitation</td>
<td>41 (50)</td>
<td>65 (42)</td>
<td>1.37 (0.80–2.36)</td>
<td>0.25</td>
</tr>
<tr>
<td>Pericardial effusion</td>
<td>27 (33)</td>
<td>41 (27)</td>
<td>1.43 (0.79–2.61)</td>
<td>0.24</td>
</tr>
<tr>
<td>Coronary malperfusion</td>
<td>7 (9)</td>
<td>11 (7)</td>
<td>1.26 (0.47–3.41)</td>
<td>0.65</td>
</tr>
<tr>
<td>Cerebral insult</td>
<td>9 (11)</td>
<td>10 (7)</td>
<td>1.86 (0.72–4.80)</td>
<td>0.20</td>
</tr>
<tr>
<td>Preoperative paraplegia</td>
<td>1 (1)</td>
<td>0 (0)</td>
<td>1.01 (0.99–1.04)</td>
<td>0.34</td>
</tr>
<tr>
<td>Visceral malperfusion</td>
<td>4 (5)</td>
<td>2 (1)</td>
<td>4.06 (0.73–22.7)</td>
<td>0.18</td>
</tr>
<tr>
<td>Malperfusion of extremities</td>
<td>17 (21)</td>
<td>24 (16)</td>
<td>1.41 (0.71–2.80)</td>
<td>0.33</td>
</tr>
<tr>
<td>Shock status</td>
<td>9 (11)</td>
<td>37 (24)</td>
<td>0.39 (0.18–0.85)</td>
<td>0.015</td>
</tr>
<tr>
<td>Previous cardiac surgery</td>
<td>14 (17)</td>
<td>25 (16)</td>
<td>1.10 (0.53–2.28)</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Data are presented as mean±SD or n (%). OR indicates odds ratio.

Results

Patient Characteristics
The 2 groups were similar with regard to preoperative patient characteristics, as shown in Table 1, except for shock status. Because of the minimal difference between groups, both groups were compared for further analysis, and no matching procedure, that is, with propensity score, was performed.

Intraoperative Parameter
Operative times and procedures are listed in Table 2. There were no differences between groups. As a repair of the aortic

Table 2. Operative Procedures in Each Group

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Aortic Cannulation (n = 82)</th>
<th>Femoral Cannulation (n = 153)</th>
<th>OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation time, min</td>
<td>357±139</td>
<td>332±138</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>CPB time, min</td>
<td>218±105</td>
<td>206±95</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>Cross-clamp time, min</td>
<td>105±45</td>
<td>105±55</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>Circulatory arrest time, min</td>
<td>20±20</td>
<td>17±24</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>Use of SCP</td>
<td>11 (13)</td>
<td>14 (9)</td>
<td>1.72 (0.74–4.02)</td>
<td>0.21</td>
</tr>
<tr>
<td>Temperature at circulatory arrest, °C</td>
<td>24.4±5.9</td>
<td>24.6±4.9</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>Total arch replacement</td>
<td>15 (18)</td>
<td>32 (21)</td>
<td>0.96 (0.56–1.64)</td>
<td>0.63</td>
</tr>
<tr>
<td>Supracoronary replacement</td>
<td>41 (50)</td>
<td>70 (46)</td>
<td>1.19 (0.69–2.03)</td>
<td>0.53</td>
</tr>
</tbody>
</table>

Data are presented as mean±SD or n (%). OR indicates odds ratio; CPB, cardiopulmonary bypass; SCP, selective cerebral perfusion.
Table 3. Early Mortality and Morbidities

<table>
<thead>
<tr>
<th></th>
<th>Aortic Cannulation (n=82)</th>
<th>Femoral Cannulation (n=153)</th>
<th>OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-hospital mortality</td>
<td>10 (12)</td>
<td>19 (12)</td>
<td>0.98 (0.43–2.21)</td>
<td>0.96</td>
</tr>
<tr>
<td>30-Day mortality*</td>
<td>11 (14)</td>
<td>35 (23)</td>
<td>0.51 (0.24–1.06)</td>
<td>0.07</td>
</tr>
<tr>
<td>Intraoperative death</td>
<td>6 (5)</td>
<td>11 (7)</td>
<td>1.02 (0.36–2.86)</td>
<td>0.97</td>
</tr>
<tr>
<td>Stroke</td>
<td>4 (5)</td>
<td>7 (5)</td>
<td>1.09 (0.31–3.86)</td>
<td>0.89</td>
</tr>
<tr>
<td>Temporary neurological dysfunction</td>
<td>13 (17)</td>
<td>31 (22)</td>
<td>0.76 (0.37–1.56)</td>
<td>0.45</td>
</tr>
<tr>
<td>Renal failure</td>
<td>10 (13)</td>
<td>18 (13)</td>
<td>1.08 (0.47–2.50)</td>
<td>0.85</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>12 (16)</td>
<td>13 (9)</td>
<td>1.85 (0.80–4.26)</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Data are presented as n (%). OR indicates odds ratio.

*Known in 148 patients in the femoral cannulation group and 81 patients in the aortic cannulation group.

Postoperative Mortality and Morbidities
Operative mortality and morbidities were listed in Table 3. Six patients in the aortic cannulation group and 11 patients in the femoral cannulation group died in the operating room. The complication rate was calculated in surviving patients, with 76 patients in the aortic cannulation group and 142 patients in the femoral cannulation group. We did not find any differences in postoperative mortality and morbidities between the groups; however, there was a trend toward lower 30-day mortality in the aortic cannulation group (14% versus 24%, P=0.07). As shown in Figure 1, the distribution of cannulation sites was not identical in each period, and therefore 30-day mortality in each period was compared between groups (Table 4). There was no statistical difference of 30-day mortality between groups in any period. Among preoperative patient characteristics, the preoperative shock status was significantly different between groups (P=0.015); therefore 30-day mortality only in patients with shock status was analyzed and the result was shown in Table 5. There was no influence of cannulation technique on 30-day mortality in this patient cohort.

Long-Term Outcome
Survival rate was 75±3%, 65±3%, 45±4%, and 32±5% at 1, 5, 10, and 15 years, respectively, in the entire cohort.

Table 4. 30-Day Mortality in Each Period

<table>
<thead>
<tr>
<th></th>
<th>Aortic Cannulation</th>
<th>Femoral Cannulation</th>
<th>OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988–1992</td>
<td>1/6 (17)</td>
<td>11/44 (25)</td>
<td>0.60 (0.06–5.70)</td>
<td>0.65</td>
</tr>
<tr>
<td>1993–1997</td>
<td>0/9 (0)</td>
<td>7/35 (20)</td>
<td>0.80 (0.68–0.94)</td>
<td>0.17</td>
</tr>
<tr>
<td>1998–2002</td>
<td>5/30 (17)</td>
<td>11/42 (26)</td>
<td>0.56 (0.17–1.84)</td>
<td>0.25</td>
</tr>
<tr>
<td>2003–2007</td>
<td>5/36 (14)</td>
<td>6/27 (22)</td>
<td>0.56 (0.15–2.10)</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Data are presented as n/N (%). OR indicates odds ratio.

Discussion
There are 3 crucial findings of this study: (1) direct ascending cannulation has been performed in the surgical treatment for AADA over a period of 20 years with acceptable mortality and morbidity at our institute; (2) there was a trend toward lower 30-day mortality in the aortic cannulation group, but there was no difference in long-term outcome between the 2 cannulation technique; and (3) despite immediate surgical treatment, AADA has a poor prognosis with only approximately 50% survival in 10 years regardless of cannulation technique.

The optimal cannulation site for the repair of AADA is still not known. The most popular site for cannulation in this setting was the femoral artery until the late 1990s. Nowadays, the axillary artery is favored by many surgeons as an alternative cannulation site aimed to avoid cerebral atherosclerosis, to prevent extension of dissection resulting in malperfusion caused by retrograde blood flow, and to facilitate antegrade cerebral perfusion during hypothermic circulatory arrest.10–17 Indeed, the axillary cannulation appears to be beneficial, especially in the treatment for atherosclerotic aneurysms as reported by the Mount Sinai group10 because it offers a physiological antegrade blood flow during cardiopulmonary bypass. It is nevertheless unclear whether axillary cannulation represents uniform advantage over traditional femoral cannulation in the treatment for AADA.
because of the following reasons. First, patients with acute dissection of the ascending aorta rarely manifest atherosclerosis or plaque in the descending aorta\(^\text{18,19}\) and therefore the risk of retrograde embolization is very low. Second, selective cannulation with catheters into the arch vessels for selective cerebral perfusion is uncomplicated and reliable without manipulation of dissected arch vessels\(^\text{20,21}\) so that the axillary cannulation is not always necessary for the establishment of selective cerebral perfusion. Third, malperfusion cannot be completely avoided even with the use of axillary cannulation\(^\text{9}\). Fourth, possible local complications with direct axillary cannulation cannot be ignored\(^\text{14}\), especially in patients with Marfan syndrome and very fragile tissue. The local complication rate can be reduced by the use of a side graft for axillary cannulation\(^\text{4,16,22}\), but this technique may be too time-consuming for an emergency situation.

As another alternative cannulation technique, direct ascending cannulation has been advocated by the Hannover group\(^\text{7,9}\). This technique is easy, fast, and straightforward, ensuring that antegrade flow in the aorta and could therefore be advantageous over the axillary cannulation, especially in situations of hemodynamic instability. Moreover, this technique requires no additional incision, and peripheral vascular injury can be avoided. To our knowledge, however, there has been only 1 comparative study regarding this issue by Reece et al\(^\text{8}\). They demonstrated that the 30-day mortality rate was significantly higher in the peripheral cannulation group than in the central cannulation group (20% versus 4%; \(P<0.05\)). In contrast to their report, we found no differences for any postoperative outcome, including mortality and stroke in the present study. The number of evaluated patients in our study is obviously more than those in the report by Reece et al (24 patients with central cannulation and 46 patients with peripheral cannulation), and we speculate that could be the reason for this discrepancy of results.

The technical concerns regarding this ascending cannulation technique are (1) danger of aortic rupture at the cannulation site and (2) cannulation into the false lumen. In regard to the first issue, Khaladj et al\(^\text{9}\) reported only 1 of 122 patients (0.8%) who had aortic rupture caused by aortic cannulation in patients with AADA. We saw no aortic rupture after aortic cannulation in our 82 patients during 20 years. We therefore consider the risk of aortic rupture caused by ascending cannulation to be extremely low. In regard to the second issue, it is true that the cannula can be inserted into the false lumen despite transesophageal echocardiography control. This is usually not remarkable unless the ascending aorta is not clamped, because the true lumen is also perfused through the large intimal tear in the ascending aorta or somewhere in the aortic arch, and the perfusion status both in the true and the false lumens is not dramatically changed through the establishment of cardiopulmonary bypass. The false lumen cannulation can be recognized after cross-clamping of the ascending aorta through a pressure difference of the radial arteries or a sudden perfusion pressure elevation in the arterial cannula. In such cases, the aorta was opened for a brief period of circulatory arrest: An incision was made in the membrane between the true and false lumens; the cannula was repositioned; and cardiopulmonary bypass was reestablished. This bail-out technique was used in 4 patients in our series, and the problem of false lumen cannulation was solved without malperfusion.

In our series, there was a trend toward a lower mortality rate in patients with aortic cannulation. Our early outcome in the aortic cannulation group, 14% mortality and 5% stroke, is well acceptable compared with other reports not only with femoral cannulation\(^\text{23}\) and ascending cannulation\(^\text{7–9}\) but also with axillary cannulation\(^\text{10–17}\) in the treatment for AADA. As described above, there are advantages and disadvantages in each cannulation technique, and the reason for this trend toward lower early mortality in the aortic cannulation technique in this series is unclear. However, our results suggest that aortic cannulation is a safe alternative method in the treatment of AADA.

To our knowledge, the present study is the first report on long-term survival after surgical treatment for AADA, comparing different cannulation techniques. In this study, the cannulation technique had no impact on long-term survival, and the cumulative survival of the entire cohort of patients was similar to other reports\(^\text{24–26}\). It can be hypothesized that cannulation techniques play no role on late outcome, and the most suitable one should be chosen for the individual patient to optimize the early outcome, considering still-high mortality rates in surgery for AADA.

**Limitations**

Some drawbacks exist in the present study. First, the cannulation site was not chosen at random but individually according to patient status and, more dominantly, surgeon preference. Thus, patient selection bias and surgeon preference bias were inevitable in this study. Second, our study cohort was relatively small, and each arm would need at least 100 patients to reach a significant difference in 30-day mortality demonstrated in this study. Third, this series is a report of a single institutional experience, and the results may not be generalized to other settings. Nevertheless, we consider that the aim of this study was accomplished, presenting the safety of the ascending cannulation technique in comparison with the femoral cannulation technique.

**Conclusion**

The cannulation site should be chosen according to patient’s pathology and status, and the present study suggests that the ascending cannulation in patients with AADA can be a safe alternative, offering acceptable early and long-term outcomes.

**Disclosures**

None.

**References**

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_Circulation_. 2009;120:S282-S286
doi: 10.1161/CIRCULATIONAHA.108.844480
_Circulation_ is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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