Institutional report - Vascular thoracic

Spinal cord protection during a thoracoabdominal aortic repair for a chronic type B aortic dissection using the aortic tailoring strategy

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Abstract

This study evaluated the clinical advantage of a novel technique to reconstruct a true lumen with aortic wall tailoring for aortic repair (aortic tailoring) or the reimplantation of intercostal arteries (vascular tube) in a chronic type B aortic dissection. Thirty-three consecutive extended thoracoabdominal aortic repairs have been performed for chronic type B dissection since 2000. The novel strategy was applied in 17 cases since 2004 including eight cases of aortic repair (group A), and nine cases of a vascular tube (group B). The other 16 cases were graft interposition in five and no reimplantation in 11 for group C. There were no surgical deaths in either group A or B, and only one late death in group C. No patients sustained transient or permanent paraplegia in group A and B, while three cases of paraplegia occurred in group C (18.8%). All of the intercostal arteries were well preserved in group A and an average of 9.8 intercostal arteries for nine patients were reimplanted in group B. The present technique can optimally preserve the intercostal arteries maximally and showed an excellent surgical mortality and morbidity, especially with regard to the protection of the spinal cord.

Keywords: Entry closure; Vascular tube; Chronic type B dissection; Paraplegia

1. Introduction

Paraplegia and paraparesis are devastating complications of thoracoabdominal aortic surgery beyond the diaphragm. The detection of the feeding intercostal arteries for the spinal cord (Adamkiewicz artery) by computed tomography (CT) or magnetic resonance (MR) angiogram allows more realistic to minimize these complications [1]. However, the reconstructed intercostal arteries occasionally develop unclear formulation with other collateral networks. The ability to prevent postoperative paraplegia by reconstructing the target intercostal arteries still remains unclear [2, 3]. The reconstruction of all of the intercostal arteries by connecting all the target intercostal arteries to the main graft is an ideal but time-consuming procedure. A simple and quick procedure for preventing paraplegia must, therefore, be established. Recently, a novel strategy was demonstrated to preserve nearly all of the target intercostal arteries. The primary feature of this strategy is that only the true lumen is preserved with the tailoring of the pseudo aneurysmal lumen in a chronic type B aortic dissection. The preserved true lumen is either applied as a conduit for aortic repair (aortic tailoring technique) or it is used for the reimplantation of the intercostal arteries (vascular tube technique) according to the number of entries on a case-by-case basis. These procedures can save operation time in comparison with individual intercostals arterial reconstruction. This study evaluated the clinical advantages of this strategy for performing surgery in a case presenting with chronic type B aortic dissection.

2. Patients and methods

2.1. Patients

The clinical records of 33 consecutive patients who underwent a surgical repair for an extended thoracoabdominal aortic aneurysm in a chronic type B dissection from 2000 to 2009 were retrospectively reviewed. A novel strategy was applied in 17 cases since 2004. There were eight cases treated by aortic repair (group A) and nine cases employed the vascular tube technique (group B). One case was switched from an aortic repair (aortic tailoring) to the vascular tube technique due to the expansion of the pseudo lumen.

Reconstruction of the intercostal arteries was performed with a graft interposition in five and no reimplantation was performed in 11 cases. These 16 cases belonged to group C. The patient characteristics for each groups are demonstrated in Table 1.

2.2. Surgical technique

A cerebrospinal fluid drainage tube was inserted for spinal cord protection on the day before the operation. A double-
lumen endotracheal tube was inserted after general anesthesia. The patient was placed in a right semi-recumbent position, and a posterolateral or left thoracoabdominal incision was made through the fifth or sixth inter-rib bone space.

A partial cardiopulmonary bypass (CPB) under mild hypothermia was applied to the patients in which distal arch had enough space to clamp, while total CPB under deep hypothermia was applied to the other cases in which there was no space to clamp. An arterial cannula was basically inserted into the femoral artery and a venous cannula was placed in the femoral vein. However, an arterial inflow was principally established with a graft placed on the right subclavian artery to establish total CPB (group A; 3/8, group B; 7/9, group C; 3/16).

Two different tailoring methods were applied to preserve a sufficient intercostal flow by preserving the true lumen. One was the aortic tailoring technique for aortic repair, which is based on the theory reported by Williams and Stone et al. [5]. The other is the vascular tube technique, which was designed and reported by our institution [6].

The aortic repair (aortic tailoring) technique was selected when the number of entries or re-entries of the dissection were limited, the true lumen was kept at a good flow and the formation of false lumen was simple anatomy. The vascular tube technique was selected when there were many entries and re-entries between the true and false lumen that cannot be repaired by aortic tailoring.

The aortic repair was performed by opening a false lumen longitudinally under circulatory arrest, basically after the sufficient core cooling for the nasopharyngeal temperature to reach 20 °C, or clamping the distal arch with mild hypothermia. The entry, which was close to the origin of the left subclavian artery was closed using interrupted mattress sutures. The aneurysmal wall of the false lumen was resected and plicated with a buttressed Teflon felt strip. The aneurysmal wall of the false lumen is plicated as small as possible. The entry is closed with interrupted mattress sutures and a buttressed Teflon felt strip. The entry is found. The abdominal branch reconstruction was applied while making a vascular tube to reduce the time of spinal cord ischemia. The proximal end of the aorta was sutured to the main graft after the proximal anastomosis.

2.3. Statistical analysis

A statistical analysis was performed using the SPSS 17.0 statistical software package for Macintosh (SPSS Inc, Chicago, IL, USA). Quantitative variables approximating a normal distribution are presented as the means ± standard deviation (S.D.). The differences between the three groups were determined using Pearson’s χ²-test for categorical variables. A P<0.05 was considered to be significant.

3. Results

3.1. Operation

All of the intercostal arteries were preserved in aortic repair (aortic tailoring), while the vascular tube technique was selected when there were many entries or re-entries between the true and false lumen that cannot be repaired by aortic tailoring.

Table 1

<table>
<thead>
<tr>
<th>Group</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>8</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>Average age (years)</td>
<td>56 (43–72)</td>
<td>50 (18–73)</td>
<td>57 (29–75)</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>6/2</td>
<td>6/3</td>
<td>13/3</td>
</tr>
<tr>
<td>Stanford type B</td>
<td>6</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Previous surgery for type A</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Marfan’s syndrome</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Follow-up time (years)</td>
<td>2.9 ± 1.5</td>
<td>2.6 ± 1.8</td>
<td>5.3 ± 2.5</td>
</tr>
</tbody>
</table>

Fig. 1. (a1) Under partial cardiopulmonary bypass with circulatory arrest, the false lumen is opened longitudinally and the entry is found. (a2) The entry is closed with interrupted mattress sutures and a buttressed Teflon felt strip. (a3) The aneurysmal wall of the false lumen is plicated as small as possible. (b1) After the distal anastomosis the false lumen is opened. (b2) The false lumen is plicated and a vascular tube is created by using a running suture. (b3) The vascular tube is attached to the main graft after the proximal anastomosis.
reconstructed 9.6 ± 3.8 (range 2–16) intercostal arteries in group B. On the other hand, five patients had 5.2 ± 2.2 (range 2–8) intercostal arteries reimplanted with graft interposition in group C. The operation features for each group are summarized in Table 2.

3.2. Mortality and morbidity

There was no hospital mortality in either groups. There was one late death in group C. No paraplegia or paraparesis occurred in group A or B, while three patients were complicated with paraplegia in group C (18.8%). In addition, there were no significant differences between the groups in the occurrence of other morbidities; such as stroke, re-exploration, wound infection, respiratory failure, tracheostomy and renal failure (Table 3).

The results of follow-up 3D CT-scans showed the well-designed shape of the tailored aorta in aortic repair and vascular tube of group A and B (Fig. 2). Six cases had recently had their aortic diameters measured and their mean values were 34.2 ± 8.8 mm (range 25–42 mm). There was no abnormal expansion of the pseudo lumen. The occlusion of the vascular tube was detected in four of nine patients treated with the vascular tube technique, however, no patients were complicated with either paraplegia or paraparesis. The diameters of the vascular tube showed no excessive expansion over 35 mm in the remaining five cases (29.7 ± 4.4; range 23.5–33.4).

4. Discussion

Advanced surgical management has improved the surgical outcomes for thoracoabdominal aortic repair, however, the mortality is still unacceptable. The latest annual survey of thoracic and cardiovascular surgery in Japan revealed that the 30-day mortality was 10.1% in chronic Stanford type B dissection, which has demonstrated a steady improvement in comparison to that in the 1997 annual survey (20.8%) [7]. Despite the improved mortality rate, surgery for the thoracoabdominal repair is still associated with a higher morbidity rate, especially including spinal cord dysfunction. Therefore, spinal cord protection remains a major concern in such a surgical intervention. Svenson attributed the major causes of the spinal cord injury to the following three events: (1) The duration and degree of ischemia; (2) a failure to re-establish the blood flow to the spinal cord; (3) the occurrence of biochemically mediated reperfusion injury [8]. The current technique was designed to reduce the duration of ischemia and to re-establish a complete blood supply to the spinal cord. The present strategy is a simple and quick method that can preserve almost all of the target intercostal arteries.

Miyamoto and colleagues used a similar aortic repair technique (aortic tailoring) and thus showed the excellent short-term and acceptable long-term outcomes in 40 cases of chronic type B surgery. There was no hospital death or paraplegia. Their survival rate was 92 ± 4% at five years and 64 ± 9% at 10 years. The freedom from re-operation for residual dissecting aneurysm was 85 ± 5% at five years and 78 ± 5% at 10 years. The major cause for re-operation was
an expanded diameter of residual dissecting aneurysm >45 mm [9]. The current data showed no late mortality in patients that had undergone aortic tailoring (2.7 ± 1.5 years; range 0.3–4.9 years). The aortic diameter in the present series was <45 mm (34.2 ± 8.8 mm; range 25–42 mm) and there were no re-operations for any expanded residual dissecting aneurysm. It is important to reshape the aorta to make it as small as possible and that should help to protect against the expansion of the aorta for several years. As Miyamoto concluded that the greatest advantage of the aortic repair technique (aortic tailoring) is the lower paraplegia rates that are achieved by preserving all of the intercostal arteries in comparison to other techniques, such as the re-implantation of only the critical intercostal arteries with graft interposition [9].

The vascular tube technique is a modification of aortic repair technique (aortic tailoring). This method can be applied to various aortic anatomies which are not suitable for aortic repair (aortic tailoring). The vascular tube technique is selected when there are many entries and re-entries between the true and false lumen that cannot be repaired by aortic repair technique. This procedure was also associated with no paraplegia. The mean number of re-implanted intercostal arteries was 9.6 ± 3.8 (range 2–16) when performing this procedure, and therefore it may provide a sufficient blood flow to the Adamkiewicz artery during the perioperative phase. Postoperative CT revealed occlusion of the vascular tube in four patients, however, no patients were complicated with either paraplegia or paraparesis.

The vascular tube probably played an important role in providing a sufficient collateral flow to the spinal cord during the perioperative period. Woo and coworkers reported no paraplegia in the acute and late phase in patients when using a beveled intercostal artery patched with an 8 mm prosthetic graft to supply all of the intercostal arteries [10]. The size of the re-implanted graft was not measured in this study but may have been kept under 20 mm. It seems to be important to maintain a small size for the interposition to the intercostal arteries. The vascular tube was shaped as small as possible to increase the graft patent rate. In addition, no abnormal expansion of the vascular tube was observed, even if patients suffered Marfan syndrome.

Generally the standard surgical therapy for a chronic type B dissecting aneurysm is graft replacement. The rate of paraplegia or paraparesis is still high and therefore still needs improvement. However, the current technique showed acceptable outcomes for the prevention of spinal cord injury. As a result, this treatment modality could therefore be one viable option for preventing the occurrence of devastating complications.

5. Conclusion

The aortic repair technique (aortic tailoring) and vascular tube technique can optimally preserve the intercostal arteries and it demonstrates excellent surgical mortality and morbidity rates including low rates of spinal cord dysfunction.

References


Conference discussion

Dr. T. Sundt (Rochester, Minnesota, USA): We’re all familiar with how challenging these cases can be and these are outstanding results. And certainly paraplegia is a discouraging complication after an otherwise successful operation, particularly when it’s delayed paraplegia I think.

It’s interesting to me that we’re still in the midst of discussing relatively extreme measures to preserve the intercostal vessels on one hand, when on the other hand thought-leaders like Grieppe and Bachet might argue that we don’t need the intercostals at all. I think the amount of interest in this issue reflects how devastating the complication of paraplegia is to both the patient and the surgeon. We’re indebted to your group for presenting a very intriguing approach to preserving the intercostals. It helps to open our minds to different ways of dealing with these things. I have three specific questions for you.

First of all, I have a question about your choice to use spinal drainage. I confess that my approach to these has been adopted from my mentor, Nick Kouchookhos. I do thoracoabdominals under circulatory arrest, and I don’t use a spinal drain unless the patient develops weakness postoperatively; I consider paraplegia an extremely devastating complication that is both to the patient and the surgeon. We’re indebted to your group for presenting a very intriguing approach to preserving the intercostals. It helps to open our minds to different ways of dealing with these things. I have three specific questions for you.

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aortic tailoring technique if the entry is very limited. But if in the lower part, we found the re-entries, we use a graft replacement in the lower part and use the tailoring technique in the upper part.

Dr. Sundt: Does the diameter of the aorta at the hiatus have an impact?
Dr. Mutsuga: We don’t care about the diameter. And if the mitral entry is in the descending aorta, we choose vascular tube technique and that’s the reason.

Dr. Sundt: And the last question is, what approach are you using to follow these? We would obviously all be concerned about expansion of the diseased tissue particularly in those individuals with connective tissue disease. There was at least one Marfan patient in your series. Are you using volumetric CTs? I worry that just looking at diameter may not be precise enough, you may need to look at aortic volumes.

Dr. Mutsuga: We usually follow-up 6 months or 1 year. Also the volumetric and the 3D CT usually are performed for the follow-up.

Dr. S. Thelin (Uppsala, Sweden): How many entries do you actually close with a tailoring technique? What is the maximum number you close?
Dr. Mutsuga: Maximum number is 2 or 3, yes, 3.