Clinical outcomes of emergency surgery for acute type B aortic dissection with rupture†

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Abstract

OBJECTIVES: The purpose of this study was to evaluate the clinical outcomes of emergency surgery for acute type B aortic dissection with rupture and to compare results between open surgery and thoracic endovascular aortic repair (TEVAR).

METHODS: Two hundred and ninety-four patients with acute type B aortic dissection were admitted to our hospital between January 2000 and March 2012. At presentation, 30 (10%) patients had rupture (20 men, 10 women; mean age, 71 ± 15 years), among whom 23 underwent emergency surgery: 9 underwent TEV AR and 14 underwent open surgery. The objective of TEV AR was closure of the primary entry site and the secondary tear site in the descending thoracic aorta.

RESULTS: In the TEV AR group, technical success was achieved: the primary entry site was closed, and bleeding was controlled in all 9 patients. There was no operative death, and 1 (13%) patient had cerebral infarction. In the open surgery group, 2 (14%) patients died during hospitalization, and 4 (29%) had cerebral infarction in the acute phase. Hospitalization tended to be longer in the open surgery group than in the TEV AR group. The overall survival rate at 1 year was 71 ± 17% in the TEV AR group and 86 ± 9% in the open surgery group (P = 0.89).

CONCLUSIONS: TEV AR for acute type B aortic dissection with rupture could be performed with relatively low morbidity and mortality, with no significant difference when compared with open surgery. The main objective of TEV AR for acute type B aortic dissection with rupture is control of bleeding, which can be achieved by closing the primary entry site and the secondary tear site in the descending thoracic aorta. If anatomically feasible and performed immediately, TEV AR is the treatment of choice for acute type B aortic dissection with rupture because it is less invasive than open surgery.

Keywords: Aortic dissection • Stanford type B • Rupture • Thoracic endovascular aortic repair • Open surgery

INTRODUCTION

Patients with acute type B aortic dissection who have complications such as rupture or organ ischaemia often require emergency surgery [1-4]. Despite recent advances in surgical techniques and perioperative management, emergency surgery for acute type B dissection with complications continues to be associated with high mortality and morbidity [5-7], particularly in patients who have aortic rupture. Trimarchi et al. [8] reported that emergency surgery for acute type B aortic dissection with rupture has a mortality rate of higher than 50% according to the International Registry of Acute Aortic Dissection (IRAD).

Thoracic endovascular aortic repair (TEVAR) for acute type B aortic dissection with complications has attracted increasing interest because it is very effective and associated with low mortality and morbidity [9,10]. However, few patients with acute type B aortic dissection accompanied by rupture were included in these studies.

We retrospectively studied patients with acute type B aortic dissection associated with rupture. Our main objectives were to evaluate the clinical outcomes of emergency surgery for acute type B aortic dissection with rupture and to compare results between open surgery and TEV AR.

MATERIALS AND METHODS

Subjects

The study group comprised of 294 consecutive patients with acute type B aortic dissection who were admitted to Yokohama City University Medical Center from January 2000 through...
March 2012. Patients who presented with dissection due to iatrogenic or traumatic reasons were excluded.

Among the 294 patients, 236 had no complications and 58 (20%) had complications, including 30 (20 men and 10 women; 10%) with aortic rupture. We diagnosed the rupture by the presence of extravasation around the aorta and/or by the presence of mediastinal haematoma on computed tomography (CT). Patients who had only pleural effusion without mediastinal haematoma were excluded. Contained ruptured patients who had only pain were also excluded. The mean age of patients was 71 ± 15 years. Among the patients with rupture, 23 underwent emergency surgery: TEVAR was performed in 9 patients (TEVAR group), and open surgery in 14 (open surgery group). Twelve patients in the open surgery group could not undergo TEVAR historically and socially. Two patients in the open surgery group could not undergo TEVAR anatomically. There were 7 patients who did not undergo intervention. Five of them refused intervention mainly due to their old age. Conservative treatment was indicated in another patient, and the other patient had refractory shock and died before operation.

Endovascular technique

All interventions were guided by C-arm fluoroscopy and were performed by a cardiothoracic surgeon in the operating room, with the patient under general anaesthesia. The common femoral artery was exposed. Heparin (1 mg/kg) was administered. Under guidance with transesophageal echocardiography, a curved extrastiff wire was placed into the ascending aorta through the true lumen of the aorta.

Two different stent grafts were used in the present series. Handmade stent grafts made of a Gianturco Z-stent and a Dacron graft were used in the first 2 patients, and Gore TAG endovascular prostheses (W.L. Gore and Associates, Flagstaff, AZ, USA) were used in 7. Stent grafts with a larger diameter (equivalent to 110–120% of the circumference of the true lumen) were used depending on the results of preoperative CT.

Angiography was performed to confirm the primary entry site and secondary tear site. The stent graft was positioned and deployed to close the primary entry site and the secondary tear site in the descending thoracic aorta. Post-dilatation with an aortic balloon catheter was performed, and angiography was performed again to confirm the closure of the primary entry site, closure of the secondary tear site, absence of an endoleakage and absence of an enhanced false lumen at the descending thoracic aorta.

In 2 patients, the proximal landing zone was Z2 [11], and the left subclavian artery was occluded. In 1 of these patients, an axillary-axillary bypass was performed because the right vertebral artery was interrupted by preoperative CT [12].

Open surgical technique

Seven patients underwent lateral thoracotomy, 4 underwent full sternotomy and 3 underwent partial sternotomy with lateral thoracotomy. The aortic arch and descending thoracic aorta were replaced in 5 patients, the partial aortic arch and descending thoracic aorta were replaced in 2, the descending thoracic aorta was replaced in 6 and the descending thoracic aorta and thoracoabdominal aorta were replaced in 1. One patient had mesenteric ischaemia with rupture. Partial resection of the small intestine was performed after replacement of the aortic arch and descending thoracic aorta.

Data collection and follow-up

Data were obtained from the patients’ medical records or by telephone interviews. Follow-up CT was conducted 1 week after operation and at least once a year after discharge to evaluate short- and mid-term outcomes. Late aortic events were defined as aortic surgery, progression to acute type A aortic dissection, recurrence of acute type B aortic dissection, reoperation and rupture. The follow-up rate was 91% (2 patients lost to follow-up).

Statistical analysis

The results are expressed as mean ± standard deviation. Unpaired Student’s t-tests and Fisher χ² tests were used to compare categorical variables. Time-related changes in freedom from aorta-related events and survival were analysed by the Kaplan–Meier method. A P-value of ≤0.05 was considered statistically significant.

RESULTS

Patient demographic characteristics and perioperative management

Table 1 shows the clinical characteristics of the 9 patients in the TEVAR group and the 14 patients in the open surgery group. The mean age was slightly higher in the TEVAR group than in the open surgery group (76 ± 9 vs 64 ± 19 years). The maximum aortic diameter at disease onset was similar in the groups. There were no differences between the groups about malperfusion, aortic surgery, progression to acute type A aortic dissection, recurrence of acute type B aortic dissection, reoperation and rupture. The follow-up rate was 91% (2 patients lost to follow-up).

### Table 1: Baseline clinical characteristics

<table>
<thead>
<tr>
<th></th>
<th>TEVAR (N = 9)</th>
<th>Open surgery (N = 14)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>76 ± 9</td>
<td>64 ± 19</td>
<td>0.09</td>
</tr>
<tr>
<td>Gender, male/female</td>
<td>6/3</td>
<td>9/5</td>
<td>0.91</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>5 (56)</td>
<td>8 (57)</td>
<td>0.94</td>
</tr>
<tr>
<td>Hyperlipidaemia, n (%)</td>
<td>0 (0)</td>
<td>2 (14)</td>
<td>0.24</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>COPD, n (%)</td>
<td>2 (22)</td>
<td>1 (7)</td>
<td>0.30</td>
</tr>
<tr>
<td>Previous cardiac surgery, n (%)</td>
<td>1 (11)</td>
<td>1 (7)</td>
<td>0.74</td>
</tr>
<tr>
<td>Maximum diameter of aorta (mm)</td>
<td>51.6 ± 11.1</td>
<td>43.9 ± 11.2</td>
<td>0.13</td>
</tr>
<tr>
<td>With malperfusion, n (%)</td>
<td>0 (0)</td>
<td>3 (21)</td>
<td>0.14</td>
</tr>
<tr>
<td>Preoperative shock, n (%)</td>
<td>2 (22)</td>
<td>6 (43)</td>
<td>0.31</td>
</tr>
<tr>
<td>Preoperative CPR, n (%)</td>
<td>1 (11)</td>
<td>2 (14)</td>
<td>0.83</td>
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COPD: chronic obstructive pulmonary disease; CPR: cardiopulmonary resuscitation; TEVAR: thoracic endovascular aortic repair.
The mean operation time was 142 ± 68 min in the TEVAR group and 508 ± 161 min in the open surgery group. The mean bleeding volume was 842 ± 1756 ml in the TEVAR group and 3592 ± 2335 ml in the open surgery group (Table 2).

Early outcomes

Both the primary entry and secondary tear sites in the descending thoracic aorta were closed, and bleeding was controlled at operation in all 9 patients in the TEVAR group. But 3 patients needed to undergo reintervention. Follow-up CT revealed a Type 3 endoleak in 1 patient. In another patient, CT revealed the patency of the false lumen of the descending thoracic aorta because of the presence of the secondary tear at the level of the diaphragm. In another patient, a new ulcer-like projection appeared at the proximal edge of the stent graft. The second session of TEVAR was performed within a week after the first session for those 3 patients.

Table 3 shows the early postoperative outcomes in both the TEVAR and open surgery groups. In the TEVAR group, there was no operative death within 30 days after admission. In the open surgery group, 2 patients (14%) died within 30 days after admission. In this study, 3 patients had cardiopulmonary arrest before operation. One of these patients underwent TEVAR, and 2 underwent open surgery after cardiopulmonary resuscitation. The former patient who underwent TEVAR survived, but had severe cerebral infarct and paraplegia. The latter 2 patients who underwent open surgery died within 30 days after admission.

The proportion of patients who underwent early reintervention was significantly higher in the TEVAR group than in the open surgery group. No patient had respiratory failure and surgical site infection in the TEVAR group. There was a trend towards a longer hospital stay in the open surgery group than in the TEVAR group.

Late outcomes and aortic events

In the TEVAR group, 2 patients died of rupture of another aortic aneurysm. The dissecting aneurysm of the thoracoabdominal aorta expanded acutely after the first operation in 1 of these patients. Three months after the first operation, the thoracoabdominal aortic aneurysm ruptured, and the patient refused surgical therapy and died. Another patient already had an arch aneurysm exceeding 60 mm in diameter at the time of TEVAR of the descending thoracic aorta. We planned to perform an additional session of TEVAR, but the aneurysm ruptured 5 months after the first operation, and the patient died. In the open surgery group, 2 patients died in the late phase. 1 patient died of graft infection and another patient died of pneumonia.

In the TEVAR group, the aorta-related event-free rate was 67 ± 16% at 3 months and 53 ± 17% at 1 year. In the open surgery group, the aorta-related event-free rate was 86 ± 9% at 3 months, 77 ± 12% at 1 year and 77 ± 12% at 5 years. The difference between the groups was not significant (P = 0.25; Fig. 1).

In the TEVAR group, the overall survival rate was 86 ± 13% at 3 months and 71 ± 17% at 1 year. In the open surgery group, the overall survival rate was 86 ± 9% at 1 year and 77 ± 12% at 5 years. The difference between the groups was not significant (P = 0.89; Fig. 2).

DISCUSSION

Rupture is the leading cause of death in patients with acute type B aortic dissection, occurring at a rate of 3.6–20% [9, 13, 14]. The clinical outcomes of open surgery for acute type B aortic dissection with rupture in our institute were very good when compared with the results of IRAD. However, several problems remain to be solved, such as the prolonged operation time, high bleeding volume and high incidence of postoperative respiratory failure. We recently introduced TEVAR for the management of

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### Table 2: Operative data

<table>
<thead>
<tr>
<th></th>
<th>TEVAR (N = 9)</th>
<th>Open surgery (N = 14)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of operation</td>
<td>142 ± 68</td>
<td>508 ± 161</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>(min)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Volume of bleeding</td>
<td>842 ± 1756</td>
<td>3592 ± 2335</td>
<td>0.01</td>
</tr>
<tr>
<td>(ml)</td>
<td></td>
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### Table 3: Early postoperative outcomes

<table>
<thead>
<tr>
<th></th>
<th>TEVAR (N = 9)</th>
<th>Open surgery (N = 14)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative death, n (%)</td>
<td>0 (0)</td>
<td>2 (14)</td>
<td>0.24</td>
</tr>
<tr>
<td>Cerebral infarct, n (%)</td>
<td>1 (11)</td>
<td>4 (29)</td>
<td>0.32</td>
</tr>
<tr>
<td>Paraplegia, n (%)</td>
<td>1 (11)</td>
<td>1 (7)</td>
<td>0.74</td>
</tr>
<tr>
<td>Dysphagia, n (%)</td>
<td>1 (11)</td>
<td>2 (14)</td>
<td>0.83</td>
</tr>
<tr>
<td>Respiratory failure, n (%)</td>
<td>0 (0)</td>
<td>5 (36)</td>
<td>0.04</td>
</tr>
<tr>
<td>Renal failure, n (%)</td>
<td>1 (11)</td>
<td>0 (0)</td>
<td>0.20</td>
</tr>
<tr>
<td>Surgical site infection, n (%)</td>
<td>0 (0)</td>
<td>4 (29)</td>
<td>0.08</td>
</tr>
<tr>
<td>Early reintervention, n (%)</td>
<td>3 (33)</td>
<td>0 (0)</td>
<td>0.02</td>
</tr>
<tr>
<td>Days of hospitalization (day)</td>
<td>35 ± 24</td>
<td>61 ± 45</td>
<td>0.10</td>
</tr>
</tbody>
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Figure 1: Aorta-related event-free rate of patients in the TEVAR group and the open surgery group. The difference between the groups was not significant (P = 0.25).
acute type B aortic dissection with rupture in our institute and found that the procedure was very effective, with low mortality and morbidity. The main objective of the present study was to compare outcomes between open surgery and TEVAR in patients who had acute type B aortic dissection with rupture and to assess surgical strategies for this condition.

TEVAR for acute type B aortic dissection with rupture is associated with two major problems. First, the ruptured adventitia is present. The management of the residual ruptured adventitia of the aorta is thus an important concern. Thrombosis of the false lumen near the ruptured adventitia is required to control bleeding by TEVAR. Therefore, our main objective of TEVAR is closure of the primary entry site and the secondary tear site in the descending thoracic aorta. If the false lumen near the ruptured adventitia remains patent after TEVAR, bleeding cannot be controlled. Therefore, if we assess that the false lumen near the ruptured adventitia cannot be thrombosed by TEVAR, open surgery must be performed [15]. However, we did not encounter such patients in our series.

Secondly, TEVAR has anatomical limitations. In our study, 2 patients underwent open surgery since the introduction of TEVAR because TEVAR was contraindicated. In one of these patients, the ascending aorta had expanded to over 40 mm in diameter. The other patient had an aneurysm of the aortic arch. On retrospective evaluation of the 12 patients who were treated before the introduction of TEVAR, TEVAR would have been contraindicated in 3 of these patients.

The early outcomes of TEVAR for acute type B aortic dissection with rupture were acceptable when compared with those of open surgery. Technical success was achieved, and there was no operative death within 30 days after admission in the TEVAR group. The mean operation time was shorter, and the mean bleeding volume was smaller in the TEVAR group than in the open surgery group, indicating that TEVAR was less invasive than open surgery.

In our series, 3 patients had cardiopulmonary arrest before operation, requiring cardiopulmonary resuscitation. Two of these patients underwent open surgery, and the other received TEVAR. The 2 patients who underwent open surgery after cardiopulmonary resuscitation died within 30 days after admission, but these were the only operative deaths in the open surgery group. The patient who underwent TEVAR after cardiopulmonary resuscitation had severe cerebral infarction and paraplegia, but survived. The IRAD investigators reported that patients with severe hypotension or shock on admission and at surgery had the worst outcomes, with 85.0% of patients dying during the first week after admission [16]. With the exception of the patients who required cardiopulmonary resuscitation before operation, all patients in our series survived, irrespective of whether they received open surgery or TEVAR.

The proportion of patients who underwent early reintervention was significantly higher in the TEVAR group than in the open surgery group. Garbade et al. reported that the need for reintervention in patients who underwent TEVAR was associated with poor aortic tissue quality, challenging anatomical characteristics and the device used. In their study, the risk of reintervention was lower in the open surgery group than in the TEVAR group [17]. Three patients underwent second sessions of TEVAR within 1 week after the first session in our study, but there were no complications or operative deaths. Reintervention by multiple TEVAR procedures was considered less invasive than open surgery.

Acute type B aortic dissection with rupture can lead to complications such as malperfusion. In our study, 3 patients in the open surgery group had malperfusion with rupture. Early central repair is considered essential for the effective management of malperfusion associated with acute type B aortic dissection. No patient had malperfusion in the TEVAR group in our series. However, we believe that TEVAR can achieve central repair earlier than open surgery and is therefore better suited for the management of malperfusion than open surgery.

Khoynezhad et al. [10] obtained the survival rates of 82% at 1 year and 78% at 5 years in patients who underwent TEVAR for complicated acute type B aortic dissection. We consider these results excellent, but there have been no reports of the results of TEVAR for acute type B aortic dissection with rupture. In our study, thrombosis of the false lumen around the ruptured adventitia was achieved in all patients after TEVAR, and during the mean follow-up period of 9 months, no patient had rerupture at the site of stent-graft placement. Two patients died of rupture of aortic aneurysms at sites not applied stent grafts. The early indication of intervention for residual regions without rupture has to be considered and applied, soon after the success of the management of acute type B aortic dissection with rupture. Of course, close postoperative surveillance is mandatory because of the risk of aortic events at such untreated sites. Appropriate additional treatment might have saved the lives of the 2 patients who died.

Our study had several limitations. Because this is a retrospective clinical study, randomization of study has not been done. The number of patients is also quite small in this study because of a few incident rate of acute type B aortic dissection with rupture. From the standpoint of statistical analysis, comparison between TEVAR and open surgery in this study may not have strong impact on the conclusion, because selection of treatment strategy has not been identical. As a matter of fact, indications of TEVAR and open surgery are not completely same. However, although it seems that two different treatments were done at two different periods of time, 2 patients underwent open surgery even after the introduction of TEVAR as the first choice of treatment in our institute. What we would like to emphasize in this study is the improvement of the management of acute type B aortic dissection with rupture in the acute phase by the introduction of TEVAR in our institute. Although our study has many
During follow-up, there were no events at the site of stent-graft TEVAR allows additional treatment to be performed, if necessary. TEVAR can stabilize the condition of such patients more promptly than open surgery. The low invasiveness of TEVAR allows additional treatment to be performed, if necessary. During follow-up, there were no events at the site of stent-graft placement. We currently consider TEVAR the treatment of the first choice for the management of acute type B aortic dissection with rupture.

Conflict of interest: none declared.

REFERENCES


APPENDIX. CONFERENCE DISCUSSION

Dr W. Schiller (Bonn, Germany): You showed a small group of 30 patients with ruptured acute type B dissection, of whom 14 consecutive patients had been treated by open surgery over the course of nine years. Then, in a period of just over three years, nine consecutive patients were treated by TEVAR. Therefore, my first question is about the indication for treatment and if the recent increase in the number of treated patients is due to a change in the indications. To which time period do the seven patients who were not treated belong? Did you have any deaths on the way to the OR or while positioning the patient on the OR table?

Survival of the TEVAR group is 71.4% after one year, which is not significantly worse compared to open surgery where the one-year survival is almost 86%. Your manuscript indicates a discharge to home of only 57.1% for patients with open surgery, and of 66.7% for those with TEVAR, which is clearly lower than the one-year survival in each group. What was added to the other patients who survived one year, and in which treatment group are the two patients who were lost to follow-up, and how could they influence the given survival rates?

You mentioned late complications and reinterventions after TEVAR. Others report aorto-oesophageal fistulas and other severe complications. In your study you have a trend towards better results for open surgery. The one-year survival for open surgery was better than in the TEVAR group. I’m not sure about your conclusions, why you go on with TEVAR: do you think that TEVAR could be a better short-term solution for stabilizing these patients at first, and that planned open surgery after, for example, two weeks, could be the better long-term solution?

Dr A. Mattens (Hannover, Germany): I think you should just repeat the questions again in a shorter form to give him the chance to answer directly.

Dr Schiller: Was there a change in indications? Because in the first nine years you had 14 patients and then in three years you had nine patients; what changed?

Dr Minami: By the first question you mean incidence of change? Sorry.

Dr Schiller: In the first nine years of your time frame, you had 14 patients. And then in three years you had nine patients, which is much more, of course. And in the whole group there are 30 patients, of whom you said seven patients refused surgery. Are these very sick patients? Why do you suddenly have many more patients per year? Are the indications comparable for open surgery and TEVAR?

Dr K. Imoto (Yokohama, Japan): I am a co-author of this paper. The incidences of perioperative complications were almost the same. But recently we have more elderly patients. Before, we didn’t operate on the 80 or 90 year old patient with rupture. But recently, yes, because we can use TEVAR. So that has changed.

Dr Schiller: So the indication changed and the results are not comparable in this way?

Dr Imoto: Yes, we are doing the more elderly patients.

Dr Schiller: Okay. The next point was you give a survival in the TEVAR group of 71% after one year and in the open surgery group of almost 86%, but your manuscript indicates that only 57% of the patients with open surgery were discharged home. So what happened to those other patients who survived one year: did they have a longer hospital stay than one year, or what happened to them?

To summarize: after open surgery, one-year survival was 86%, but your manuscript says that only 57% of the patients were discharged home.

Dr Imoto: We just showed the postoperative survival. But a number of the patients who underwent open surgery suffered from general weakness or several complications, so such patients could not be discharged for a long time. That’s quite different from the TEVAR.

Dr Schiller: And so the last point is, do you think it could be an option to treat acutely with TEVAR and to operate on the patients maybe two weeks, or a month later (because we know that TEVAR can result in complications in the long-term)?
Dr Imoto: In fact, directly TEVAR-related late complications, critical complications, are very rare. Most of the complications were related to another aortic aneurysm. Two patients refused redo operation for another aneurysm. So I think that at the initial operation, TEVAR is the best option compared to open surgery.

Dr A. Martens: Just to comment on that, I think we all, as surgeons, don’t really like to operate on an acute ruptured type B dissection if we have a TEVAR programme, so probably this is the best solution for every patient in the acute phase. But one remark: if you’re talking about sizes of 10 or 8 in a group, you shouldn’t discuss statistical differences in detail.

Dr K. Park: I have just one question. Did you include older patients on the intention-to-treat basis? I mean, did you include all the patients who were planned to undergo TEVAR? Because, to my knowledge, there are patients who experience a failure of the procedure. So do you mean that the procedure was 100% successful, or did you exclude some patients who were intended to undergo TEVAR but failed in the angio suite?

Dr M. Masuda (Yokohama, Japan): This is just an intention-to-treat study, that is the reason we have seven patients with refusal.

Dr Park: You mean that the procedure is 100% successful, so if you intended to cover the proximal entry, you succeeded in all cases; very good result.