Institutional report - Vascular thoracic

Surgical strategies for organ malperfusions in acute type B aortic dissection

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Abstract

This study is retrospectively to evaluate strategies for organ malperfusion on the view point of two mechanisms (true lumen collapse in the aorta—Ao type, or branch dissection—Br type) in acute type B aortic dissection. There were 16 of Ao type and 4 of Br type in 20 patients with organ malperfusion. In Ao type, we performed entry closure in 12 patients, surgical bypass grafting in two to superior mesenteric artery (SMA) in one and femoral artery in two, and surgical fenestration in two. In Br type, we performed interventional non-covered stenting to the orifice of visceral arteries in two patients, surgical bypass to SMA with ileum resection in one, and surgical bypass to SAM and renal arteries in one. Five patients in 16 of Ao type died within 30 days that had two multiple organ failure after entry closure, one aortic injury during endovascular stent graft repair, two more multiple organ failure after femoral bypass, however, all four patients in Br type were rescued. Central aortic operation to true lumen collapse with entry closure for Ao type ischemia and organ reperfusion with extra-anatomical bypass or non-covered stent to ischemic arteries for Br type ischemia should be performed before catastrophic status.

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Keywords: Acute aortic dissection; Organ malperfusion; Surgical strategies

1. Introduction

Patients with life-threatening complications of acute type B aortic dissection are at very high risk and require emergency treatment using open surgical aortic graft replacement, thoracic aortic stent-grafting, interventional or surgical abdominal fenestration, or catheter reperfusion or extra-anatomic surgical bypass, or both [1–6]. Two pathophysiologic mechanisms of visceral ischemia have been proposed [2]. The first involves the true lumen collapse in the thoraco-abdominal aorta (true lumen collapse in the aorta= Ao type ischemia). The second involves symptomatic branch vessel obstruction extending dissection into visceral arteries with narrowed true lumen compressed by false lumen (branch dissection= Br type ischemia). We determine management strategies on the view point of these two mechanisms (Ao or Br type ischemia). The purpose of this study is retrospectively to evaluate our strategies for organ malperfusion in acute type B aortic dissection.

2. Methods

We managed 130 consecutive patients of acute type B aortic dissection between January 1998 and December 2007. We performed emergent surgical treatment for 20 patients (15.4%) with organ malperfusion. These 20 patients included 13 males and 7 females aged from 40 to 80 years, with a median age of 62 years. Patients’ parameters are summarized in Table 1.

The site of ischemic organ was kidney in four, intestine in 15, and lower limb in 13. A mean duration between an index dissection and an operation was 7.3 days (range, 0–62 days). There were 12 patients (60%) in whom index dissection and an operation occurred within three days.

These patients were classified into two ischemic types according to CT-scans (Fig. 1) in order to determine what kind of operative strategy is chosen. There was true lumen collapse in the thoracoabdominal aorta (true lumen collapse in the aorta=Ao type ischemia) in 16 and symptomatic branch vessel obstruction extending dissection into visceral arteries with narrowed true lumen compressed by false lumen (branch dissection= Br type ischemia) in four.

In Ao type, we firstly performed entry closure before falling multiple organ failure in 12 patients. The additional operation was succeedingly performed to the organs in which ischemia remained. The additional operations were surgical bypass grafting in two to superior mesenteric artery (SMA) in one and femoral artery in two, and surgical fenestration in two (Fig. 2). Entry closure was performed by a stent graft inserted into the descending thoracic aorta via the aortic arch (so-called open stent grafting= OS) in 11 and transluminal endovascular aortic stent-graft repair (TEVAR) in one.

In Br type, we performed interventional non-covered stenting to the orifice of visceral arteries in two patients,
### Table 1: Patient characteristics

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Ischemic organ</th>
<th>Period (day)</th>
<th>Type of ischemia</th>
<th>Operation</th>
<th>Prognosis</th>
<th>Follow-up period</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>63</td>
<td>F</td>
<td>K, B, L</td>
<td>0</td>
<td>Ao</td>
<td>OS</td>
<td>Alive</td>
<td>114</td>
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<tr>
<td>2</td>
<td>47</td>
<td>M</td>
<td>K, B, L</td>
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<td>Ao</td>
<td>OS</td>
<td>Alive</td>
<td>108</td>
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<tr>
<td>3</td>
<td>78</td>
<td>F</td>
<td>L</td>
<td>20</td>
<td>Ao</td>
<td>AxF bypass, SMA bypass</td>
<td>Early death</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>72</td>
<td>M</td>
<td>B</td>
<td>3</td>
<td>Ao</td>
<td>OS</td>
<td>Early death</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>66</td>
<td>M</td>
<td>B, L</td>
<td>2</td>
<td>Ao</td>
<td>OS</td>
<td>Early death</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>80</td>
<td>M</td>
<td>L</td>
<td>1</td>
<td>Ao</td>
<td>AxF bypass</td>
<td>Early death</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>66</td>
<td>F</td>
<td>B</td>
<td>0</td>
<td>Ao</td>
<td>TEVAR</td>
<td>Early death</td>
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</tr>
<tr>
<td>8</td>
<td>47</td>
<td>M</td>
<td>B</td>
<td>1</td>
<td>Br</td>
<td>Branch stenting (CA, SMA)</td>
<td>Alive</td>
<td>65</td>
</tr>
<tr>
<td>9</td>
<td>70</td>
<td>M</td>
<td>K, B, L</td>
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<td>Ao</td>
<td>OS, AxF bypass</td>
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<tr>
<td>10</td>
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<td>F</td>
<td>B</td>
<td>7</td>
<td>Ao</td>
<td>OS</td>
<td>Alive</td>
<td>57</td>
</tr>
<tr>
<td>11</td>
<td>79</td>
<td>M</td>
<td>B</td>
<td>4</td>
<td>Br</td>
<td>SMA bypass, intestinal resect</td>
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<td>51</td>
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<tr>
<td>12</td>
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<td>OS</td>
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<tr>
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<td>K, B, L</td>
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<td>Br</td>
<td>SMA bypass, rt renal bypass</td>
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<tr>
<td>14</td>
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<td>M</td>
<td>L</td>
<td>0</td>
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<td>OS, AxF bypass</td>
<td>Alive</td>
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<tr>
<td>15</td>
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<td>L</td>
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<td>Alive</td>
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</tr>
<tr>
<td>16</td>
<td>73</td>
<td>F</td>
<td>B, L</td>
<td>14</td>
<td>Ao</td>
<td>Flap fenestration</td>
<td>Alive</td>
<td>17</td>
</tr>
<tr>
<td>17</td>
<td>53</td>
<td>M</td>
<td>B</td>
<td>62</td>
<td>Br</td>
<td>Branch stenting (SMA)</td>
<td>Alive</td>
<td>16</td>
</tr>
<tr>
<td>18</td>
<td>74</td>
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<td>B, L</td>
<td>7</td>
<td>Ao</td>
<td>Flap fenestration</td>
<td>Alive</td>
<td>15</td>
</tr>
<tr>
<td>19</td>
<td>60</td>
<td>M</td>
<td>L</td>
<td>3</td>
<td>Ao</td>
<td>OS, AxF bypass</td>
<td>Late death</td>
<td>6</td>
</tr>
<tr>
<td>20</td>
<td>57</td>
<td>M</td>
<td>B, L</td>
<td>0</td>
<td>Ao</td>
<td>OS</td>
<td>Alive</td>
<td>11</td>
</tr>
</tbody>
</table>


M, male; F, female; K, kidney; B, bowel; L, lower limb; Ao, true lumen collapse in the aorta—Ao type ischemia; Br, branch dissection—Br type ischemia; OS, entry closure by stent graft inserted into the descending thoracic aorta via the aortic arch, so-called open stent grafting; Ax- F, axillo-femoral; Ao-F, aorto-femoral; CA, celiac artery; SMA, superior mesenteric artery; TEVAR, transluminal endovascular aortic stent graft repair.

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**Fig. 1.** Two types of ischemia into visceral arteries according to CT scans. (a) True lumen collapse compressed by false lumen in the aorta—Ao type ischemia. (b) Symptomatic branch vessel obstruction extending dissection into visceral arteries with narrowed true lumen compressed by false lumen (branch dissection—Br type ischemia).

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**Fig. 2.** Ao type ischemia (a, b: preoperative CT, c: postoperative CT after one month). There was occlusion or near occlusion of the true lumen of the descending thoracic aorta shown by emergency CT. The collapsed true lumen improved at one month after entry closure.

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**3. Results**

Five patients died within 30 days. Two in 11 of OS died because of multiple organ failure after emergent entry closure over 6 h from index ischemia with severe metabolic acidosis. Only one of TEVAR died because of intraoperative aortic injury by the sheath inserted into the collapsed true lumen. Two in three of femoral bypasses alone died because of multiple organ failure with disseminated intravascular coagulation syndrome and aortic rupture of the false lumen. Five patients (31%) in 16 of Ao type died, however, all four patients of Br type were rescued. Postoperative complications occurred in three patients, including one mediastinitis in OS, two transient renal deficiencies in OS and SMA/RA bypass, and no neurological deficiency. Fifteen patients, except for five deaths, were discharged to their own home (Table 1).
4. Discussion

Medical treatment is usually performed as the initial approach for acute type B dissections \[7\]. Patients with life-threatening complications of acute type B aortic dissection are at very high risk associated with a high operative mortality of 36–60% \[8\] and require emergency treatment using open surgical aortic graft replacement, thoracic aortic stent-grafting, interventional or surgical abdominal fenestration, or catheter reperfusion or extra-anatomical surgical bypass, or both. Endovascular techniques have been proposed as a less invasive alternative before catastrophic state. Recently, excellent results of entry closure by endovascular stent-graft repair and direct non-covered stent-treatment to dissected visceral arteries were reported, which excellent interventional technology supported \[1, 3, 5, 6, 8\].

Two pathophysiologic mechanisms of ischemia have been proposed \[2\]. The first involves the true lumen collapse within the descending thoracic aorta. This process occurs, most commonly, in the setting of a deep proximal tear with an absence of a large distal fenestration. The false lumen pressure increases as a result of poor outflow, which in turn results in true lumen compression that ultimately inhibits flow to the viscera and lower limb. The second involves symptomatic branch vessel obstruction extending into visceral arteries with narrowed true lumen compressed by false lumen without detectable blood flow.

Orihashi subscribes four perfusion patterns of visceral arteries. 1) No dissection in the branch artery with detectable blood flow. 2) The dissection extending into the branch artery with patent and dominant true lumen associated with small non-perfused or perfused false lumen. 3) The dissection extending into the branch artery with narrowed true lumen compressed by false lumen without detectable blood flow. 4) No dissection in the branch artery but the orifice obstructed by the intimal flap in the aorta \[9\]. We proposed it is classified into two perfusion patterns as an organ malperfusion. One is dissection extending into branch arteries with narrowed true lumen compressed by false lumen without detectable blood flow (branch dissection = Br type ischemia) and the other is dissection with organ malperfusion by the collapsed true lumen in the aorta (true lumen collapse in the aorta = Ao type ischemia). We determine management strategies on the view point of these two mechanisms (Ao or Br type ischemia). Thus, we proposed central aortic operation to collapsed true lumen with entry closure for Ao type ischemia and organ reperfusion treatment with extra-anatomical bypass or non-covered stent directly to ischemic arteries for Br type ischemia.

The interval between the appearance of complications and surgical treatment is related to the high mortality and morbidity of complicated acute type B dissection. If severe metabolic acidosis develops because of delayed surgery after the onset of ischemia and irreversible necrosis, organs cannot be salvaged even if entry closure restores blood flow via the true lumen. Resection of the necrotic ilium is needed for such catastrophic cases \[4\]. Instead of fenestration and reconstruction of the ischemic arteries, entry closure is a radical treatment for acute type B dissection when ischemia remains reversible. CT is important for finding risk factors related to complicated acute dissection before the onset of complications. When collapse of the true lumen and branch dissection are recognized on CT scans in a patient with acute type B dissection, a false lumen that is a cul-de-sac without re-entry is an important indicator for a high risk of complicated acute dissection. Multi-slice CT can provide details about true-false communications and the visceral arteries.

The majority of patients with complicated type B dissections not only have the main entry located immediately distal to the origin of the left subclavian artery, but also have a spiral aorta with collapse of the true lumen. These factors complicate transluminal endovascular aortic stent graft repair (TEVAR) via the femoral or iliac artery and reintervention is often required. Successful TEVAR via the right axillary artery for complicated dissection has been reported \[10\], so progress in TEVAR techniques and materials has led to the same results as those of open stent grafting.

Unlike TEVAR, there are no type I endoleaks after open stent grafting, which is achieved by direct suturing to the aortic arch and allows easy anchoring across the arch.

Fig. 3. Br type ischemia (a: near occlusion of the orifice of celiac artery, b: after stenting into celiac artery). Intervventional non-covered stenting to the orifice of visceral arteries (celiac and superior mesenteric artery) was performed in case 8.

Fig. 4. Survival curve.

One more death occurred during a median follow-up of 31.7 (range, 11–114) months, one related to the arch graft (not stent graft) chronic infection of a patient with mediastinitis eight months after operation. The other 15 patients had no complications and no dissection-related events. The overall survival at five years was 70% (Fig. 4).
vessels. TEVAR also has anatomical limitations, such as a tortuous and narrow iliac artery or aorta, and there is difficulty managing the arch vessels using special materials like fenestrated grafts or branch grafts. Furthermore, TEVAR requires a stent graft of the tapering type with different proximal and distal diameters. In particular, the proximal diameter differs from the distal diameter in aortic dissection with a collapsed true lumen. Open stent grafting with sternotomy allows concomitant heart surgery, total arch replacement, coronary artery bypass grafting, and Bentall’s procedure, as well as others. Open stent grafting also allows effective management of arch vessels with abundant atherosclerotic plaque, dilatation of the ascending aorta, and annuloaortic ectasia. However, TEVAR might be able to achieve better results for difficult cases in the future with progress in stent-graft materials. Open stenting is one option for endovascular stent-graft repair of acute type B dissection, but the major disadvantages of open stent grafting are complications related to cardiopulmonary bypass under selective cerebral perfusion [11]. This is the reason why emergency surgery after stabilizing the general condition is recommended for complicated acute type B dissection associated with ischemia.

Ao type frequently had more serious complications compared with Br type because of other multiple organ failures in many cases. Therefore, early entry closure before falling multiple organ failure is more important for Ao type. It will be expected that TEVAR is a less invasive and effective procedure for early entry closure. On the other hand, Br type frequently had single organ failure at the lesion through only one vessel and interventional treatment for a visceral artery was effective. However, Br has only four experiences and a conclusion cannot be clearly drawn.

In conclusion, management strategies on the view point of these two mechanisms (Ao or Br type ischemia) should be selected, that central aortic operation to a collapsed true lumen with entry closure for Ao type ischemia and organ reperfusion with extra-anatomical bypass or non-covered stent directly to ischemic arteries for Br type ischemia, before catastrophic status with severe metabolic acidosis.

References