Risk Factors Affecting Survival after Surgical Repair of Ruptured Abdominal Aortic Aneurysm

Hideyuki Kunishige, MD, Yoshimitsu Ishibashi, MD, Masakazu Kawasaki, MD, Kiyotaka Morimoto, MD, and Nozomu Inoue, MD

Purpose: The purpose of this study is to identify the risk factors affecting the high mortality rates associated with the treatment of ruptured abdominal aortic aneurysm (AAA).

Methods: In this retrospective study, the subjects consisted of 105 patients who underwent repair of ruptured AAA at our institution from December 1984 to March 2012. We compared the patients of ruptured AAA in survival group with those in death group to evaluate the clinical factors in ruptured AAA mortality.

Results: The operative and in-hospital mortality of ruptured AAA patients was 22.9% compared with 1.9% for that of non-ruptured AAA patients. The mean hemoglobin level was significantly lower in death group than in survival group. Intraoperative bleeding volume was significantly higher in death group than in survival group. Cox proportional hazard analysis showed that level 3 or 4 according to the Rutherford classification, preoperative hemoglobin level of less than 9.0 g/dl, intraoperative blood loss volume of more than 3000 ml, postoperative bowel ischemia and class 3 or 4 according to the Fitzgerald classification were significantly associated with high mortality.

Conclusion: These findings showed that every effort to maintain preoperative hemodynamic stability reduces volumes of blood loss in operation, and to minimize postoperative deterioration of organ functions would be essential to improve patient survival.

Keywords: ruptured abdominal aortic aneurysm, postoperative mortality

The operative mortality following non-ruptured abdominal aortic aneurysm (AAA) has achieved satisfactory results. It has been attributed to improved surgical techniques and postoperative risk management. In contrast, incidence of death following surgery for ruptured AAA remains high despite similar improvements in perioperative management. The purpose of this study was to identify the risk factors affecting the high mortality rates associated with the treatment of ruptured AAA.

Material and Methods

Between December 1984 and March 2012, a total of 630 consecutive patients underwent surgery for AAA at our institution, 105 (16.7%) of whom required emergency surgery for ruptured AAA. All patients had computed tomography (CT) scan and were diagnosed with an accurate date of onset. Ruptured AAA was diagnosed on the basis of acute abdominal pain and/or lumbago and by CT evidence of an aortic rupture. The size of the aneurysm was determined by CT or the operative report. Surgical exposure was gained through a midline incision and occasionally rapid control of ruptured AAA was achieved proximally by manual compression. The infrarenal aorta was then cross-clamped with vascular
forceps, after which clamps were placed on the iliac arteries. All patients were treated with an aortic bifurcation graft, either to the iliac or femoral arteries. There was no patient who received endovascular aneurysm repair (EVAR) for ruptured AAA. First EVAR for non-ruptured AAA was performed in 2008 in our institution and since then EVAR was performed only to patients for elective non-ruptured AAA. Surgical intervention was generally not undertaken if the patient declined operation, had a known serious comorbidity such as advanced malignancy, or was otherwise in unsuitable conditions, such as refractory loss of consciousness, cardiac arrest, severe dementia, or poor functional states.

Operative mortality was defined as death occurring within 30 days of surgery, regardless of whether the patient has or has not been discharged from the hospital. Deaths that occurred after 30 days postoperatively without discharge were defined as in-hospital deaths. The patients were divided into survival group and death group.

The preoperative factor included age, gender, the creatinine (Cr) and hemoglobin (Hb) level on admission, the size of aneurysm. Hemodynamic status of patients defined according to the Rutherford classification\(^\text{1}\) that level 1: no hypotension (pain only); level 2: transient hypotension, with satisfactory response to resuscitation (presumed contained rupture); level 3: incomplete response to resuscitation, with persistent or recurrent hypotension and/or no restoration of urine output; and level 4: negligible response to resuscitation.

The intraoperative factors included blood loss, type of rupture, and operation time. We checked the amount of blood loss by counting the amount of blood collected in a suction bottle during the operation. Rupture types were defined according to the Fitzgerald classification\(^\text{2}\) that type 1 included intramural bleeding or a small hematoma, type 2 included a hematoma below the renal arteries and including the pelvis, type 3 comprised a hematoma extending above the renal arteries and into the pelvis, and type 4 comprised free blood in the peritoneal cavity.

The postoperative factors included myocardial infarction, respiratory failure, renal failure, brain infarction and bowel ischemia.

Statistical analyses were performed with the Mann-Whitney U test for comparisons between the survival and death groups. Data analysis is performed with the use of Dr. SPSS II for Windows software (version 11.01J; SPSS, Tokyo, Japan). Significance was assumed at a p level of <0.05. Results are expressed as the mean ± standard deviation.

**RESULTS**

One hundred and five patients underwent repair of ruptured AAA and five hundred and twenty five patients underwent AAA repair for non-ruptured aneurysms during the study period. The operative and in-hospital mortality of ruptured AAA patients was 22.9% (24/105) compared with 1.9% (10/525) for that of non-ruptured AAA patients.

The average age of patients repaired for ruptured AAA during the study period was 71.9 ± 9.2 years and the mean aneurysm diameter of preoperative CT scan was 71.2 mm. The sexual distribution was 84 male patients (80.0%) and 21 female patients (20.0%).

Ruptured AAA patients were surgically treated and divided into operative survival group (n = 81) and death group (n = 24). Various factors were compared between the two groups (Fig. 1). A comparison of variable observed between groups is listed in Table 1.

**Preoperative factors**

The mean of preoperative hemoglobin level was 10.6 ± 2.6 g/dl for survival group and 9.3 ± 2.4 g/dl for death group. Rutherford classification level 1 patients were 50 for survival group and 6 for death group, level 4 patients were 12 for survival group and 15 for death group.

**Intraoperative factors**

The mean volumes of blood loss at operation were 2074 ± 3404 g for survival group, compared with
Multivariate Cox proportional hazard analysis was applied for the survival or death group to determine the independent effects of mortality for surgical treatment (Table 3). Among Preoperative factors, hemoglobin level less than 9.0 g/dl, state of shock and level 3 or 4 according to the Rutherford classification were statistically significant. Among intraoperative factors, intraoperative blood loss volume of more than 3000 ml and type 3 or 4 according to the Fitzgerald classification were statistically significant. Among post operative factors, bowel ischemia was statistically significant.

### Table 1  The relationship with prognosis after surgical repair of ruptured abdominal aortic aneurysm and parameters

<table>
<thead>
<tr>
<th>Preoperative factor</th>
<th>Survival group (n = 81)</th>
<th>Death group (n = 24)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>71.3 ± 9.1</td>
<td>73.9 ± 9.3</td>
<td>NS</td>
</tr>
<tr>
<td>Male:Female</td>
<td>66:15</td>
<td>18:6</td>
<td>NS</td>
</tr>
<tr>
<td>Creatinine (mg/dl)</td>
<td>1.4 ± 0.8</td>
<td>1.6 ± 0.9</td>
<td>NS</td>
</tr>
<tr>
<td>Hemoglobin (g/dl)</td>
<td>10.6 ± 2.6</td>
<td>9.3 ± 2.4</td>
<td>0.0291</td>
</tr>
<tr>
<td>AAA size (mm)</td>
<td>73.3 ± 23.7</td>
<td>64.0 ± 28.9</td>
<td>NS</td>
</tr>
<tr>
<td>Rutherford classification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>level 1</td>
<td>50</td>
<td>6</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>level 2</td>
<td>11</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>level 3</td>
<td>8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>level 4</td>
<td>12</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Intraoperative factor</td>
<td>Blood loss (g)</td>
<td>2074 ± 3404</td>
<td>3844 ± 4055</td>
</tr>
<tr>
<td>Fitzgerald classification</td>
<td>type 1</td>
<td>30</td>
<td>4</td>
</tr>
<tr>
<td>type 2</td>
<td>26</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>type 3</td>
<td>18</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>type 4</td>
<td>7</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Postoperative factor</td>
<td>Myocardial infarction</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>4</td>
<td>4</td>
<td>NS</td>
</tr>
<tr>
<td>Renal failure</td>
<td>4</td>
<td>6</td>
<td>NS</td>
</tr>
<tr>
<td>Brain infarction</td>
<td>1</td>
<td>1</td>
<td>NS</td>
</tr>
<tr>
<td>Bowel ischemia</td>
<td>0</td>
<td>2</td>
<td>0.009</td>
</tr>
</tbody>
</table>

AAA: abdominal aortic aneurysm; NS: not significant

### Table 2  Comparison of Fitzgerald classification with parameters

<table>
<thead>
<tr>
<th></th>
<th>Hb (g/dl)</th>
<th>Blood loss (g)</th>
<th>Shock (%)</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>12.0</td>
<td>947</td>
<td>0.0</td>
<td>12.9</td>
</tr>
<tr>
<td>Type 2</td>
<td>11.6</td>
<td>1684</td>
<td>22.2</td>
<td>14.8</td>
</tr>
<tr>
<td>Type 3</td>
<td>9.1</td>
<td>2013</td>
<td>53.3</td>
<td>26.7</td>
</tr>
<tr>
<td>Type 4</td>
<td>7.8</td>
<td>5778</td>
<td>100.0</td>
<td>63.2</td>
</tr>
</tbody>
</table>

Hb: hemoglobin

3844 ± 4055 g for death group. Extent of hematoma, Fitzgerald classification was different between the two groups. Significantly, classification type 1 patients were 30 for survival group and 4 for death group, type 4 patients were 7 for survival group and 12 for death group. Table 2 noted a steady rise in intraoperative blood loss, rates of shock and hospital mortality rates with advancing Fitzgerald classification.

### Postoperative complications

Respiratory failure occurred in 4 patients of survival group (4.9%), and 4 patients of death group (16.7%). Renal failure occurred in 6 patients of survival group (7.4%), and 4 patients of death group (16.7%). Bowel ischemia was lethal complication occurring in 2 patients of death group (8.3%) that was more often than survival group.

Multivariate Cox proportional hazard analysis was applied for the survival or death group to determine the independent effects of mortality for surgical treatment (Table 3). Among Preoperative factors, hemoglobin level less than 9.0 g/dl, state of shock and level 3 or 4 according to the Rutherford classification were statistically significant. Among intraoperative factors, intraoperative blood loss volume of more than 3000 ml and type 3 or 4 according to the Fitzgerald classification were statistically significant. Among post operative factors, bowel ischemia was statistically significant.

### Discussion

The mortality rate of ruptured AAA remains remarkably
sistent hypotension despite fluid resuscitation was closely associated with mortality rate. Additionally, preoperative hemoglobin level less than 9.0 g/dl, reflected the volume of blood loss and the blood transfusion requirement, which influenced the mortality rate in our study as in others.\textsuperscript{14–16)} In principle, we did not use catecholamines before the operation except for patients who required cardiopulmonary resuscitation and those in prolonged state of severe shock with level 3 or 4 according to Rutherford classification. Once a diagnosis of ruptured AAA has been made, it is important to concentrate on resuscitating the patient from shock state by massive volume infusion and transfer the patient to the operating room as soon as possible. But a laparotomy should not be undertaken without preparing blood for transfusion.

Intraoperative blood loss and extent of hematoma due to massive hemorrhage were also showed to be significant factors associated with mortality. Robert, et al.\textsuperscript{17)} suggested that permissive hypotension given to maintain a systolic blood pressure of 80–100 mmHg until aortic control achieved is a method used to decrease the risk of uncontrolled hemorrhage. This technique is to prevent an increase in blood pressure from excessive volume admission in order to avoid advancing Fitzgerald classification, converting a contained retroperitoneal hemorrhage into a free intraperitoneal hemorrhage.\textsuperscript{8)} Crawford advocated that no significant attempt should be made for blood volume resuscitation until the time of surgery, and that the systolic blood pressure be maintained at 50–70 mmHg with small volume of whole blood or crystalloid until the aorta is clamped.\textsuperscript{18)}

Bowel ischemia was significantly associated with the postoperative mortality. Intra-abdominal hypertension is an important factor in the development of bowel ischemia and begins when hematoma from aortic rupture and edema from fluid resuscitation reduce abdominal domain. A reduced abdominal compartment and elevated intra-abdominal pressure compress the vena cava, liver,
bowel, and kidneys and worsen end-organ perfusion. Rasmussen, et al.\textsuperscript{19} suggested that initial use of mesh-based abdominal closure after ruptured AAA repair minimizes abdominal compartment syndrome and reduce the rate of mortality as the result of multiple organ failure. Renal failure has also been extensively analyzed.\textsuperscript{20-22} Abbott, et al.\textsuperscript{23} suggested performing aggressive postoperative dialysis and the use of special postoperative hyperalimentation fluid regimens to decrease this mortality rate. In our study, respiratory failure and renal failure were tend to be occurred in death group rather than survival group, however there was no significant difference statistically, it was suggested as a certain trend.

The ideal treatment of ruptured AAA is prevention. Approximately, almost our ruptured AAA patients were unaware of the AAA before rupture. The implementation of a screening program has been suggested to decrease the incidence of ruptured aneurysms. Wilmink, et al.\textsuperscript{24} used ultrasound scanning to screen all men older than 50 years and reduced the incidence rate of rupture by 49%. Continued recognition of patients of non-ruptured aneurysm and repair in the elective setting with low mortality rate remains the ideal treatment, either with open or endovascular management. Regarding ruptured AAA, our findings showed that every effort to maintain preoperative hemodynamic conditions, to reduce volumes of blood loss at operation, and to minimize deterioration of organ functions postoperatively is all essential to improve patient survival.

There were several limitations to the present investigation. This study was consisted of small numbers and not a prospective controlled randomized study. A potential bias exists because of the other factors influencing the outcome of our patients with various complications such as pulmonary emphysema, and making it difficult to precisely determine the critical size for aortic rupture. More detailed study of these issues is needed.

Furthermore, the therapeutic strategies for ruptured AAA operation have changed over the years, particularly for the high risk patient, where new interventional methods with endovascular management may show promising result. Some surgeons have reported the advantages of EVAR even for ruptured AAA. The first series describing EVAR for ruptured AAA by Ohki, et al.\textsuperscript{25} included 12 patients treated with a custom-made stent graft, with a mortality rate of 12%, suggesting that EVAR for ruptured AAA could potentially improve the traditionally high mortality rates associated with open repair. Since then, the dissemination of endovascular technology has allowed centers to offer EVAR to a wide range of patients with more complex anatomy, and to perform EVAR as the first line of treatment for ruptured AAA in many cases.\textsuperscript{26} Mehta, et al.\textsuperscript{27} reported they achieved a mortality rate of 18% with emergent endovascular repair of hemodynamically stable and unstable patients. Davenport, et al.\textsuperscript{28} asserted, the performance of EVAR in ruptured AAA patients with favorable anatomy could potentially result in lower morbidity and decreased transfusion requirements, as compared with open repair. However this time, we have not yet introduced EVAR for ruptured AAA. More detailed study of these issues is needed.

This study might provide a direction for the continued discussion of management of patients with ruptured AAA.

**Disclosure Statement**

All authors have no conflict of interest.

**References**


