Determining Perioperative Mortality in Patients with Ruptured Abdominal Aortic Aneurysm: Insights from a Retrospective Cohort Study

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ABSTRACT

Objective: This retrospective cohort study analyzed factors determining perioperative mortality in patients with ruptured abdominal aortic aneurysm (rAAA) undergoing open surgical repair (OSR) or endovascular aneurysm repair (EVAR).

Materials and Methods: 147 rAAA patients who underwent OSR (n=37) or EVAR (n=110) between 2000 and 2017 were included. Demographic data, intraoperative details, and perioperative complications were assessed. Logistic regression analysis identified factors associated with perioperative mortality. The primary endpoint was perioperative mortality rate, and the secondary endpoint focused on factors determining 30-day mortality.

Results: Overall perioperative mortality was 19.04% (28/147), with 8.1% (3/37) for OSR and 22.7% (25/110) for EVAR (p=0.139). The non-survived group had more unfit patients (82.1% vs. 47.9%, p=0.002), higher preoperative serum creatinine levels (1.8±1.74 vs. 1.4±5.89, p=0.011), and higher rates of aortic balloon usage (64.3% vs. 22.7%, p<0.001) and cardiac arrest (28.6% vs. 3.4%, p<0.001). Multivariable analysis identified age >80 years (adjusted odds ratio [aOR] 9.785, p=0.003), unfit patient status (aOR 3.35, p=0.028), aortic balloon usage (aOR 5.54, p=0.036), postoperative myocardial infarction (aOR 13.995, p<0.001), postoperative congestive heart failure (aOR 15.22, p=0.038), and abdominal compartment syndrome (aOR 23.397, p<0.001) as independent predictors of 30-day mortality.

Conclusion: No significant difference in perioperative mortality was found between OSR and EVAR in rAAA patients. Several independent factors predicting 30-day mortality were identified, providing valuable insights for clinicians in predicting outcomes and improving patient care in rAAA cases.

Keywords: Ruptured abdominal aortic aneurysm; perioperative mortality factors (Siriraj Med J 2024; 76: 480-487)

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INTRODUCTION

Rupture abdominal aortic aneurysm (rAAA) is a life-threatening condition in the field of surgery, demanding prompt intervention. Traditionally, open surgical repair (OSR) has been the established invasive treatment for rAAA. However, over the past two decades, endovascular aortic aneurysm repair (EVAR) has emerged as a proven method for reducing 30-day mortality in asymptomatic AAA repair[1,2] and has gained increasing popularity for rAAA management.[3,4]

Despite advancements in pre-hospital care, fast-track protocols, and endovascular technologies, it remains unclear whether there have been improvements in the outcomes related to 30-day mortality in rAAA.[5,6] Also, the existing literature lacks a comprehensive analysis of the specific factors contributing to perioperative mortality in both open and endovascular treatments for rAAA.

Therefore, the primary objective of this retrospective cohort study was to analyze the 30-day mortality rates and identify the factors that contribute to perioperative mortality in both OSR and EVAR for rAAA. By examining a large dataset of patients, this study aimed to provide valuable insights into the effectiveness of these treatment modalities and potentially guided clinical decision-making for better patient outcomes.

MATERIALS AND METHODS

Study design and ethical approval

This retrospective cohort study utilized data from a prospective database approved by the Siriraj Institution Review Board (SIRB Protocol no. 612/2561). The database included information on patients diagnosed with ruptured abdominal aortic aneurysm (rAAA) who underwent either open surgical repair (OSR) or endovascular aortic aneurysm repair (EVAR) at our institute from January 2000 to December 2017.

Patient selection

A total of 150 patients with rAAA were initially included in the study. However, three patients were excluded due to aortoenteric and aortocaval fistula diagnoses in two cases, and one case with missing data. The inclusion criteria consisted of patients aged 18–90 years old with a radiological diagnosis of rAAA or confirmation through intraoperative findings.

Preoperative factors

Various preoperative factors were considered, including age, gender, coronary arterial disease, chronic obstructive pulmonary disease, hypertension, dyslipidemia, type 2 diabetes, cerebrovascular disease, current smoking, unfit patient status, cardiac arrhythmia, antiplatelet drug usage, hemoglobin level, creatinine level, and coagulogram results. The selection of patients with rAAA, whether fit or unfit, has been previously described based on their cardiac, respiratory, and renal status in the UK EVAR 1 and 2 trials.[7]

Intraoperative factors

The treatment strategy (EVAR vs. OSR), intraoperative aortic balloon occlusion, cardiac arrest, intraoperative blood loss, intraoperative blood replacement, and procedure duration were analyzed as intraoperative factors. Efforts were made to stabilize patients' hemodynamic status before surgery through hypotensive resuscitation and limited fluid resuscitation to promptly diagnose issues and enable them to recover from a state of shock. The intraoperative aortic balloon occlusion was employed in case where patients were deemed unstable, specifically those who were unconscious or had low systolic blood pressure (less than 80 mmHg).

Postoperative factors

Postoperative factors included postoperative myocardial infarction, postoperative congestive heart failure, abdominal compartment syndrome, chest infection, ischemic colitis, and wound infection. These factors were examined to assess postoperative complications and outcomes.

Abdominal compartment syndrome (ACS) is characterized by the presence of intraabdominal pressure exceeding 20 mmHg, accompanied by the onset of organ dysfunction or failure.[8] The tool for measuring bladder pressure is a three-way Foley catheter using the patient's urine as pressure medium. A minimum of 25 mL should be instilled into the bladder, and the patient should be in the supine position.[9]

Outcome measures

The primary outcome measured in this study was the perioperative mortality rate. Additionally, secondary outcomes focused on identifying factors contributing to 30-day mortality and comparing postoperative complications and re-interventions between EVAR and OSR.

Statistical analysis

Data were recorded and analyzed using PASW Statistics 18.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to summarize the characteristics of the study population. Univariable analyses were initially conducted to examine the association between 30-day mortality and various factors. Categorical variables were analyzed using chi-square tests or Fisher's exact tests,

as appropriate. Continuous variables were compared using t-tests or Mann–Whitney U tests, depending on the distribution of the data. Factors that were found to be significant in the univariable analysis ($p < 0.05$) were then included in the multivariable logistic regression analysis. The multivariable analysis aimed to identify independent predictors of 30-day mortality. Variables were entered into the model using a stepwise selection method based on their significance in the univariable analysis and their clinical relevance. Adjusted odds ratios (aOR) with 95% confidence intervals (CIs) were calculated to quantify the strength of association between the independent predictors and the 30-day mortality. A *p-value* < 0.05 was considered statistically significant. Missing data were handled through complete case analysis, whereby cases with missing data were excluded from the specific analysis.

RESULTS

Of the 37 patients in the OSR group, 34 survived while 3 patients died within 30 days after the operation. Among the 110 patients who underwent EVAR, 85 survived and 25 patients died within 30 days after the operation. The overall 30-day mortality for rAAA was 19%, with 22.7% for EVAR and 8.1% for OSR ($p = 0.139$).

We analyzed a total of 147 patients, comprising 119 patients in the survived group and 28 patients in the non-survived group. The mean age of the survived group was 70.33±12.2 years old, while the average age was 74.82±8.8 years old for the non-survived group ($p = 0.069$). The most common comorbidity in both groups was hypertension. However, there was a significant difference in the percentage of unfit patients, with 47.9% of the patients in the survived group being classed as unfit compared to 82.1% in the non-survived group ($p = 0.002$) (Table 1). The definition of the unfit patient status was based on the UK EVAR 1 and 2 trials[7], which considered cardiac, respiratory, and renal conditions.

In terms of preoperative blood chemistry, we found a significant difference in the level of serum creatinine (mg/dL) between the survived group (1.40±5.89) and the non-survived group (1.80±1.74), ($p = 0.011$). Additionally, there were no significant differences in the level of hemoglobin (g/dL) and coagulogram levels between both groups (Table 1).

For intraoperative details (Table 2), there was no statistically significant difference between the survived and non-survived groups in EVAR treatment ($p = 0.086$). However, the usage of intraoperative aortic balloon occlusion was significantly higher in the non-survived group (18 patients, 64.3%) compared to the survived group (27 patients, 22.7%) ($p < 0.001$). Additionally, the percentage of cardiac arrest was significantly higher in the non-survived group (8 patients, 28.6%) compared to the survived group (4 patients, 3.4%) ($p < 0.001$).

Regarding early postoperative complications (Table 3), we observed a statistically significant increase in postoperative congestive heart failure and myocardial infarction in the non-survived group compared to the survived group (10.7% vs. 0.8%, $p = 0.022$ and 53.6% vs. 10.1%, $p < 0.001$, respectively). Similarly, the incidence of abdominal compartment syndrome was significantly higher in the non-survived group than in the survived group (53.6% vs. 12.6%, $p < 0.001$).

Table 4 presents the crude and adjusted odds ratios (95% CI) for the factors associated with 30-day mortality. Logistic regression analysis was performed to determine the statistical significance of these factors. Age > 80 years old (aOR, 9.785; 95% CI, 2.128–45.008; $p = 0.003$), unfit patient status (aOR, 3.35; 95% CI, 1.136–9.893; $p = 0.028$), aortic balloon usage (aOR, 5.54; 95% CI, 1.116–27.54; $p = 0.036$), postoperative myocardial infarction (aOR, 13.995; 95% CI, 3.171–61.767; $p < 0.001$), postoperative congestive heart failure (aOR, 15.22; 95% CI, 1.163–199.2; $p = 0.038$), and abdominal compartment syndrome (aOR, 23.397; 95% CI, 5.551–98.614; $p < 0.001$) were independent predictors of 30-day mortality.

When comparing EVAR and OSR (Table 5), differences in procedural characteristics were observed. The length of the procedure was significantly shorter in the EVAR group (155 minutes) compared to the OSR group (245 minutes) ($p < 0.001$). Intraoperative blood loss was also significantly lower in the EVAR group (300 ml) compared to the OSR group (3500 ml) ($p < 0.001$). Similarly, the EVAR group required significantly less intraoperative blood replacement (1 unit) compared to the OSR group (7 units) ($p < 0.001$).

DISCUSSION

In this study, we aimed to analyze the perioperative mortality rates and factors influencing mortality in patients undergoing OSR and EVAR for rAAA. Our findings indicate that perioperative mortality is higher in OSR, but there was no statistically significant difference between OSR and EVAR. Several factors were identified as independent predictors of 30-day mortality in rAAA, including an unfit patient status, age over 80 years old, intraoperative aortic balloon usage, postoperative myocardial infarction, postoperative congestive heart failure, and abdominal compartment syndrome. Below, we discuss these findings in detail and explore their implications.

The absence of a significant difference in perioperative

TABLE 1. Baseline characteristics of the patients with ruptured AAA.

Baseline characteristics	Survived (n=119)	Non-survived (n=28)	*p*-value
Age, mean (SD) years	70.33 (12.2)	74.82 (8.8)	0.069
Male gender, no (%)	103 (86.6%)	24 (85.7%)	1.000
Coronary arterial disease, no (%)	20 (16.8%)	5 (17.9%)	1.000
COPD, no (%)	12 (10.1%)	3 (10.7%)	1.000
Hypertension, no (%)	93 (78.2%)	20 (71.4%)	0.610
Dyslipidemia, no (%)	35 (29.4%)	7 (25%)	0.816
Type 2 Diabetes, no (%)	26 (21.8%)	5 (17.9%)	0.835
Cerebrovascular disease, no (%)	10 (8.4%)	1 (3.6%)	0.635
Current smoking, no (%)	17 (14.3%)	6 (21.4%)	0.387
Unfit patient status, no (%)	57 (47.9%)	23 (82.1%)	***0.002***
Cardiac arrhythmia, no (%)	8 (6.7%)	1 (3.6%)	1.000
Antiplatelet drug, no (%)	28 (23.5%)	7 (25%)	1.000
Hemoglobin level, mean (SD) g/dl	9.59 (2.05)	9.80 (2.69)	0.657
Creatinine level, mean (SD) mg/dl	1.4 (5.89)	1.8 (1.74)	***0.011***
PT, mean (SD) sec	14.5 (3.11)	14.5 (2.51)	0.964
APTT, mean (SD) sec	28.7 (16.7)	29 (9.64)	0.501

Abbreviation: no, number; SD, standard deviation; COPD, chronic obstructive pulmonary disease; PT, prothrombin time; PTT, partial thromboplastin time.
A *p*-value<0.05 indicates statistical significance.

TABLE 2. Intraoperative variables of the patients with ruptured AAA.

Intraoperative variables	Survived (n=119)	Non-survived (n=28)	*p*-value
EVAR treatment, no (%)	85 (71.4%)	25 (89.3%)	0.086
Aortic balloon occlusion, no (%)	27 (22.7%)	18 (64.3%)	***<0.001***
Cardiac arrest, no (%)	4 (3.4%)	8 (28.6%)	***<0.001***
Intraoperative blood loss, median (Min–Max) ml	425 (20–14900)	500 (50–21000)	0.195
Intraoperative blood replacement, median (Min–Max) unit	2 (0–19)	2.5 (0–17)	0.270
Length of procedure, median (Min–Max) mins	170 (50–530)	207.5 (90–590)	0.061

A *p*-value<0.05 indicates statistical significance.

TABLE 3. Postoperative complications of the patients with ruptured AAA.

Baseline characteristics	Survived (n=119)	Non-survives (n=28)	*p*-value
Congestive heart failure	1 (0.8%)	3 (10.7%)	***0.022***
Postoperative myocardial infarction	12 (10.1%)	15 (53.6%)	***<0.001***
Abdominal compartment syndrome	15 (12.6%)	15 (53.6%)	***<0.001***
Chest infection	29 (24.4%)	8 (28.6%)	0.827
Ischemic colitis	8 (6.7%)	3 (10.7%)	0.734
Wound infection	6 (5.0%)	1 (3.6%)	1.000

A *p*-value<0.05 indicates statistical significance.

TABLE 4. Results from logistic regression analysis of the factors associated mortality in the patients with ruptured AAA.

Factors	Crude OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
Age > 80 years old	3.284 (1.257–8.579)	***0.015***	9.785 (2.128–45.008)	***0.003***
Unfit patient status	2.739 (0.830–9.032)	0.098	3.352 (1.136–9.893)	***0.028***
Creatinine level >1.3 mg/dl	0.974 (0.876–1.083)	0.626		
EVAR treatment	3.313 (0.679–16.16)	0.139	3.241 (0.667–15.75)	0.145
Aortic balloon usage	2.379 (0.730–7.752)	0.150	5.543 (1.116–27.54)	***0.036***
Cardiac arrest	11.5 (3.163–41.81)	***< 0.001***	9.87 (0.96–78.7)	0.087
Postoperative Myocardial infarction	10.29 (3.968–26.67)	***< 0.001***	13.995 (3.171–61.767)	***< 0.001***
Abdominal compartment syndrome	8 (3.191–20.05)	***< 0.001***	23.397 (5.551–98.614)	***< 0.001***
Postoperative congestive heart failure	15.9 (1.2–211.6)	***0.036***	15.22 (1.163–199.2)	***0.038***

A *p*-value<0.05 indicates statistical significance.

mortality rates between OSR and EVAR in our study aligns with previous research in this field. For instance, the AJAX trial[10] conducted in the Netherlands reported a 30-day mortality rate of 21% for EVAR compared to 25% for OSR (p = 0.66), with an overall perioperative mortality of 23.2%. Similarly, the ECAR trial[11] conducted in France reported a 30-day mortality rate of 18% for EVAR compared to 24% for OSR (p = 0.239), with an overall perioperative mortality of 20.5%. On the other hand, the IMPROVE trial[12] conducted in the UK reported a 30-day mortality rate of 35.4% for EVAR compared to 37.4% for OSR (p = 0.62), with an overall perioperative mortality of 36.3%. These trials collectively suggest that both OSR and EVAR are viable treatment options for rAAA patients, as they yield similar outcomes in terms of perioperative mortality.

TABLE 5. Comparison results of endovascular and open repair in the patients with ruptured AAA.

Variables	EVAR (n=110)	Open surgical repair (n=37)	*p*-value
Unfit status	71 (64.5%)	9 (24.3%)	***<0.001***
Length of procedure, median (Min–Max) minutes	155 (50–590)	245 (95–530)	***<0.001***
Intraoperative blood loss, median (Min–Max) ml	300 (20–2100)	3500 (500–8500)	***<0.001***
Intraoperative blood replacement, median (Min–Max) units	1 (0–19)	7 (3–24)	***<0.001***
Aortic balloon occlusion usage	30 (27.3%)	15 (40.5%)	0.191
Perioperative complications	54 (49.1%)	22 (59.5%)	0.367
Abdominal compartment syndrome	22 (20%)	8 (21.6%)	0.978
Perioperative re-interventions	22 (20%)	4 (10.8%)	0.309
Length of ICU stay, median (Min–Max) days	2 (0–90)	5 (0–80)	0.637
Length of Hospital stay, median (Min–Max) days	13.5 (1–180)	15 (1–120)	0.527

A *p*-value<0.05 indicates statistical significance.

Our study identified several factors that independently predicted 30-day mortality in patients with rAAA who did not survive the perioperative period. Notably, we found that an unfit patient status was associated with a high mortality rate after both open surgical repair (OSR) and endovascular aneurysm repair (EVAR). This highlights the importance of carefully assessing patient fitness and comorbidities when considering treatment options for rAAA. Our findings align with a previous EVAR trial[13] focused on the elective treatment of AAA in unfit patients, emphasizing the significance of patient fitness in determining outcomes.

An advanced age, explicitly being over 80 years old, was also identified as a significant predictor of increased mortality risk in rAAA patients. This finding is consistent with Antonopoulos CN et al.[14], who reported that age over 80 years old was associated with in-hospital mortality after OSR and EVAR in rAAA. This result suggests that the patient age should be considered when evaluating the risks and benefits of different treatment options in this population.

The use of aortic balloon occlusion during the procedure was identified as a parameter that predicted 30-day mortality, indicating the potential impact of intraoperative interventions on patient survival. Similar to our findings, several articles[15-20] have discussed the use of intraoperative aortic balloon in rAAA, which is associated with high perioperative mortality rates. For instance, Mehta M et al.[18] demonstrated that the use of aortic balloon occlusion in hemodynamically unstable rAAA patients was associated with a 33% increased risk of death.

Holst J et al. [20] also found that aortic balloon occlusion in hemodynamically unstable patients treated with EVAR resulted in a 27% increased risk of death. Furthermore, if a patient requires aortic balloon occlusion during the operation, postoperative care and monitoring will be more focused on the patient's general condition and potential complications related to balloon occlusion, such as aortic dissection or distal embolization to visceral organs. These considerations are crucial for intensive care unit management and ensuring optimal patient outcomes.

Postoperative complications, such as myocardial infarction, congestive heart failure, and abdominal compartment syndrome, were also found to be associated with a significantly higher risk of 30-day mortality. Myocardial infarction and other cardiac complications frequently contribute to mortality in patients with rAAA.[21] Abdominal compartment syndrome, often a

result of intraoperative hypotension and the use of aortic balloon occlusion, is also associated with a high 30-day mortality rate. Previous studies[19,22,23] have indicated that the occurrence of this complication is correlated with a preoperative blood pressure below 70 mmHg, the application of aortic balloon occlusion, and intraoperative blood replacement exceeding 5 units.[23] These findings emphasize the importance of vigilant postoperative monitoring and the prompt management of complications to improve patient outcomes.

While our study provides valuable insights, it has certain limitations to note too. First, it was conducted in a single-center setting, which may limit the generalizability of our findings. Multi-center studies with larger sample sizes are needed to validate and apply our results to a broader population. Second, the retrospective nature of our study introduces the possibility of selection bias and confounding variables. Although statistical adjustments were made, residual confounding factors cannot be ruled out. A prospective study design or a randomized controlled trial would provide stronger evidence and minimize the impact of confounding factors.

Additionally, our study focused solely on perioperative mortality rates and did not consider long-term outcomes, such as overall survival or quality of life. Evaluating these long-term outcomes would provide a more comprehensive understanding of the effectiveness of OSR and EVAR in managing rAAA. Lastly, the study period spanned several years, during which advancements in surgical techniques, perioperative care, and imaging modalities may have occurred. These temporal changes could influence the outcomes and potentially limit the generalizability of our findings to current clinical practice.

CONCLUSION

In conclusion, our study enhances the understanding of perioperative mortality and the factors influencing outcomes in rAAA patients undergoing OSR and EVAR. The absence of a significant difference in perioperative mortality rates between the two treatment modalities suggests their viability as treatment options. However, individual patient characteristics and predictive factors, such as an unfit patient status, age over 80 years old, intraoperative aortic balloon interventions, postoperative myocardial infarction, postoperative congestive heart failure, and abdominal compartment syndrome, must be considered when making treatment decisions. Future research should further investigate the impact of these factors and develop strategies for improving the outcomes in this high-risk patient population.

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Conflicts of Interest Declaration

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