



Evaluation of Preoperative Predictors of 30-Day Mortality in Patients with Ruptured Abdominal Aortic Aneurysm

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Purpose: Ruptured abdominal aortic aneurysm (RAAA) is a rare, extremely dangerous condition. Previous studies have published preoperative, intraoperative, and postoperative data; however, there are not enough studies on the preoperative factors alone. Here we studied the preoperative predictors of 30-day mortality in patients with RAAA.

Materials and Methods: We conducted a retrospective, consecutive review of the medical records of 57 patients who received management for RAAA between February 2005 and December 2016. We analyzed the association between preoperative predictors and 30-day mortality in patients with RAAA. The initial systolic blood pressure (SBP) and hemoglobin level (HbL), which were proven as significant predictors by multivariate logistic regression analysis, were compared using receiver operating characteristic curves.

Results: Overall, early mortality was 29.8%. Results of logistic regression analysis found that 30-day mortality in patients with RAAA was associated with the initial SBP (odds ratio [OR], 0.922; 95% confidence interval [CI], 0.874-0.973; P=0.003) and initial HbL (OR, 0.513; 95% CI, 0.289-0.91; P=0.023). Area under the curves were 0.89 for the initial SBP and 0.78 for the initial HbL. The initial SBP with a cut-off value of 90 mmHg had a sensitivity of 85% and specificity of 88.2%. At a cut-off of 10.5, the sensitivity and specificity of HbL for death were 75% and 70.6%, respectively.

Conclusion: The initial SBP and HbL are independent preoperative predictors of early mortality in patients with RAAA.

Key Words: Aorta, Aneurysm, Rupture, Mortality

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INTRODUCTION

Rupture and impending rupture of an abdominal aortic

aneurysms (AAA) are fatal diseases. Especially, ruptured AAA (RAAA) is the first aneurysmal manifestation in up to 50% of patients. The mortality rate of RAAA is a mean of

50%, which is significantly higher compared to the mortality rate of 2.9% in patients who have undergone elective operation for non-ruptured AAAs [1,2]. There have been significant improvements in the survival rate of patients with RAAA in the last decade; however, there is not enough studies to explicitly confirm the preoperative predictors in patients with RAAA [3]. Thus, we studied the preoperative predictors for 30-day mortality in patients with RAAA.

MATERIALS AND METHODS

1) Study population

A retrospective analysis of all patients with RAAA treated at Gyeongsang National University Hospital of South Korea from February 2005 to December 2016 was conducted. We identified 66 patients with RAAA. We excluded patients who refused treatments (operation or endovascular aneurysm repair [EVAR]) and those who were transferred to another hospital before termination of treatment. Based on these criteria, 9 patients were excluded, and 57 patients with RAAA were finally included in our study.

Data extracted from the medical records included demographic characteristics, clinical characteristics, and biochemical markers, such as the hemoglobin and serum creatinine levels on arrival.

2) Definitions

We defined computed tomographic findings of RAAA as (1) a retroperitoneal hematoma adjacent to an AAA; (2) active extravasation of contrast material; or (3) the draped aorta sign (this sign is considered present when the posterior wall of the aorta is either not identifiable as distinct from adjacent structures, or when it closely follows the contour of adjacent vertebral bodies) [4]. Since the patients with impending rupture were not included in this study, we have not included the definition of this particular condition.

3) Treatments

The permissive hypotension in the protocol was defined as a systolic blood pressure (SBP) of 80 and 100 mmHg. Patients with RAAA were considered unstable if they met all the following criteria: 1) patients with preoperative shock (SBP <80 mmHg), 2) those who received a preoperative packed red blood cell transfusion >5 units, and 3) those who received preoperative intubation. Anatomic suitability was defined as (1) a minimum length of the infrarenal anchoring segment of 15 mm; (2) an infrarenal neck diameter of 20 mm to 32 mm; and (3) an ipsilateral iliac diameter of

6 mm to 20 mm, with at least one iliac artery able to accommodate an endograft system without obstructing calcifications, tortuosity, or thrombosis.

In stable patients, if no images were taken from outside hospitals, computed tomography angiography was performed. For anatomically suitable patients with hemodynamic stability, EVAR was performed first. However, unstable patients were transferred directly to the angiography room, and they received aortic endovascular balloon occlusion (AEBO). If the hemodynamic status of patients who were anatomically suitable were stable after AEBO, we considered treatment with EVAR as possible.

4) Statistical analysis

Missing data were not replaced or imputed. We calculated P-value using the Fisher exact or Pearson chi-square test for categorical variables, and the Mann-Whitney U-test for continuous variables. Significance was set at P-value less than 0.05 ($P < 0.05$). To evaluate the preoperative predictors for 30-day mortality, we used logistic regression analysis. In the multivariate model, we included relevant variables with $P < 0.2$ in the univariate analysis. The statistically significant values for 30-day mortality proven by multivariate regression analysis were compared by using receiver operating characteristic (ROC) curves. All statistical analyses were performed using IBM SPSS Statistics ver. 24.0 software (IBM Co., Armonk, NY, USA) and R version 3.3.3 for Windows (R Foundation for Statistical Computing, Vienna, Austria).

5) Ethical approval

This retrospective study was approved by the Institutional Review Board of the Gyeongsang National University Hospital (IRB no. GNUH 2017-05-004).

RESULTS

During the study period, 66 emergency patients were admitted to Gyeongsang National University Hospital. Of these, only 57 patients met the inclusion criteria. Patients were mostly men (46, 80.7%) with a median age of 70 years (interquartile range [IQR], 63-75 years). Thirty-five patients (61.4%) were smokers or ex-smokers (the latter of whom had not smoked within the last 1-year), and 21 patients (36.8%) had a previous history of AAAs. Hypertension was the main past medical condition of patients with RAAA (50.9%). Overall, 57 patients (100%) presented with symptoms, and 52 patients (91.2%) had abdominal pain upon admission to the hospital (Table 1).

RAAA manifested with a median diameter of 6.8 cm (IQR,

Table 1. Demographic characteristics of patients with RAAA

Variable	Patient (n=57)
Age (y)	70 (63-75)
Male	46 (80.7)
Smoker	35 (61.4)
Previous history of AAA	21 (36.8)
Hypertension	29 (50.9)
DM	14 (24.6)
CRF	3 (5.3)
ACS ^a	15 (26.3)
PAOD	9 (15.8)
COPD	12 (21.1)
CVA	5 (8.8)
Symptoms	57 (100)
Abdominal pain	52 (91.2)
Abdominal distension	5 (8.8)

Values are presented as median (interquartile range) or number (%). RAAA, ruptured abdominal aortic aneurysm; AAA, abdominal aortic aneurysm; DM, diabetes mellitus; CRF, chronic renal failure; ACS, acute coronary syndrome; PAOD, peripheral arterial occlusive disease; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident.

^aIncludes stable angina, unstable angina, and acute myocardial infarction.

5.7–8.4 cm). The initial median SBP was 97 mmHg (IQR, 68.0–111.5 mmHg). Sixteen patients (28.1%) were treated with open surgical repair (OSR), and 34 patients (59.6%) were treated with endovascular aneurysmal repair (EVAR); the median duration of both treatments was 270 minutes (OSR, 220 minutes; EVAR, 180 minutes). The median duration of hospitalization was 11 days (IQR, 1.0–25.5 days). The overall 30-day mortality rate was 29.8%: 7 patients died in the emergency department before treatment, 14 patients died of excessive bleeding during treatment, 2 patients died of disseminated intravascular coagulation postoperatively, and 1 patient died of acute renal failure. On arrival, the median hemoglobin level (HbL) was 10.8 g/dL (IQR, 8.9–12.2 g/dL), and the serum creatinine level was 1.2 mg/dL (IQR, 0.9–1.6 mg/dL) (Table 2).

The independent preoperative predictors for 30-day mortality in patients with RAAA were studied. We assessed age, sex, hypertension, the size of RAAA, treatment methods (OSR or EVAR), initial SBP, HbL, and serum creatinine level. Results of univariate logistic regression analysis showed that 30-day in-hospital mortality was significantly associated with sex (odds ratio [OR], 6.3; 95% confidence interval [CI], 1.532–25.913; $P=0.011$), the initial SBP (per increase by 10 mmHg) (OR, 0.928; 95% CI, 0.89–0.967; $P<0.001$), and HbL (per increase by 1 g/dL) (OR, 0.575; 95% CI, 0.415–0.798; $P<0.001$) on arrival. Age, hypertension,

Table 2. Clinical characteristics of patients with RAAA

Variable	Patient (n=57)
Size of the RAAA (cm)	6.8 (5.7–8.4)
Initial vital sign value in the emergency department (mmHg)	
SBP	97 (68.0–111.5)
DBP	65 (52–83)
HR	82 (60–108)
RR	21 (18–26)
OSR	16 (28.1)
EVAR	34 (59.6)
Operative time (min)	270 (180–420)
Duration of hospital stay (d)	11 (1.0–25.5)
Early mortality (within 30 d)	17 (29.8)
Death in the emergency department before treatment	7 (12.3)
HbL (g/dL)	10.8 (8.9–12.2)
Serum creatinine level (mg/dL)	1.2 (0.9–1.6)

Values are presented as median (interquartile range) or number (%). RAAA, ruptured abdominal aortic aneurysm; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; RR, respiratory rate; OSR, open surgical repair; EVAR, endovascular aneurysmal repair; HbL, hemoglobin level.

treatment methods (OSR or EVAR), and serum creatinine level were not significantly associated with 30-day mortality. In the multivariate model, we included relevant variables with P -value <0.2 in the univariate analysis. Results of multivariate logistic regression analysis confirmed that in-hospital mortality was independently associated with the initial SBP (OR, 0.922; 95% CI, 0.874–0.973; $P=0.003$) and initial HbL (OR, 0.513; 95% CI, 0.289–0.91; $P=0.023$) on arrival (Table 3). Fig. 1 displays a graph of cumulative mortality vs. SBP, grouped into 10 mmHg decrements of SBP. The line of best fit demonstrates that the mortality rate increased with decreasing SBP.

We demonstrated the value of the initial SBP and HbL as a predictor of 30-day mortality. The ROC curves were used for this analysis. Fig. 2 shows that the area under the curve (AUC) of the initial SBP was 0.89, and the cut-off value of the initial SBP was 90 mmHg. The 30-day mortality rate for patients with an SBP <90 mmHg was 71.4%, whereas that for those with an SBP ≥ 90 mmHg was 5.6% ($P<0.001$). At this level of measurement, the initial SBP had a sensitivity of 85% and specificity of 88.2% for mortality. The positive predictive value (PPV) was higher than expected at 94.4%, but the negative predictive value (NPV) was lower than expected at 71.4%. The AUC of the initial HbL was 0.78. An HbL of 10.5 was evaluated as the cut-off value for mortality, as 54.5% of patients with an HbL <10.5 g/dL died

Table 3. Results of logistic regression analysis of preoperative risk factors of mortality in patients with RAAA (n=57)

Risk	Univariate analysis		Multivariate analysis	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Age	1.017 (0.937-1.103)	0.691		
Male	6.3 (1.532-25.913)	0.011 ^a	5.263 (0.445-62.274)	0.188
Hypertension	1.746 (0.553-5.511)	0.342		
Size of the RAAA	1.016 (0.987-1.045)	0.288		
OSR vs. EVAR	1.556 (0.371-6.53)	0.546		
SBP (per increase by 10 mmHg)	0.928 (0.89-0.967)	<0.001 ^a	0.922 (0.874-0.973)	0.003 ^a
HbL (per increase by 1 g/dL)	0.575 (0.415-0.798)	<0.001 ^a	0.513 (0.289-0.91)	0.023 ^a
Serum creatinine level	2.149 (0.824-5.603)	0.118	0.286 (0.041-2.014)	0.209

Multivariate analysis included variables with significant associations in the univariate analysis (P<0.2).

RAAA, ruptured abdominal aortic aneurysm; OR, odds ratio; CI, confidence interval; OSR, open surgical repair; EVAR, endovascular aneurysmal repair; SBP, systolic blood pressure; HbL, hemoglobin level.

^aThe data indicate significant differences in statistical comparisons of baseline characteristics.

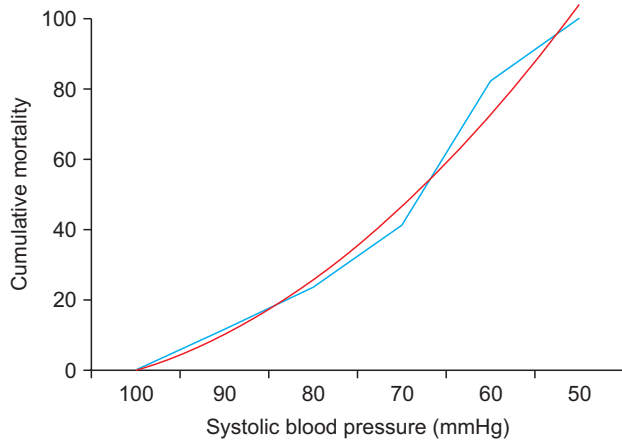


Fig. 1. Graph of cumulative mortality vs. the initial systolic blood pressure grouped into decrements of 10 mmHg. The dotted line represents the best fit.

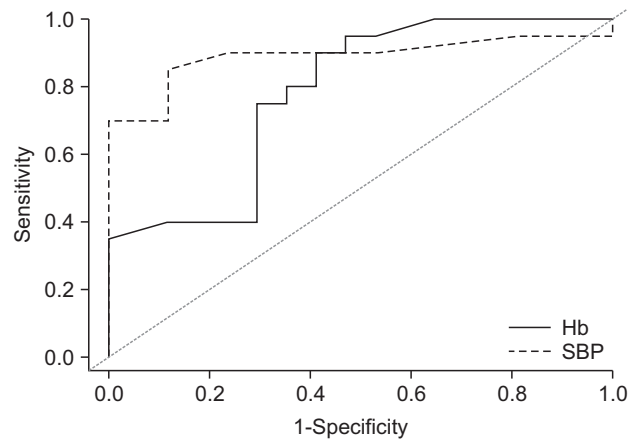


Fig. 2. Results of the receiver operating characteristic curve analysis of the initial SBP and HbL for predicting mortality. The initial SBP has an AUC value of 0.89; the HbL has an AUC value of 0.78. Hb, hemoglobin; SBP, systolic blood pressure; HbL, hemoglobin level; AUC, area under the curve.

vs. 14.3% with an HbL ≥ 10.5 (g/dL) (P<0.001). At this cut-off value, the sensitivity and specificity values were 75% and 70.6%, respectively. The PPV was once again high at 85.7%, and the NPV was low at 54.5%.

DISCUSSION

Many attempts have been made to identify the predictors of mortality associated with RAAA. Various prediction models have been studied; however, no variable system has been proven to be reliable for predicting mortality in patients with RAAA [5,6]. The glasgow aneurysm score (GAS) is one of these variable systems. The GAS calculates the risk of mortality for hospitalized patients with RAAA. It considers age, shock, myocardial disease, cerebrovascular disease, and renal disease as predictors for mortality [7]. The GAS is

a good predictor for low-risk patients with RAAA; however, it does not significantly contribute to identifying high-risk patients with RAAA [7,8]. The Vancouver score identified age, preoperative unconsciousness, and cardiac arrest as predictors for mortality [3,5], but it also has a limitation. van Beek et al. [5] showed that the Vancouver score considerably overestimated the mortality rate, with a predicted death rate of 82% vs. an observed death rate of 62% (95% CI, 52%-71%). There are a few other scoring systems, but their usefulness is also questionable [3-10].

In our study, the 30-day mortality rate was 29.8%. The preoperative predictor for 30-day mortality in patients with RAAA was identified as the initial SBP (AUC, 0.89; sensitivity, 85%; specificity, 88.2%) and HbL (AUC, 0.78; sensitivity, 75%; specificity, 70.6%) on arrival. Similar to our study,

several studies have shown that hypotension is a risk factor for mortality [1,11,12]. In almost all the studies, hypotension was defined as an SBP <80 mmHg. The Edinburgh Ruptured Aneurysm Score, University of Washington RAAA Score, and hypotension, according to various other studies, have been reported as significant predictors for mortality [11]. Some studies have shown that hypotension may induce the multiple organ failure that is a main cause of mortality [1,11,12]. However, aggressive fluid resuscitation to achieve a normal SBP is not recommended. Permissive hypotension (SBP, 80-100 mmHg) to maintain end-organ perfusion has been increasingly recommended over the last decade [11]. Until the fundamental treatment of RAAA is performed, permissive hypotension can help prevent ongoing blood loss and secondary dilution that may occur with aggressive fluid resuscitation [13].

Several studies have shown that the HbL may be a prognostic factor related to mortality. Boyle et al. [14] suggested that age, ischemic electrocardiographic findings, HbL, serum creatinine level, and loss of consciousness were preoperative risk factors. Johansen et al. [15] found that a low hematocrit level and preoperative cardiac arrest were associated with 92% and 94% mortality rates, respectively. Our study findings were similar; the AUC was 0.78 ($P < 0.001$) for mortality. Moreover, at a cut-off value of 10.5 g/dL, the HbL had a sensitivity of 75% and specificity of 70.6%.

The limitations of this study must be acknowledged. First, all the patients were selected from a single center, and this study had a small sample size, which may have caused selection bias. A larger sample size would better corroborate the mortality and the predictors of mortality in patients with RAAA. Second, we did not analyze the upper threshold of SBP. Since we only presented the significantly independent low threshold of SBP, there is a limit to using our results in clinical decision-making regarding the upper limitation of SBP [11,13].

Despite these limitations, this study represents an important investigation of the preoperative predictor associated with 30-day mortality for patients with RAAA. Our study's results showed that the initial SBP <90 mmHg and HbL <10.5 g/dL were independent predictor of 30-day mortality in patients with RAAA. A comparison of these findings with those of other reports will contribute to improving the treatment and management approaches for patients with RAAA.

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