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Predictors of Outcome in Aneurysmal Subarachnoid Hemorrhage: A Tertiary Center Experience

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ABSTRACT

AIM: To determine the risk factors affecting the mortality rate and outcomes of patients with subarachnoid hemorrhage (SAH).

MATERIAL and METHODS: The records of patients who underwent aneurysm treatment and intensive care unit (ICU) follow-up in our hospital between 2013-2021 were reviewed retrospectively. Demographics of the patients, aneurysm characteristics, complications in the ICU, the Hunt Hess score, Glasgow Coma Scale (GCS), Acute Physiologic Assessment and Chronic Health Evaluation II score (APACHE II), sepsis status, and mechanical ventilation (MV) needed during ICU admission were collected. The generalized linear mixed modeling method was used to determine independent risk factors affecting mortality.

RESULTS: The records of 91 patients who met the inclusion criteria were analyzed. The age of the patients ranged from 21 to 86 years, and the female-to-male ratio was 6 / 7, with a mean age of 49.9 ± 13.06 years. The aneurysm treatment modality was surgical in 79 patients (86.8%) and endovascular in 12 patients (13.2%). The length of the ICU stay was mean 10.96 ± 13.66 days. While 64.8% (n=59) of the patients were discharged, 7.7% (n=7) were referred to palliative care units, and 25% (n=25) died. A one-unit increase in the APACHE II score was determined to increase the risk of vasospasm 1.154 times ($p<0.001$). Analysis showed that a one-day increase in the MV day increased the mortality risk 1.838 times ($p<0.001$), and vasospasm increased the mortality risk 32.151 times ($p=0.004$)

CONCLUSION: The length of hospital stay, the day of MV, and the presence of vasospasm were determined as independent risk factors affecting mortality. Early diagnosis and rapid treatment of vasospasm, which increases mortality during ICU follow-up, positively impact patient outcomes.

KEYWORDS: Intracranial aneurysm, Subarachnoid hemorrhage, Intracranial vasospasm, Mortality, APACHE, Intensive care

ABBREVIATIONS: SAH: Subarachnoid hemorrhage, **ICU:** Intensive care unit, **CT:** Computed tomography, **ICP:** Intracranial pressure, **MV:** Mechanical ventilation, **GCS:** Glasgow coma scale, **APACHE:** Acute physiologic assessment and chronic health evaluation, **DCI:** Delayed cerebral ischemia

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INTRODUCTION

Aneurysmal subarachnoid hemorrhage (aSAH) is a serious disease that occurs at a rate of 9:100,000 population worldwide and causes 30% of the patients to die. Only 30% of survivors continue their lives independently after discharge (4). Acute, severe headache, typically the worst headache the patient has ever experienced, is typical in anamnesis (39). The gold standard for diagnostic evaluation of SAH is non-contrast head computed tomography (CT), followed by lumbar puncture if the CT does not show any bleeding (1).

Considering many factors such as the patient's age, general medical condition, location of the aneurysm, and the size of the bleeding, the most appropriate option either endovascular coiling or neurosurgical clipping is determined, and the risk of bleeding is controlled. The first step of treatment is to stop the bleeding (25). All patients should be followed closely in the intensive care unit (ICU) to detect complications early and prevent new bleeding. It is crucial to avoid vasospasm and hydrocephalus and avoid rebleeding and cerebral ischemia with optimal hemodynamic monitoring during follow-up (28).

Guidelines are published regularly on the issues to be considered in the ICU follow-up of patients (3,4,33,39). In this way, patients can be followed more carefully regarding complications that may arise, and treatment is faster and more effective. Although mortality and morbidity have decreased over the years as surgical and ICU treatments have been updated through research, they are still high. Many studies are conducted to predict and reduce mortality rates (17,18, 20,31,36,37,40,45,46,49).

In this study, we aimed to evaluate the risk factors affecting the mortality rate and outcomes of patients with SAH.

MATERIAL and METHODS

This study was designed retrospectively and was carried out at Marmara University Pendik Training and Research Hospital.

This study was performed in compliance with the Helsinki Declaration and approved by the Marmara University Faculty of Medicine Clinical Research Ethics Committee (Number: 09.2020.1152).

All patients diagnosed with aneurysmatic SAH who underwent an occlusive operation in our hospital and were followed up in the ICU between 2013 and 2021 were evaluated. Each patient's follow-up period was defined as the time between admission to the hospital and discharge.

Patients who underwent the occlusive procedure or ICU follow-up in an external center were excluded from the study.

Patients who met the inclusion criteria were analyzed. In addition to the patient's demographic information, the Hunt-Hess score, Glasgow coma scale (GCS), Acute Physiologic Assessment and Chronic Health Evaluation II (APACHE II) score, sepsis status, and mechanical ventilation (MV) requirements during ICU admission were collected.

Sepsis and septic shock were defined according to Sepsis-3 criteria. (38). The diagnosis of acute kidney injury was made according to the Kidney Disease Improving Global Outcomes (KDIGO) criteria (7). The type of electrolyte imbalance that developed during ICU hospitalization was examined. Intracranial pressure (ICP) was measured directly in some patients via external ventricular drain (EVD) and lumbar drainage; in other patients, it was measured indirectly by measuring the optic nerve diameter with ultrasonography (USG). The upper limit is 22 cm H20 for direct measurements and 6 mm for USG measurements (9). The diagnosis of vasospasm was made via transcranial Doppler (TCD) examinations based on clinical suspicion. Patients with a middle cerebral artery (MCA) mean flow velocity >120 cm/s were considered positive (35). Each patient's ICU length of stay and discharge type were recorded.

RESULTS

The medical records of patients who developed SAH due to intracranial aneurysm rupture and who were admitted to our center between April 2013 and September 2021 were evaluated retrospectively. A total of 183 patients enrolled in the study in neurosurgery and interventional radiology clinics. Eighteen patients transferred to the external ICU after the procedures; 63 patients who were followed up in the postoperative service and 11 patients whose files could not be reached were excluded from the study. A total of 91 patients from two clinics were included in the study (Figure 1).

The age of the patients ranged from 21 to 86 years, and the female-to-male ratio was 42:49, with a mean age of 49.9 ± 13.06 years. The mean Hunt-Hess scores, GCS, and APACHE II scores at the initial presentation were 2.35 ± 1.12, 11.05 ± 4.61, and 17.42 ± 7.66, respectively. The mean length of stay in the ICU was 11 days. The aneurysm treatment modality was surgical in 79 patients (86.8%) and endovascular in 12 patients (13.2%). Whereas 64.8% (n=59) of the patients were discharged, 7.7% (n=7) were referred to palliative care units, and 27.5% (n=25) died. Detailed information about the need for MV, infection status, aneurysm type and distribution, and complications is given in Table I.

When the clinical features of the patients were compared in terms of mortality, Hunt-Hess scores ($p<0.001$), APACHE II scores ($p<0.001$), the number of MV days ($p<0.001$), and the lengths of ICU stay ($p=0.045$) were higher in the patients who were non-survivors. The mortality percentage was higher in cases with sepsis ($p=0.002$), septic shock ($p=0.047$), MV ($p<0.001$), acute kidney injury ($p<0.001$), vasospasm ($p<0.001$), and ICP requiring intervention ($p<0.001$) (Table II).

The generalized linear mixed modeling method was used to determine the factors affecting mortality. Whereas mortality was included in the model as a dependent variable, variables found to be associated with mortality in univariate analyzes were included as independent variables. In this context, the independent variables were the Hunt-Hess score, ICU admission GCS score, APACHE II score, number of MV days, length of ICU stay, length of hospital stay, sepsis, septic shock, MV requirement, acute kidney injury, vasospasm, and

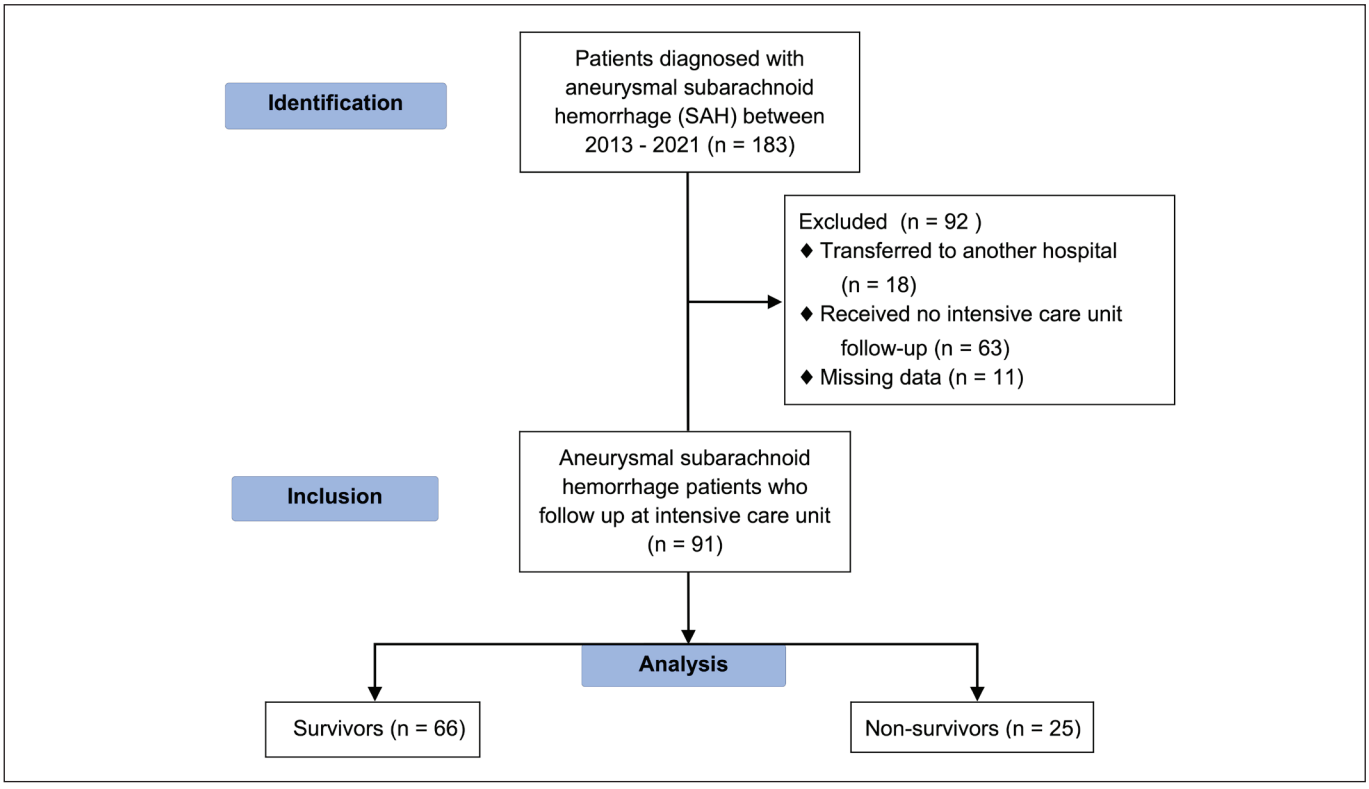

Figure 1: Flowchart of patient selection.

Table I: Demographic and Clinical Characteristics

Parameters	**Min-Max**	**Mean ± SD**
Age (years)	21-86	49.9 ± 13.06
Hunt Hess score	1-5	2.35 ± 1.12
Initial GCS at ICU	3-15	11.05 ± 4.61
GCS at discharge from ICU	7-15	14.36 ± 1.92
APACHE II score	3-35	17.42 ± 7.66
Mechanical ventilation (days)	0-72	7.24 ± 14.38
Diagnosis-intervention period (days)	0-18	1.18 ± 2.38
Length of ICU stay (days)	2-76	10.96 ± 13.66
Length of hospital stay (days)	2-110	17.35 ± 18.43
	n	**%**
Sex		
Female	42	46.2
Male	49	53.8
Sepsis	26	28.6
Septic shock	23	25.3
Need for mechanical ventilation	43	47.3
Acute kidney injury	15	16.5

Table I: Cont.

Parameters	Number of patient	Percentage
Vasospasm	38	41.8
Increased intracranial pressure (ICP) requiring intervention	28	30.8
Location of Aneurysm		
ACOM	32	35.2
MCA	30	33.0
PCOM	11	12.1
Others	22	24.2
Aneurysm Treatment		
Clip occlusion	79	86.8
Coil embolization	12	13.2
Rebleeding of aneurysm	9	10.0
Diabetes insipidus	9	9.9
Syndrome of inappropriate antidiuretic hormone secretion (SIADH)	9	9.9
Cerebral salt wasting (CSW)	16	17.6
Discharge type from ICU		
Hospital ward	59	64.8
Palliative care	7	7.7
Exitus	25	27.5

APACHE II: *Acute physiology and chronic health evaluation II score,* ***GCS:*** *Glasgow Coma Scale,* ***ICU:*** *Intensive care unit,* ***ACOM:*** *anterior communicating artery,* ***MCA:*** *middle cerebral artery;* ***PCOM:*** *posterior communicating artery.*

Table II: Comparison of Variables According to Mortality

Parameters	Mortality		Test value (z)	p-value
	Survivors (n=66)	Non-survivors (n=25)		
	Median (Q1, Q3)	Median (Q1, Q3)		
Age (years)	50.5 (43, 57)	50 (40, 59)	**-0.076**	[a]0.940
Hunt Hess score	2 (1, 3)	3 (2, 4)	**-3.888**	[a]**<0.001***
Initial GCS at ICU	15 (10, 15)	7 (3, 13)	**-4.029**	[a]**<0.001***
APACHE II score	13.5 (10, 18)	25 (21, 26)	**-4.182**	[a]**<0.001***
Mechanical ventilation (days)	0 (0, 1)	8 (4, 12)	**-5.545**	[a]**<0.001***
Diagnosis-intervention time (days)	1 (0, 2)	0 (0, 1)	**-1.233**	[a]0.218
Length of ICU stay (days)	6 (3, 10)	10 (6, 12)	**-2.009**	[a]**0.045***
Length of hospital stay (days)	12 (9, 19)	10 (6, 12)	**-2.651**	[a]**0.008***
	n (%)	**n (%)**	**Test value (χ^2)**	**p-value**
Sex			**1.345**	[b]0.246
Female	28 (66.7)	14 (33.3)		
Male	38 (77.6)	11 (22.4)		
Sepsis			**9.271**	[b]**0.002***
Absent	53 (81.5)	12 (18.5)		
Present	13 (50)	13 (50)		

Table II: Cont.

	n (%)	n (%)	Test value (χ^2)	p-value
Septic shock			**3.957**	[b]**0.047***
Absent	53 (77.9)	15 (22.1)		
Present	13 (56.5)	10 (43.5)		
Need for mechanical ventilation			**38.478**	[b]**<0.001***
Absent	48 (100)	0 (0)		
Present	18 (41.9)	25 (58.1)		
Acute kidney injury			**-**	[c]**<0.001***
Absent	62 (81.6)	14 (18.4)		
Present	4 (26.7)	11 (73.3)		
Vasospasm			**-**	[c]**<0.001***
Absent	50 (94.3)	3 (5.7)		
Present	16 (42.1)	22 (57.9)		
Increased intracranial pressure (ICP) requiring intervention			**22.430**	[b]**<0.001***
Absent	55 (87.3)	8 (12.7)		
Present	11 (39.3)	17 (60.7)		
ACOM aneurysms			**1.885**	[b]0.170
Absent	40 (67.8)	19 (32.2)		
Present	26 (81.3)	6 (18.8)		
MCA aneurysm			**3.525**	[b]0.060
Absent	48 (78.7)	13 (21.3)		
Present	18 (60)	12 (40)		
PCOM aneurysm			**-**	[c]0.721
Absent	57 (71.3)	23 (28.8)		
Present	9 (81.8)	2 (18.2)		
Other aneurysms			**-**	[c]0.981
Absent	50 (72.5)	19 (27.5)		
Present	16 (72.7)	6 (27.3)		
Aneurysm Treatment			**-**	[c]0.999
Clip occlusion	57 (72.2)	22 (27.8)		
Coil embolization	9 (75)	3 (25)		
Rebleeding of aneurysm			**-**	[c]0.257
Absent	61 (74.1)	21 (25.9)		
Present	5 (55.6)	4 (44.4)		
Diabetes insipidus			**-**	[c]0.252
Absent	61 (74.4)	21 (25.6)		
Present	5 (55.6)	4 (44.4)		
Syndrome of inappropriate antidiuretic hormone secretion (SIADH)			**-**	[c]0.999
Absent	59 (72)	23 (28)		
Present	7 (77.8)	2 (22.2)		
Cerebral salt wasting (CSW)			**-**	[c]0.542
Absent	53 (70.7)	22 (29.3)		
Present	13 (81.3)	3 (18.8)		

Q1: *First quartile,* ***Q3:*** *Third quartile,* [a]*Mann–Whitney U test,* [b]*Pearson chi-square test* [c]*Fisher's exact test *p<0.05,* ***APACHE II:*** *Acute physiology and chronic health evaluation II score,* ***ACOM:*** *Anterior communicating artery,* ***MCA:*** *Middle cerebral artery,* ***PCOM:*** *Posterior communicating artery.*

ICP requiring intervention. In the first stage, all independent variables were included in the analysis, the variable with the lowest level of significance (the highest p-value) in the obtained model was removed from the model, and the analysis was repeated. This process was repeated until only variables with a statistically significant effect remained in the model. Information about the obtained model is presented in Table III.

In the model obtained at the last stage, it was determined that the length of hospital stay, the days of MV, and the presence of vasospasm were significantly included. A one-day increase in the length of hospital stay increased the risk of mortality 0.503 times (p<0.001). Analysis showed that a one-day increase in the MV days increased the mortality risk by 1.838 times (p<0.001), and vasospasm increased the mortality risk by 32.151 times (p=0.004) (Table III).

The clinical characteristics of the patients were compared in terms of vasospasm, the Hunt-Hess scores (p=0.001), APACHE II scores (p<0.001), the numbers of MV days (p<0.001), and lengths of stay in the ICU (p<0.001) were found to be higher in patients with vasospasm, and lower ICU initial GCS score (p<0.001). The percentage of vasospasm was higher in patients with sepsis (p<0.001), septic shock (p<0.001), MV requirement (p<0.001), acute kidney injury (p<0.001), and ICP requiring intervention (p=0.004) (Table IV).

The generalized linear mixed modeling method was used to determine the factors affecting vasospasm. Whereas vasospasm was included in the model as a dependent variable, variables found to be associated with vasospasm in univariate analyzes were included as independent variables. In this context, the independent variables were the Hunt-

Table III: Factors Affecting Mortality

	OR	95% CI	t	p-value
Reference	5.517	0.644-47.291	1.594	0.117
Length of hospital stay (days)	0.503	0.353-0.718	-3.869	**<0.001***
Mechanical ventilation (days)	1.838	1.329-2.540	3.768	**<0.001***
Vasospasm	32.151	3.243-318.750	3.033	**0.004***

p<0.05, **OR: Odds ratio, **CI:** Confidence interval.*

Table IV: Comparison of Variables According to Vasospasm

Parameters	Vasospasm		Test value (z)	p-value
	Absent (n=53)	Present (n=38)		
	Median (Q1, Q3)	Median (Q1, Q3)		
Age (years)	50 (42, 56)	52.5 (41, 59)	-0.862	[a]0.389
Hunt Hess score	2 (1, 2)	3 (2, 4)	-3.335	**[a]0.001***
Initial GCS at ICU	15 (12, 15)	7.5 (3, 15)	-3.793	**[a]<0.001***
APACHE II score	13 (10, 17)	24 (14, 26)	-4.289	**[a]<0.001***
Mechanical ventilation (days)	0 (0, 0)	8 (3, 19)	-6.474	**[a]<0.001***
Diagnosis-intervention time (days)	1 (0, 2)	0 (0, 1)	-1.277	[a]0.202
Length of ICU stay (days)	5 (3, 8)	10 (6, 22)	-4.025	**[a]<0.001***
Length of hospital stay (days)	11 (9, 13)	14 (9, 33)	-1.677	[a]0.093
	n (%)	n (%)	Test value (χ^2)	p
Sex			**0.039**	[b]0.844
Female	24 (57.1)	18 (42.9)		
Male	29 (59.2)	20 (40.8)		
Sepsis			**932.645**	**[b]<0.001***
Absent	50 (76.9)	15 (23.1)		
Present	3 (11.5)	23 (88.5)		
Septic shock			**25.854**	**[b]<0.001***
Absent	50 (73.5)	18 (26.5)		
Present	3 (13)	20 (87)		

Table IV: Cont.

	n (%)	n (%)	Test value (χ^2)	p
Need for mechanical ventilation			**41.028**	[b]**<0.001***
Absent	43 (89.6)	5 (10.4)		
Present	10 (23.3)	33 (76.7)		
Acute kidney injury			**19.644**	[b]**<0.001***
Absent	52 (68.4)	24 (31.6)		
Present	1 (6.7)	14 (93.3)		
Increased intracranial pressure (ICP) requiring intervention			**8.439**	[b]**0.004***
Absent	43 (68.3)	20 (31.7)		
Present	10 (35.7)	18 (64.3)		
ACOM aneurysms			**0.368**	[b]0.544
Absent	33 (55.9)	26 (44.1)		
Present	20 (62.5)	12 (37.5)		
MCA aneurysm			**2.465**	[b]0.116
Absent	39 (63.9)	22 (36.1)		
Present	14 (46.7)	16 (53.3)		
PCOM aneurysm			**-**	[c]0.757
Absent	46 (57.5)	34 (42.5)		
Present	7 (63.6)	4 (36.4)		
Other aneurysms			**0.009**	[b]0.926
Absent	40 (58)	29 (42)		
Present	13 (59.1)	9 (40.9)		
Aneurysm Treatment			**1.596**	[b]0.206
Clip occlusion	44 (55.7)	35 (44.3)		
Coil embolization	9 (75)	3 (25)		
Rebleeding of aneurysm			**-**	[c]0.160
Absent	50 (60.5)	32 (39.5)		
Present	3 (33.3)	6 (66.7)		
Diabetes insipidus			**-**	[c]0.157
Absent	50 (61)	32 (39)		
Present	3 (33.3)	6 (66.7)		
Syndrome of inappropriate antidiuretic hormone secretion (SIADH)			**-**	[c]0.999
Absent	48 (58.5)	34 (41.5)		
Present	5 (55.6)	4 (44.4)		
Cerebral salt wasting (CSW)			**0.542**	[b]0.462
Absent	45 (60)	30 (40)		
Present	8 (50)	8 (50)		

Q1: *First quartile,* ***Q3:*** *Third quartile,* [a]*Mann–Whitney U test,* [b]*Pearson chi-square test* [c]*Fisher's exact test* *$p<0.05$, ***APACHE II:*** *Acute physiology and chronic health evaluation II score,* ***ACOM:*** *Anterior communicating artery,* ***MCA:*** *Middle cerebral artery,* ***PCOM:*** *Posterior communicating artery.*

Table V: Factors Affecting Vasospasm

	OR	95% CI	t	p-value
Reference	0.056	0.022-0.145	-6.236	**<0.001***
APACHE II score	1.154	1.098-1.212	5.969	**<0.001***

APACHE II: *Acute physiology and chronic health evaluation II score,* ***OR:*** *Odds ratio,* ***CI:*** *Confidence interval.*

Hess score, GCS score at time of ICU admission, APACHE II score, number of MV days, and length of ICU stay. In the first stage, all independent variables were included in the analysis, the variable with the lowest level of significance (the highest p-value) in the obtained model was removed from the model, and the analysis was repeated. This process was repeated until only variables with a statistically significant effect remained in the model, and the results are given in Table V.

It was determined that only the APACHE II score was statistically significant in the model obtained in the last stage. One-unit increase in the APACHE II score was determined to increase the risk of vasospasm by 1.154 times (p<0.001) (Table V).

DISCUSSION

We performed a retrospective study on aneurysmal SAH patients who were followed up in the ICU of our hospital. We showed that SAH was associated with 27% mortality. Previous studies indicated that bleeding in the acute stage and late complications in ICU follow-up are important causes of mortality. We identified the length of hospital stay, the days of MV, and the presence of vasospasm as independent risk factors affecting mortality.

In our study, mortality was 27% (n=25) in 91 patients with aneurysmatic SAH who were followed up and treated in the ICU. Mortality rates between 20% and 44% are reported in patients with aneurysmal SAH, and our mortality rate is consistent with the literature (4,28,30,32,34,39,41,44). In a study by Mourelo-Farina et al., 536 patients followed in the ICU due to SAH were examined, and it was reported that patients who were non-survivors had higher APACHE II and Hunt-Hess scores (HH) at the time of admission and lower GCS scores, in line with our results (27). In addition, recent studies have shown HH5 grade at 48 hours to be an independent risk factor for mortality and a better tool than the initial HH grade (23).

In the International Subarachnoid Aneurysm Trial (ISAT) study, it was reported that if there is a possibility of both surgical and radiological intervention to the aneurysm, the method of choice should be neuroradiological coiling, and mortality and morbidity are significantly reduced in these patients. In patients with a ruptured intracranial aneurysm, for which endovascular coiling and neurosurgical clipping are therapeutic options, the outcome in terms of survival free of disability at one year is significantly better with endovascular coiling (24,25). In our study, we did not observe any difference in mortality between surgical clipping and neuroradiological coiling, which is used as an aneurysm intervention method, but this result may be due to the low number of patients who underwent coiling.

In our study, the median number of days spent on MV during the ICU stay was eight in the group of patients who were non-survivors and zero in the patients who survived. MV duration was identified as an independent risk factor that increased mortality by 1.8 times. Udy et al. stated that 63% of aneurysmatic SAH patients need MV, and the presence of MV is an independent risk factor that increases mortality by 1.69 times (42). The study by Bouvet et al. showed that the overall one-year mortality is high, and the functional status is poor, in critical stroke patients who need MV (2).

Although the development of sepsis and septic shock prolonged ICU and hospital stays in our study, they were not identified as independent risk factors for mortality. A recent study demonstrated that sepsis was one of the main systemic complications during the hospital stay in patients with aneurysmal SAH, and sepsis was a modifiable factor associated with poor functional outcomes at long-term follow-up (11).

Complications frequently encountered in patients with aneurysmatic SAH include increased ICP, rebleeding, and disturbances in serum sodium values. In our study, increased ICP requiring intervention was higher in non-survivors. van Donkelaar et al. reported a higher rate of ICP requiring intervention in non-survivors (43). In our study, rebleeding rates were similar in both groups. Due to the small number of patients with rebleeding, no significant difference could be found in mortality. In many studies, rebleeding has been found to be an independent risk factor for mortality (16,19).

Vasospasm developed during ICU hospitalization, prolonged ventilation, and prolonged hospitalization were identified as independent risk factors for mortality. The most influential risk factor for mortality was vasospasm, with a 32-fold increased risk. The incidence of vasospasm in patients was 41%, and mortality was 58% in patients who developed vasospasm. Many studies have shown that vasospasm directly affects the survival of patients (15). Depending on the criteria used, the incidence of vasospasm after SAH reaches up to 70 percent (9,14). In a review by Neifert et al., 43% of patients had angiographic vasospasm, and 33% had delayed cerebral ischemia (DCI). It has been shown that the development of DCI in patients increases mortality by 3.7 times (28).

Many studies have also searched for methods to reduce vasospasm risk, the most important risk factor for mortality in our study. Foudhaili et al. showed that early out-of-bed mobilization after subarachnoid hemorrhage is associated with better functional outcomes and lower rates of vasospasm

(10).

APACHE II and Hunt-Hess scores were significantly higher in our vasospasm patients group. A review showed the presence of signs of SAH severity on CT as a risk factor for the development of cerebral vasospasm (12). Various scoring systems have been proposed to predict vasospasm and DCI (8,22,33). However, there is not yet a widely used scoring system. Therefore, in our study, the Hunt-Hess score was used for SAH staging, and the APACHE II score was used to determine the severity of the patient's condition during hospitalization in the ICU.

In our study, initial GCS score at time of ICU admission was lower in the vasospasm group. The World Federation of Neurological Surgeons (WFNS) scoring system used for SAH severity staging includes the patient's GCS and clinical evaluation. The score increases with a decrease in GCS and clinical worsening. Although the WFNS scoring system is used in SAH staging, various studies have proven that it can predict vasospasm and is a risk factor for vasospasm (22).

Forty-seven percent of our patients required MV during their stay in the ICU, 86% of the patients who developed vasospasm needed MV, and the median number of MV days was eight days. In a study evaluating the risk factors for cerebral vasospasm in patients with SAH, 51.5% of patients with vasospasm needed MV (29). In addition to the more prolonged need for MV in patients with vasospasm, these patients also require longer ICU stays. Sepsis and septic shock are more common in the vasospasm group.

In our study, vasospasm was observed in 65% of patients with elevated ICP requiring intervention. Studies showed the development of acute hydrocephalus as an independent risk factor for vasospasm (21,26). In our study, the presence of hypertension was similar in both groups. However, there are studies in the literature in which hypertension is an independent risk factor for the development of vasospasm (9,13). In our study, aneurysm treatment procedures and localization did not affect vasospasm. Many studies have not shown a relationship between vasospasm and aneurysm localization (5,6,13,26,47,48).

Our study's limitations include its retrospective and single-center nature and its small patient population. We do not know the status of the patients who were referred to an external center after aneurysm treatment, and the number of patients who underwent endovascular coiling is small.

CONCLUSION

In our study to determine the risk factors affecting mortality and patient outcomes in patients with SAH, we determined the mortality rate to be 28%. The length of hospital stay, the days of MV, and the presence of vasospasm were identified as independent risk factors affecting mortality. Although the severity of the patient's disease at the time of admission is a crucial factor affecting mortality, it is a risk factor that cannot be mitigated. Early diagnosis and rapid treatment of vasospasm, which increases mortality during ICU follow-up, has a positive effect on patient outcomes. These identified risk factors should be carefully considered during follow-up of SAH patients in the ICU.

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AUTHORSHIP CONTRIBUTION

Study conception and design: ME, AS, YB, IC, BB
Data collection: ME, AS, YB, IC, BB
Analysis and interpretation of results: ME, AS, YB, IC, BB
Draft manuscript preparation: ME, AS, YB, IC, BB
Critical revision of the article: ME, AS, YB, IC, BB
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All authors (ME, AS, YB, IC, BB) reviewed the results and approved the final version of the manuscript.

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