



## Research

# Comprehensive Analysis of Factors Affecting Surgical Outcomes in Intracranial Aneurysm Patients with Poor Prognosis

## Kötü Prognozlu İntrakraniyal Anevrizma Hastalarında Cerrahi Sonuçları Etkileyen Faktörlerin Kapsamlı Analizi

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### ABSTRACT

**Objective:** This research study examines the surgical outcomes of patients with severe aneurysmal subarachnoid hemorrhage (aSAH) based on data from a single center. The traditional conservative management approach has shown poor outcomes, leading to the consideration of surgical interventions. This study aims to assess the importance of surgical clipping in improving functional outcomes and identify factors influencing prognosis.

**Methods:** The study included 27 patients with poor-grade aSAH who underwent surgical interventions within 72 hours of the event. Data collected included patient demographics, clinical presentation, imaging findings, surgical details, complications, length of hospital stay, and functional outcomes at follow-up.

**Results:** The findings indicate that surgical interventions, including aneurysm clipping and decompressive craniectomy, were performed in selected cases. However, overall functional outcomes were limited, with a small number of patients showing favorable recovery. The six-month mortality rate was high, with infection and massive brain edema as leading causes of death. Advanced age was associated with increased mortality risk. Factors such as gender, clinical status upon admission, imaging findings, aneurysm location, and timing of surgery did not significantly impact the risk of death or length of survival.

**Conclusion:** This study contributes to understanding surgical management strategies for poor-grade aSAH. Further research and advancements are needed to improve outcomes. Identifying predictive factors for prognosis can aid in treatment decision-making and provide realistic expectations for recovery. The study underscores the complexity of poor-grade aSAH and the ongoing debate regarding optimal surgical interventions in these cases.

**Keywords:** Intracranial aneurysms, poor-grade, surgical outcomes, prognosis, timing of surgery

### ÖZ

**Amaç:** Bu araştırma, kötü dereceli anevrizmal subaraknoid kanamalı (aSAH) hastaların cerrahi sonuçlarını tek merkezden elde edilen verilere dayanarak incelemektedir. Kötü dereceli aSAH olguları daha yüksek klinik şiddet ve daha kötü prognozlarla ilişkilidir. Geleneksel konservatif tedavi yaklaşımının kötü sonuçlar vermesi, anevrizmanın erken kliplenmesi gibi cerrahi müdahalelerin potansiyel tedavi stratejileri olarak değerlendirilmesine yol açmıştır. Bu çalışma, fonksiyonel sonuçların iyileştirilmesinde cerrahi kliplenmenin önemini değerlendirmeyi ve prognozu etkileyen faktörleri belirlemeyi amaçlamaktadır.

**Gereç ve Yöntem:** Çalışmaya, olaydan sonraki 72 saat içinde cerrahi müdahale uygulanan kötü dereceli aSAH'li 27 hasta dahil edildi. Toplanan veriler arasında hasta demografik özellikleri, klinik görünüm, görüntüleme bulguları, cerrahi ayrıntılar, komplikasyonlar, hastanede kalış süresi ve takipteki fonksiyonel sonuçlar yer alıyordu.

**Bulgular:** Bulgular, seçilmiş olgularda anevrizma kliplenmesi ve dekompresif kranyektomiye içeren cerrahi müdahalelerin uygulandığını göstermektedir. Bununla birlikte, genel fonksiyonel sonuçlar sınırlıydı ve az sayıda hasta olumlu iyileşme gösterdi. Altı aylık ölüm oranı yüksekti;

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enfeksiyon ve ağır beyin ödemi başlıca ölüm nedenleriydi. İleri yaş, artan ölüm riskiyle ilişkilendirildi. Cinsiyet, başvuru sırasındaki klinik durum, görüntüleme bulguları, anevrizmanın yeri ve ameliyatın zamanlaması gibi faktörler, ölüm riskini veya hayatta kalma süresini önemli ölçüde etkilemedi.

**Sonuç:** Bu çalışma, kötü dereceli aSAH için cerrahi tedavi stratejilerinin anlaşılmasına katkıda bulunmaktadır. Sonuçların iyileştirilmesi için daha fazla araştırma ve ilerlemeye ihtiyaç vardır. Prognoz için öngörücü faktörlerin belirlenmesi, tedaviye karar verilmesine yardımcı olabilir ve iyileşme için gerçekçi beklentiler sağlayabilir. Çalışma, düşük dereceli aSAH'ın karmaşıklığının ve bu olgularda optimal cerrahi müdahalelerle ilgili devam eden tartışmanın altını çiziyor.

**Anahtar Kelimeler:** İntrakraniyal anevrizmalar, kötü-dereceli, cerrahi sonuçlar, prognoz, ameliyatın zamanlaması

## INTRODUCTION

Aneurysmal subarachnoid hemorrhage (aSAH) is a severe state characterized by hemorrhaging into the subarachnoid area due to the rupture of an intracranial aneurysm (1,2). Poor-grade aSAH refers to cases with a higher clinical severity, typically classified as Hunt and Hess grades IV and V. These patients face markedly poorer outcomes and numerous challenges in their management (3,4). Surgical intervention, particularly aneurysm clipping, has been increasingly considered as a potential treatment strategy in poor-grade aSAH cases (3,5,6). This research paper aims to provide insights into the surgical results of individuals with low-grade aSAH.

The traditional approach to the management of aSAH involved conservative measures as the primary therapy, with surgery postponed for individuals who have survived the initial critical period (5,7). However, this approach was associated with high mortality rates and poor functional outcomes in a substantial proportion of patients. Recent evidence suggests that aggressive surgical intervention, such as early aneurysm clipping, may yield improved functional outcomes (3,5-7). Ultra-early surgery has also been explored as a potential strategy to enhance overall survival rates. Consequently, the role of surgical intervention in poor-grade aSAH cases has become a topic of increasing interest and debate.

In this research study, we present the outcomes of surgical interventions performed on patients with poor-grade aSAH, based on data collected from a single tertiary neurosurgery facility. Our objective is to evaluate the significance of surgical clipping in enhancing functional results in these patients and identify factors that may influence the overall prognosis. By analyzing the specific roles of patient characteristics such as age, gender, and imaging findings, we intend to offer significant insights on how these characteristics predict the functional outcomes of patients with poor-grade aSAH. This study contributes to the existing body of knowledge regarding surgical management strategies for poor-grade aSAH and seeks to enhance our understanding of the

potential benefits and limitations of surgical interventions in this challenging patient population.

## METHODS

The study complied to the ethical principles of the Declaration of Helsinki and was authorized by the University of Health Sciences Türkiye, Eskişehir City Hospital Non-Interventional Clinical Research Ethics Committee (decision no: ESH/GOEK-2023/45, date: 17.08.2023). All people who participated in this study have provided informed consent. Patient data were de-identified and handled in strict confidentiality to ensure privacy and compliance with data protection regulations. This study utilized a retrospective single-center analysis to comprehensively evaluate surgical outcomes in poor-grade intracranial aneurysm patients. The study aimed to navigate the challenges associated with the management of this patient population and provide insights into their surgical outcomes.

The study involved adult participants aged 18 years or older who met specific criteria: (1) confirmation of at least one intracranial aneurysm using cerebral computed tomography angiography (CTA) and/or digital subtraction angiography (DSA); (2) Initial clinical assessment upon admission classified as Hunt and Hess grades IV or V; and (3) Surgical intervention within 72 hours after the onset of coma.

Participants who met any of these criteria were excluded from the study: (1) non-aneurysmal subarachnoid hemorrhage (sSAH) or sSAH of unknown etiology, (2) patients with aneurysms in the posterior circulation, (3) patients categorized as Hunt and Hess grades I, II, or III at arrival, (4) patients who ultimately received endovascular treatment instead of surgical intervention, (5) patients who suffered rebleeding from a remaining aneurysm after prior surgery, (6) patient with severe comorbid disease that affects consciousness.

Patient data were collected retrospectively from electronic medical records, radiological reports, and surgical databases. The collected information included demographic characteristics, clinical presentation, imaging

findings, surgical details, postoperative problems, duration of hospitalization, and functional status at the following evaluations.

The primary outcome measures assessed in this study were functional outcomes, including neurological status and quality of life, evaluated at follow-up. Secondary outcome measures included perioperative complications, length of hospital stay, and mortality rates.

### Statistical Analysis

We utilized statistical methods such as the t-test and chi-square test, when needed, to present a clear summary of the main characteristics of our study sample. To identify characteristics associated with the risk of mortality and duration of life, we utilized Cox proportional hazard analysis, univariate and multivariate logistic regression

analysis, to identify characteristics associated with the risk of mortality and duration of life. All statistical analyses were conducted, and the results were found to be significant at a significance level of less than 0.05. SPSS was used for all statistical analyses.

## RESULTS

The study comprised 102 individuals with spontaneous SAH, 73 of whom had aneurysmal SAH. Twenty-seven patients had a poor-grade clinical condition upon admission, comprising 14 males and 13 females (Table 1).

Regarding the severity of SAH, 27 patients had Hunt and Hess scores of grades 4 or 5, indicating a more severe clinical presentation. Additionally, 21 patients had Fisher grade 4, suggesting a higher degree of subarachnoid blood on imaging.

**Table 1.** A compilation of data on each patient's clinical condition, Fisher grade, specific type and timing of surgery and the subsequent outcomes after 6 months

Patient	H-H grade	Fisher grade	Location	Surgery	Time of surgery (hours)	Outcome (GOS)
1	4	4	MCA	Clipping	48	1
2	5	4	MCA	Clipping	<24 h	1
3	5	4	ICA	Wrapping	72	1
4	4	4	aCom	Clipping	<24 h	3
5	4	3	aCom	Clipping	48	4
6	5	4	MCA	Clipping	48	1
7	5	4	MCA	Clipping	<24 h	1
8	5	4	aCom	Clipping	<24 h	3
9	4	3	MCA	Clipping	48	5
10	5	4	MCA	Clipping	48	1
11	5	4	aCom	Clipping	<24 h	4
12	4	4	MCA	Clipping	<24 h	3
13	4	3	MCA	Clipping	<24 h	1
14	5	4	MCA	Clipping	<24 h	1
15	5	4	aCom	Clipping	72	1
16	4	3	aCom	Clipping	<24 h	2
17	4	3	MCA	Clipping	48	5
18	5	4	aCom	Clipping	<24 h	4
19	4	4	pCom	Clipping	<24 h	3
20	5	4	aCom	Clipping	72	5
21	5	4	MCA	Wrapping	<24 h	1
22	5	4	MCA	Clipping	48	1
23	4	3	pCom	Clipping	48	2
24	4	4	MCA	Clipping	<24 h	3
25	5	4	MCA	Clipping	<24 h	1
26	5	4	aCom	Clipping	<24 h	1
27	5	4	aCom	Clipping	<24 h	1

H-H: Hunt-Hess, GOS: Glasgow Outcome Scale, aCom: Anterior communicating artery, MCA: Middle cerebral artery, pCom: Posterior communicating artery, ICA: Internal carotid artery

Imaging techniques played a crucial role in the diagnosis and evaluation of aneurysms. Of the patients, 24 had their aneurysms detected by CTA, while 3 cases required DSA for detection, as CTA failed to identify these aneurysms. Importantly, all aneurysms detected by CTA were confirmed by subsequent DSA. The majority of aneurysms (14) were located in the middle cerebral circulation, followed by 10 in the anterior cerebral circulation and 3 in the ophthalmic artery.

Complications associated with the ruptured aneurysm included intraparenchymal hematoma in 9 patients and intraventricular hematoma in 7 patients.

Treatment strategies varied among the patients. Sixteen patients underwent surgical clipping within 24 hours of admission, while 21 patients required the insertion of

an external ventricular drain (EVD). Among the surgical approaches, eight patients underwent a standard pterional craniotomy, and 19 patients underwent an extensive unilateral decompressive craniectomy. Aneurysm clipping was performed in 25 cases, while 2 patients underwent aneurysm wrapping.

Post-surgical complications included hydrocephalus, requiring ventriculoperitoneal shunt surgery in 7 patients, and the development of massive brain edema in 4 patients (Table 2).

The average duration of follow-up in this study was 14 months. Only a small number of patients, (4) exhibited a favorable functional outcome, indicating a low rate of recovery. Notably, the mortality rate at the six-month mark was substantial, with 51% of patients succumbing to their condition. Infection and massive brain edema were identified as the leading causes of death. Univariate regression analysis showed that older age was linked to an increased risk of mortality, with an odds ratio of 1.027 per year and a 94% confidence interval (CI). Conversely, factors such as gender, clinical status upon admission, Fisher grade, aneurysm location, parent vessel size, cerebral edema development, the existence of cerebral hemorrhage, and performing ultra-early surgical intervention did not have a significant impact on the likelihood of mortality.

Individuals with poor-grade acute SAH have an average survival length of 4.2 months with a standard deviation of 0.5 months. The survival rates at various times during the study were as follows: 0.783 (95% CI 0.731-0.971) at one month, 0.696 (95% CI 0.531-0.912) at two months, and 0.522 (95% CI 0.353-0.772) at six months of follow-up. These figures indicate a gradual decrease in survival rates over time, underscoring the challenging nature of this condition and the limited long-term prognosis for patients with poor-grade acute SAH.

Further analysis using univariate Cox regression showed that variables like patient age, gender, clinical condition at admission, Fisher scale score, parent vessel size, aneurysm location, severe edema occurrence, cerebral hemorrhage existence, and operation timing did not significantly impact patient survival time.

## DISCUSSION

Severe clinical grades of aSAH are associated with significantly worse prognoses compared to milder clinical grades. The debate regarding the optimal timing and extent of surgical intervention in these patients has persisted for a long time.

**Table 2.** Basic characteristics of participants

Factors		Mean
Age		56
Follow-up		14
Gender	Male	14
	Female	13
Hunt-Hess	Grade 4	11
	Grade 5	16
Fisher	Grade 3	6
	Grade 4	21
Side	Left	9
	Right	5
	Midline	10
Vessels	ICA	1
	MCA	14
	aCom	10
	pCom	2
ICH		9
IVH		7
Craniectomy	Pterional	8
	Decompressive	19
Surgery	Clipping	25
	Wrapping	2
VPS		7
Timing of surgery	<24 h	16
	48	8
	72	3
Status	Alive	12
	Death	15

MCA: Middle cerebral artery, aCom: Anterior communicating artery, ICA: Internal carotid artery, pCom: Posterior communicating artery, ICH: Intracerebral hematoma, IVH: Intraventricular hematoma, VPS: Ventriculo-peritoneal shunt

Conservative therapy was preferred for severe aSAH before large intracerebral hematomas occurred (8). Studies have shown that performing rapid surgical removal of a blood clot and clipping of an aneurysm at the same session can lead to improved outcomes. Recent studies indicate that intensive surgical treatment is beneficial for those with severe cases of aSAH. Early surgery during the first three days after the seizure may improve functional outcomes. Some studies even suggest a technique for improving treatment outcomes called ultra-early surgery (done within 24 hours) (7,9,10). Nevertheless, death and morbidity rates continue to be high despite these encouraging findings. Advanced age and surgical scheduling (ultra-early vs. early) do not appear to have a substantial impact on the risk of death or the duration of survival (11-13). Different surgical approaches were employed, including standard pterional craniotomy and extensive unilateral decompressive craniectomy. The choice of the specific approach depended on the characteristics and needs of each patient (2,8). Aneurysm clipping was the primary surgical intervention in 25 cases, with aneurysm wrapping performed in 2 patients. These findings are consistent with the prevailing treatment options for intracranial aneurysms, which involve a combination of surgical techniques tailored to the individual patient's condition.

High intracranial pressure (ICP) often occurs in patients with severe aSAH and can be caused by various pathogenic mechanisms. Inserting an EVD is a routine procedure to manage elevated ICP and drain fluid from the ventricular system. EVD implantation is generally effective but poses risks like rebleeding and infection. It is crucial to carefully analyze the association between EVD insertion and the greater likelihood of aneurysm re-bleeding (14-16).

The initial clinical grade upon admission plays a crucial role in predicting overall outcomes in aSAH patients. While some studies argue against the predictive value of the initial clinical grade, others highlight its significant correlation with final outcomes. The widely used Hunt-Hess grading scale, based on the patient's clinical status, aids in evaluating aSAH patients. Incorporating clinical grading into outcome prognosis assists in treatment decision-making and realistic expectations for recovery.

The exceedingly complex pathological process that is aSAH is generally acknowledged. Its development is regulated by a number of pathophysiological pathways, and its clinical effects are highly variable, and subject to a variety of outside influences. The prognosis is still poor despite recent improvements, especially for patients with severe aSAH. Poor-grade aSAH patients who go untreated

have an almost 100% mortality rate (6,17). However, some people can have positive functional outcomes with the right therapy. Such favorable outcomes were seen in 22% of the patients in our series. Lashkarivand et al. (2) reported that 21.9% of their patients were independent, which aligns with the current study's results. Regrettably, there is no universally accepted method to determine whether patients with low scores are expected to have a favorable result (18). Our analysis indicates that a prediction model may precisely evaluate the mortality risk for patients with aSAH by taking into account a number of features identified in our research. Wilby et al. (19) demonstrated that aggressive treatment for severe aSAH is both clinically essential and cost-effective. Considering that the management of a low-grade aSAH patient incurs double the cost of managing a good-grade aSAH patient, it is important to take into account the entire ongoing medical cost (20).

Age is often considered a significant factor in the prognosis of many diseases, including aSAH. As people age, they may have a higher risk of complications and slower recovery due to decreased physiological reserve and the presence of comorbidities. However, in our study, advanced age did not appear to have a substantial impact on the risk of death or the duration of survival. Some studies have suggested that women may have worse outcomes than men, possibly due to hormonal differences or differences in vascular anatomy (3,8,17). In our study, gender did not significantly impact patient survival time. This could be due to the relatively small sample size or the specific characteristics of the patient population.

## CONCLUSION

This thorough assessment of surgical results in intracranial aneurysm patients provides insight into the intricate nature of this ailment and the related challenges. The study findings indicate a limited rate of positive recovery, substantial mortality at six months, and a gradual decrease in survival rates over time. Advanced age emerged as a significant risk factor for increased mortality, while other factors investigated did not exhibit substantial influences on patient outcomes. These results contribute to the existing literature on poor-grade SAH and emphasize the need for further research and advancements in the management of this challenging condition.

## ETHICS

**Ethics Committee Approval:** The study complied to the ethical principles of the Declaration of Helsinki and was authorized by the University of Health Sciences Türkiye, Eskişehir City Hospital Non-Interventional Clinical Research

Ethics Committee (decision no: ESH/GOEK -2023/45, date: 17.08.2023).

**Informed Consent:** All people who participated in this study have provided informed consent.

## FOOTNOTES

### Authorship Contributions

Surgical and Medical Practices: M.B., H.M., S.E., Concept: M.B., H.M., S.E., Design: M.B., H.M., S.E., Data Collection or Processing: M.B., H.M., S.E., Analysis or Interpretation: M.B., H.M., S.E., Literature Search: M.B., H.M., S.E., Writing: M.B., H.M., S.E.

**Conflict of Interest:** No conflict of interest was declared by the authors.

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