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Short-Term Outcomes of Aneurysmatic/Non-Aneurysmatic Patients Operated for Spontaneous Subarachnoid Hemorrhage: A Tertiary Referral Center

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ABSTRACT

We aimed to retrospectively analyze patients with aneurysmal dilatation and vascular malformation who presented with spontaneous SAH.
Clinical data in patients files, Preoperative and postoperative neurological and radiological findings, age, gender, and treatment results were evaluated retrospectively.
The same team performed surgery on 38 (47.5%) patients. Twenty (52.6%) of the patients included in the study were female, and 18 (47.3%) were male. There were 33 patients with detected bleeding aneurysms, three with bleeding AVMs, and two patients with non-bleeding aneurysms.
It was determined that 5% of the patients had a Fisher score of 1, 34% had a Fisher score of 2, 24% had a Fisher score of 3, and 37% had a Fisher score of 4. Ten patients died. There were signs of vasospasm in 18 patients. Nine (50%) of 18 patients with vasospasm survived, and 9(50%) died. Eleven patients had hydrocephalus. EVD was inserted in 10 patients. Lamina terminalis was opened in 29 patients. The vessel with the most common aneurysm was the isolated AcomA aneurysm, with a rate of 31.5% (n=12). MCA aneurysm was found with the second frequency with a rate of 23.6% (n=9)
Spontaneous subarachnoid hemorrhage is a disease with high mortality and morbidity in neurosurgery. Rebleeding, vasospasm, onset GCS, Fisher score, and experienced surgical equipment are among the factors affecting the treatment outcome. Multidisciplinary treatment in centers where diagnosis, treatment, and follow-up can be made by the same team will reduce mortality and morbidity rates.

Keywords: Subarachnoid hemorrhage, Aneurysm, Fisher, Microsurgical Clipping

Introduction

Blood leakage most commonly causes nontraumatic spontaneous subarachnoid hemorrhage (SAH) in the subarachnoid space as a result of rupture of an aneurysm sac in the vessels located in the brain, cerebellum, and spinal cord (1,2). Other causes of spontaneous SAH include bleeding due to hypertension, arteriovenous malformation (AVM), bleeding diathesis, tumors, and mycotic aneurysms (3,4). The incidence of spontaneous SAH has been reported at the highest rate of 25/100,000 in Japan and approximately 10-16/100,000 in other countries (2,3,5).

The clinical and radiological classification of SAH is essential in developing treatment strategies and predicting the prognosis. The most frequently used parameters are the Glasgow Coma Score (GCS), the Hunt & Hess Scale (H&H) and World Federation of Neurosurgeons Scale (WFNS) for clinical evaluation and the Fisher score used in cranial computed tomography (CT) for radiological evaluation (6,7).

Rebleeding and vasospasms are the most critical complications of SAH, which lead to mortality and morbidity. The risk of rebleeding is reduced with early surgery, and some studies have reported that vasospasms come to the fore. It has also been reported that early surgery is beneficial for better monitoring and treating vasospasms (8,9).

The primary purpose of treatment is the closure of the aneurysmal sac with microsurgery, and interventional methods, such as endovascular coil-stent, should be performed without delay, thereby reducing morbidity and mortality (10).

We aimed to retrospectively examine patients who had aneurysmal dilatation and presented with spontaneous SAH. The aneurysms were detected

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via examinations and were operated by the same team in the last 2 years.

Materials and Methods

Permission for the study was obtained from the Ethics Committee of the Yüzüncü Yıl University Clinical Researches No: 2022/08-12. Between September 2020 and January 2023, the data of 80 patients who presented with spontaneous SAH due to vascular pathology in the Neurosurgery Clinic of Yüzüncü Yıl University were analyzed. Patients operated on by the same surgical team were included in the study. Patients treated endovascularly were excluded. Clinical data from patients' files, preoperative and postoperative neurological and radiological findings, age, sex, and treatment results were retrospectively evaluated.

Neurological status at the time of admission was evaluated using the GCS. To diagnose SAH, 2 × 64 slice CT was performed; moreover, to diagnose an aneurysm, three-dimensional CT angiography (CTA-3D) or digital subtraction angiography (DSA) was performed. The operating room had two high-speed drills, a microscope with Kinevo 900 4K capability, and microsurgery hand tools. Furthermore, the operating room had the ability to record surgeries on digital media (Zeiss, Germany). In addition to this technical equipment, Yaşargil Titanium clips (Aesculap AG & Co, Tuttlingen, Germany) and Sugita clips were used to microsurgically clip aneurysms.

All patients underwent pterional craniotomy and Sylvian dissection. Wide pterional craniotomy and interhemispheric dissection were also added in selected cases.

Statistical Analysis: Descriptive statistics for continuous variables are expressed as means, standard deviations, standard error values, and minimum and maximum values, whereas categorical variables are expressed as numbers and percentages. The chi-square test was used to determine the relationships between categorical variables, and where necessary, rate comparisons were made. The independent t-test or paired t-test was used to compare continuous variables. The statistical significance level was set at 0.05; Statistical Package for the Social Sciences, version 20, was used for all statistical analyses.

Results

Between September 2020 and January 2023, 80 patients were hospitalized due to an aneurysm. Of these patients, 39 were female (mean age, 56.92 ± 17.7 years), and 41 were male (mean age, 55.36 ± 13.3 years). Seventy-five patients (93.7%) were diagnosed with bleeding aneurysms, three (3.75%) were diagnosed with AVM, and two (2.5%) were diagnosed with non-bleeding aneurysms. CTA was performed on 52 (65%) patients; the same team performed surgery on 38 (47.5%) patients. Thirty-eight patients operated by the same team were included in the study. Of the 38 patients included in the study, 20 (52.6%) were female, and 18 (47.3%) were male. Furthermore, 33 patients had bleeding aneurysms, three had bleeding AVMs, and two had non-bleeding aneurysms. No statistically significant difference in the mean age was observed between women (58.95 ± 18.34 years) and men (53.94 ± 11.2 years) who underwent surgery ($p > 0.05$) (Table 1).

It was determined that 5% of the patients had a Fisher score of 1, 34% had a Fisher score of 2, 24% had a Fisher score of 3, and 37% had a Fisher score of 4 (Graphic 1).

Ten patients died. Eighteen patients had signs of vasospasm, of whom nine (50%) survived and nine (50%) died. Vasospasm was present in nine of the 10 patients with exitus ($p < 0.05$) (Table 2).

A statistically significant difference in the GCS scores was observed between the time of admission to the hospital and the time of discharge, and the GCS score of the patients at discharge was significantly higher ($p < 0.05$) (Table 3).

The difference in the GCS scores between admission and discharge of patients who underwent surgery and survived was statistically significant, and the GCS scores were significantly higher at discharge (Table 4).

Postoperatively, DSA was not performed due to vasospasm in one patient, and DSA was performed with a Ca channel blocker in the same session. Eleven patients had hydrocephalus. An external ventricular drainage (EVD) was inserted into 10 patients. Lamina terminalis was opened in 29 patients. Furthermore, of the 29 patients whose lamina terminalis was opened, 21 (72.4%) did not have hydrocephalus (Table 5).

The most common site of aneurysm was the isolated anterior communicating artery (AComA), with a rate of 31.5% (n = 12), followed by the

Table 1. Demographic Characteristics of Diseases That Underwent Surgery By The Same Team

Surgery (n=38)(%)	Age (mean±stddev) (IQR)	56.57±15.38(46-65.5)
Sex	female	20 (%52.6)
	male	18 (%47.3)
Type	ruptured	33 (86.84)
	microaneurysm with AVM	3 (%7.9)
	unruptured	2 (%5.2)
DSA (+)	preoperative	25 (%65.78)
	postoperative	1 (%2.63)
complication	(+)	18 (%47.36)
	(-)	20 (%52.63)
hydrocephali	(+)	11 (%28.94)
	(-)	27 (%71.05)
EDV	(+)	10 (%26.31)
	(-)	28 (%73.68)
Lamina therminalis	(+)	29 (%76.31
	(-)	9 (%23.68)
Number of Aneurysm	one	34 (%76.31)
	two	5 (%23.68)
Vasospasm	(+)	18 (%47.36)
	(-)	20 (%52.63)
VP shunt	(+)	5 (%13.15)
	(-)	33 (%86.84)
IVH	(+)	13 (%34.21)
	(-)	25 (%65.78)
Survey	alive	28 (%73.68)
	exitus	10 (%26.31)

middle cerebral artery, with a rate of 23.6% (n = 9) (Table 6).

When the aneurysms were examined in terms of their sizes, aneurysms with a size between 5 and 10 mm were the most common, found in 61% of the patients (n = 23) (Graphic 2).

Discussions

With the effect of many genetic and acquired factors, vessel wall enlargement may occur. When these changes in the cranial vessels are added to the hemodynamic stress and pressure increase in many natural bifurcation areas in the Willis polygon, favorable conditions for aneurysmal SAH occur. In sudden hypertensive pressure, spontaneous SAH occurs with very high mortality and morbidity (11).

The incidence of SAH is approximately 10/100,000 population per year. The risk of rupture of unruptured aneurysms is on average 1%-2% per year (12). Many risk factors have been identified that cause SAH due to an aneurysm, which has high mortality and morbidity rates.

In the development of SAH due to the rupture of the aneurysm sac, the localization, type, and size of the aneurysm are essential. Furthermore, old age and female sex were also shown to be among the risk factors for aneurysm rupture (13,14).

A study involving bleeding (n=26) and control (n=106) participants found a statistically significant relationship between high systolic blood pressure, smoking, drinking more than five cups of coffee per day, and SAH development due to an aneurysm (15). In our series, high systolic blood pressure was detected at presentation in all patients with SAH due to an aneurysm presenting with bleeding.

Intraventricular hemorrhage (IVH) (13%-28%), intraparenchymal hemorrhage (more common in distal aneurysms), and rarely subdural hemorrhage (2%-8%) patterns can also be seen in patients with aneurysmal SAH (16). Intraventricular bleeding is mostly seen in AComA aneurysms. It is attributed

Table 2. The Relationship Between Survey and Vasospasm

	Vasospasm (+) (n=18)	Vasospasm (-) (n=20)		p-value
alive	9(%50)	19(%95)	10.9	0.003
exitus	9(%50)	1(%5)		
total	18(%100)	20(%100)		

Table 3. The Relationship Between Admission GCS and Discharge GCS

(n=38)	surgery patients	mean±stderr	t	p-value
GCS	admission GCS	9.92±0.66	-2.48	0.018
	discharge GCS	11.39±0.84		

Table 4. GCS Results of Live Surgery Patients

n=28	alive surgery patients	mean±stderr	*t*	*p-value*
GCS	admission GCS	11.42±0.61	-6.107	0.0001
	discharge GCS	14.35±0.28		

Table 5. Relation Between The Opening of The Lamina Terminalis and Hydroceplalus

	opening of the lamina terminalis	non-opening of the lamina terminalis	Total (n=38)
Hydrocephalus (-)	21 (%77.7)	6 (%22.2)	27(%100)
Hydrocephalus (+)	8 (%72.7)	3 (%27.2)	11(%100)

to its close proximity to the ventricle (17). In a study by Hernesneyn and Eren et al., IVH has been most frequently seen in IVH AComA bleeding (10). In our series, IVH was observed in 6 of the 12 patients with AComA bleeding.

In the literature, it has been reported that the incidence is high in the age range of 40-60 years. Furthermore, it has been reported that it is seen twice as often in women (18,19). In our study, contrary to the literature, the number of female (n = 20) and male (n = 18) patients was very close to each other (F/M = 1.1) (Table 1). Again, in our study, 52.7% of the patients were between the ages of 40 and 60 years, consistent with the literature. However, no statistically significant difference in the mean ages was observed between both sexes.

Most aneurysms (88%) arise in the anterior circulation of the Willis polygon, as reported in a prospective study involving 4,060 patients with unruptured intracranial aneurysms (International Study of Unruptured Intracranial Aneurysms) (20).

AComA aneurysms are the most common type of aneurysm in the anterior circulation of the Willis polygon. It has also been reported that AComA aneurysms are more common in men (21). In their aneurysm surgery series of 344 cases, Ulutas et al. have reported that AComA aneurysms were the most common, and posterior communicating artery (PComA) aneurysms were the second most common (22). Eren et al., in their retrospective study, have found AComA, MCA, and PComA aneurysms to be the most common. In our study, isolated AComA aneurysms were observed in 31.5% of the patients, which is consistent with the literature (10) (Table 6).

CT is considered the gold standard for radiological diagnosis in patients with SAH in the early stage. The Fisher scale was recorded in all patients during CT examination. It was determined that 5% of the patients had a Fisher score of 1, 34% had a Fisher score of 2, 24% had a Fisher score of 3, and 37% had a Fisher score of 4 (Graphic 1). Consistent with the literature, patients with high Fisher scores had a higher incidence of vasospasm and higher mortality and morbidity rates.

Mahesh et al. (23), in their study comparing CTA and DSA, have reported that the sensitivity and specificity values of CTA in diagnosing intracranial aneurysms were 90% and 93%, respectively, for the first observer. The gold standard for diagnosing and evaluating aneurysms, the most common cause of spontaneous SAH, is DSA. Despite this, it has been reported that 5%-10% of DSA can give false-negative results (24).

Table 6. Aneurysm Types

Aneurysm types	N=38(%)
ACOM	12 (%31.5)
MCA	9 (%23.6)
microaneurysm with AVM	3 (%7.9)
ICA	3 (%7.9)
PICA+Acom	2 (%5.3)
ICA+A1	1 (%2.6)
PCom+Acom	1 (%2.6)
ICA+PCom	1 (%2.6)
A1+MCA	1 (%2.6)
Achor	1 (%2.6)
PComA+MCA	1 (%2.6)
Distal A2	1 (%2.6)
A2	1 (%2.6)
A1	1 (%2.6)

Furthermore, as an invasive procedure, it can lead to various complications. For this reason, thin-section scanning CTA and magnetic resonance angiography, which are less invasive methods, have been used recently, and it is clear that they can be an alternative to DSA. CTA was performed in 17 of the 38 patients included in our study, and DSA was performed in 21 patients.

Hydrocephalus is a complication observed during and after treatment in patients with SAH. Approximately 10%-20% of patients with aneurysmal SAH eventually require the placement of a ventriculoperitoneal (VP) shunt for the permanent diversion of cerebrospinal fluid due to posthemorrhagic hydrocephalus (25,26).

Another study has reported that a VP shunt was placed into 14.1% of cases due to hydrocephalus (22). In our series, 11 patients had hydrocephalus. EVD was inserted into 10 patients. A VP shunt was inserted in five (13.5%) patients due to permanent hydrocephalus, consistent with the rates in the literature. In 29 patients, the lamina terminalis was opened during surgery. Twenty-one (72.4%) of the 29 patients whose lamina terminalis was opened did not have hydrocephalus (Table 5). Lamina terminalis opening was evaluated as a very effective method for providing brain relaxation during surgery and for forming postoperative permanent hydrocephalus.

Rebleeding and vasospasm are the most severe complications in patients with SAH. With the increase in early surgery rates, rebleeding has decreased, and vasospasm has become more critical. Vasospasm usually occurs after 48 h, and the probability of being seen in the first 2 weeks is relatively high (4,27,28). It has been reported that the rate of vasospasm seen after SAH is 30%-45% due to mixed mechanisms triggered by vasospasmogenic blood products in the subarachnoid space (29,30). In another study, it has been reported that there is a relationship between vasospasm and the amount of blood in the subarachnoid space (29,30).

Despite successful aneurysm surgery, vasospasm can result in focal, progressive neurological deficits or death. Vasospasm-related morbidity and mortality occurred in 15 (6%) and 17 (6.8%) patients, respectively. In another study, 33.9% of our patients who developed vasospasm died (9,22,28).

In our series, 18 patients had signs of vasospasm, of whom nine (50%) survived and 9 (50%) died. In our study, vasospasm was present in 9 of the 10 patients who died ($p < 0.05$).

The prognosis of SAH can be determined according to the current neurological picture. The neurological picture of the patients is measured using the Hunt and Hess classification and the World Federation of Neurosurgeons Scale (WFNS). Both scales have limitations due to variability among observers (31).

Glasgow Coma scale, which is one of the WFNS score parameters, is a frequently used neurological picture evaluation scale with less observer variability (32)

Our study used the Glasgow Coma Scale to determine the patient's consciousness level and neurological status. Consistent with the literature in our study, patients with low GCS and high Fisher scores had a worse prognosis.

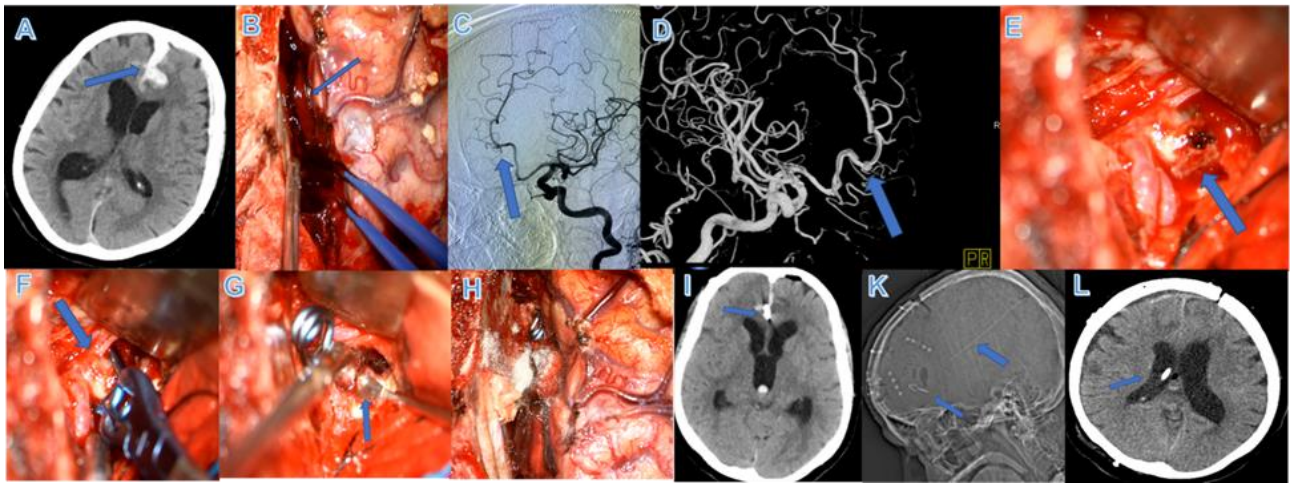

Fig. 1. Distal A2 aneurysm presenting with spontaneous subarachnoid hemorrhage and its microsurgical treatment
A-Preoperative cranial CT: Subarachnoid hemorrhage seen as hyperdense in the interhemispheric area on cranial CT (Blue arrow)
B-Intraoperative image of interhemispheric hemorrhage (Blue arrow)
C/D-Preoperative DSA Angiography /3D: Distal A2 aneurysm (Anterior/posterior view -Blue Arrows)
E-Revealing the intraoperative aneurysm after dissection with the interhemispheric approach
F-During intraoperative aneurysm clipping
G/H- Intraoperative view of the interhemispheric approach after clipping
I-K-Postoperative cranial CT: Image of aneurysm clips (Blue arrow)
L-Treatment of hydrocephalus by placing a ventriculoperitoneal shunt (Blue arrow) upon the development of hydrocephalus

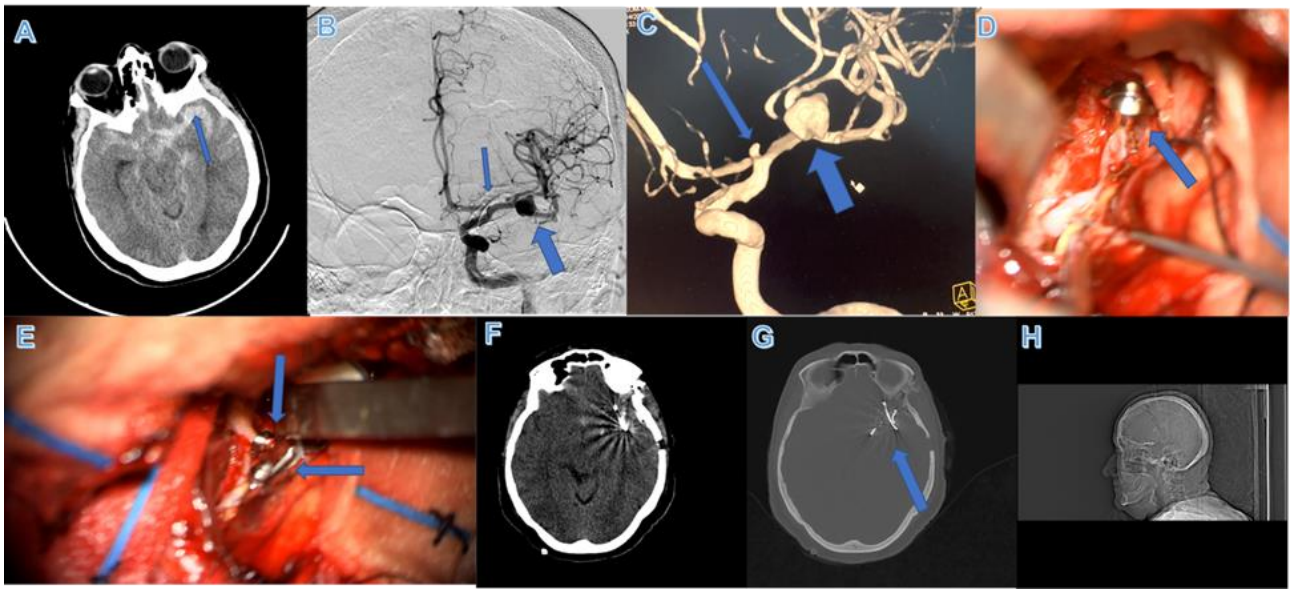

Fig. 2. Microsurgical treatment of A1 and MCA aneurysms presenting with spontaneous subarachnoid hemorrhage
A- Preoperative cranial CT- Hyperdense subarachnoid hemorrhage areas on cranial CT (Blue Arrow)
B/C-Preoperative DSA Angiography /3D: Aneurysm at ICA-A1 junction (Thin blue arrow) - MCA aneurysm (Thick blue arrow)
D-Dissection of intraoperative aneurysm with pterional approach, exposure of MCA. aneurysm after temporary clip (blue arrow) attachment to ICA
E-Intraoperative view of ICA and A1 junction and MCA clips
F/G/H-Postoperative cranial CT-bone window-scenogram: Image of aneurysm clips

Spontaneous SAH is a disease with high mortality and morbidity in neurosurgery. Rebleeding, vasospasm, onset GCS, Fisher score, and experienced surgical equipment are among the factors affecting the treatment outcome. The diagnosis of this disease should be made urgently,

and the cause of bleeding should be determined. The patient should be treated with surgical or endovascular methods, depending on the patient's suitability, without wasting time. Even in the absence of hydrocephalus, opening the lamina terminalis during surgery will reduce the pressure in the brain as a result of bleeding, clear the blood in the subarachnoid space, and facilitate surgical dissections. Multidisciplinary treatment in centers where diagnosis, treatment, and follow-up can be performed by the same team will reduce the mortality and morbidity rates.

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Abbreviations:

SAH: subarachnoid hemorrhage

AVM: arteriovenous malformation

GCS: Glasgow Coma Scale

H&H: Hunt & Hess

CT: computed tomography

CTA: computed tomography angiography

DSA: digital subtraction angiography

EVD: external ventricular drainage

IVH: intraventricular hemorrhage

ICA: internal carotid artery

PComA: posterior communicating artery

AChor: anterior choroidal artery

AComA: anterior communicating artery

MCA: middle cerebral artery

A1: anterior cerebral artery A1 segment

A2: anterior cerebral artery A2 segment

IQR: interquartile range

WFNS: World Federation of Neurosurgeons Scale

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