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Vasospasm as a Complication after Aneurysmal Rupture and Its Relation with Surgical Clipping and Endovascular Coiling among a Georgian Sample

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Abstract

Background: Potentially lethal, aneurysmal subarachnoid hemorrhage has a bad prognosis for many individuals. Over the past few decades, endovascular and surgical interventions have been developed, including surgical clipping, and endovascular coiling. Patients who have aSAH are also susceptible to delayed cerebral ischemia and cerebral vasospasm. The aim of this study is to compare the outcome of endovascular coiling with surgical clipping in patients with SAH, specifically in relation to prevalence of vasospasm, in the country of Georgia. **Method:** In this study, we present a retrospective review of the outcomes of 217 patients with acute subarachnoid hemorrhage who underwent endovascular coiling or surgical clipping. The data were gathered from patients who are admitted to New Vision University Hospital and Caucasus Medical Center in Tbilisi, Georgia, between 2017 and 2022. **Results:** Vasospasm was prevalent in 217 of the patients who had aneurysmal rupture when they first appeared. Endovascular coiling or surgical clipping was used to treat aneurysmal rupture. In our sample, 24.81 percent of patients who underwent coiling experienced vasospasm after 14 days, compared to 31.25 percent of patients who underwent clipping. After endovascular coiling and surgical clipping, the severity of vasospasm was only slightly different, according to Lindegaard ratios. Finally, 32 patients (23.35 percent) died after coiling whereas 55 patients (68.75 percent) died within three decades of clipping. **Conclusion:** After 5 years of data collection, this study has demon-

strated the most favorable option for treatment is endovascular coiling. However, the treatment choice takes multiple factors into account, and clipping is not ideal for some ruptured aneurysms. Despite the fact that endovascular coiling is usually successful and minimally invasive, complications can occur and additional monitoring and potential surgical intervention are indicated.

Keywords

Aneurysms, Subarachnoid Hemorrhage, Surgical Clipping, Endovascular Coiling, Vasospasm

1. Introduction

Intracranial aneurysms are a focal, thin-walled dilation of the blood vessels in the brain that mostly occur in the circle of Willis, at the bifurcations. About 85% of aneurysms are present along the circle of Willis [1] [2]. With a mean age of 50 and a general gender ratio of 1:1, the prevalence of cerebral aneurysm is roughly 3.2 percent worldwide. After age 50, this ratio significantly shifts, with a growing female predominance nearing 2:1, which is considered to be caused by a drop in circulating estrogen that lowers the amount of collagen in the vascular tissue. Morbidity and mortality are exceedingly high following a brain aneurysm rupture. Nearly 25% of people pass away within the first 24 hours and 50% do so during the following 3 months. The prognosis of ruptured aneurysm can be affected by factors such as aneurysm location, age, presence of concomitant conditions like hypertension, vasospasm intensity and how much intraventricular bleeding there is [3] [4].

Ruptured aneurysm causing SAH is high in some populations like Finnish and Japanese [5]. Subarachnoid hemorrhages can lead to a pool of blood under the arachnoid mater that increases the intracranial pressure and prevents more blood from flowing into the brain. Approximately one third ultimately remain permanently dependent on nursing care, and only 30% are able to return to independent living [6]. The clinical outcome depends on multiple factors, including the severity of the acute bleed, the patient's initial condition, the presence or absence of early rebleeding, and the presence or absence of delayed cerebral ischemia (DCI). Pulmonary and cardiac complications are also prognostically relevant.

Aneurysmal SAH can have various complications on the brain, like hydrocephalus, Rebleeding. hyponatremia, and vasospasm [7]. Cerebral vasospasm, characterized as central or diffuse reversible narrowed blood vessel type because of contraction of smooth muscle in the wall of arteries [8], is a severe complication of aneurysmal subarachnoid hemorrhage and is considered to be one of the main causes of complications or poor prognosis and even death in 1 of 5 patients in the Caucasus region. Cerebral vasospasm was thought to cause the delayed

ischemic neurological deficit; thus, evidence suggests that this is a reductivism, because interventions that have effectively targeted cerebral vasospasm have not improved the outcome [9]. The exact mechanism that leads to cerebral vasospasm remains unexplained; however, most of the studies suggested that calcium plays an important role in developing the vasospasm as well as free radicals and the inflammation that follows the hemorrhage and Endothelin concentrations.

In the past, surgical clipping of aneurysms was the only effective method to manage aneurysmal subarachnoid aneurysmal hemorrhage (aSAH). In 1990, the Guglielmi detachable coil—a detachable platinum coil device was first introduced in clinical practice. Since then, coiling, which has the advantage of being minimally invasive and with a better access to the posterior circulation, has gained worldwide acceptance as an alternative treatment [10].

Currently, to the best of our knowledge, there is not enough data in the medical literature comparing vasospasm prevalence in relation to endovascular coiling and surgical clipping in Georgia. Thus, the aim of this study is to compare the outcome of endovascular coiling with surgical clipping in patients with SAH, specifically in relation to prevalence of vasospasm, in the country of Georgia.

2. Method

In this study we present a retrospective analysis of the results of 217 patients, treated either by endovascular coiling or surgical clipping, with a diagnosis of acute subarachnoid hemorrhage. All patients between the age of 3 and 82 years old who presented with a subarachnoid hemorrhage were included in this study. Patients were excluded from this study if they have died before any management. The data was collected from patients admitted to New Vision University Hospital (NVUH) and Caucasus Medical Center, in Tbilisi, Georgia, from 2017 till 2022.

The first-line diagnostic study was computed tomography/computed tomography with angiography, which is used for diagnosis of subarachnoid hemorrhage, the presence of aneurysm, and determining its size, shape and localization of aneurysms. Usually, this type of examination is enough to determine appropriate treatment tactics (clipping/coiling). However, digital angiography is considered as the gold standard for determining the appropriate tactics and techniques for endovascular treatment of aneurysmal subarachnoid hemorrhage [11]. In some cases, endovascular intervention (coiling) has proceeded directly after the aneurysm diagnosis (digital angiography).

2.1. Endovascular Coiling

137 patients have undergone Endovascular coiling. This technique was performed under general anesthesia. In most cases in our study the right femoral artery was punctured, but some exceptional cases had to be done from the brachial or radial artery or by a direct puncture to the carotid artery from the neck.

With the help of a micro-wire, a microcatheter was inserted into the aneurysm. Then, through this microcatheter, the aneurysm was completely filled out with descending size coils.

In 16 patients, coiling was done using balloon assistance, while in the other 121 patients, coiling was done without balloon assistance. The average endovascular procedure lasted 45 minutes. With the aid of a balloon catheter, coils are introduced into the aneurysm lumen when the aneurysm has a wide neck. The balloon forms a temporary wall at the aneurysm neck, and after that the aneurysm cavity is filled out with coils. This technique is broadly used in cases of complicated aneurysms [11].

When the aneurysm has a wide neck, coils are inserted into the aneurysm lumen with the assistance of a balloon catheter. Two main complications arise after endovascular coiling which are thromboembolic complication and vasospasm. Anticoagulation and anti-aggregate therapy are mostly used to manage thromboembolic complications. In our case, a nimotop infusion (8 ml nimotop/500ml physiological solution) was performed throughout the operation in the guide catheter and in the microcatheter. 5000 units of Heparin were injected intravenously if the procedure lasted longer than one hour.

2.2. Surgical Clipping

80 patients had surgical clipping. This technique has also been done under general anesthesia and it requires an open surgery. A craniotomy is performed to access the ruptured aneurysm, depending on the site of the aneurysm.

A microscope was used to locate the artery and carefully follow it to the aneurysm. Then the aneurysm was isolated and freed from the nearby structures by forceps. The clip is then held open with a tweezer-like applier and placed across the aneurysm neck, while paying attention to the small perforators arteries. After that, the jaws of the clip close on the aneurysm neck, blocking the blood flow to it. The clips are made of titanium, and stay in the brain on the artery permanently.

The main complications faced after surgical clipping are vasospasm, brain swelling, infarction and hypotension.

3. Results

3.1. Coiling

137 patients had endovascular coiling; 82 patients underwent endovascular treatment within 48 hours of subarachnoid hemorrhage, 29 patients within 48 - 72 hours, and 29 patients within 72 hours (**Table 1**).

The sex distribution was female—77 patients (56%) and male—60 (44%). Age ranged from 3 to 82 years.

Endovascular procedures we performed; Intra-operative thrombosis developed in 8 (5.8%).

Mechanical thrombectomy was performed in all these cases. 10 (7.3%) patients

Table 1. Time of management.

Hours	No of patients	Percentage
Within 48 hours	82	59.8%
Within 48 - 72 hours	29	21.2%
Within 72 hours	26	19%
Total	137	100%

developed total Progressive vasospasm. The severity of vasospasm was calculated using the Lindegaard ratio, with the following distribution (Table 2)

Intraoperative aneurysm rupture occurred in 3 (2.2%) cases. In all cases, the aneurysm was timely removed from the bloodstream. Intraoperative rupture did not affect clinical outcome 92 patients were admitted with Hunt-Hess scale I-III. Postoperative mortality was reported to be 19.5% (18/92 patients) (Table 3).

It is important to note here that the Percentage total refers to the total number of mortalities among the group of endovascular coiling, concerning the patients admitted with HHS I-III.

In the 45 patients presenting with Hunt-Hess IV-V, the mortality rate was 51.1% (23/45) (Table 4).

Postoperative mortality was reported to be 29.9% (41/137 patients).

3.2. Clipping

80 patients underwent surgical clipping. Among them 45 (56.25%) were male, and 35 were female (43.75%)

Among these patients, 25 of them (31.25%) developed vasospasm. The severity of vasospasm was calculated using the Lindegaard ratio, and its distribution was the following (Table 5).

58 (72.5%) patients were admitted with Hunt-Hess scale I-III while 22 patients (27.5%) were admitted with Hunt-Hess scale IV-V (Table 6).

Among these admissions, the mortality rate was significantly higher than those who had endovascular treatment (68.75% 55/80) (Table 7).

4. Discussion

The effects of treatment modalities (endovascular coiling or surgical clipping) on the incidence of cerebral vasospasm following aneurysmal subarachnoid hemorrhage (aSAH) remain controversial. This study focuses on the techniques used in managing SAH (endovascular coiling and surgical clipping) and compares their outcomes specifically on vasospasm.

Among 217 patients who presented with an aneurysmal rupture, the prevalence of vasospasm was 27.19%. The management of aneurysmal rupture was done by either surgical clipping or endovascular coiling. Among our sample, 31.25% of patients treated with clipping developed vasospasm within 14 days, while 24.81% of those treated with coiling developed vasospasm within 14 days.

Table 2. Lindegaard ratio in patient who underwent endovascular coiling.

Lindegaard ratio	Cases	Percentage
3 - 4.5	103	75.18%
4.5 - 6	25	18.24%
>6	9	6.56%
Total	137	100%

Table 3. Percentage of patient with HHS I-III.

	Hunt-Hess scale I-III	Percentage	Percentage Total
Hospital Admission	92	67.1%	
Mortality	18	19.5%	13.1%
Survival Rate	74	80.5%	

Table 4. Percentage of patient admitted with HHS IV-V.

	Hunt-Hess scale IVV	Percentage	Percentage Total
Hospital Admission	45	32.9%	
Mortality	23	51.1%	16.7%

Table 5. Lindegaard ratio for patient who underwent surgical clipping.

	Cases	Percentage
3 - 4.5	55	68.75%
4.5 - 6	20	25%
>6	5	6.25%
Total	80	100%

Table 6. Hunt-Hess scale for hospital admission in patients who underwent surgical clipping.

	Hospital Admissions	Percentage
Hunt & Hess Scale I	30	37.5%
Hunt & Hess Scale II	15	18.75%
Hunt & Hess Scale III	13	16.25%
Hunt & Hess Scale IV	12	
Hunt & Hess Scale V	10	12.5%
Total	80	100%

Table 7. Mortality rate among patients who underwent surgical clipping.

	Cases	Percentage
Deaths	55	68.75%
Survival Rate	25	31.25%
Total	80	100%

The Lindegaard ratios showed a relatively small difference in the severity of vasospasm after endovascular coiling and surgical clipping. Finally, 55 patients died within 3 decades after clipping (68.75%), while 32 patients (23.35%) died after coiling.

Our study showed that the rate of developing vasospasm was higher after surgical clipping than after endovascular coiling. These results are consistent with other studies. A retrospective study done by Taha *et al.* on 133 patients showed that the frequency of vasospasm was 17.4% in coiling and 45.4% in clipping. They also showed that coiling is safer to use than clipping [12]. Li ZQ *et al.* showed that in a sample of 186 patients, the incidence of vasospasm was significantly lower in endovascular coiling than in clipping [13]. A study done in Turkey in 2021 showed that despite the fact that symptomatic vasospasm was higher in the coil group, there was no statistically significant difference between the two groups [14].

When calculating the Lindegaard ratio in clipping and coiling, the results weren't significantly different. The Lindegaard ratio is defined as the ratio between mean flow velocities in Middle cerebral artery (MCA) and ipsilateral internal carotid artery (ICA) as measured with transcranial Doppler (TCD) and its primary utility is to confirm the presence of vasospasm. Our findings showed that vasospasm in patients who underwent coiling is relatively milder than those who had surgical clipping. It is important to note that the risk factors for developing vasospasm after aSAH are female gender, young age, localization of the aneurysm (usually anterior cerebral artery), loss of consciousness after the rupture and poor neurological grading on the admission [15]. It is noteworthy that these factors haven't been all assessed in this study, thus, further investigations should be done.

Finally, among our patients, the mortality rate was significantly higher among patients who had surgical clipping (68.75%) than among those who had endovascular coiling (23.35%). The results regarding mortality after surgical clipping or endovascular coiling have been different. A meta-analysis done by Belavadi R. *et al.* showed that endovascular coiling has been associated with less mortality than surgical clipping [16]. However, Ahmed *et al.* showed that mortality was higher after endovascular coiling [17]. Another meta-analysis done in Japan also reported in-hospital mortality of 7.1% after surgical clipping and 12.2% after endovascular coiling of the aneurysm [18]. A lot of factors can be taken into consideration here; first surgical clipping is an open surgery, exposing the brain to more stress and increased risk of infection more than endovascular coiling

which is minimally invasive. Second, the age of the patient, as well as previous medical history should be considered when discussing the best treatment option. However, surgical clipping has the benefit of low recurrence compared to endovascular coiling [16].

5. Limitation

This study had several limitations. First, a relatively significant number of patients were admitted with a Hunt and Hess scale IV and V (overall 30.87%), which means they were already admitted in a severe state. This might have affected the results in this study. Second, in clipped patients, surgery related damage might have been diagnosed as a symptomatic vasospasm, further affecting the results. Third, this study has been done on patients with age varying from 3 till 82 years old. This should be taken into consideration when discussing the result because the risk of vasospasm decreases with advanced age [19]. Finally, it is important to note that there is a clear difference between the number of patients in the two groups, which might have caused sampling bias.

6. Conclusion

Aneurysm burst is a critical clinical issue that needs quick diagnosis and care. Operative intervention must be carried out as soon as possible to avoid aneurysm rupture again. After an aneurysm rupture, it is advised to seek medical attention in 72 hours, and ideally within 24 hours. This study showed that endovascular coiling has lower mortality, and less prevalence of vasospasm, which makes it a better technique among our sample. However, it must be important to emphasize that the best decision will always differ depending on each patient, and it's also procedure-related, surgeon-related (expertise, years of experience), and hospital factors (Availability of resources) before getting the final and best decision to manage each specific case.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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