

Research Paper

Endovascular Coiling Versus Neurosurgical Clipping for Aneurysmal Subarachnoid Hemorrhage: Single-center Experience



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ABSTRACT

Background and Aim: Subarachnoid hemorrhage (SAH) resulting from ruptured intracranial aneurysms is associated with high mortality rates and presents a significant clinical challenge. The primary interventions to mitigate the risk of rebleeding and improve patient outcomes are neurosurgical clipping and endovascular coiling. While neurosurgical clipping has historically been the gold standard, endovascular coiling offers a less invasive alternative. Accordingly, this study compares the efficacy and outcomes of these two interventions in patients with aneurysmal SAH.

Methods and Materials/Patients: A total of 65 consecutive patients with aneurysmal SAH, treated either with neurosurgical clipping or endovascular coiling, were included in the retrospective cohort study. Functional outcomes were assessed using the modified Rankin score, and the complications were evaluated.

Results: No significant differences were found in functional outcomes between neurosurgical clipping and endovascular coiling groups ($P=0.92$); however, patients undergoing endovascular coiling had shorter lengths of in-hospital and in-intensive care unit stays compared to those treated with neurosurgical clipping ($P=0.02$). Conversely, endovascular coiling was associated with higher intervention costs ($P<0.01$). Subgroup analyses based on disease severity revealed small differences in functional outcomes between the two groups.

Conclusion: While both neurosurgical clipping and endovascular coiling demonstrate comparable efficacy in preventing rebleeding and improving functional outcomes, they present distinct advantages and considerations. Future studies should be performed to improve treatment algorithms and patient outcomes in this complex clinical situation. Additionally, larger prospective studies are needed to validate these findings and provide stronger evidence for guiding clinical decision-making.

Keywords:

Subarachnoid hemorrhage (SAH), Aneurysm, Endovascular coiling, Neurosurgical clipping

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Highlights

- No difference in modified Rankin score outcomes between clipping and coiling (P=0.92).
- Coiling led to shorter hospital stays compared to clipping (P=0.02).
- Coiling was significantly more expensive than clipping (P<0.01).
- Subgroup analysis showed better outcomes with clipping in certain WFNS/modified Rankin scores.
- Mortality and complication rates were similar between the groups.

Plain Language Summary

A subarachnoid hemorrhage (SAH) is a type of stroke caused by bleeding around the brain, often due to a burst aneurysm. This condition can be life-threatening and needs urgent treatment to prevent further bleeding and brain damage. Two common methods are used to treat aneurysmal SAH, namely neurosurgical clipping, which involves open brain surgery to place a clip on the aneurysm, and endovascular coiling, a less invasive procedure that fills the aneurysm with a tiny coil using a catheter inserted through the blood vessels.

This study compared the outcomes of these two treatments in 65 patients with aneurysmal SAH. The goal was to understand which approach might be more effective in real-world settings. The researchers looked at patients' recovery, hospital stay duration, and treatment costs. The results showed no significant difference in long-term recovery or survival between the two groups. However, patients who had endovascular coiling generally spent less time in the hospital and intensive care, suggesting faster recovery. On the other hand, coiling was significantly more expensive than surgical clipping. In some patient subgroups, clipping led to better functional outcomes.

These findings are important because they support the idea that both treatment options are effective, but they come with different trade-offs. For doctors, patients, and healthcare systems—especially those with limited resources, understanding these differences can help in making more informed, personalized treatment decisions. More large-scale studies are needed to confirm these results and improve treatment planning for people affected by this dangerous condition.

1. Introduction

Subarachnoid hemorrhage (SAH) due to aneurysmal rupture is a relatively common disease with a reported prevalence of 10 to 15 people per 100000 population in the USA [1]. Aneurysmal SAH is related to 30-day mortality rates of 80% to 100% compared to 33% to 50% in SAH overall [2]. This life-threatening condition is commonly diagnosed with a non-contrast brain computed tomography scan with or without diagnostic lumbar puncture [3]. Interventions are primarily trying to resuscitate the patient and reduce dependence in survivors. There are two common methods used for the treatment of SAH, trying to reduce rebleeding after SAH, including surgical clipping and endovascular coiling [4].

The gold standard intervention for SAH treatment is neurosurgical clipping [5]. This method is performed by clipping the aneurysm using a titanium clip and through access using a large craniotomy. Neurosurgical clipping results in an extended recovery time and is related to an increased risk of complications [5]. Minimally invasive methods, such as endovascular coiling, have been developed with advancements in interventional neuroradiology as an alternative treatment for aneurysmal SAH [6]. In this method, a platinum coil is attached to a microcatheter tip, which delivers it to the aneurysm lumen. Then, the coil is detached from the microcatheter, resulting in intra-aneurysmal thrombosis and its closure. Some studies suggest that the independence rate is higher in patients who were treated using endovascular coiling compared to neurosurgical clipping, with an increased risk of

rebleeding in the coiling method [7]. However, there are contradictory results demonstrated by other studies regarding outcomes and complications [5].

There is a controversy between the studies regarding the efficacy and complications of each approach. Furthermore, these results could vary a lot in different settings and populations. To the best of our knowledge, no published investigation has been conducted comparing neurosurgical clipping and endovascular coiling in Iran. Therefore, this study compares these two conventional methods for aneurysmal SAH in our center with a focus on functional outcomes.

2. Materials and Methods

Study design and setting

This was a retrospective cohort study performed on consecutive patients with aneurysmal SAH who underwent either neurosurgical clipping or endovascular coiling at the [Sayad-Shirazi](#) or [5-Azar](#) hospitals (both affiliated with [Golestan University of Medical Sciences](#)). The patients were referred for surgery from November 2016 to March 2021 and were followed up for two years. The medical records of each patient were extracted and were later used for comparison between the two approaches. This cohort was conducted adhering to the Declaration of Helsinki and its later amendments. We report the study based on strengthening the reporting of observational studies in epidemiology criteria for cohort studies.

Study participants

All patients afflicted with aneurysmal SAH who were referred to our two hospitals and were treated with either neurosurgical clipping or endovascular coiling were included in this cohort. The exclusion criteria were as follows: a) non-aneurysm-related SAH (including traumatic); b) deceased patients before the intervention; c) patients who were transferred to other centers for intervention; and d) those who did not undergo any of these interventional approaches. The included participants were treated with each of the two approaches based on the consensus between the neurosurgical and interventional neuroradiology groups. All neurosurgical clippings were performed by one neurological surgeon (Rouzbeh Shams Amiri), and all endovascular coilings were placed by one interventional neuroradiologist (Rahim Kohansal).

Variables, data source, and measurement

All data were retrieved from patients' medical records. The Hunt and Hess (H&H) and World Federation of Neurological Societies (WFNS) classifications were used to assess the severity of the SAH based on the patient's clinical condition. The patients were graded regarding radiological SAH findings based on the modified Fisher scale (mFS). Functional outcomes were evaluated according to the modified Rankin score (mRS). A good functional outcome was considered as an $mRS \leq 2$. We also extracted data regarding post-op complications, length of stay in hospital, length of stay in intensive care unit, and treatment cost.

Statistical methods

IBM SPSS software, version 21 (IBM Corporation, Armonk, NY, USA) was used for statistical analysis. Continuous variables were reported as Mean \pm SD, and categorical variables were reported as frequency (percentage). Continuous variables were compared using the independent t-test. Categorical variables were compared using the chi-square test or Fisher's exact test. A $P < 0.05$ was considered statistically significant.

3. Results

Baseline characteristics of the study participants

A total of 65 patients entered the study (mean age, 51.12 ± 18.6 years old; 49.3% female), of whom 54 underwent neurological clipping and 11 were treated with endovascular coiling. [Table 1](#) demonstrates the demographic data of each study group. There was no significant difference between the study groups regarding age, diabetes mellitus, hypertension, hyperlipidemia, opium consumption, and smoking. The mean H&H score was 2.44 ± 1.28 in the neurosurgical group and 1.91 ± 1.14 in the endovascular group. Likewise, the endovascular group had lower WFNS (mean, 2.43 ± 1.54 vs 1.45 ± 0.93) and mFS (mean, 2.63 ± 1.23 vs 1.91 ± 0.94) compared to the neurosurgical group. However, these differences were not significant ($P = 0.20, 0.05, \text{ and } 0.10$, respectively).

Outcomes and complications

No significant relationship was detected between the mRS scores between the neurosurgical clipping group and the endovascular coiling group (1.65 ± 2.28 vs 1.73 ± 2.05 ; $P = 0.92$). As shown in [Table 2](#), the length of in-hospital stay was significantly lower in the endovascular



Table 1. The demographic data of each study group

Variables	Mean±SD/No. (%)			P
	NC (n=54)	EC (n=11)	Total (n=65)	
Age (y)	50.67±11.9	53.36±18.6	51.12±13.1)	0.54
Female	-	-	32(49.3)	-
DM	6(11.1)	5(45.5)	11(16.9)	0.06
HTN	24(44.4)	7(63.6)	31(47.7)	0.20
HLP	4(7.4)	2(18.2)	6(9.2)	0.20
Opium	20(37.0)	1(9.1)	21(32.3)	0.10
Smoking	17(31.5)	1(9.1)	18(27.7)	0.07
H&H	2.44±1.285	1.91±1.14	-	0.20
WFNS	2.43±1.54	1.45±0.93	-	0.05
mFS	2.63±1.23	1.91±0.94	-	0.10



Abbreviations: NC: Neurosurgical clipping; EC: Endovascular coiling; SD: Standard deviation; DM: Diabetes mellitus; HTN: Hypertension; HLP: Hyperlipidemia; H&H: Hunt and Hess score; WFNS: World federation of Neurological Societies; mFS: Modified Fischer scale.

group compared to the neurosurgical group (9.64±6.04 days vs 17.69±10.73 days; P=0.02). Likewise, the length of in-intensive care unit stay was lower in the coiling group compared to the clipping group (5.64±3.59 days vs 11.94±10.30 days); however, it was not significant (P=0.05). In contrast, intervention cost was significantly higher in the endovascular group compared to the neurosurgical group (34.36 million Toman ±10.70 vs 15.36 million Toman ±5.11; P<0.01). Hospital cost also was higher in the coiling group compared to the clipping group (50.15±29.23 million Toman vs 29.76±24.04

million Toman), still, it did not reach the level of significance (P=0.05).

The mortality rate was not significantly different between the two study groups (Table 3). There was a total of 12 cases of hydrocephalus, all of which were shunted, and there was no difference between the two groups in this regard. Additionally, there was one case that experienced bleeding during coiling and subsequently underwent open surgery with a good outcome (mRS≤2).

Table 2. Outcomes in each study group

Outcome	No. (%)		Total	P
	NC (n=54)	EC (n=11)		
Modified Rankin score	1.65(2.28)	1.73(2.05)	-	0.92
Hospital LOS (days)	17.69(10.73)	9.64(6.04)	-	0.02
Intensive care unit LOS (days)	11.94(10.30)	5.64(3.59)	-	0.05
Intervention Cost (million Toman)	15.36 (5.11)	34.36(10.70)	-	< 0.01
Hospital Cost (million Toman)	29.76(24.04)	50.15(29.23)	-	0.05

Abbreviations: NC: Neurosurgical clipping; EC: Endovascular coiling; LOS: Length of stay.



Table 3. Complication rates in the study groups

Outcome	No. (%)			P
	NC (n=54)	EC (n=11)	Total (n=65)	
Post-op ICH	-	-	1(1.5)	-
Additional intervention	-	-	1(1.5)	-
Readmission	-	-	9(13.8)	-
Intra-op ICH	-	-	1(1.5)	-
Hydrocephalus	-	-	12(18.5)	-
Shunting	-	-	12(18.5)	-
Infection	-	-	10(15.4)	-
Hyponatremia	-	-	3(4.6)	-
Mortality	9(16.7)	1(9.1)	10(15.4)	-

Abbreviation: NC: Neurosurgical clipping; EC: Endovascular coiling; ICH: Intracranial hemorrhage.


Table 4. Good functional outcome (mRS≤2) based on SAH severity in each study group

Scale	Score	NC	EC	P
H&H	1	13	3	0.30
	2	18	4	0.10
	3	5	0	-
	4	1	0	-
	5	2	2	0.60
WFNS	1	22	5	0.01
	2	8	2	0.40
	3	3	0	-
	4	4	0	0.60
	5	2	0	-
mFS	1	10	4	0.50
	2	18	2	0.03
	3	2	1	0.20
	4	9	0	0.30
	5	NA	NA	NA



Abbreviations: mRS: Modified Rankin scale; SAH: Subarachnoid hemorrhage; NC: Neurosurgical clipping; EC: Endovascular coiling; H&H: Hunt and Hess score; WFNS: World federation of neurological societies; mFS: Modified Fischer scale; NA: Not applicable.

Subgroup analysis of good functional outcome (mRS \leq 2) based on the H&H score showed no significant differences (Table 4). We observed a significant difference between the two groups in WFNS score equal to one, in which 22 good functional outcomes were seen in the neurosurgical group compared to 5 in the endovascular group (P=0.01). Besides, there was a significant difference between the two groups in those with mFS scores equal to two; meanwhile, mRS \leq 2 was seen in 18 of 19 patients in the neurosurgical group compared to 2 of 5 patients in the endovascular group (P=0.03). Other scores did not reach the level of significance.

4. Discussion

The management of aneurysm-related SAH offers a significant challenge due to its life-threatening nature and potential for devastating consequences. In our retrospective cohort study, we compared the efficacy and outcomes of two conventionally employed treatment modalities for aneurysmal SAH, namely neurosurgical clipping and endovascular coiling. The findings validate existing literature in highlighting the severity and high mortality rates associated with aneurysmal SAH. This emphasizes the critical need for prompt intervention to alleviate the risk of rebleeding and improve patient outcomes. Both neurosurgical clipping and endovascular coiling serve as the main strategies in this regard, with distinct advantages and limitations [8].

Neurosurgical clipping was considered the gold standard intervention for a long time and involves the placement of a titanium clip via a craniotomy to isolate the aneurysm [9]. While it is considered an effective option in securing the aneurysm and reducing the risk of rebleeding, this approach is associated with expanded recovery times and heightened risks of complications. Conversely, endovascular coiling offers a less invasive alternative, wherein a platinum coil is delivered to the aneurysm via a microcatheter, building up intra-aneurysmal thrombosis and its closure. Our study suggests comparable efficacy between these two methods in preventing rebleeding and improving functional outcomes.

Notably, the present analysis revealed several key findings regarding the comparative outcomes of neurosurgical clipping versus endovascular coiling. While there were no significant differences in functional outcomes, as assessed by mRS, between the two groups, certain trends were observed. The patients undergoing

endovascular coiling experienced shorter lengths of in-hospital and in-ICU stays, indicative of potentially faster recovery times and reduced healthcare and resource utilization.

However, it is essential to interpret these findings cautiously, considering the inherent biases associated with retrospective cohort studies and the limited sample size of our cohort.

Moreover, our study identified a significant disparity in intervention costs between neurosurgical clipping and endovascular coiling, with the latter demonstrating higher associated expenses. This economic consideration is paramount, particularly in resource-constrained healthcare settings, and warrants further exploration to inform cost-effective treatment strategies.

Subgroup analyses based on the H&H and WFNS classifications provided additional insights into the differential impacts of neurosurgical clipping and endovascular coiling on functional outcomes across varying disease severities. While no significant differences were observed in overall functional outcomes, subgroup analyses revealed nuanced distinctions, particularly in patients with WFNS scores of one and mFS scores of two. These findings underscore the importance of personalized treatment approaches tailored to individual patient characteristics and disease severity profiles.

As mentioned earlier, there is a discrepancy between the published studies regarding the most efficacious approach [10]. In a systematic review and meta-analysis conducted by Luo et al., five studies were assessed to overcome this issue. They found that endovascular coiling is superior to surgical clipping regarding functional outcome and cerebral ischemia. On the contrary, technical failure was more common in the endovascular group. They did not find any significant difference between the two groups regarding rebleeding and mortality [5]. In another systematic review and meta-analysis performed by Ahmed et al. 22 studies were included for meta-analysis. Despite the other review, they found that endovascular coiling is related to increased mortality rate, rebleeding, and retreatment. They showed that other complications are more prevalent in the clipping group; furthermore, more rehabilitation was needed in this group [4]. Jiang et al. [11] published an article in 2020 comprising 64 studies with different types. The study found that for subjects with ruptured aneurysms, clipping was correlated with a lower mortality and rebleeding rate in comparison with



those who underwent coiling. However, between the clipping and coiling groups, the results were comparable regarding the rate of poor outcomes, ischemic infarct, or vasospasm.

For unruptured aneurysms, clipping was correlated with an increased risk of bad outcomes, but no significant difference was found in mortality compared to coiling. Clipping also decreased the rate of hydrocephalus and partial occlusion while increasing the complete occlusion rate for ruptured aneurysms. Considering only randomized controlled trials, clipping for ruptured aneurysms was associated with a higher rate of bad outcomes [11]. A recent study showed lower retreatments, incomplete occlusion, and short-term mortality rates in the neurosurgical group. Still, this approach was associated with higher ischemic infarction and longer length of stay [12].

Unlike many previously published articles in which different surgeons and neuro-interventionists performed the interventions, in our centers, only one physician performed the surgeries, and one did the interventions. This could minimize the risk of operator bias and result in more valid results. However, we should acknowledge the limitations of this study, including its retrospective nature, two-center design, indication for patient selection, and relatively small sample size .

Future prospective studies with larger sample sizes and longer follow-up durations are needed to validate our findings and provide more robust evidence to guide clinical decision-making.

5. Conclusion

This article contributes to the present research concerning the ideal management of aneurysmal SAH by comparing the outcomes and complications of the two major interventions. While both modalities demonstrate comparable efficacy in preventing rebleeding and improving functional outcomes, they present distinct advantages and considerations. A detailed understanding of patient-specific factors, disease severity, and economic implications is essential in selecting the most appropriate treatment strategy for individual patients. It seems that the best decision-making is either through teamwork between a neurovascular interventionist and a vascular-trained neurosurgeon, or by having the intervention performed by a hybrid vascular neurosurgeon. Future studies should be performed to improve treatment algorithms and patient outcomes in this complex clinical situation.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of [Golestan University of Medical Sciences](#), Gorgan, Iran (Code: IR.GOUMS.REC.1399.192). Informed consent was obtained from all participants/their families before their inclusion in the study.

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Authors' contributions

Conceptualization and study design: Rouzbeh Shams Amiri and Seyed Aidin Sajedi; Data collection: Ali Batiar, Rouzbeh Shams Amiri and Rahim Kohansal; Data analysis and interpretation: Ali Batiar and Rouzbeh Shams Amiri; Drafting the article: Ali Batiar, Fateme Shahrokhi and Mohsen Nabiuni; Critically revising the article: Rouzbeh Shams Amiri, Mohammad Hossein Mirbolouk, Seyed Aidin Sajedi; Reviewing submitted version of manuscript: Rouzbeh Shams Amiri; Approving the final version of the manuscript: All authors.

Conflict of interest

The authors declared no conflict of interest.

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