



Original Article

# Analysis of the impact of intraventricular hemorrhage on the functional outcome of ruptured anterior cerebral artery aneurysm after clipping

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## ABSTRACT

**Background:** Various clinical symptoms and variables have been suggested as potential indicators of outcomes in patients with subarachnoid hemorrhage (SAH) resulting from ruptured intracranial aneurysms. The detailed discussion of the consequences of intraventricular hemorrhage (IVH), frequently reported in cases of anterior communicating artery (ACoA) aneurysms, is still pending. The study aimed to assess the results of aneurysm surgery performed early versus delayed in patients with SAH, specifically focusing on the occurrence of IVH.

**Methods:** This study involved patients with ACoA aneurysms who experienced SAH and underwent microsurgical clipping of the aneurysm. A retrospective review was conducted on the patients' medical records. The modified Rankin score was compared between two groups of patients based on the presence or absence of IVH.

**Results:** Ninety-one participants (52 males and 39 females) were included in the study. The initial computed tomography scan showed that 20 patients (with a mean age of  $51 \pm 13.7$  years) had IVH, while 71 patients (with a mean age of  $45.8 \pm 11.7$  years) did not have any signs of IVH. The proportion of patients with poor functional outcomes after six months was 55% in the presence of IVH, compared to 25.4% in patients without IVH, indicating a significant difference in outcome between the two groups ( $P < 0.016$ ).

**Conclusion:** Patients with SAH having aneurysms located in the ACoA associated with the intraventricular hemorrhage had a poor functional outcome.

**Keywords:** Aneurysm, Anterior communicating artery, Intraventricular hemorrhage, Lamina terminalis, Outcome

## INTRODUCTION

A ruptured intracranial aneurysm stands as the primary cause of non-traumatic subarachnoid hemorrhage (SAH).<sup>[10,15,22]</sup> The diagnostic cornerstone often lies in brain computed tomography (CT) scans to assess SAH, which can occasionally bring about additional complexities such as intraventricular hemorrhage (IVH), hydrocephalus, intracerebral hemorrhage, or infarcts.<sup>[2,18]</sup> Particularly, ruptured anterior communicating artery (ACoA) aneurysms commonly coincide with IVH due to their proximity to the lamina terminalis (LT) and the third ventricle.<sup>[7,23]</sup> It is generally recommended to opt for early microsurgical intervention for ruptured aneurysms to mitigate the risks linked with re-

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bleeding.<sup>[24]</sup> However, this approach might only apply to some patients due to the potential complexities in surgical planning stemming from various clinical conditions, which are proposed as predictors for aneurysm surgery outcomes.<sup>[16]</sup> Identifying these factors and conditions can significantly impact patient outcomes and aid decision-making. Despite the frequent occurrence of IVH in ruptured ACoA aneurysms,<sup>[19]</sup> its precise influence on the outcomes of microsurgically treated patients still needs to be discussed more. Sure, after discussing the potential complexities in surgical planning and the importance of identifying factors influencing patient outcomes, it is crucial to delve deeper into the impact of IVH on the outcomes of patients undergoing microsurgical treatment for ruptured ACoA aneurysms. Despite the common occurrence of IVH in cases of ruptured ACoA aneurysms, a comprehensive discussion regarding its specific influence on the outcomes of patients who have undergone microsurgical treatment remains limited. Understanding the implications of IVH in this context is essential for better prognostication and tailored decision-making regarding treatment strategies. By elucidating the potential correlation between IVH and postoperative outcomes in microsurgically treated patients, healthcare professionals can refine their predictive models and treatment approaches. A more nuanced understanding of how IVH affects patient recovery and prognosis following microsurgical interventions for ruptured ACoA aneurysms could significantly contribute to optimizing patient care and surgical strategies.

## MATERIALS AND METHODS

A retrospective study was done on the management of a ruptured anterior cerebral artery aneurysm presenting with SAH, focusing on the use of clipping. A total of 91 patients were included in the study. All information, such as clinical and radiological data, SAH grade based on the Hunt and Hess scale, WFNS score, and modified Fischer grade, were recorded. To compare, two groups were formed based on whether or not intra-ventricular hemorrhage was observed on the non-contrast computed tomography (CT) brain scan during the presentation. The at-discharge and 6-month follow-ups were recorded. The result was evaluated using the modified Ranking scale. The data were analyzed utilizing Statistical Package for the Social Sciences software version 23.0. The data for quantitative variables were given as the mean  $\pm$  standard deviation, whereas frequencies and percentages were used to describe the qualitative factors. The comparison of two qualitative variables was conducted utilizing either the Chi-square or Fisher's exact tests. The changes were deemed significant when *P*-values were below 0.05.

## RESULTS

Ninety-one patients were analyzed in the study. the clinical-demographic profile is described in Table 1. The mean age

of the included patients was  $48.9 \pm 12.2$  years. The youngest patient was 19 years old. Fifty-two (57.1%) patients were male, whereas 39 (42.9%) were female. Headache (87, 95.6%) and altered sensorium (39, 42.9%) were the predominant symptoms at the presentation of the patients, whereas 11 (12.1%) of patients had neurological deficits at the presentation. It was found that 20 (22%) of the patients had an IVH on the initial CT scan done at the time of admission.

The extension to the ventricles, especially the third ventricle, was due to the blood passing from the subarachnoid cisterns and LT. Fifty-eight (63.7%) patients had a history of hypertension, and 30 (33%) had a history of smoking for variable durations. The most frequent Glasgow coma scale (GCS) at presentation was 15 in 62 (68.1%) patients, followed by 14 in 12 (13.2%) and 13 in 10 (11.0%) patients. The poor Hunt and Hess grade was found in 26 (28.6%), and poor WFNS was found in 11 (12.1%) patients. The patient was followed up for six months. It was found that the patients with IVH (20/91) had moderate GCS (13–8) at presentation in 9 (40%) patients, and it was found to be significant ( $P = 0.000$ ). Similarly, poor Hunt and Hess (3–5) were found in 12 (60%) patients with intraventricular hemorrhage, which were statistically significant ( $P = 0.000$ ). Ten (11%) patients had clinical vasospasm requiring intensive medical management. The difference between the IVH and no IVH groups was statistically significant ( $P = 0.038$ ). However, no statistically significant correlation was found between cardiomyopathy and IVH ( $P = 0.06$ ). The overall survival rate was 82.4%, with in-hospital mortality seen in 16 (17.6%). The functional outcome was assessed with a modified Rankin scale (mRS). Poor outcomes at discharge (mRS 3–6) were seen in 23 (25.3%) patients. The comparison of functional outcome at discharge is shown in Table 2. At 6-month follow-up, 72 patients were available. The functional outcome at 6 months follow-up of alive individuals is described in Table 3. The mortality rate at 6 months was 1.2%, with poor functional outcome (mRS 3–6) observed in 8 (8.9%) patients. The difference in poor functional outcomes (mRS 3–6) between the two groups was significant (18/25.4% vs. 11/55%;  $P = 0.016$ ). A significant correlation ( $P = 0.016$ ) was found between poor outcomes and IVH. The vasospasm was found to have a significant correlation with poor outcomes ( $P = 0.000$ ).

## DISCUSSION

There is still ongoing debate and uncertainty surrounding various aspects of aneurysm surgery, such as the optimal timing for the procedure and the factors that can help predict the outcome.<sup>[3]</sup> The authors present varying perspectives on the optimal timing of surgery, considering the potential risks of vasospasm and surgical complications. In addition, there is ongoing debate surrounding the prognostic factors and predictive clinical conditions that influence the outcome

**Table 1:** Clinical and demographic profile.

	No IVH (n=71)	IVH (n=20)	P-value
Age (year)	45.85±11.7	51.25±13.7	
Gender			
Male (n=52)	40 (56.3)	12 (60)	
Female (n=39)	31 (43.7)	8 (40)	
HTN (n=58)	48 (67.6)	10 (50)	0.19
Smoking (n=30)	20 (28.2)	10 (50)	0.104
GCS			
15–14	62 (87.3)	12 (60.0)	<b>0.000</b>
13–9	9 (12.9)	8 (40.0)	
<8	0 (0)	0 (0)	
Hunt and Hess			
1	21 (29.6)	2 (10)	<b>0.000</b>
2	35 (49.3)	6 (30)	
3	15 (21.1)	6 (30)	
4	0 (0)	4 (20)	
5	0 (0)	2 (10)	
Vasospasm (n=10)	5 (7%)	5 (25)	<b>0.038</b>
Cardiomyopathy (n=5)	2 (2.8)	3 (15)	0.069
mRS at discharge			
Good	53 (74.6)	9 (45.0)	<b>0.016</b>
Poor	18 (25.4)	11 (55.0)	
mRS at six months			
Good	57 (81.4)	9 (45.0)	<b>0.004</b>
Poor	5 (7.1)	3 (15.0)	

IVH: Intraventricular hemorrhage, GCS: Glasgow coma scale, HTN: Hypertension, mRS: Modified Rankin Scale, Bold value: Significant (P<0.005)

**Table 2:** Comparison of mRS score at discharge.

mRS score	No IVH (n=71) (%)	IVH (n=20) (%)	P-value
0	27 (38)	4 (20)	0.010
1	20 (28)	4 (20)	
2	6 (8.5)	1 (5)	
3	5 (7)	1 (5)	
4	2 (2.8)	0 (0)	
5	0 (0)	2 (10)	
6	8 (11.3)	8 (11.3)	

mRS: Modified Rankin scale, IVH: Intraventricular hemorrhage

**Table 3:** Comparison of mRS score at 6-month follow-up.

mRS score	No IVH (n=63) (%)	IVH (n=12) (%)	P-value
0	36 (57.1)	7 (5.8)	0.021
1	17 (26.9)	2 (1.6)	
2	5 (7.9)	0 (0)	
3	2 (3.1)	1 (8.3)	
4	2 (3.1)	0 (0)	
5	0 (0)	0 (0)	
6	1 (1.5)	2 (1.6)	

mRS: Modified Rankin scale, IVH: Intraventricular hemorrhage

of aneurysm surgery.<sup>[13,14]</sup> Several factors have been studied extensively by medical researchers to determine their potential in predicting the risk of vasospasm and outcome after SAH or aneurysm surgery. These factors include the grading of SAH, changes in blood pressure, electrocardiogram readings, hyponatremia, haptoglobin genotype, neuropeptides, and various biomarkers. Numerous studies have proposed and evaluated the effectiveness of these factors in assessing the risks mentioned above. There currently needs to be agreement among medical researchers regarding the optimal timing for surgical treatment of ruptured intracranial aneurysms. Ross *et al.*<sup>[17]</sup> conducted a prospective study involving 1168 patients who were categorized into three groups according to the timing of their surgical intervention. The study findings suggested that age and clinical grading at presentation were the only factors influencing the outcome. Based on their analysis, the researchers concluded that the surgery timing did not significantly impact the surgical outcome. Some other authors have also obtained similar results regarding the timing of surgery.<sup>[8,11]</sup> On the other hand, some researchers have concluded that the results could be more satisfactory when the surgery is performed during the intermediate period of the event. This is due to the higher risk of vasospasm.<sup>[9,12]</sup> The potential for vasospasm and its associated complications in aneurysm surgery during the intermediate phase (days 4–15) is well-documented.<sup>[1]</sup> Many clinical conditions and factors have been thoroughly examined in the pathophysiological study of vasospasm.<sup>[6]</sup> The presence of blood in the ventricular cavity is a significant clinical condition frequently seen in cases of ruptured ACoA aneurysm. The relationship between IVH and surgical outcomes, as well as the timing of the surgery in cases of ruptured ACoA aneurysms, has yet to be extensively studied. While early surgery is not a widely accepted approach, it has been suggested by numerous authors in previous studies.<sup>[4,5]</sup> Early surgery has been found to have significant benefits, such as reducing the risk of fatal re-bleeding and shortening hospital stays.<sup>[11,25]</sup> We also support early aneurysm clipping as the primary approach for treating uncomplicated cases based on our research as medical professionals. However, in certain situations, additional factors may need to be considered. Based on our research in the field of medical treatment, we have found that the occurrence of IVH can be a strong indicator of adverse outcomes in cases involving microsurgical treatment of ruptured ACoA aneurysms. Patients with ruptured ACoA aneurysm who had IVH on their initial CT scans experienced a generally poor surgical outcome in comparison to those without IVH. However, regarding the timing of the surgery, patients who underwent delayed microsurgical treatment after IVH was detected on the initial CT scan experienced a more favorable surgical

outcome. The precise mechanism behind the poor prognosis observed in patients with IVH remains uncertain. We hypothesize that this could be caused by an excessive release of brain natriuretic peptide (BNP) resulting from the direct injury to the hypothalamus caused by the passage of blood into the third ventricle through the ruptured LT. Cerebral vasospasm in SAH is often attributed to the significant role played by BNP. Svirni *et al.*<sup>[20,21]</sup> investigated the correlation between BNP and post-cerebral vasospasm. Their findings revealed a significant relationship between BNP levels and the occurrence of vasospasm. It was shown that the BNP level showed a significant increase in patients who had IVH caused by ACoA involvement. The researchers hypothesized that the proximity of the hypothalamic perforating vessels to the ACoA complex could lead to hypothalamic damage in cases of a ruptured ACoA aneurysm. This, in turn, could result in changes in the secretion level of BNP. Our findings suggest that patients who underwent delayed microsurgical treatment had significantly improved outcomes when IVH was present alongside ruptured ACoA. While the exact molecular pathophysiology of this mechanism requires further investigation, it is clear that timely intervention can make a significant difference. Our study suggests that when blood leaks into the third ventricle in cases of ruptured ACoA, patients may face an increased risk of surgical complications. Hence, postponing surgery could yield better results for patients with ACoA aneurysm.

## CONCLUSION

The occurrence of IVH can be a strong indicator of adverse outcomes in cases involving microsurgical treatment of ruptured ACoA aneurysms. Patients with ruptured ACoA aneurysms who had IVH on their initial CT scans experienced generally poor surgical outcomes in comparison to those without IVH.

## Ethical approval

The Institutional Review Board approval is not required.

## Declaration of patient consent

Patient's consent are not required as there are no patients in this study.

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## Conflicts of interest

There are no conflicts of interest.

## Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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