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Endovascular treatment on ruptured wide-neck intracranial aneurysms: Single-center retrospective study on efficacy and safety

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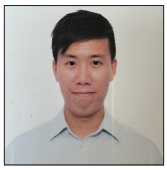

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ABSTRACT

Objectives: The aim of this single-center retrospective study was to evaluate the efficacy and safety of endovascular treatment for ruptured intracranial wide-neck aneurysms.

Material and Methods: This single-center retrospective study aims to evaluate cases of ruptured wide-neck intracranial aneurysms treated endovascularly between 2018 and 2023 at Pamela Youde Nethersole Eastern Hospital in Hong Kong. Patient demographics, aneurysmal characteristics, procedural devices used, peri-procedural complications, and post-procedural angiographic and clinical outcomes will be analyzed. The primary outcome will be the complete occlusion rate of the treated aneurysms and the incidence of peri-procedural complications. Secondary outcome will include clinical outcomes assessed using the modified Rankin scale (mRS). We hypothesize that flow diversion may represent an efficient and safe endovascular treatment option for ruptured wide-neck aneurysms.

Results: The median age of patients was 60 years, with a predominance of females (74.2%). Aneurysms were commonly located in the anterior communicating artery (25.8%) and posterior communicating artery (21.2%), measuring a median size of 4.2 mm with a dome-to-neck ratio <2 in the majority (98.4%). Follow-up angiography at 6 and 12–24 months showed near-complete occlusion rates of 76.4% and 84.2%, respectively. Flow diversion exhibited significantly higher rates of complete occlusion compared to other treatments ($P = 0.021$ at 6 months, $P = 0.049$ at 12–24 months). Ischemic complications occurred, including thromboembolism in 3.0% and coil protrusion causing parent artery occlusion in 4.5% of cases, primarily during simple coiling procedures. Hemorrhagic complications, such as re-ruptured aneurysms, were noted in 12.1% of cases. Favorable clinical outcomes (mRS 0–2) were observed in 54.5%, 62.1%, and 63.6% of patients at 1, 6, and 12 months, respectively, with poorer outcomes associated with severe subarachnoid hemorrhage (SAH) and larger aneurysm size (>6 mm) ($P = 0.017$ for modified Fisher scale III–IV; $P = 0.009$ and 0.001 for large aneurysm (>6 mm) at 6 months and 12–24 months, respectively).

Conclusion: We observed relatively satisfactory outcomes regarding the efficacy and safety of endovascular treatment for ruptured wide-neck intracranial aneurysms. Flow diversion with or without adjunctive coiling emerged as an effective treatment option with a high rate of aneurysmal occlusion and acceptable complication rates. Our study highlighted that large aneurysms (>6mm) and poor grades of SAH were associated with poorer clinical outcomes. These findings underscore the need for prospective studies with larger sample sizes to validate and refine our results.

Keywords: Endovascular treatment, Flow diversion, Ruptured wide-neck intracranial aneurysms, Treatment outcome

INTRODUCTION

Acute subarachnoid hemorrhage (SAH) related to wide-neck intracranial aneurysms is not uncommon and often presents significant therapeutic challenges. The role of endovascular embolization in treating ruptured cerebral aneurysms is well established and is often employed as an emergency treatment to reduce the high morbidity and mortality associated with SAH.[1,2] However, endovascular treatment for ruptured wide-neck intracranial aneurysms is particularly challenging due to the higher risk of coil protrusion, which can lead to parent artery thrombosis and compromised blood flow.[3]

Various endovascular techniques have been developed in recent decades to address wide-neck aneurysms, generally including balloon-assisted or stent-assisted coiling, flow diversion, and intrasaccular devices.[4-6] The use of dual-antiplatelet therapy (DAPT) with flow diverters or stents potentially increases peri-procedural complication rates, particularly intracranial hemorrhage and rebleeding of the ruptured aneurysms, compared to simple coiling or balloon-assisted coiling. The risk of bleeding is further elevated when additional surgical procedures, such as external ventricular drainage insertion or decompressive craniectomy, are required.[7,8] The thrombogenicity of flow diverters and stents also raises concerns about in-stent stenosis and thrombosis.[9]

In addition, the high technical demands of stent-assisted coiling can increase peri-procedural complications and reduce treatment efficacy. These demands include longer procedural times with the double-catheter technique, challenging navigation of the coiling microcatheter through the stent interstices, stent malposition, and incomplete coiling, which can lead to long-term recurrence of the aneurysms.[10,11] Flow diversion, in contrast, is relatively straightforward and operates by diverting blood flow away from the aneurysm. It serves as a scaffold for endothelialization across the aneurysm neck, leading to progressive occlusion and thrombosis of the aneurysmal sac.[12,13] Both stent-assisted coiling and flow diversion are generally considered last-resort options if other modalities fail in the treatment of acutely ruptured aneurysms.[14,15]

Therefore, this retrospective study aims to evaluate the efficacy and safety of different endovascular treatments for acutely ruptured wide-neck intracranial aneurysms. In addition, we hypothesize that flow diversion could be a safe and efficient treatment option for ruptured cerebral aneurysms.

MATERIAL AND METHODS

This single-center retrospective study was approved by the ethics committee of our hospital in Hong Kong. Patients who underwent endovascular interventions for ruptured wide-neck intracranial aneurysms between June 2018 and June 2023 were included in the study. The patients were categorized based on the treatment modalities used: simple coiling, balloon-assisted coiling, stent-assisted coiling, and flow diversion treatment with or without adjunctive coiling. Wide-neck aneurysms were defined as those with a neck diameter of ≥4 mm or a dome-to-neck ratio of <2.

Inclusion criteria consisted of consecutive patients with ruptured wide-neck intracranial aneurysms confirmed by computed tomography (CT) angiography or digital subtraction angiography (DSA), who received acute endovascular treatment. Acute SAH was confirmed by plain CT scans of the brain and graded using the modified Fisher Scale. For staged flow diversion treatment, patients must have undergone endovascular intervention within 30 days. In this study, a single ruptured wide-neck aneurysm was treated in each patient. Exclusion criteria included patients with SAH caused by non-aneurysmal diseases or trauma, contraindications to contrast agents, and severe comorbidities such as heart, renal, or liver failure.

Neurointerventional treatment

Catheter cerebral angiography was performed to evaluate the ruptured aneurysms in all cases. The treatment strategy was determined collaboratively by senior neurointerventionists and vascular neurosurgeons. All procedures were conducted with patients in a supine position under general anesthesia, utilizing a biplane angiography system. Multiple projections and rotational angiography were employed to assess the target aneurysm, the parent vessel, and the appropriate wall apposition of the device post-deployment. Calibrated measurements were taken using the DSA system's software to determine the diameter of the target vessel for appropriate device sizing.

A 6–8 French long sheath, with or without an intermediate catheter, was utilized via femoral arterial access. Coil embolization, balloon inflation, stent placement, or flow diverter deployment were performed using corresponding appropriate microcatheters. In cases of ruptured aneurysms treated with stent-assisted coiling or flow diversion, aspirin and clopidogrel were administered through a nasogastric tube 3 h before the embolization procedure. For patients undergoing flow diverter deployment alone, a suitable device was selected and deployed to cover the aneurysm neck, ensuring secure anchoring at both proximal and distal sides of the aneurysmal neck.

In cases treated with stent-assisted coiling or flow diversion with adjunctive coiling, an appropriate stent or flow diverter was selected based on the size of the parent artery and aneurysm, and positioned distally to the aneurysm. The stent or flow diverter was navigated across the aneurysm either

partially or completely after coiling the aneurysmal sac. All procedures were conducted under heparinization following the initial coil embolization or immediately after stent placement or flow diverter deployment. Post-procedure, patients undergoing stent-assisted coiling or flow diversion were placed on DAPT comprising 75 mg of clopidogrel daily for 6 months and 80 mg of aspirin daily lifelong.

Peri-procedural complications

Peri-procedural complications are categorized into ischemic and hemorrhagic complications. Ischemic complications include thromboembolism, in-stent stenosis, and coil protrusion leading to occlusion of the parent artery. Hemorrhagic complications include new intraventricular or intracerebral hemorrhage, and inadvertent aneurysmal perforation resulting in rebleeding. Diagnosis of all complications was conducted by specialists in neurosurgery, interventional neuroradiology, and diagnostic neuroradiology, utilizing peri- and post-procedural CT or magnetic resonance imaging of the brain. Due to the absence of standardized classifications for peri-procedural complications, the current categorization was based on clinical judgment.

Angiographic and clinical outcome

We assessed both angiographic and clinical outcomes using electronic health care records. Angiographic follow-ups for aneurysms were conducted with DSA at 6-month and 12-month intervals post-intervention. If 12-month imaging was unavailable, the most recent imaging available (typically between 12 and 24 months post-procedure) was reviewed. Non-invasive imaging modalities such as magnetic resonance angiogram, cone-beam CT of cerebral angiogram, or CT cerebral angiogram were used in some cases as alternatives to DSA for follow-up. The Raymond-Roy occlusion classification was employed to grade endovascularly treated aneurysms, classifying them as complete occlusion, residual neck (obliteration of aneurysmal sac >90%), or residual aneurysm (obliteration of aneurysmal sac <90%). Near-complete occlusion was considered equivalent to complete occlusion and residual neck.

Regarding clinical outcomes, patients were evaluated using the modified Rankin scale (mRS) at 1-month, 6-month, and 12-month intervals during follow-up visits with neurosurgeons and rehabilitation physicians. The modified Rankin scale (mRS) evaluates activity limitations on a scale from 0 (no symptoms) to 6 (death), with functional outcomes categorized as favorable (mRS 0–2) or unfavorable (mRS 3–6). The date of death was recorded if a patient passed away before the 6-month follow-up assessment.

Statistical analysis

Measurement data were reported as mean ± standard deviation and analyzed using the *t*-test for normally distributed data. For non-normally distributed data, measurement data were presented as median (range) and analyzed using the Wilcoxon rank-sum test. Enumeration data were presented as numbers and percentages, and Fisher's exact test was employed for analysis. $P < 0.05$ was considered statistically significant.

RESULTS

Patient's demographics and aneurysmal characteristics

Patient baseline characteristics are summarized in Table 1. A total of 66 patients underwent endovascular treatment for ruptured wide-neck intracranial aneurysms, with 49 (74.2%) being female and 17 (25.8%) male. The median age was 60 years (interquartile range: 50.3–71.8 years).

Table 1: Patient baseline characteristics.

Variable	All patients (*n*=66)
Age (years)	60 (50.3–71.8)
Female sex (%)	49 (74.2)
Modified Fisher scale (%)	
I	7 (10.6)
II	3 (4.5)
III	14 (21.2)
IV	42 (63.6)
Size of aneurysm (mm)	4.2 (3.0–5.8)
Neck diameter (mm)	2.4 (1.9–3.4)
Neck diameter >4 mm (%)	15 (22.7)
Dome to neck ratio <2 (%)	65 (98.4)
Aneurysm location (%)	
Anterior circulation	57 (86.4)
Posterior circulation	9 (13.6)
ICA: clinoid segment	3 (4.5)
ICA: ophthalmic segment	9 (13.6)
ICA: communicating segment	3 (4.5)
ICA: posterior communicating artery	14 (21.2)
Middle cerebral artery: M1	5 (7.6)
Middle cerebral artery: M2	1 (1.5)
Anterior communicating artery	17 (25.8
Anterior cerebral artery: A1	3 (4.5)
Anterior cerebral artery: A2	2 (3.0)
Posterior cerebral artery: P2	1 (1.5
Basilar artery	3 (4.5)
Vertebral artery	1 (1.5)
Superior cerebellar artery	1 (1.5)
Anterior inferior cerebellar artery	2 (3.0)
Posterior inferior cerebellar artery	1 (1.5)

Variables are expressed as the median (interquartile range) or number of patients (%). ICA: Internal carotid artery

The most common aneurysm location was the anterior communicating artery (*n* = 17, 25.8%) followed by the posterior communicating artery segment of the internal carotid artery (*n* = 14, 21.2%). The median size of the aneurysms was 4.2 mm (interquartile range: 3.0–5.8 mm). Nearly, all aneurysms had a dome-to-neck ratio <2 (*n* = 65, 98.4%). Some aneurysms had a neck diameter >4 mm (*n* = 15, 22.7%). Most patients presented with severe SAH (Grade III, *n* = 14, 21.2%; Grade IV, *n* = 42, 63.6%) based on the modified Fisher scale.

Angiographic outcomes

Table 2 summarizes the angiographic outcomes. Among patients available for follow-up at the 6-month interval (*n* = 34), all endovascular treatments achieved a near-complete occlusion rate of 76.4% (complete occlusion, *n* = 13, 38.2%; residual neck, *n* = 13, 38.2%). At the 12–24-month interval, among patients available for follow-up (*n* = 38), the efficacy rate of near-complete occlusion was 84.2% (complete occlusion, *n* = 20, 52.6%; residual neck, *n* = 12, 31.6%).

At the 6-month interval, the efficacy rates of near-complete occlusion were as follows: simple coiling (*n* = 26, 76.4%), balloon-assisted coiling (*n* = 3, 60.0%), stent-assisted coiling (*n* = 1, 100%), and flow diversion with or without adjunctive coiling (*n* = 6, 100%). At the 12-month interval, the efficacy rates were as follows: simple coiling (*n* = 22, 81.4%), balloon-assisted coiling (*n* = 4, 80.0%), stent-assisted coiling (*n* = 1, 100%), and flow diversion with or without adjunctive coiling (*n* = 5, 100%).

For flow diversion with or without adjunctive coiling, the rates of complete occlusion were 83.3% (*n* = 5) at the 6-month interval and 100.0% (*n* = 5) at the 12–24-month interval. Compared to other endovascular modalities, flow diversion with or without adjunctive coiling achieved significantly higher rates of complete occlusion (*P* = 0.021 at 6-month and *P* = 0.049 at 12–24-month intervals).

Peri-procedural complication outcome

Table 3 presents the peri-procedural complications. For ischemic complications, thromboembolism occurred in 3.0% (*n* = 2/66) of cases, both in simple coiling procedures. Coil protrusion causing parent artery occlusion occurred in 4.5% (*n* = 3/66) of cases, including one each in simple coiling, balloon-assisted coiling, and stent-assisted coiling. There were no ischemic complications reported in the flow diversion with or without adjunctive coiling group (0/7).

Regarding hemorrhagic complications, new intraventricular/intracerebral hemorrhage occurred in 1.5% (1/66) of cases, involving a simple coiling procedure. Re-ruptured aneurysmal bleeding was observed in 12.1% (8/66) of cases, with six instances in simple coiling and two in balloon-assisted coiling. No hemorrhagic complications were noted in the flow diversion with or without adjunctive coiling group (0/7).

Overall, there were no statistically significant differences in complication rates between the flow diversion with or without adjunctive coiling group and other endovascular modalities.

Table 2: Angiographic outcome.

Endovascular modalities	**All endovascular treatment (*n*=34) (%)**	**SC (*n*=22) (%)**	**BAC (*n*=5) (%)**	**SAC (*n*=1) (%)**	**FD+FD with adjunctive coiling (*n*=6) (%)**	***P*-value (other modalities vs. FD)**
Available follow-up at 6-month (*n*=34)						
Complete occlusion (I)	13 (38.2)	5 (22.7)	2 (40.0)	1 (100.0)	5 (83.3)	0.021
Residual neck (II)	13 (38.2)	11 (50.0)	1 (20.0)	0 (0.0)	1 (16.7)	
Near-complete occlusion (I)+(II)	26 (76.4)	16 (72.7)	3 (60	1 (100.0)	6 (100.0)	
Residual aneurysm (III)	8 (23.5)	6 (27.2)	2 (40.0)	0 (0.0)	0 (0.0)	
Endovascular modalities		**SC (*n*=27)**	**BAC (*n*=5)**	**SAC (*n*=1)**	**FD+FD with adjunctive coiling (*n*=5)**	
Available follow-up at 12-month and 12-24 months (*n*=38)						
Complete occlusion (I)	20 (52.6)	11 (40.7)	3 (60.0)	1 (100.0)	5 (100.0)	0.049
Residual neck (II)	12 (31.6)	11 (40.7)	1 (20.0)	0 (0.0	0 (0.0)	
Near-complete occlusion (I)+(II)	32 (84.2)	22 (81.4)	4 (80)	1 (100.0)	5 (100.0)	
Residual aneurysm (III)	6 (15.8)	5 (18.5)	1 (20.0)	0 (0.0)	0 (0.0)	

Variables are expressed as the number of patients available for follow-up (%). SC: Simple coiling, BAC: Balloon-assisted coiling, SAC: Stent-assisted coiling, FD: Flow diversion

Clinical outcome

Table 4 presents the clinical outcomes assessed by the modified Rankin score (mRS) at 1-month, 6-month, and 12-month intervals. The percentages of patients achieving favorable clinical outcomes (mRS score 0–2) were 54.5% (36/66), 62.1% (41/66), and 63.6% (42/66) at 1-month, 6-month, and 12-month intervals, respectively.

At the 1-month follow-up, a poor grade of SAH was significantly associated with poor clinical outcomes (mRS score 3–6) (43.9%, 29/66, P = 0.017). Larger aneurysm size (>6mm) also showed significant associations with poor clinical outcomes (mRS score 3–6) at 1-month (12.1%, 8/66, P = 0.009), and at 6-month and 12-month follow-ups (12.1%, 8/66, P = 0.001).

Table 3: Peri-procedural complications.

Variable	All endovascular modalities (*n*=66) (%)	SC+ BAC+ SAC (*n*=59)	SC (*n*=45)	BAC (*n*=10)	SAC (*n*=4)	FD+FD with adjunctive coiling (*n*=7)	*P*-value (FD+FD with adjunctive coiling VS Other endovascular modalities)
Ischemic complications							1
Thromboembolism	2 (3.0)	2	2	0	0	0	
Coil protrusion leading to parent artery occlusion	3 (4.5)	3	1	1	1	/	
In-stent stenosis	0 (0.0)	0	/	/	0	0	
Hemorrhagic complications							0.584
New intraventricular/ intracerebral hemorrhage	1 (1.5)	1	1	0	0	0	
Inadvertent aneurysmal perforation resulting in rebleeding	8 (12.1)	8	6	2	0	0	

Variables are expressed as number of complications (%). SC: Simple coiling, BAC: Balloon-assisted coiling, SAC: Stent-assisted coiling, FD: Flow diversion

Table 4: Factors associated with clinical outcome.

Post-procedural time interval	1-month			6-month			12-month		
mRS of patients (*n*=66)	0-2 (*n*=36, 54.5%) (%)	3-6 (*n*=30)	*P*-value	0-2 (*n*=41, 62.1%) (%)	3-6 (*n*=25)	*P*-value	0-2 (*n*=42, 63.6%) (%)	3-6 (*n*=24)	*P*-value
Variable									
Female	25 (37.9)	24 (36.4)	0.403	31 (47.0)	18 (27.3)	0.778	32 (48.5)	17 (25.8)	0.771
Age (≥51 years)	25 (37.9)	24 (36.4)	0.403	29 (43.9)	20 (30.3)	0.563	29 (43.9)	20 (30.3)	0.251
mFS grade (III–IV)	27 (40.9)	29 (43.9)	**0.017**	32 (48.5)	24 (36.4)	0.076	33 (50.0)	23 (34.8)	0.137
Aneurysm of anterior circulation	32 (48.5)	25 (37.9)	0.721	36 (54.5)	21 (31.8)	0.721	37 (56.0)	20 (30.3)	0.713
Aneurysm size (>6 mm)	1 (1.5)	8 (12.1)	**0.009**	1 (1.5)	8 (12.1)	**0.001**	1 (1.5)	8 (12.1)	**0.001**
Simple coiling	26 (39.4)	19 (28.8)	0.596	28 (42.4)	17 (25.8)	1	28 (42.4)	17 (25.8)	0.602
Balloon-assisted coiling	4 (6.1)	6 (9.1)	0.492	5 (7.6)	5 (7.6)	0.485	6 (9.1)	4 (6.1)	1
Stent-assisted coiling	2 (3.0)	2 (3.0)	1	3 (4.5)	1 (1.5)	1	3 (4.5)	1 (1.5)	1
Flow diversion+Flow diversion with adjunctive coiling	4 (6.1)	3 (4.5)	1	4 (6.1)	3 (4.5)	1	5 (7.6)	2 (3.0)	1
Ischemic complications	1 (1.5)	4 (6.1)	0.169	2 (3.0)	3 (4.5)	0.359	2 (3.0)	3 (4.5)	0.345
Hemorrhagic complications	6 (9.1)	2 (3.0)	0.275	6 (9.1)	2 (3.0)	0.699	6 (9.1)	2 (3.0)	0.7

Variables are expressed as number of patients (%). mRS: Modified Rankin score, mFS: Modified Fisher scale

No statistically significant associations were found between favorable functional outcomes and other factors such as gender, advanced age, aneurysm location, endovascular modality, or related ischemic or hemorrhagic complications.

DISCUSSION

Managing wide-neck intracranial aneurysms in the acute ruptured setting presents significant challenges. Our single-center retrospective study demonstrates that endovascular treatments generally achieve satisfactory efficacy on treating ruptured wide-neck aneurysms. These findings are consistent with previous systematic reviews and meta-analyses covering both ruptured and unruptured wide-neck aneurysms.[4-6] Our study specifically found superior efficacy of flow diversion with or without adjunctive coiling compared to other endovascular modalities, with statistically significant results. Complete aneurysmal occlusion rates were 83.3% at 6 months and 100% at 12–24-month intervals for flow diversion with or without adjunctive coiling, aligning with prior research on ruptured aneurysms treated with flow diverters.[12,14]

In terms of peri-procedural complications, all endovascular techniques showed acceptable outcomes, except for a relatively high incidence of re-ruptured aneurysmal bleeding (12.1%, 8/66). Notably, most re-ruptures occurred in cases treated with simple coiling (six cases) and balloon-assisted coiling (two cases). The risk of inadvertent aneurysmal rupture during packing of the sac remains a concern. Conversely, no re-ruptures were observed in cases treated with flow diverters, which avoid direct manipulation of the aneurysmal sac, thereby probably minimizing this risk. In adjunctive coiling cases, we believe that loosely packed coils can also reduce re-rupture risk. In addition, coil protrusion leading to parent artery occlusion was observed in cases of coiling wide-neck aneurysms, occurring in three instances across simple, balloon-assisted, and stent-assisted coiling procedures. This highlights a significant drawback of coiling in wide-neck aneurysms due to the potential for coil prolapse and subsequent ischemic events. Flow diversion addresses this issue by focusing solely on reconstructing the parent artery with complete coverage of the aneurysmal sac. Furthermore, concerns persist regarding the use of DAPT in cases of acute ruptured aneurysms. In our study, no hemorrhagic complications were reported during follow-ups at 6 months and 12–24-month intervals among patients treated with flow diversion with or without adjunctive coiling or stent-assisted coiling, comparable with findings in other literatures.[15-17] However, larger clinical trials are necessary to further assess complication rates associated with flow diversion in ruptured aneurysms. Our findings support the beneficial use of flow diversion in managing ruptured wide-neck intracranial aneurysms, emphasizing its potential advantages in achieving durable occlusion while mitigating certain procedural risks associated with traditional coiling techniques.

In our study, 63.6% of patients achieved a favorable clinical outcome at the 12-month interval following acute SAH due to ruptured aneurysms. We observed that large aneurysm size (>6 mm) was significantly associated with unfavorable clinical outcomes (mRS 3–6). Specifically, eight out of nine cases with large ruptured wide-neck intracranial aneurysms presented with severe SAH (one case Grade III and seven cases Grade IV on the modified Fisher scale), leading to symptomatic vasospasm and poor clinical outcomes. The severity of SAH also correlated significantly with poor clinical outcomes at the 1-month interval, consistent with our overall findings. No statistically significant differences were found among different endovascular treatment modalities in achieving better clinical outcomes. Managing large aneurysms typically requires more coils to achieve near-complete occlusion, which prolongs procedural times.[18] This challenge is compounded in wide-neck aneurysms, where more complex neurointerventions such as the jailing technique in stent-assisted coiling may be necessary, further extending procedural durations.[19] In contrast, flow diverter deployment offers a relatively straightforward treatment approach with potentially shorter treatment times, which could be advantageous in managing these complex cases.[20]

There are several limitations to our study that should be acknowledged. First, it was retrospective in nature, which introduces potential biases inherent in such study designs. The subgroup analysis of procedural efficacy, safety, and clinical outcomes across different endovascular treatment modalities was constrained by our sample size, particularly for cases with stent-assisted coiling where follow-up data were limited. Therefore, any comparisons between these groups should be interpreted cautiously. In addition, our study was conducted at a single center, which may limit the generalizability of our findings to other settings or populations. Variations in patient demographics, treatment practices, and healthcare systems in different localities could influence outcomes and may not necessarily reflect our results. These limitations underscore the need for larger prospective studies conducted across multiple centers to validate our findings and provide more robust evidence regarding the optimal management of ruptured wide-neck intracranial aneurysms using various endovascular techniques.

CONCLUSION

We observed relatively satisfactory outcomes regarding the efficacy and safety of endovascular treatment for ruptured wide-neck intracranial aneurysms. Flow diversion with or without adjunctive coiling emerged as an effective treatment option with a high rate of aneurysmal occlusion and acceptable complication rates compared to other endovascular modalities. Our study highlighted that large aneurysms (>6 mm) and poor grades of SAH were associated with poorer clinical outcomes. These findings underscore the need for prospective studies with larger sample sizes to

validate and refine our results. Future research should aim to further elucidate the optimal management strategies for ruptured wide-neck intracranial aneurysms.

Ethical approval

The research/study was approved by the Central Institutional Review Board at Hospital Authority, Hong Kong, number CIRB-2024-282-4.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

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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