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CASE REPORT

An unusual etiology of subarachnoid hemorrhage, basilar artery perforator aneurysms, in Macao: Three case reports and review of literature

Ieong-Chon Man, Tam-Man Pan, Kuok-Cheong U

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Ieong-Chon Man, Tam-Man Pan, Kuok-Cheong U, Department of Radiology, Hospital Conde S. Januário, Macao SAR 999078, China

Corresponding author: Kuok-Cheong U, MD, Chief Doctor, Department of Radiology, Hospital Conde S. Januário, Ruoxian Xie Alley, Lobby Area, Macao SAR 999078, China. kuokcu1@gmail.com

Abstract

BACKGROUND

Subarachnoid hemorrhage is a severe neurological condition that requires prompt and appropriate treatment to prevent complications. Aneurysms are the most common cause of spontaneous subarachnoid hemorrhage. Conversely, basilar artery perforator aneurysms (BAPAs) are a rare etiology. There is no consensus on the optimal management of ruptured BAPAs in the acute setting.

CASE SUMMARY

We present a case series of 3 patients with ruptured BAPAs who were treated at our institution. Two patients had a modified Fisher grade of I, and one had a grade of IV on initial presentation. The aneurysms were detected by computed tomography angiography in two cases and conventional angiography in one case. The 3 patients underwent endovascular treatment with Guglielmi detachable coils. Post-treatment, the patients had good clinical outcomes, and follow-up brain computed tomography scans showed reduced subarachnoid hemorrhage without any new hemorrhage. However, one patient experienced a cerebral infarction 2 months later and eventually succumbed to the condition. The other 2 patients showed progressive recovery, and no aneurysm recurrence was observed at the 2-year follow-up.

CONCLUSION

Endovascular treatment may be a preferable approach for managing ruptured BAPAs compared with surgical intervention or conservative management. Early detection and prompt treatment is important to achieve favorable patient outcomes.

Key Words: Basilar artery; Intracranial aneurysm; Endovascular treatment; Subarachnoid hemorrhage; Case report

Core Tip: Basilar artery perforator aneurysms are a rare cause of subarachnoid hemorrhage. This case series of 3 patients treated with endovascular coiling suggested that this approach may be preferable for managing ruptured basilar artery perforator aneurysms compared with surgical intervention or conservative management. Early detection and prompt treatment are critical. Treatment plans should be individualized based on the patient's specific circumstances. Further research is needed to establish evidence-based guidelines for the optimal management of this rare condition.

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INTRODUCTION

Basilar artery perforator aneurysms (BAPAs) are an uncommon etiology of subarachnoid hemorrhage[1]. Their diagnosis necessitates a high degree of suspicion because they are often small, partially thrombosed, and supplied by diminutive vessels. Because of slow blood flow, BAPAs may exhibit delayed filling, making them challenging to detect on initial angiography[2]. In this case series, we presented 3 patients with ruptured BAPAs who underwent successful endovascular coiling. Two patients demonstrated good clinical outcomes; one patient succumbed to cerebral infarction 2 months post-treatment.

The optimal management of BAPAs remains debatable, with surgical, endovascular, and conservative approaches all being viable options depending on individual patient circumstances. Larger studies are essential to determine the natural history of these lesions and refine treatment strategies. This case series underscored the importance of meticulous angiographic techniques and heightened awareness for accurate diagnosis and timely intervention to achieve favorable patient outcomes.

CASE PRESENTATION

Chief complaints

Case 1: A 58-year-old female presented with sudden onset of dizziness and nausea.

Case 2: A 79-year-old female presented with a 1-h history of headache and vomiting.

Case 3: A 31-year-old female presented with a 30-min history of headache, nausea, and vomiting.

History of present illness

Case 1: The patient initially had a Glasgow Coma Scale (GCS) score of 15 but rapidly deteriorated becoming poorly responsive with bilateral gaze deviation and a GCS score of 3.

Case 2: The patient presented with a 1-h history of headache and vomiting.

Case 3: The patient suddenly developed poor responsiveness, coma (GCS 3), and desaturation (SpO_2: 78%).

History of past illness

Case 1: The patient had a history of hypertension.

Case 2: The patient had a history of hypertension.

Case 3: This patient had a disease-free medical history.

Personal and family history

Cases 1-3: None of the patients had a family history of neurovascular disease.

Physical examination

Case 1: Blood pressure: 154/89 mmHg; Level of consciousness: Comatose (GCS 3); Pupillary response: Sluggish bilaterally; Extraocular movements: Bilateral gaze deviation; Corneal reflex: Absent bilaterally; Motor response: Flaccid posturing; and Babinski sign: Positive bilaterally.

Case 2: Blood pressure: 198/79 mmHg; Level of consciousness: Drowsy (GCS 10); Pupillary response: Sluggish; Extraocular movements: Nystagmus; Motor response: Bilateral weakness; Meningeal signs: Neck stiffness, Kernig's sign, and Brudzinski's sign were present.

Case 3: Blood pressure: 146/76 mmHg; Oxygen saturation: Decreased (SpO_2 78%); Level of consciousness: Comatose (GCS 3); Pupillary response: Non-reactive, fixed pupils bilaterally; Extraocular movements: Absent or minimal response to oculocephalic reflex (Doll's eye); Corneal reflex: Absent bilaterally; Gag reflex: Absent; Motor response: Flaccid or decerebrate posturing; Babinski sign: Positive bilaterally.

Laboratory examinations

Cases 1-3: All 3 patients exhibited normal findings on laboratory examinations including: Hemoglobin concentration with an average of 12.3 g/dL; Renal function: Serum urea with an average of 3.5 mmol/L; Serum creatine with an average of 78 μmol/L; Liver function: serum aspartate aminotransferase with an average of 23 U/L and serum alanine aminotransferase with an average of 34 U/L; Sodium with an average of 140 mmol/L; potassium with an average of 3.9 mmol/L; and Chloride with an average of 103 mmol/L.

Imaging examinations

Case 1: Urgent brain CT and CT angiography revealed a ruptured left superior cerebellar artery aneurysm with pontine and right cerebellar hematomas (Figure 1). Angiography showed the aneurysm noted in the left side of the basilar artery (Figure 1).

Case 2: Head CT showed bilateral temporal lobe subarachnoid hemorrhage and fourth ventricle hematoma (Figure 2). Cerebral angiography revealed a small (2.0 mm × 2.0 mm) wide-necked aneurysm in the P2 segment of the left posterior cerebral artery (Figure 2).

Case 3: Urgent brain CT revealed a ruptured aneurysm of the meningeal branch of the left vertebral artery with cerebellar vermis hematoma and intraventricular hemorrhage (Figure 3). Angiography showed a double berry-shaped aneurysm supplied by the left posterior inferior cerebellar artery branch and an unruptured right-sided basilar artery perforator aneurysm (Figure 3).

FINAL DIAGNOSIS

Case 1

Ruptured left superior cerebellar artery aneurysm with pontine and right cerebellar hematomas.

Diagnostic reasoning: The patient presented with sudden onset headache, nausea, and vomiting, consistent with subarachnoid hemorrhage. CT and digital subtraction angiography imaging confirmed the presence of a ruptured aneurysm arising from the left superior cerebellar artery, with associated pontine and contralateral cerebellar hematomas. Other considerations included arteriovenous malformation, dural arteriovenous fistula, and hemorrhage from a tumor, but the imaging findings were most consistent with a ruptured saccular aneurysm. The location arising from a basilar perforating artery is unusual.

Prognostic characteristics: The presence of brainstem and bilateral cerebellar hematomas suggested a more severe initial presentation, which may be associated with a higher risk of neurological deficits and complications. However, timely endovascular treatment and management of hydrocephalus with an external ventricular drain can improve outcomes.

Case 2

Ruptured small wide-necked aneurysm in the P2 segment of the left posterior cerebral artery.

Diagnostic reasoning: The patient presented with headache and meningism, raising suspicion for subarachnoid hemorrhage, which was confirmed on CT. Cerebral angiography revealed a small (2.5 mm) aneurysm with a relatively wide neck arising from the P2 segment of the left posterior cerebral artery. Given the location and morphology, alternate diagnoses such as dissection or vasculitis were considered less likely. Perforator aneurysms in this location are uncommon.

Prognostic characteristics: The small size of the aneurysm and the absence of significant intraparenchymal hemorrhage were favorable prognostic factors. However, the wide neck of the aneurysm may make endovascular treatment more challenging, potentially impacting the risk of complications and long-term outcome.

Case 3

Ruptured aneurysm of the meningeal branch of the left vertebral artery with cerebellar vermis hematoma and intraventricular hemorrhage and an unruptured right-sided basilar artery perforator aneurysm.

Diagnostic reasoning: This patient presented with thunderclap headache and depressed consciousness. Imaging confirmed subarachnoid, intraventricular, and intracerebellar hemorrhage. The unusual location of the ruptured aneurysm arising from a meningeal branch of the left vertebral artery made it challenging to initially identify and required repeat angiography. The additional finding of a small unruptured aneurysm arising from a right basilar perforator was also noted. Other diagnostic considerations included vascular malformations or hemorrhage from a

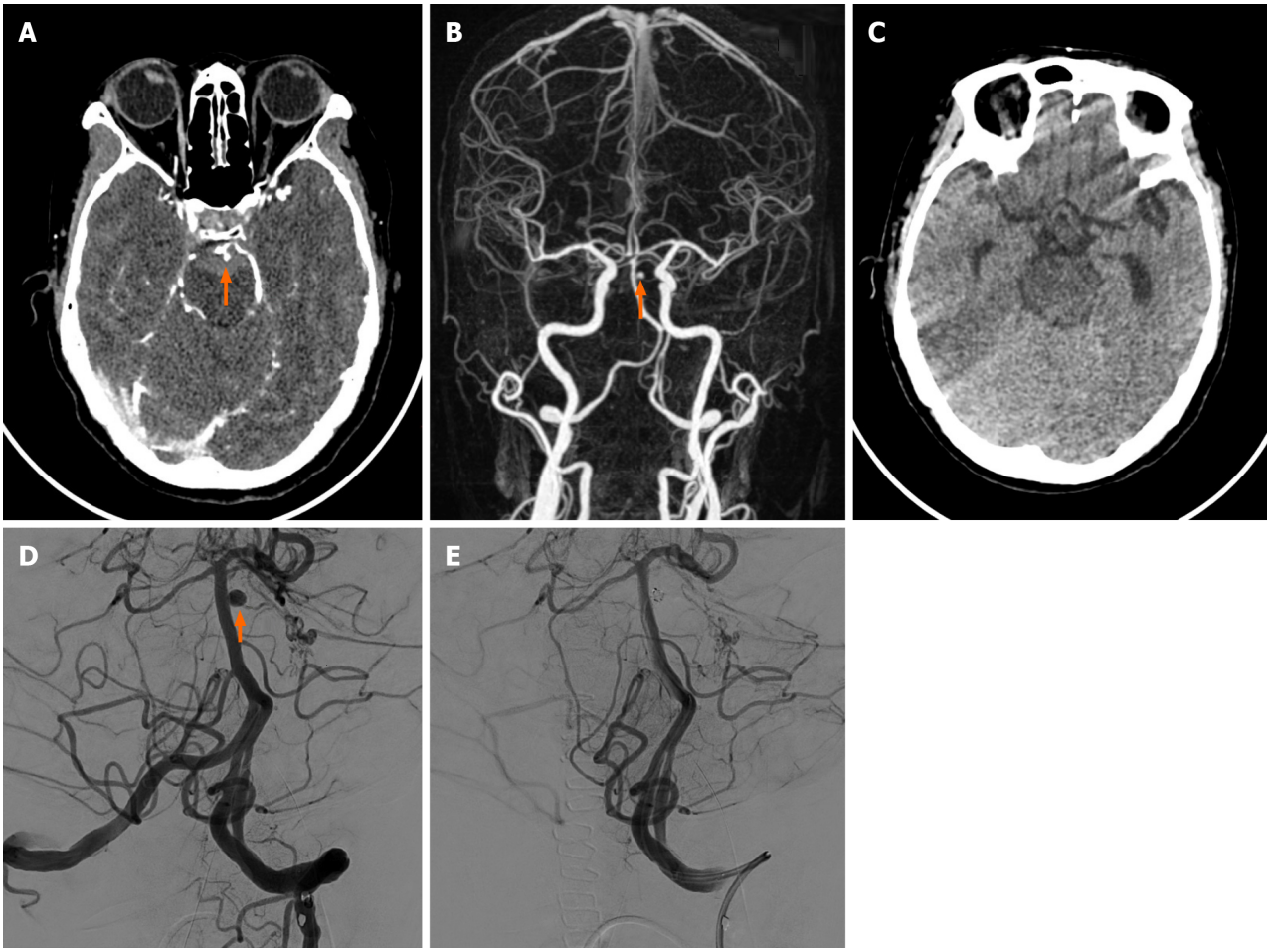

Figure 1 Case 1. A: Axial enhanced brain computed tomography of a 58-year-old female showed a tiny aneurysm found in the left superior cerebellar artery. Subarachnoid hemorrhage was noted; B: Three-dimensional reconstruction showed a 4.2 mm × 3.0 mm × 2.6 mm aneurysm found in the left superior cerebellar artery; C: Follow-up brain computed tomography (24 months post-operation) showed no new subarachnoid hemorrhage; D: Angiography showed the aneurysm noted on the left side of the basilar artery was clearly visualized by the frontal and lateral views; E: A 3.0 mm × 80.0 mm metallic coil was impacted into the aneurysm sac. Follow-up angiogram confirmed complete embolization and parent artery was intact.

tumor.

Prognostic characteristics: The presence of intraventricular hemorrhage and cerebellar hematoma suggested a more severe initial presentation, which may be associated with a higher risk of complications such as hydrocephalus and neurological deficits. The unruptured basilar artery perforator aneurysm added complexity to the management and required careful follow-up. Early endovascular treatment and management of hydrocephalus can improve outcomes, but the overall prognosis may be guarded given the extent of the initial hemorrhage.

TREATMENT

The management of posterior fossa aneurysms requires a tailored approach based on the specific location, morphology, and presentation of each aneurysm. In the presented cases, a combination of surgical and endovascular interventions was used to address the immediate life-threatening situations and prevent further hemorrhage.

Case 1

The patient underwent an emergency posterior fossa craniectomy to decompress the brainstem and cerebellum, followed by endovascular coiling of the ruptured left superior cerebellar artery aneurysm. This two-pronged approach was intended to alleviate the mass effect caused by the pontine and right cerebellar hematomas while securing the aneurysm to promote healing.

Case 2

Metallic coils were used for the successful endovascular embolization of a small, wide-necked aneurysm in the P2 segment of the left posterior cerebral artery. Because of the challenging location and morphology of the aneurysm, the parent artery was sacrificed to achieve complete occlusion and minimize the risk of future rupture. Although this approach effectively secured the aneurysm, it also had the potential risk of ischemic complications in the territory

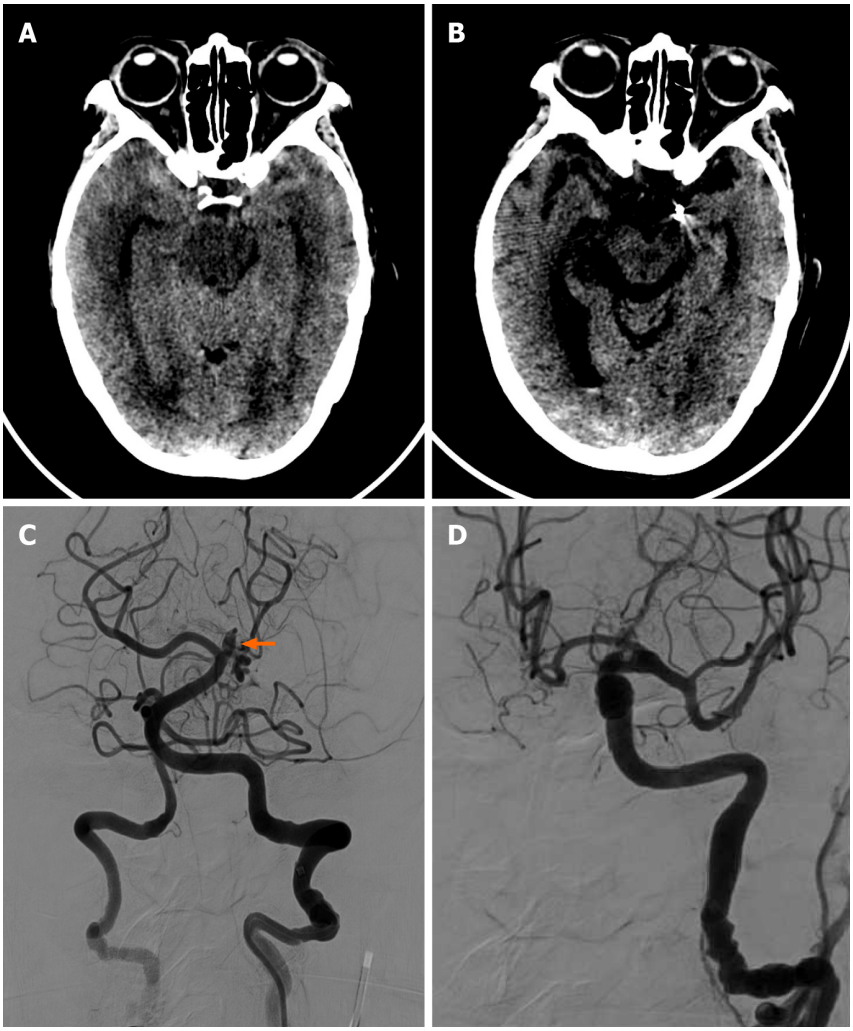

Figure 2 Case 2. A: Axial brain computed tomography of a 79-year-old female showed bilateral subarachnoid hemorrhage in the bilateral temporal region; B: Axial brain computed tomography post-treatment showed the previous subarachnoid hemorrhage in the bilateral temporal region had subsided. No intracranial hemorrhage was found; C: Angiography showed a bulging aneurysm in the basilar perforated branches; D: Final angiography showed complete embolization of the aneurysm.

supplied by the sacrificed artery.

Case 3

The patient presented with a unique combination of a ruptured aneurysm of the meningeal branch of the left vertebral artery and an unruptured right-sided BAPA. Both aneurysms were successfully treated in a single session using endovascular coil embolization, highlighting the benefit of this minimally invasive approach in managing multiple aneurysms while reducing the patient's overall procedural risk.

OUTCOME AND FOLLOW-UP

Case 1

The patient's GCS score improved significantly from 3 to 10 following the emergency posterior fossa craniectomy and endovascular coiling of the aneurysm. Follow-up brain CT scans at 6 months and 24 months post-treatment demonstrated no aneurysm recurrence, indicating a favorable long-term outcome.

Case 2

Although the post-treatment CT showed resolution of the subarachnoid hemorrhage, the patient unfortunately experienced a left cerebellar infarction 2 months later, likely due to the sacrifice of the parent artery during the embolization procedure. This ischemic complication ultimately led to the patient's demise, underscoring the delicate balance between aneurysm occlusion and preservation of the arterial supply in the posterior fossa.

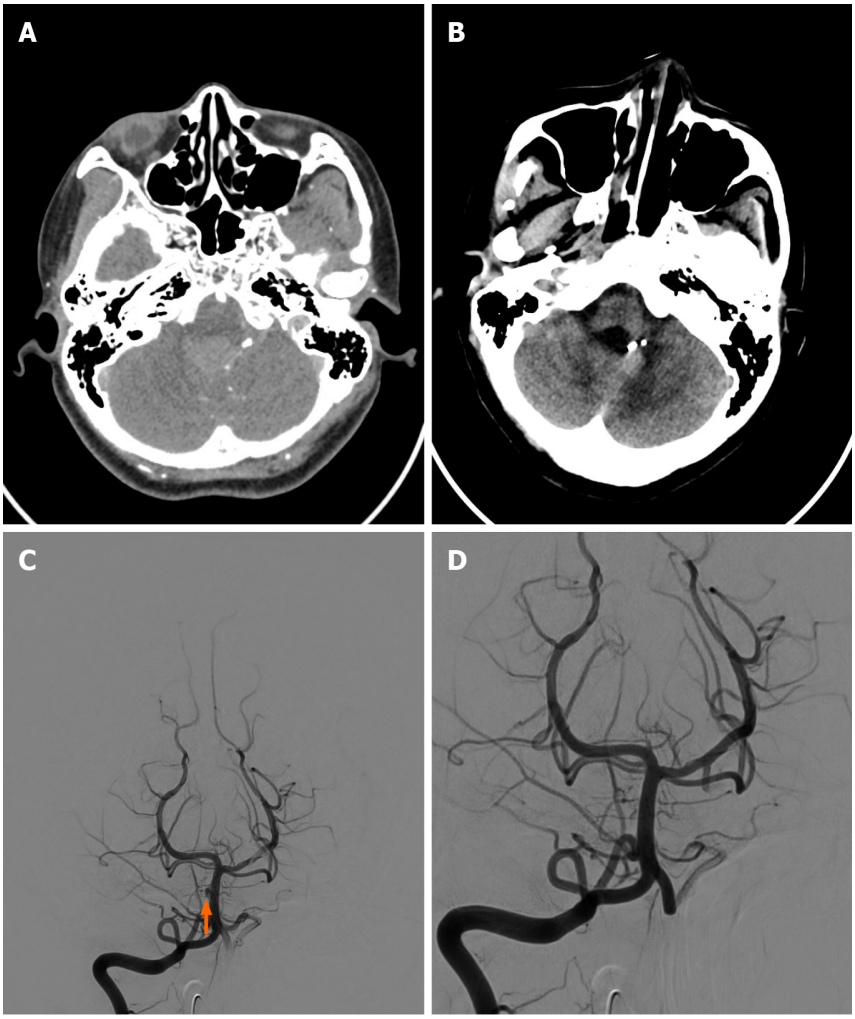

Figure 3 Case 3. A: Axial brain computed tomography with contrast of a 31-year-old female showed an irregular saccular structure found in one of the left distal vertebral artery meningeal branches; B: Follow-up (24 months) axial brain non-contrast computed tomography of the same patient showed the previous subarachnoid hemorrhage regressed, and no new subarachnoid hemorrhage was noted; C: Angiography showed a tiny semi-circle saccular lesion noted on the right side of the basilar artery, and it was considered an unruptured basilar artery perforator aneurysm; D: Metallic coil embolization of these aneurysms was performed.

Case 3

The patient's condition improved following the successful endovascular coil embolization of both the ruptured aneurysm of the meningeal branch of the left vertebral artery and the unruptured right-sided BAPA. Follow-up CT scans at 6 months and 24 months post-treatment revealed no aneurysm recurrence, suggesting a favorable long-term outcome and the effectiveness of the endovascular approach in this case.

Literature review

We analyzed 80 BAPA cases including the three cases reported here (Tables 1 and 2[1,3-29]). The mean age of the patients was 56.7 years (range: 2-82 years), and the mean aneurysm diameter was 2.1 mm (range: 0.2-7.0 mm). Forty-three percent of the aneurysms were located in the distal third of the basilar artery, whereas 57% were in the middle third. Ninety-eight percent of BAPAs presented with diffuse subarachnoid hemorrhage or focal perimesencephalic/prepontine subarachnoid hemorrhage on CT. Notably, up to 60% of the lesions were not visible on initial catheter angiography.

Twenty-five patients received conservative treatment with a mean follow-up of 10.2 months (range: 1-78 months). Seven patients (11.1%) developed brainstem infarction, and two patients experienced rebleeding after the initial subarachnoid hemorrhage. Among the 52 surgically treated cases, 6 underwent open surgery, and 46 received endovascular therapy using various embolic materials, including coils (6 cases), stents (6 cases), Onyx (2 cases), flow diverters (28 cases), electrothrombosis (3 cases), and a flow redirection endoluminal device (1 case). The treatment and follow-up timeline of our BAPA patients is shown in Figure 4.

DISCUSSION

Subarachnoid hemorrhage is a common neurological disease; its causes can be divided into traumatic and nontraumatic.

Table 1 Demographic and treatment data for each patient

Patient	Age in yr	Sex	Modified Fisher grade	Detection on initial angiography	Size in mm	Location of perforating artery of BA	Treatment	Material for embolization	Infarction post-treatment	Rebleed after treatment	Clinical outcome	Length of follow-up
1	58	F	1	Yes	4.2 × 2.6 × 3.0	Mid 1/3	Endovascular	Coils	No	No	Stable	18 months
2	79	F	1	Yes	2.0 × 2.0 × 2.5	Distal 1/3	Endovascular	Coils	Yes	No	Dead	2 months
3	31	F	4	Yes	3.0 × 2.5 × 3.0	Mid 1/3	Endovascular	Coils	No	No	Stable	24 months

BA: Basilar artery; F: Female.

Nontraumatic subarachnoid hemorrhage is usually due to aneurysm rupture. BAPA is a rare disease whose diagnosis requires a high degree of suspicion. The first case was reported by Ghogawala *et al*[1] in 1996. Even with high suspicion, BAPA is easy to ignore because the aneurysm is small, usually partly thrombosed, and supplied by small-caliber blood vessels[2,3]. They usually show delayed filling secondary to slow blood flow, which may be difficult to see[4,5]. Sixty-one percent of the lesions were not found in the first angiography, and the lesions became obvious on repeated angiography. Therefore, in the process of angiography, good patient fixation and sufficient injection are the guarantee of diagnosis. Two of our cases were identified by CT angiography, and aneurysms could also be found in the subsequent angiography.

The etiology of BAPA is unknown. It is considered to originate from separation, and some thrombosis may occur at the time of diagnosis. They are considered to be more benign than other ruptured aneurysms. Among the patients treated conservatively, 2 patients bled again 15 d after the attack[5,20]. However, 7 patients with conservative treatment also had spontaneous perforator stroke, and the clinical consequences ranged from mild to severe[5,9,10,22].

From such a small series of case reports, we cannot draw a decisive conclusion about the optimal treatment algorithm. Surgical, endovascular, or conservative treatment should be carefully discussed according to the actual situation of each patient.

Endovascular techniques include coiling, overlapping stents, liquid embolization, and shunt placement. Direct coiling of BAPAs is rarely possible because it requires catheterization of very small diameter perforators, which are usually at right angles to the main basilar artery. In addition, these aneurysms are too small to safely place coils, and the preservation of perforator patency is another problem. In the published cases, the aneurysms were in the middle of the basilar artery, most of which were treated with coils, and there was no rebleeding or cerebral embolism[8,18,21]. Among the reported cases of BAPA treated with overlapping stents, 6 patients had no complications of embolization. Stenting is technically easier than coil embolization because it does not require a microcatheter to pass through the perforator[6,15,19,26,28].

Flow diverters are sometimes deployed for BAPA treatment; this off-label application is considered to reduce flow enough to cause the occlusion of these thrombosis-prone aneurysms while maintaining the patency of the parent vessel to meet ongoing physiological needs. Elsheikh *et al*[29] described the use of a flow diverter in the treatment of BAPA. Eighteen patients were treated with flow diversion for BAPA, and one case of puncture embolism and two cases of rebleeding occurred. Kuhn *et al*[25] published a case report on the use of a flow redirection endoluminal device (FRED) to treat BAPA. The FRED is a double-layered, self-expanding braided nickel titanium alloy mesh fluid diverter. The double-

Table 2 Review of previously published basilar artery perforated aneurysm cases

Author	Yr of publication	Age in yr	Location of perforating artery of BA	Treatment	Pontine infarction	Rebleed subarachnoid hemorrhage	Clinical outcome	Length of follow-up
Ghogawala *et al*[1]	1996	56	Distal	Surgery	No	No	Stable	6 months
Hamel *et al* [11]	2005	44	Mid	Surgery	No	No	Residual ataxia	7 months
Fiorella *et al* [12]	2006	13	Distal 1/3	Endovascular	No	No	Stable	6 months
Sanchez-Meija *et al*[7]	2007	27	Distal 1/3	Surgery	No	No	Stable	Unknown
		68	Mid 1/3	Surgery	No	No	Stable	Unknown
		2	Mid 1/3	Surgery	No	No	Stable	Unknown
Park *et al*[13]	2009	54	Distal 1/3	Conservative	No	No	Stable	16 months
		67	Distal 1/3	Conservative	No	No	Stable	16 months
		53	Distal 1/3	Conservative	No	No	Stable	1 month
Mathieson *et al*[12]	2010	51	Distal 1/3	Surgery	No	No	Mild amnesia	Unknown
Chen *et al*[8]	2012	66	Mid 1/3	Endovascular	No	No	Stable	24 months
		28	Mid 1/3	Endovascular	No	No	Stable	18 months
Nyberg *et al* [15]	2013	50	Mid 1/3	Endovascular	No	No	Stable	2 months
		60	Mid 1/3	Endovascular	No	No	Stable	4 months
Ding *et al*[9]	2013	58	Distal 1/3	Conservative	No	No	Stable	6 wk
		55	Distal 1/3	Conservative	Yes	No	Stable	19 months
		62	Distal 1/3	Endovascular	Yes	No	Hemiparesis	22 months
Chalouhi *et al* [16]	2014	65	Mid 1/3	Endovascular	No	No	Stable	6 months
Chavent *et al* [4]	2014	55	Distal 1/3	Conservative	No	No	Stable	6 months
		39	Distal 1/3	Conservative	No	No	Stable	12 months
		59	Distal 1/3	Conservative	No	No	Stable	6 months
Forbrig *et al* [5]	2015	71	Mid 1/3	Conservative	Yes	Yes	Hemiparesis	11 months
		65	Mid 1/3	Conservative	Yes	No	Hemiparesis	15 months
		82	Mid 1/3	Conservative	Yes	No	Hemiparesis	6 months
		60	Distal 1/3	Conservative	Yes	No	Stable	78 months
		53	Distal 1/3	Conservative	No	No	Stable	6 months
		72	Distal 1/3	Conservative	No	No	Mild cognitive impairment	5 months
		59	Distal 1/3	Endovascular	No	Yes	Hemiparesis	23 months
		71	Distal 1/3	Endovascular	No	No	Hemiparesis	60 months
Aboukais *et al*[17]	2016	67	Distal	Conservative	No	No	Stable	6 wk
Daruwalla *et al*[3]	2016	76	Mid	Conservative	No	No	Dead	16 d
Finitsis *et al* [10]	2017	59	Distal	Conservative	No	No	Stable	6 wk

		78	Distal	Conservative	Yes	No	Quadriparesis	12 months
		53	Mid	Conservative	No	No	Stable	6 wk
		62	Mid	Endovascular	No	No	Stable	3 months
Chau *et al*[19]	2017	53	Distal	Endovascular	No	No	Stable	6 months
Satti *et al*[6]	2017	52	Mid	Endovascular	No	No	Stable	7 months
Buell *et al*[18]	2018	62	Mid 1/3	Endovascular	No	No	Stable	49 months
		63	Mid	Endovascular	No	No	Stable	50 months
Bhogal *et al*[20]	2019	65	Mid	Endovascular	No	No	Stable	3 months
		55	Distal	Endovascular	No	No	Stable	9 months
		66	Mid	Endovascular	No	No	Stable	12 months
		41	Mid	Endovascular	Yes	No	Stable	5 months
		52	Mid	Endovascular	No	No	Stable	4 months
		39	Mid	Endovascular	No	No	Stable	3 months
		59	Mid	Conservative	No	No	Stable	3 months
		57	Distal	Conservative	No	No	Stable	1 month
		62	Distal	Conservative	No	Yes	Hemiparesis	2 months
Enomato *et al*[22]	2020	60	Distal 1/3	Conservative	Yes	No	Stable	2 months
Nathan *et al*[24]	2020	62	Distal 1/3	Conservative	No	No	Stable	30 months
		48	Distal 1/3	Conservative	No	No	Stable	12 months
Mizuno *et al*[21]	2020	69	Mid 1/3	Endovascular	No	No	Stable	1 month
Sattur *et al*[26]	2020	62	Mid 1/3	Endovascular	No	No	Stable	3 months
Inoue *et al*[28]	2020	72	Mid 1/3	Endovascular	Yes	No	Stable	3 months
Ma *et al*[23]	2021	52	Distal 1/3	Endovascular	No	No	Stable	6 months
	2021	48	Mid 1/3	Endovascular	No	No	Stable	18 months
	2021	65	Mid 1/3	Endovascular	No	No	Dead	N/A
Kuhn *et al*[25]	2021	Unknown	Mid 1/3	Endovascular	Yes	No	Stable	12 d
Mutlu *et al*[27]	2022	64	Mid 1/3	Endovascular	No	No	Stable	2 wk
Elsheikh *et al*[29]	2022	57 (40-78 ± 10.7)	N/A	Endovascular	Yes (1 case)	Yes (2 cases)	Stable (16 cases); dead (2 cases)	Median: 180 d

BA: Basilar artery; N/A: Not available.

layered shunt part of the device can be accurately positioned above the aneurysm, and the flared end can fix the device in the parent vessel without affecting the flow into the branch vessel/perforator. This is particularly important along the basilar artery because the device reduces the coverage of uninvolved perforators. Other flow diverters do not have this special design and will cover more orifices over the entire length of the unit. There were no postoperative complications. However, the number of cases was small, and more cases are needed to prove the efficacy of FRED[25].

In addition to the embolization methods mentioned above, Ma *et al*[23] reported a case of treatment of BAPA with electrothrombosis. There are two potential advantages of intravascular electrothrombosis. First, immediate hemostasis is effective. This concentrated current reduces treatment time compared with coil embolization. In addition, intravascular electrothrombosis may alleviate bleeding earlier than flow diverter implantation. Second, the overall risk of bleeding was reduced. Compared with catheterization and coiling, electrothrombosis improves the efficiency of microsurgery, and the wire head can be inserted more safely into the aneurysm[23]. Efficiency of microsurgery, and the wire head can be inserted more safely into the aneurysm[23].

All of our cases were treated with coiling because the neck of the aneurysms were quite wide, and we successfully embolized the aneurysms using a microcatheter. Patients with endovascular treatment had better clinical outcomes.

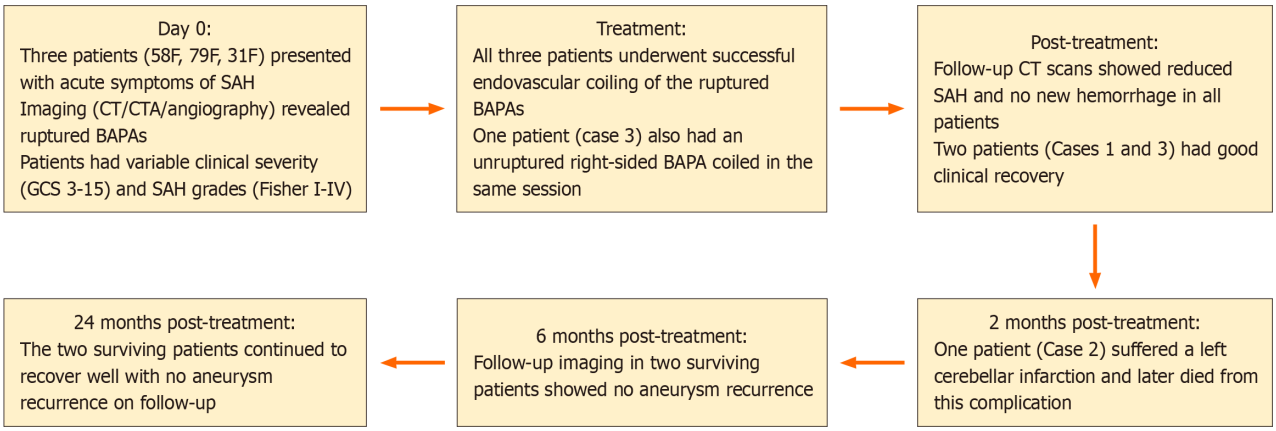

Figure 4 Treatment and follow-up timeline of patients with basilar artery perforator aneurysm. BAPA: Basilar artery perforator aneurysm; CT: Computed tomography; CTA: Computed tomography angiography; F: Female; GCS: Glasgow Coma Score; SAH: Subarachnoid hemorrhage.

Another patient was treated with conservative treatment, and the clinical condition gradually improved after treatment. All patients underwent follow-up brain CT after 1 month, which showed that the previous subarachnoid hemorrhage had been absorbed and no new subarachnoid hemorrhage had been noted. Two patients recovered well and were in good condition at the 24 months follow-up; the other patient experienced cerebral infarction and died.

CONCLUSION

Rupture of BAPA is a rare cause of subarachnoid hemorrhage. Careful angiographic techniques and repeated diagnostic cerebral angiography may be necessary for correct diagnosis. BAPA can spontaneously form thrombosis, but it may also rebleed or be related to basilar artery perforator infarction. In selected cases, these lesions can initially be treated with the most appropriate treatment. Larger studies are needed to fully understand the natural history and improve the treatment strategy for these lesions.

FOOTNOTES

Author contributions: Man IC conceived and designed the study, collected and analyzed the data, and drafted the manuscript; Pan TM and U KC participated in the analysis and interpretation of the data and critically revised the manuscript for important intellectual content; All authors read and approved the final manuscript.

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Country of origin: China

ORCID number: Ieong-Chon Man 0009-0005-6870-5300; Kuok-Cheong U 0009-0000-1795-516X.

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