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Endovascular management of ruptured distal posterior inferior cerebellar artery aneurysms

A retrospective cohort study

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Abstract

Distal posterior inferior cerebellar artery (PICA) aneurysm is a kind of rare intracranial aneurysm with controversial evidence in managements. The main purposes of this research are to study the safety and effectiveness of parent artery occlusion (PAO) compared with selective aneurysm coiling (SAC) as well as figure out factors that affect the outcomes.

All characteristics of patients that diagnosed with ruptured distal PICA aneurysm and treated with endovascular management in our hospital from July 2009 to February 2016 were retrospectively collected. Details include complete occlusion rate, procedure-related complications and Modified Rankin Scale (mRS) of 31 months (mean) follow-up.

Total 36 patients finally met the criterions and were included in the present study. New imaging infarction was observed in 12 (33.33%) patients. And 10 of them showed no apparent neurological dysfunctions after 34 months (mean) follow-up; 1 remained coma status since the symptom onset; and 1 patient died. 27 (75%) patients got a mRS $\leq$ 2 at the discharge while 20 (86.96%) patients with 3-year follow-up after the operation. There is no significant difference between patients treated with SAC and PAO in both complications and functional recovery in 3-years follow-up period. Hunt&Hess classification (H&H), age, and hydrocephalus are risk factors for functional recovery at discharge.

PAO is safe and efficient in the management of distal PICA aneurysms while complications and outcomes are similar with SAC. H&H, age, and hydrocephalus are predicting factors for the mRS at discharge. Further prospective study is still needed to confirm the results of present study.

Abbreviations: DSA = digital subtraction angiography, H&H = Hunt&Hess classification, mRS = modified Rankin Scale, PAO = parent artery occlusion, PICA = posterior inferior cerebellar artery, SAC = selective aneurysm coiling, SAH = subarachnoid hemorrhage.

Keywords: cerebral aneurysm, endovascular management, parent artery occlusion, posterior inferior cerebellar artery, selective aneurysm coiling, subarachnoid hemorrhage

1. Introduction

Posterior inferior cerebellar artery (PICA) aneurysm accounts for about 0.5% to 3% of all intracranial aneurysms and 20% of posterior circulation aneurysms.[1] Mortality due to recurrent hemorrhage within 48 hours after the first rupture of PICA aneurysm is 3 times than those of ruptured aneurysms in anterior circulation.[2] Thus the emergent management is vitally important in patients of ruptured PICA aneurysms. Common strategies for PICA aneurysms are microsurgical clipping and endovascular selective aneurysm coiling (SAC). Both clipping and SAC were reported to be safe and effective.[3–6] Only few data focus on the comparison of these 2 managements. Previous studies indicated that clipping leads to more postoperative complications than SAC in those patients with proximal PICA aneurysms.[7] And SAC was reported to have higher recurrence rate.[8] Furthermore, SAC could not be practiced easily when facing dissecting or wide-neck aneurysm or twist patent artery.

PICA was divided into 5 segments as Lister referred.[9] Although aneurysm can locate in any segments of PICA, distal PICA aneurysm has a lower incidence than aneurysm in proximal segments. Since distal segments of PICA lack perforators to medulla, parent artery occlusion (PAO) with coils or Onyx is also practiced instead of clipping or SAC. Few studies with limited cases reported that PAO is safe and effective in the management of distal PICA aneurysms.[10–14] PAO could decrease re-rupture rate while increase the risk of infarction though most infarction is reported to be clinical silent. [10–14]

The main purpose of this study is to analyze the safety and efficiency of PAO in the management of ruptured distal PICA aneurysm by comparing the procedure-related complications and outcomes of patients managed by SAC and PAO. The factors that would impact clinical outcomes are also analyzed.

2. Methods

2.1. Study design

The ethics committee of the second affiliated hospital of Zhejiang university approved this study. By reviewing our institutional

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The authors have no conflicts of interest to disclose.

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prospective database of all endovascular procedures from July 2009 to February 2016, all records of patients diagnosed with ruptured distal PICA aneurysm and treated with endovascular management were collected. Then all patients met the criteria were divided into 2 groups by the management. One managed by SAC while another by PAO. Patient demographics, pretreatment clinical status, treatment methods, procedure-related complications, characteristics of the aneurysm, obligation grade, post-treatment recurrence, and outcomes were reviewed and analyzed by certified neurosurgeons who were blinded to the research information. Factors that may affect the outcomes were also analyzed. Clinical follow up was conducted by structured outpatient visit or telephone interview at 6 months, 1 year, 2 years, and 3 years after the operation by neurosurgeons that blinded to the research. Imaging follow-up of conventional angiography was recommended at 6 months and 18 months after the treatment in all patients. The flow of this study is summarized in Figure 1.

2.2. Inclusion criteria of patients

1. Subarachnoid hemorrhage (SAH) or cerebellar hematoma diagnosed with CT scan.
2. PICA aneurysm is the cause of SAH/hematoma.
3. The aneurysm located in distal segments of PICA.
4. Managed by endovascular procedure in our hospital.

2.3. Endovascular procedures

All patients were managed with endovascular treatment under general anesthesia. After a 6-French introducer sheath was placed in the right femoral artery, a 5-French guiding catheter was advanced into the vertebral artery, proximal to the lesion. Systemic heparinization was then performed by administering a 3000 IU bolus, followed by a continuous infusion of 1000 IU/h throughout the procedure. After an optimal angiographic projection was achieved, a micro catheter was directed into the lesion through the guide wire. PAO and SAC were selectively operated depending on the type of the criminal aneurysm and the condition of the parent artery. SAC (stent assisted if necessary) was preferred in patients with saccular aneurysm while parent arteries are neither twist nor narrow. PAO was adopted in patients with dissecting aneurysm or when SAC could not be performed. Coils were placed through the micro catheter into the aneurysm and detached under fluoroscopy. When facing wide neck aneurysms, SAC would be assisted with a stent by using semi-deploy technique. PAO was performed with coils, Onyx only or both coils and Onyx. The capability of the patient to tolerate PICA occlusion was assessed in diagnostic angiogram based on the presence and size of potentials collateral vessels, such as contralateral PICA, ipsilateral anterior inferior cerebellar artery, and superior cerebellar artery. Several types of coils and stents were used. (Axium, Micro Therapeutics, CA; Cosmos, Terumo, CA; Enterprise stent, Cordis Corporation, FL; Solitaire AB stent, Micro Therapeutics, CA). Onyx (Micro Therapeutics, CA) was the liquid embolic agent that used in several patients. After the procedure, patients were continuously monitored for at least 24 hours in our neurosurgery intensive care unit. Patients who underwent stent-assisted coiling receive clopidogrel and aspirin for 3 months. After that, aspirin alone was administered for at least 1 year.

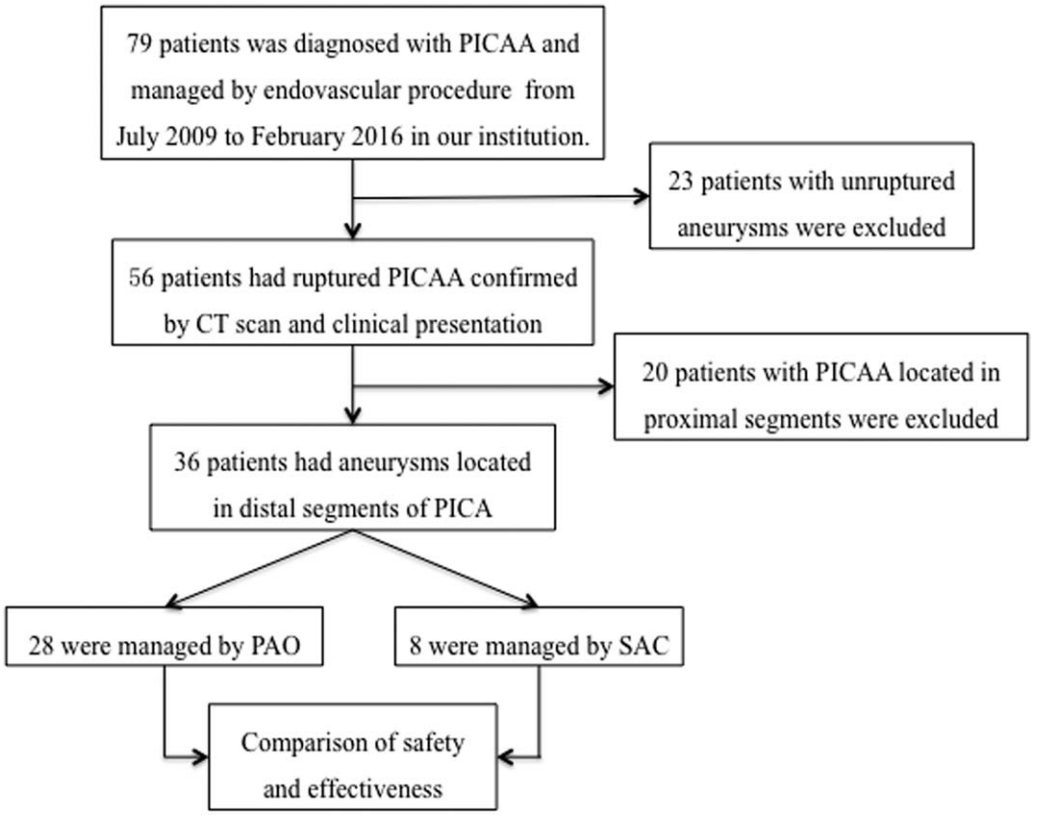

Figure 1. Study design of the research. PICAA: posterior inferior cerebellar artery aneurysm, PAO = parent artery occlusion, PICAA = posterior inferior cerebellar artery aneurysm, SAC = selective aneurysm coiling.

2.4. Definitions

The segments of PICA was determined as Lewis referred.[1] The tonsillomedullary segment, the telovelotonsillar segment and the cortical segment are defined as distal segments of PICA in our research (Fig. 2). String sign, abnormal dilation, fusiform morphology, or double lumens made the diagnosis of dissecting aneurysm of PICA. Pretreatment clinical status was evaluated by Hunt&Hess classification (H&H). The occlusion the parent vessel was defined as no contrast medium flows into during the angiography (Fig. 3). Clinical outcome after procedure was evaluated by using the Modified Rankin Scale (mRS). And mRS ≤ 2 was defined as favorable outcome. Procedure-related complications such as intraoperative rupture and thrombosis developed within stent were calculated. Intraoperative rupture was diagnosed by the exit of the tip of the coil or the micro catheter outside the limit of the aneurysmal sac or extravasation of contrast medium. CT scan was used to determine the SAH, hematoma, and new cerebral infarction.

2.5. Statistical Analyses

Data were analyzed by 2 independent experienced neurosurgeons. All data analysis was conducted by STATA12.0. Fisher exact test was used to examine categorical variables. Mann–Whitney *U* test was used for ranked data like H&H and mRS. Logistic regression analysis was performed to determine independent associations between clinical outcomes and risk factors like H&H, and so on. Values of $P < .05$ were considered statistically significant.

3. Results

3.1. Patient and aneurysm population

Between July 2009 to February 2016, 36 patients were finally included. 28 of them were managed by PAO, while 8 patients by SAC. Baseline characteristics of these patients are summarized in Table 1. All patients with arteriovenous malformation (AVM) (6 patients) or multiple aneurysms (4 patients) were managed by PAO rather than SAC, which indicated a preference of strategy in these specific patients. But there was no statistical significance of all baseline characteristics between the 2 groups.

3.2. Procedure-related complications

Compared with SAC, patients managed by PAO showed lower rate of intraoperative hemorrhage, lower mortality rate (3.57% vs 12.5%) as well as higher complete occlusion rate (100% vs 87.5%). More patients arouse imaging infarction of cerebella in the group of PAO than SAC (39.29% vs 12.50%) though there was no statistical significance. Details of procedure-related complications are showed in Table 2. Among all 12 (33.33%) patients with new imaging cerebella infarction, none of them showed apparent neurological deficits except 1 patient remain unconscious since the symptom onset. 1 patient that managed by PAO died after the operation mainly because the serious condition at admission. And 1 patient died because of intraoperative hemorrhage in the group of SAC but no statistical significance was found when compared with the group of PAO.

In addition, 4 of 8 patients with aneurysms located in the tonsillomedullary segment were managed with PAO. All these patients showed no neurological deficits after the procedure.

3.3. Outcomes with long-term follow-up

Mean time of follow-up was 31 months. The mRS showed no statistical difference in 2 managements (Table 3). Most patients (75%) had favorable outcomes at discharge in both groups. 1 of 8 patients in the SAC group died because of intraoperative hemorrhage. 2 patients managed by PAO lost of follow-up at 1 year after discharge. No recurrent hemorrhage was found in all patients. Only 1 of 8 patients managed by SAC and 8 of 28

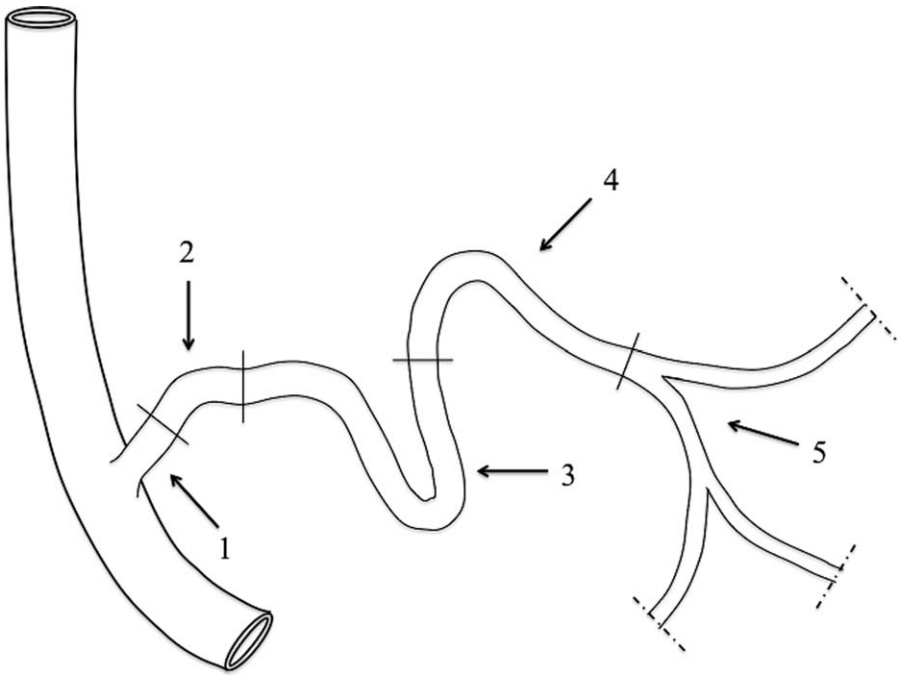

Figure 2. Anatomy of the posterior inferior cerebellar artery. 1st: anterior medullary segment; 2nd: lateral medullary segment; 3rd: tonsillomedullary segment; 4th: telovelotonsillar segment; 5th: cortical segment. 3rd/4th/5th are defined as distal segments.

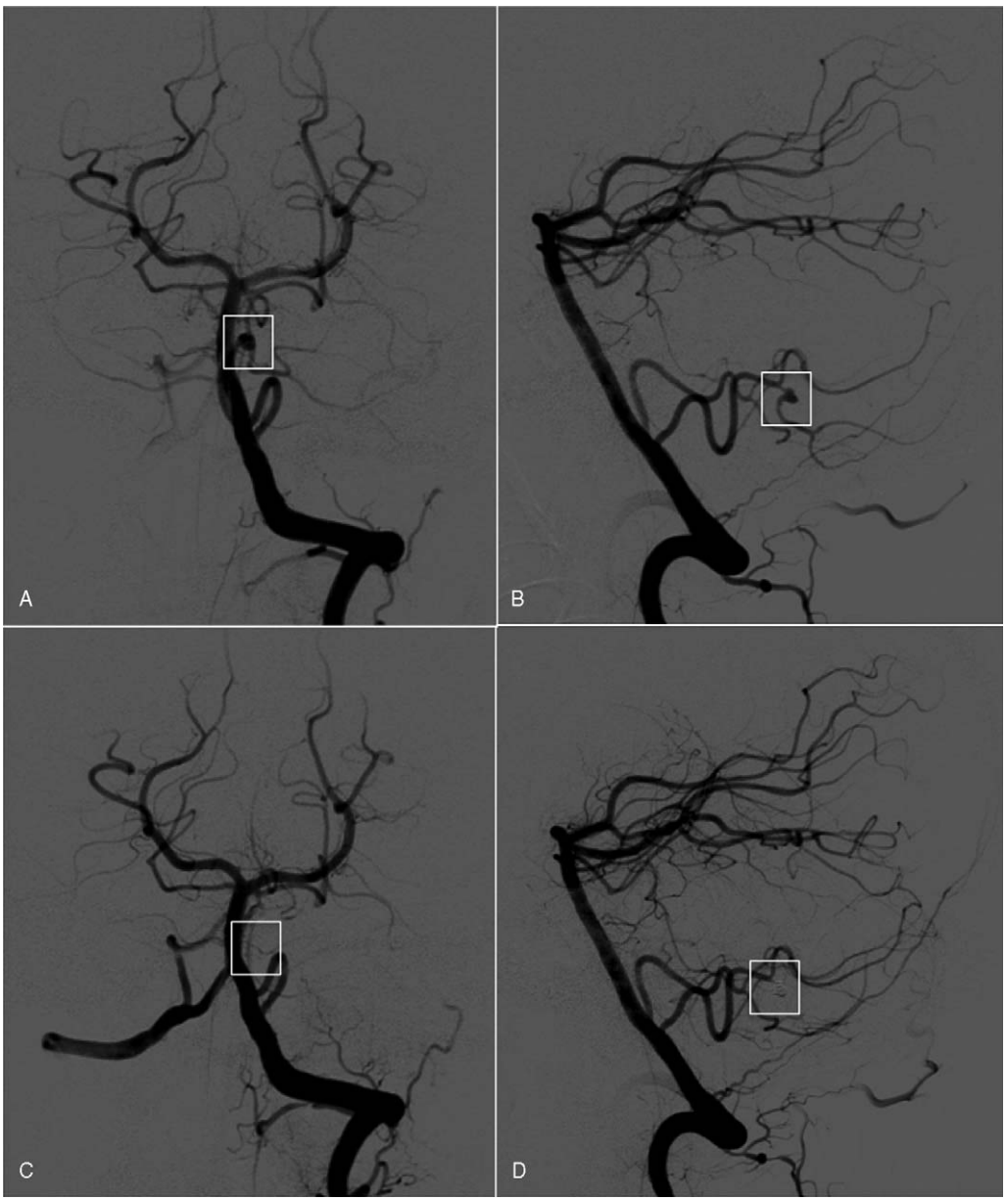

Figure 3. Angiography of a 56 year-old female patient. The white rectangle indicates the location of the aneurysm of cortical segment. A&B: before the parent artery occlusion. C&D: The contrast medium cannot flow into the aneurysm and the parent artery after occluded by coils.

patients managed by PAO had a digital subtraction angiography (DSA) review and no recurrence were detected.

3.4. Risk factors of clinical outcome

Positive correlation was found between H&H, age, hydrocephalus, and the mRS at discharge by the correlational analyses. And positive correlation between hydrocephalus and mRS still exists at 1 year after the management (Table 4).

4. Discussion

PICA is one of the most complex cerebellar arteries because of its different kinds of variations and tortuous course as well as its relationship to lower cranial nerves and the brainstem. Thus the management of PICA aneurysm is always challenging. PICA could be divided into 5 segments as Lewis et al referred.[1] And it can also be divided into proximal and distal segments in several ways. Proximal PICA could be defined as VA-junction or the first 1 cm of PICA as Lehto et al referred.[4] This definition is mostly adopted when the aneurysm is going to be managed by microsurgery. Because it emphasis the relationship between the aneurysm and the lower cranial nerves. Under this definition, the conclusion that proximal PICA aneurysms have higher rate of lower cranial nerve deficits when managed with microsurgery were confirmed in several researches.[4,15,16] When it comes to the endovascular management, proximal PICA is always defined as anterior medullary and lateral medullary segments of the parent artery, since there are critical brainstem perforators which branch off from the first 2 proximal medullary segments.[1] Though PAO is widely accepted as an optimal choice for distal PICA aneurysm, there was few data about the safety and efficiency of PAO as the

Table 1

Basic information.

	SAC	PAO	Total	*P* value
Number	8	28	36	—
Mean age (95%CI)	57.63 (45.92–69.33)	53.25 (48.96–57.54)	54.22 (50.26–58.18)	.36
Male patients	1 (12.50%)	9 (32.14%)	10 (27.78%)	.40
Conscious disorder	5 (62.5%)	11 (39.29%)	16 (44.44%)	.42
Hunt&Hess (Admission)	3	3	3	.06
Dissecting aneurysms	2 (25%)	7 (25%)	9 (25%)	1.00
Located in left side*	4 (50%)	19 (67.86%)	23 (63.89%)	.42
Intraventricular hematoma	6 (75%)	22 (78.57%)	28 (77.78%)	1.00
Multiple aneurysms	0 (0%)	4 (14.29%)	4 (11.11%)	.56
Aneurysms in other locations	0 (0%)	3 (10.71%)	3 (8.33%)	1.00
AVM	0 (0%)	6 (21.43%)	6 (16.67%)	.30

* 1 case with posterior inferior cerebellar artery aneurysms of both sides is included.

PAO = parent artery occlusion, SAC = selective aneurysm coiling, AVM = arteriovenous malformation.

Table 2

Procedure-related complications.

	SAC	PAO	Total	*P* value
Number	8	28	36	—
Intraoperative hemorrhage	1 (12.5%)*	0 (0%)	1 (2.78%)	.22
Operation failure	1 (12.5%)*	0 (0%)	1 (2.78%)	.22
Post-operative hemorrhage	0 (0%)	0 (0%)	0 (0%)	—
Complete occlusion	7 (87.5%)	28 (100%)	35 (97.22%)	.22
Hydrocephalus	4 (50.00%)	9 (32.14%)	13 (36.11%)	.42
Cerebellar infarction	1 (12.50%)	11 (39.29%)	12 (33.33%)	.22
Mortality	1 (12.5%)*	1 (3.57%)	2 (5.56%)	.40

* 1 patient had intraoperative hemorrhage and died.

PAO = parent artery occlusion, SAC = selective aneurysm coiling.

Table 3

Clinical outcomes.

	SAC	PAO	Total	*P* value
mRS $\leq$2 (Discharge)	6/8 (75%)	21/28 (75%)	27/36 (75%)	.46
mRS $\leq$2 (1 year)	6/8 (75%)	22/26 (84.62%)	28/34 (82.35%)	.82
mRS $\leq$2 (2 years)	7/8 (87.5%)	20/23 (86.96%)	27/31 (87.10%)	.85
mRS $\leq$2 (3 years)	4/5 (80%)	16/18 (88.89%)	20/23 (86.96%)	.78
Recurrence	0/1 (0%)	0/8 (0%)	0/9 (0%)	—

PAO = parent artery occlusion, SAC = selective aneurysm coiling, mRS = modified rankin scale.

Table 4

Risk factors of clinical outcome.

	mRS			
Correlation index	Discharge	1 y	2 y	3 y
Hunt&Hess	0.53*	0.30	0.28	0.14
Age	0.44*	0.18	0.16	0.05
Consciousness disorder (Onset)	0.33	0.25	0.14	0.11
Intraventricular hematoma	0.26	0.09	0.05	−0.26
Hydrocephalus	0.48*	0.37*	0.26	0.14
Cerebellar infarction	0.31	0.14	0.22	0.19
PAO	0.25	0.09	0.1	0.23

* $P < .05$.

PAO = parent artery occlusion, mRS = modified rankin scale; y: year (s).

management of distal PICA aneurysm based on this definition exists. 28 patients were managed by PAO making this the biggest series of distal PICA aneurysm managed by PAO up to now.

Procedure-related complications of endovascular management mainly are hemorrhage and thromboembolism. A research included 13 cases of ruptured distal PICA aneurysm managed with endovascular management reported 1 case with operation related hemorrhage and 1 case with thromboembolic event because of stent placement failing during the operation.[17] Chalouhi et al reported 19 cases of distal PICA aneurysms managed by endovascular management. Intraoperative hemorrhage happened in 3 (15.79%) cases.[6] Procedure-related hemorrhage only happened in 1 case during the SAC in our series, which lead to the death of the patient, and no thromboembolic events were observed within stents during all procedures. Since the distal PICA aneurysm always have small sac and located in twisty parent artery, PAO may provides a more simple choice than SAC since less operation may decrease the risk of intraoperative hemorrhage. Another major complication of PAO is the ischemic infarction. Aneurysms' location, as well as collateral circulation, plays the most important role.[18] It is well recognized that the proximal segments of PICA have artery branches supply blood to medulla lacking collateral circulation.[17] Thus the occlusion of these segments may lead to death. Oran et al reported 1 aneurysm located at the anterior medullary segment managed by PAO resulted in brain stem infarction.[19] But the occlusion of distal segments was reported to be safe with no apparent neurological deficits. Isokangas et al reported 6 cases underwent PAO and only 2 of them showed transient neurological deficits.[20] Another 10 cases in a report showed no new neurological deficits after PAO.[13] There were 12 (33.33%) patients in this series showed imaging infarction totally. 11 of them happened in the group of PAO. Though there was no statistical significance between these 2 groups, the infarction still could not be ignored. Trivelato et al compared selective coiling and PAO, they concluded that PAO was significantly associated with higher risk of ischemia.[21] No new neurological deficits were detected except 1 patient remained coma since symptom onset in our series. This result suggests that PAO may lead to more image infarction than SAC, but there would not be apparent neurological deficits.

Few data of aneurysms located in tonsillomedullary segment managed by PAO exists. Li et al reported 4 such cases with good clinical outcome.[14] In this research, we classified the tonsillomedullary segment into distal segment. 4 of 8 patients with aneurysms located in tonsillomedullary segment were managed with PAO. No patients showed apparent neurological deficits after the procedure. The definition of distal PICA should include the tonsillomedullary segment since the occlusion of parent vessel may not lead to brainstem infarction.

Twenty seven (75%) patients of all 36 cases in our research recovered well at discharge, 82.35% at 1 year after the operation and 86.96% at 3 years after the operation. No rehemorrhage event was detected. There was no statistical difference between the mRS between the 2 groups, which indicated that PAO is a safe choice for ruptured distal PICA aneurysm.

Fujimura et al reported a case of fatal rebleeding after selective embolization of dissecting PICA aneurysms[22] while PAO is reported to have no recurrence or lower rate of recurrence.[14,23,11,21] Those 9 patients in our institution that took repeated DSA examination at 1 year after the operation showed no recurrence. The number of these cases was so limited that the recurrence rate of aneurysms cannot be reflected well. Further

follow-up is still needed. According to a retrospect analysis of cases with PICA aneurysms from 3 centers, the recurrence rate of endovascular management is 14.7% and procedure-related complications happened in 11.8% patients.[8]

The positive correlations between H&H, hydrocephalus, age, and mRS at discharge were confirmed in our research, which revealed similarity in several other researches.

The development of endovascular technology supplied new choice for the management of intracranial aneurysms now, such as the appliance of flow diversion device. Though the parent artery of PICA aneurysm is narrow and twisted, Levitt et al and Marcus et al also managed aneurysms located in PICA or vertebral arteries with flow diverter successfully.[24,25]

There were several deficits in our research. The case number is limited, especially the number of patients with aneurysms located in the tonsillomedullary segment. Few patients had image follow-up, which may influence the assessment of the recurrence rate. Data of this research is retrospectively collected which may cause several biases. The conclusions still need to be tested in multicenter prospective researches.

5. Conclusion

PAO is safe and efficient in the management of distal PICA aneurysms with similar complications and outcomes compared with SAC. PAO may cause cerebellar infarction but no apparent neurological deficits. H&H classification, age as well as hydrocephalus are associated with mRS at discharge. The conclusion still needs to be confirmed by further prospective study.

Author contributions

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Software: Ligen Shi.
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Writing – review & editing: Ligen Shi, Jing Xu, Jianmin Zhang.

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