Microsurgical management of aneurysms of the superior cerebellar artery - lessons learnt: An experience of 14 consecutive cases and review of the literature

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ABSTRACT

Objective: This is a retrospective study from January 2002 to December 2012 analyzing the results of microsurgical clipping for aneurysms arising from the superior cerebellar artery (SCA).

Materials and Methods: All patients with SCA were evaluated with computerized tomography angiography and/or digital subtraction angiography (DSA) prior to surgery. All patients in our series underwent microsurgical clipping and postoperative DSA to assess the extent of aneurysm occlusion. The Glasgow outcome scale (GOS) and the modified Rankin's scale (mRS) were used to grade their postoperative neurological status at discharge and 6 months, respectively.

Results: Fourteen patients had SCA aneurysms (ruptured-9, unruptured-5). There were 10 females and 4 males with the mean age of 47.2 years (median - 46 years, range = 24–66 years). Subarachnoid hemorrhage (SAH) was seen in 11 patients. The mean duration of symptoms was 2.5 days (range = 1–7 days). The WFNS score at presentation was as follows: Grade 1 in 10 cases, II in 2 cases, III in 1 case and IV in 1 case. In the 9 cases with ruptured SCA aneurysm, average size of the ruptured aneurysms was 7.3 mm (range = 2.5–27 mm, median = 4.9 mm). The subtemporal approach was used in the first 7 cases. The extradural temporopolar (EDTP) approach was used in the last 5 cases. Complications include vasospasm (n = 6), third nerve palsy (n = 5) and hydrocephalus (n = 3). Two patients died following surgery. At mean follow-up 33.8 months (median - 25 months, range = 19–96 months), no patient had a rebleed. At discharge 9 (64%), had a GOS of 4 or 5 and 3 (21%) had a GOS of 3. At 6 months follow-up, 10/14 (71%) patients had mRS of 0–2, and 2 (14%) had mRS of 5.

Conclusions: Aneurysms of the SCA are uncommon and tend to rupture even when the aneurysm size is small (<7 mm). They commonly present with SAH. The EDTP approach avoids complication caused by temporal lobe retraction and injury to the vein of Labbe.

Key words: Accessory superior cerebellar artery, aneurysm, extradural temporopolar approach, subarachnoid hemorrhage, superior cerebellar artery

Access this article online	
Quick Response Code:	Website: www.asianjns.org
	DOI: 10.4103/1793-5482.151513

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Introduction

Aneurysms arising from the superior cerebellar artery (SCA) constitute about 1.7% of all aneurysms (16). Previous authors have combined them with basilar trunk aneurysms while discussing surgical approaches and management. However, the surgical management of these aneurysms has its own distinct intricacies and requires careful planning, especially in deciding the trajectory of approach. The past decade has also seen an increasing role of endovascular treatment for all aneurysms, especially for aneurysms of the posterior circulation, where it has superseded microsurgical clipping. However, in the Indian scenario, endovascular experience is often unavailable or very expensive. Microsurgical clipping then becomes a primary modality of treatment for these patients. This series reflects the experience of the senior author (DP) in managing SCA aneurysms.

Aim of the study and design

This is a retrospective study from January 2002 to December 2012 to analyze the surgical results of aneurysms arising from the SCA at a tertiary care neurosurgical center in South India.

Materials and Methods

Clinical data of all cases with a diagnosis of SCA aneurysm were collected retrospectively. All patients were evaluated with computerized tomography (CT) angiography and digital subtraction angiography (DSA) prior to surgery. Patients having aneurysms of the SCA were included in our study. All patients in our series underwent microsurgical clipping and postoperative DSA to assess the extent of aneurysm occlusion. All patients were followed-up in the outpatient clinic after discharge. The Glasgow outcome scale (GOS) and the modified Rankin' scale (mRS) were used to grade their postoperative neurological status at discharge and 6 months, respectively.

Results

Between January 2002 and December 2012, 606 patients with 780 aneurysms were treated in our hospital. Of these, 14 patients had aneurysms involving the SCA. However, SCA rupture was seen in only 9 cases, in 3 cases the subarachnoid hemorrhage (SAH) was from other co-existing aneurysms (middle cerebral artery [MCA]-1, anterior communicating [ACom]-1, distal anterior cerebral artery [DACA]-1) [Table 1]. All cases the SCA aneurysm was managed surgically.

There were 10 females and 4 male with the mean age of 47.2 years (median - 46 years, range =24–66 years).

Subarachnoid hemorrhage was seen in 11 patients (from associated aneurysm in three patients). One patient had acute onset of ptosis along SAH. The mean duration of symptoms was 2.5 days (range =1–7 days). The WFNS score at presentation was as follows: Grade 1 in 10 cases, II in 2 cases, III in 1 case, and IV in 1 case.

Six patients (42%) had multiple aneurysms (MCA bifurcation-3, ACom-1, DACA-1, postcerebral artery (PCA)-1, internal carotid artery (ICA) infundibulum-2, M1 segment-1). In a patient with a incompletely embolized right frontoparietal arteriovenous malformation (AVM), follow-up imaging revealed residual AVM and the development of multiple *de novo* flow related aneurysm, which included a SCA aneurysm [case 12, Tables 1 and 2].

Two patients presented with features of hemifacial pain for 1 and 3 months, respectively.

Another vascular anomaly seen was the duplication of the SCA with an aneurysm on the duplicated SCA [case 10, Tables 1 and 2].

In the 9 cases with ruptured SCA aneurysm, average size of the ruptured aneurysms was 7.3 mm (range =2.5–27 mm, median = 4.9 mm). There was 1 giant aneurysm (27 mm). In all cases of proximally originating aneurysm, the dome of the aneurysm was seen pointing superiorly between the ipsilateral PCA and SCA.

Craniotomy and approaches

Multiple approaches were used in for exposure and clipping of SCA aneurysms. The subtemporal approach was used in the first 7 cases. In 3 cases, additional skull base techniques (orbitozygomatic osteotomy-1, zygomatic osteotomy-2) were utilized. The extradural temporopolar (EDTP) approach was used in the last 5 cases. In all 5 cases, an extradural clinoidectomy was performed; an additional zygomatic osteotomy was needed in one case. The retromastoid suboccipital approach was taken in one case with a partially thrombosed distal SCA aneurysm [case 8, Table 2].

Superior cerebellar artery clipping had to be abandoned when a co-existing DACA ruptured during cranial access and a large frontotemporoparietal decompressive craniectomy had to be performed [case 6, Table 2].

Table 1: Features at presentation of patients with SCA aneurysm

Case	Age	Sex	Ruptured (yes/no)	Presentation	WFNS grade	Size (mm)	Associated neurological deficits
1	46	Female	Yes	SAH	1	10	Nil
2	45	Male	Yes	SAH, ptosis (left)	1	27	Left 3rd nerve palsy
3	55	Female	Yes	SAH	2	5	Nil
4	46	Female	Yes	SAH	2	5	Nil
5	45	Male	No	SAH from ruptured MCA aneurysm	4	5.3	Right hemiparesis with Broca's aphasia
6	65	Female	No	SAH from ruptured DACA aneurysm	1	8.5	Nil
7	24	Female	Yes	SAH	1	4	Nil
8	63	Female	No	Facial pain	1	25	Sensory loss along V1, V2, V3
9	34	Female	Yes	SAH	1	3.8	Nil
10	38	Female	Yes	SAH	1	3.5	Nil
11	51	Female	No	Facial pain	1	8	Nil
12	55	Male	No	IVH	1	5	Nil
13	66	Female	Yes	SAH	3	4.9	Nil
14	28	Male	Yes	SAH	1	2.5	Nil

SCA – Superior cerebellar artery; SAH – Subarachnoid hemorrhage; MCA – Middle cerebral artery; DACA – Distal anterior cerebral artery; IVH – intraventricular hemorrhage

Table 2: Surgical approaches and outcome of patients operated for SCA aneurysm

Approach	Postoperative cranial nerve palsy	Other operative/postoperative complications	Follow-up (months)	Remarks
Subtemporal	3rd	Nil	24	Independent
Subtemporal		Venous infarction	-	Died
Subtemporal	3rd	Transient hemiparesis, vasospasm	96	Independent
Subtemporal	3rd	Hydrocephalus	48	VP shunt done. Independent
Subtemporal		Hydrocephalus	24	Left SCA aneurysm with ruptured left MCA and unruptured right ICA aneurysm. Left MCA aneurysm clipped on along with decompressive craniectomy in the first sitting. Then SCA and ICA clipped with VP shunt and autologous cranioplasty. Dependent
Abandoned		Intraoperative rupture of DACA aneurysm	-	Presented with ruptured DACA aneurysm. Died
EDTP	3rd	Nil	30	SAH in pregnancy. Healthy child delivered at term. Independent
Retro sigmoid sub-occipital	5th	Nil	19	Associated PCA aneurysm coiled in the second sitting. Independent
Subtemporal	-	Nil	26	Independent
EDTP	7th	Nil	22	Aneurysm of accessory SCA. Independent
Subtemporal	3rd	Nil	30	Independent
EDTP	Nil		72	Associated right parietal lobe AVM with right MCA aneurysm and SAH. Right MCA aneurysm clipped, AVM embolized. IVH 1-year later. DSA showed residual AVM and de novo aneurysms of Acom, left M1, left MCA bifurcation and left SCA. Acom aneurysm broad-necked and hence wrapped. Others clipped. Independent
EDTP	Nil	Pseudomeningocoele, hydrocephalus	6	VP shunt. Dependent
EDTP	3rd		9	Behcet's syndrome, died of ST elevation MI at 9 months

ICA – Internal carotid artery; ACom – Anterior communicating; MCA – Middle cerebral artery; PCA – Postcerebral artery; SAH – Subarachnoid hemorrhage; IVH – Intraventricular hemorrhage; VP – Ventriculoperitoneal shunt; SCA – Superior cerebellar artery; DACA – Distal anterior cerebral artery; AVM – Arteriovenous malformation; MI – Myocardial infarction; DSA – Digital subtraction angiography, EDTP – Extradural temporopolar

Clipping

Aneurysm clipping was attempted in 11 patients. In two patients (SCA duplication-1, distal partially thrombosed SCA-1) the aneurysm was trapped. All patients underwent postoperative DSA. Complete angiographic occlusion of the SCA was achieved in all 11 patients where clipping was attempted. There was no filling into the aneurysm in cases where the aneurysm had been trapped.

Management of neighboring aneurysms

In 2 cases (case 5 and case 12), SAH was due to ruptured co-existing MCA aneurysms. In both cases, they were clipped in the first sitting and the unruptured SCA and along with other neighboring aneurysms (contralateral ICA in case 5) (ipsilateral M1, MCA bifurcation and ACom in case 12) were clipped electively in a second sitting. One unruptured contralateral PCA (case 8) was coiled. In 2 cases, ipsilateral ICA infundibulum was wrapped with muscle and cotton strips.

We performed transcranial Doppler twice daily in all patients to detect vasospasm. Vasospasm was seen in 6/12 patients, in 2 cases it resulted in delayed weaning from ventilatory support mandating a tracheostomy. In all cases, hypertension and hypervolemia were maintained till resolution of vasospasm.

Morbidity

The most common complication, which occurred following surgery, was oculomotor nerve palsy, which was seen in 5 patients (38%). Four patients had complete resolution, and one patient had partial improvement within 3 months of surgery. One patient developed transient facial nerve palsy (House and Brackmann Grade 2). Hydrocephalus was seen 3 patients and needed ventriculoperitoneal (VP) shunts. One patient with preoperative trigeminal neuralgia developed transient numbness over the face following surgery [Table 3].

Mortality

Two patients died following surgery. One patient had an intraoperative rupture of an associated DACA aneurysm with severe brain swelling. SCA clipping was abandoned, and a decompressive craniectomy was performed. However, the patient developed diffuse brain edema and died. One patient developed a frontotemporoparietal hemorrhagic infarct following surgery and underwent decompressive craniectomy and lax duraplasty; however, he developed malignant brain edema and died.

Follow-up

At mean follow-up 33.8 months (median - 25 months, range = 6–96 months), we saw no patients with rebleed. Twelve of the 14 patients were discharged from hospital. At discharge 9 (64%), had a GOS of 4 or 5 and 3 (21%) had a GOS of 3 [Table 4]. At 6 months follow-up, 10/14 (71%) patients had mRS of 0–2, and 2 (14%) had mRS of 5 [Table 4]. One patient on

Table 3: Complications following microsurgical clipping of SCA aneurysms

Total patients	14
Vasospasm	6
3rd nerve palsy	5
Hydrocephalus	3
Infection	2
Hemorrhagic infarction	1
Facial palsy	1

SCA – Superior cerebellar artery

Table 4: WFNS score at presentation, outcome at discharge and 6 months

	n=14 (%)
WFNS score (at presentation)	
1	10 (71)
2	2 (14)
3	1 (7)
4	1 (7)
GOS (at discharge)	
4-5	9 (64)
3	3 (21)
1	2 (14)
Modified Rankin's score (at 6 months) (*n*=12) (%)	
0-2	10 (71)
5	2 (14)

GOS – Glasgow outcome scale

treatment for Behcet's syndrome died following a myocardial infarction 9 months following surgery.

Illustrative cases

- Case 1: A 34-year-old female patient presented with severe acute headache and vomiting of 2 days duration. At the time of admission, she had neck rigidity and no other neurological deficits. CT scan showed fisher Grade 1 SAH. DSA done showed a 3.8 mm aneurysm arising from the right SCA, just distal to its origin from the basilar artery (BA), pointing upward and posteriorly. She underwent aneurysm clipping by subtemporal approach. Postoperative DSA showed complete aneurysm occlusion and preserved flow in the distal SCA [case 9, Table 2 and Figure 1a-f]
- Case 2: A 45-year-old male was seen in the emergency with sudden onset headache and loss of consciousness. He had hemiparesis on the right side. CT showed SAH with a hematoma in the left temporal lobe. Angiogram showed a left MCA aneurysm, right ICA and left SCA aneurysms. He underwent surgery for clipping of the ruptured left aneurysm. Following surgery, he had a brain swelling, and the bone flap was not replaced. Over the next 1-year, he could stand with support but began to develop hydrocephalus. After 15 months, he underwent VP shunt, bone flap re-implantation and simultaneous clipping of the left SCA and right MCA. At 2 years follow-up, he has residual right hemiparesis is dependent on caregivers for daily activities [case 5, Table 2 and Figure 2a-f].

Discussion

Aneurysms affecting the SCA are uncommon, and their natural history has not been well-understood.[1] Very few large series report surgical treatment of this condition. In this present study, we found that aneurysms of the SCA occurred at an incidence of 1.8% of all aneurysms, which is similar to the figure seen in literature.[2] We also corroborate an association with multiple aneurysms (42%) earlier noted by Peluso *et al*.[2]

The most common presentation was SAH, even though occasionally it may present as a mass lesion causing compressive neuropathy [Figure 3a-d]. Interestingly these aneurysms bled even when the aneurysm size was small. In our series, 8/14 patients had aneurysms smaller than 5.3 mm. All these patients had aneurysm arising within 2 mm of the SCA origin. A similar observation was made by Jin *et al*. in their series 32 aneurysms arising from the SCA and other smaller case reports, indicating that these aneurysms may be prone to rupture at a smaller size.[3-5] While the number of cases in our series is too small to make recommendations, we feel that even small aneurysms of the SCA should be treated.

The oculomotor, trochlear, and the trigeminal nerve are related to the course of the SCA and can be affected due to aneurysmal compression.[2,6,7] One patient in our series had ptosis along with SAH. Two patients had facial pain; in these cases the aneurysm was placed more distally along the SCA. No patient our series had trochlear involvement. Brainstem compression and collicular hemorrhage causing hemiparesis and hearing loss have also been reported, but we did not encounter any these clinical sign in our series.[6]

The SCA arises from the basilartrunk. Cadaveric studies have found that it is one of the most constant posterior fossa arteries, however, the pattern of origin from the BA may vary, and Yasargil has classified them into 7 patterns.[8,9] Cadaveric studies by Hardy *et al*. have demonstrated unilateral duplication of the SCA (pattern G) in 7/50 cases.[8] In case 10 [Tables 1, 2 and Figure 4a-f] the aneurysm was seen arising from duplicated SCA, 1.9 mm from its origin from the basilar trunk. To the best of our knowledge, an aneurysm arising from an accessory SCA has not been reported. Another anatomical variation we noted was in case 12, where the aneurysm was seen on the left SCA, and the right SCA and PCA appeared to arise from a common trunk, this matched pattern D according to Yasargil's classification [Figure 5a-e]. This aberrant origin of the SCA has been seen very rarely in cadaveric studies.[8,9] We also the noticed the development of a *de novo* aneurysm in one patient with an associated AVM (case 15), where the

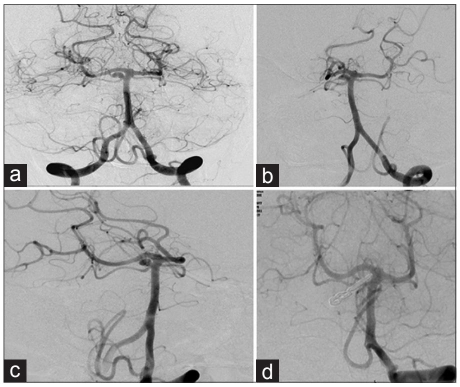

Figure 1: (a-c) A 34-year-old female patient presented with severe acute headache and vomiting of 2 days duration. DSA done shows a 3.8 mm aneurysm arising from the right SCA, just distal to its origin from the basilar artery, pointing upward and posteriorly. (d) She underwent aneurysm clipping by subtemporal approach. Postoperative DSA showed complete aneurysm occlusion and preserved flow in the distal SCA

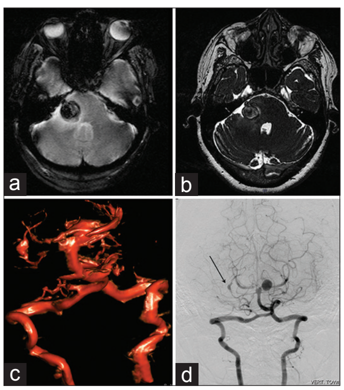

Figure 3: (a and b) MRI of a patient with trigeminal neuralgia, a T2 hypointense lesion is seen in the right cerebellopontine angle, the susceptility weighted imaging shows evidence of blood (c) Computerized tomography angiogram shows a partially thrombosed distal right SCA aneurysm with a left sided PCA aneurysm. (d) Digital subtraction angiography shows only partial filling right SCA aneurysm, the left PCA aneurysm appears to be fusiform involving the main vessel. The SCA aneurysm was trapped using a retromastoid approach; the PCA aneurysm was coiled later

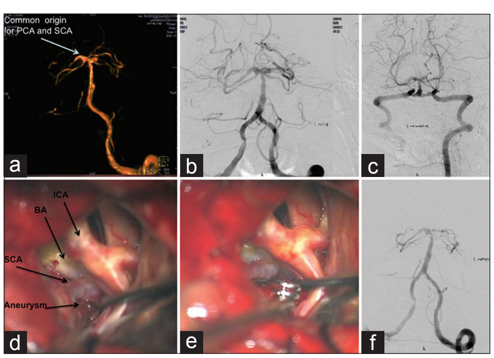

Figure 5: (a) CTA and (b and c) DSA of a 66-year-old female with Grade 3 SAH showing a 4.9 mm aneurysm arising from the left SCA, directed upward and posteriorly. The right PCA and SCA are seen arising from a single common trunk. The aneurysm was clipped using a temporopolar approach. (d) The aneurysm arising from the SCA, distal to its origin. (e) And the final clip placement across the aneurysm neck. (f) Postoperative angiogram shows complete occlusion of the aneurysm and flow across the patent SCA)

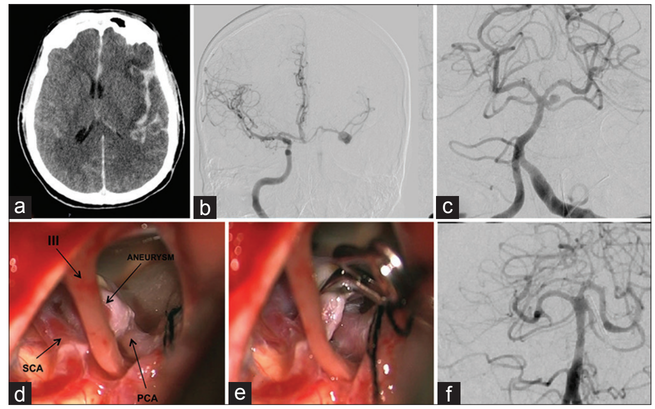

Figure 2: (a) CT showed SAH with a hematoma in the left temporal lobe in a 45-year-old male seen in the emergency with sudden onset headache and loss of consciousness. (b) DSA showing a left MCA and ICA aneurysm, and (c) shows a superiorly directed SCA aneurysm. (d) Operative pictures seen through a subtemporal approach with the aneurysm arising from the SCA, the oculomotor nerve and PCA are seen in close relation. (e) The final clip placement across the aneurysm, and (f) DSA showing complete occlusion of the aneurysm

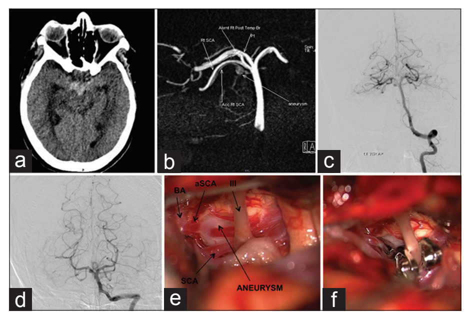

Figure 4: (a) A 38-year-old women presented with SAH in the interpeduncular cistern. Initial DSA showed no aneurysm. (b-d) Computerized tomography angiogram and DSA done 6 weeks later showed a fusiform aneurysm arising from an accessory superior cerebellar artery (aSCA), which took origin from the basilar artery distal to the main SCA (e and f) Intraoperative pictures of the surgical field through a temporopolar approach, showing a fusiform aneurysm arising from the aSCA, which was then trapped (BA: Basilar artery, SCA: Superior cerebellar artery, aSCA: Accessory superior cerebellar artery, III - oculomotor nerve)

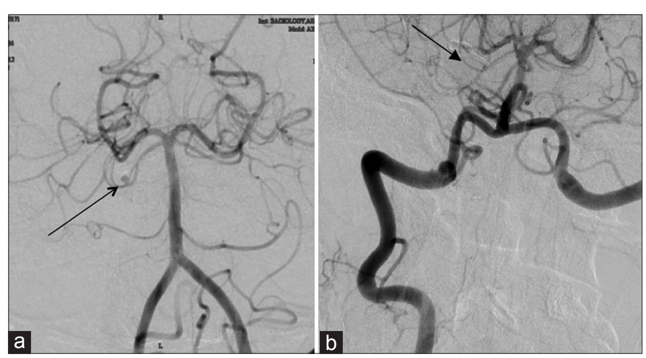

Figure 6: (a) A 28-year-old man with SAH was found to have an upward directed aneurysm arising in the distal SCA (open arrow), which was approached by the temporopolar approach. (b) Postoperative angiogram after clipping shows complete occlusion of the aneurysm neck and flow through the parent vessel (closed arrow)

SCA aneurysm developed in the follow-up angiogram taken a year after clipping of preexisting flow related MCA aneurysm. In the above cases, vascular anomalies and AVM probably contributed to the altered dynamics of blood flow and the development of the aneurysms.

Aneurysms arising from the proximal SCA projecting superiorly lie in the space between the PCA and SCA. In the past, the proximal SCA and the rostral basilar were considered perforator free zones.[3,10-12] This perception has been challenged by cadaveric studies which show that this zone gives rise to critical interpeduncular perforators supplying oculomotor nerve, the posterior thalamus, the substantia nigra, the red nucleus and the floor of the fourth ventricle, and the proximal occlusion of the SCA during clip application can cause brainstem dysfunction and cerebellar infarction due to poor distal collateralization.[6,8,13,14]

Aneurysms of the SCA have been previously discussed along with the basilar trunk or laterobasilar aneurysms.[2,15] We have attempted to discuss only those aneurysms, which originated on or distal to the BA-SCA junction, not involving the basilar trunk. Endovascular treatment in these patients was not feasible due to cost of the procedure.

The surgical options used for aneurysms arising from the SCA in our series include the subtemporal approach, alone in combination with the transsylvian corridor and the EDTP transcavernous approach.[15-20] We feel that the main factors to be considered during surgery for these aneurysms include (1) height of the basilar bifurcation in relation to the posterior clinoids (2) direction of projection of the fundus (3) SCA origin in relation to the tentorial edge and (4) relationship of the SCA to the oculomotor nerve [Figures 1-6].

The basilar bifurcation is normally located at the pontomesencephalic junction. Surgically, a more relevant landmark is the relationship of the basilar bifurcation with the dorsum sella, normally the bifurcation occurs within 5 mm of the dorsum sella.[19] In normal cases, the SCA origin is seen medial to the free edge of the tent, in cases of high bifurcation the origin occurs above the tent and cases of low bifurcation it occurs below the tent. The initial cases ($n = 7$) were approached using a subtemporal corridor, in 2 cases it was combined with the transsylvian approach. The advantage of the subtemporal approach is that it gives the shortest trajectory to the aneurysm, easy control of the basilar trunk, and visualization of perforating vessels arising from the P1 segment and BA. In cases where the SCA arises at the tentorial hiatus or below it, dividing the tentorium gives access to the aneurysm neck. Tentorial division was needed in two cases, in both cases the maneuver allowed us to visualize a low-lying SCA origin. However, the traction imparted to the temporal lobe, especially when the brain is swollen is significant may lead to an injury to the vein of Labbe or the sacrifice of one or more temporal polar veins causing venous ischemia and fatal postoperative intracranial hypertension. Recognition of these difficulties has led us to change our approach to the EDTP transcavernous approach for aneurysms of the upper basilar and the SCA. The EDTP approach gives a more anterior trajectory to the aneurysm neck along with excellent visualization of the basilar trunk, posterior communicating arteries and the PCA. This approach allows the oculomotor nerve to be freed along its course from the brainstem to the superior orbital fissure. Dividing the dural rings after extradural clinoidectomy allows the ICA to be retracted medially. In addition, extension of the dural cut in the direction of the optic nerve allows for greater optic nerve mobilization. Since the SCA lies lower than the basilar bifurcation, an orbital osteotomy can be spared. All patients developed oculomotor nerve palsy following surgery, which inevitably resolved in 3–6 months.

The main point of concern following clipping SCA aneurysms is the patency of the SCA distal to the clip and kinking of the BA by the tip of the clip blades. In our series, two patients underwent aneurysm trapping without neurological sequelae, one was a partially thrombosed distal SCA aneurysm and the other arose from a duplicated SCA where vascular supply to the brainstem probably arose from the main SCA.

Following successful clip occlusion of the SCA aneurysm, the postoperative outcome was dependent on the preoperative neurological status (WFNS score), vasospasm, hydrocephalus, and the presence of associated aneurysms.

Conclusions

Aneurysms of the SCA are uncommon and tend to rupture at event when the aneurysm size is small (<7 mm). They are associated with a tendency for multiple intracranial aneurysms. They commonly present with SAH but may cause symptoms due to compression of the 3rd or the 5th cranial nerves. They can be approached through the subtemporal or the EDTP approach; however, the EDTP approach avoids complication caused by temporal lobe retraction and injury to the vein of Labbe.

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How to cite this article: Nair P, Panikar D, Nair AP, Sundar S, Ayiramuthu P, Thomas A. Microsurgical management of aneurysms of the superior cerebellar artery - lessons learnt: An experience of 14 consecutive cases and review of the literature. Asian J Neurosurg 2015;10:47-48.

Source of Support: Nil, **Conflict of Interest:** None declared.