Received: 22.01.2013 / **Accepted:** 08.03.2013
DOI: 10.5137/1019-5149.JTN.7836-13.1

Posterior Inferior Cerebellar Artery Aneurysms: Operative Strategies Based on a Surgical Series of 27 Patients

Posterior İnferior Serebellar Arter Anevrizmaları: 27 Hastalık Cerrahi Seri Temelinde Operatif Stratejiler

Gopalakrishnan Chittur VISWANATHAN, Girish MENON, Suresh NAIR, Mathew ABRAHAM

Sree Chitra Tirunal Institute for Medical Sciences & Technology, Department of Neurosurgery, Trivandrum, India

Corresponding Author: Gopalakrishnan Chittur VISWANATHAN / E-mail: doc_gopal@yahoo.com

ABSTRACT

AIM: Posterior inferior cerebellar artery (PICA) aneurysms are uncommon. The natural history and management of these aneurysms remains poorly understood. Surgical treatment of PICA aneurysms is challenging in view of their close neurovascular relationship.

MATERIAL and METHODS: Data relating to clinical presentation, radiological findings, operative approaches and outcomes were analyzed in 27 consecutive patients surgically treated for PICA aneurysms in a single hospital between January 1991 and December 2010.

RESULTS: Headache was the most common presentation (100%) followed by gait ataxia (14.8%) and lower cranial nerve dysfunction (7.4%). SAH was seen in 20 patients, intraventricular hemorrhage in 22 patients, and 3 had evidence of intracerebellar hematoma. Eighteen aneurysms were located proximally and 9 were located distally. The 25 saccular and 2 fusi-saccular aneurysms were secured by direct clipping (24 cases) or aneurysmorrhaphy (3 cases) using a far-lateral suboccipital (without condylar resection) or midline/ paramedian suboccipital approach. Overall outcome at the time of hospital discharge was excellent or good in 88.9% of the patients.

CONCLUSION: PICA aneurysms, by virtue of their rarity and strategic location pose a unique technical challenge. Depending on the PICA segment affected, variations in the surgical corridor and clipping strategy were major contributors to good outcomes.

KEYWORDS: Posterior inferior cerebellar artery, Intracranial aneurysm, Subarachnoid hemorrhage, Far lateral suboccipital approach, Outcome

ÖZ

AMAÇ: Posterior inferior serebellar arter (PISA) anevrizmaları nadirdir. Bu anevrizmaların doğal öyküsü ve takibi iyi bilinmemektedir. PISA anevrizmalarının cerrahi tedavisi, yakın nörovasküler ilişkileri nedeniyle zordur.

YÖNTEM ve GEREÇLER: 1991 Ocak ile 2010 Aralık ayları arasında tek bir hastanede PISA anevrizmaları için cerrahi olarak tedavi edilen arka arkaya 27 hastanın klinik durumu, radyolojik bulguları, operatif yaklaşımlar ve sonuçları ile ilgili veriler analiz edilmiştir.

BULGULAR: En sık başlangıç bulgusu başağrısı (%100) olup sonrasında yürüme ataksisi (%14,8) ve alt kraniyal sinir disfonksiyonu (%7,4) gelmektedir. 20 hastada SAK, 22 hastada intraventriküler kanama ve 3 hastada intraserebel hematom bulguları görülmüştür. On sekiz anevrizma proksimalde ve 9'u distalde yer almaktadır. 25 sakküler ve 2 fusisakküler anevrizma bir uzak lateral suboksipital (kondiler rezeksiyon olmadan) veya orta hat / paramedian suboksipital yaklaşım kullanılarak anevrizmorafi (3 olgu) veya doğrudan klipleme (24 olgu) ile tedavi edilmiştir. Hastaneden taburcu olma zamanında genel sonuç hastaların %88,9'unda mükemmel veya iyi olmuştur.

SONUÇ: Nadir olmaları ve stratejik konumları nedeniyle PISA anevrizmaları benzersiz bir teknik zorluğa yol açarlar. İlgili PISA segmentine bağlı olarak cerrahi koridor ve klipleme stratejisindeki değişiklikler, iyi sonuçlar açısından temel katkıda bulunan faktörler olmuşlardır.

ANAHTAR SÖZCÜKLER: Posterior inferior serebellar arter, İntrakraniyal anevrizma, Subaraknoid kanama, Uzak lateral suboksipital yaklaşım, Sonuç

INTRODUCTION

Aneurysms arising from the posterior inferior cerebellar artery (PICA) are uncommon. The incidence ranges from 0.49-3% of all intracranial aneurysms (13, 25). More than 80% of PICA aneurysms arise from the vertebral artery (VA)-PICA junction which are often grouped under the heading 'vertebrobasilar artery' aneurysms (19). A much smaller proportion arises from the distal segment of PICA with most arising proximal to the choroidal point. Rebleeding rates of these aneurysms is high thereby potentiating the need for early surgery. The anatomy of PICA is quite variable (21) and angiograms might not be always helpful in locating these aneurysms during the initial study. This stresses the need to do a bilateral vertebral artery angiogram in cases of subarachnoid hemorrhage (SAH) to

look for PICA aneurysms. The incidence of lower cranial nerve palsies following surgical treatment of these aneurysms can be as high as 60%. (1,12,13,17,18,22,24,27). This complication is often due to handling of the lower cranial nerves during dissection of the aneurysm to achieve successful clipping. Though operative techniques such as condylar drilling as part of the far lateral approach have been used to widen the exposure, it has not decreased this complication rate significantly. (1,2,12,27) The infrequency of these aneurysms makes evaluation with relation to treatment outcome necessary to understand management options.

In this article we retrospectively analyze the clinical features, case management and results in 27 consecutive PICA aneurysms operated at our institute. We also discuss regarding the operative approach for proximal PICA aneurysms and question the need for condylar resection routinely.

MATERIAL and METHODS

All patients with an imaging diagnosis of PICA aneurysm for the period January 1991 to December 2010 who were surgically treated had their charts retrospectively reviewed. For the purpose of data analysis PICA aneurysms were grouped as proximal and distal, the former including aneurysms at the origin or along the anterior medullary & lateral medullary segments of the artery. Data were collected regarding demographics, presenting signs and symptoms, World Federation of Neurosurgical Societies (WFNS) grade, computed tomography (CT) findings, aneurysm location and anatomy, management strategy and postoperative neurological complications. Patient outcome was assessed using Glasgow outcome scale (GOS) scores at the time of discharge and at 6 months follow-up.

Surgical Procedure

We have routinely approached proximal PICA aneurysms using a lateral suboccipital route. Proximal control of the vertebral artery is achieved either by an extradural exposure of the vessel or intradurally, just after dural entry. The lateral foramen magnum rim is removed but we do not consider, drilling of the lateral occipital condyle necessary for adequate exposure. The key point for finding the origin of PICA is at the root exit zone of the hypoglossal nerve. The proximal perforators especially to the brainstem often pose a difficulty in order to clearly delineate the aneurysm. The aneurysmal neck can often be defined by sharp dissection keeping in mind its proximity to critical neurovascular structures. A median or paramedian craniectomy in the prone position provides easy and direct access for distal aneurysms involving the tonsillomedullary, telovelotonsillary and cortical segments of PICA.

RESULTS

Patient Demographics and Clinical Characteristics

Twenty-seven patients underwent surgery for a diagnosis of PICA aneurysm of which 20 (74%) were females. The average age of the group was 44.6 years (range 25 to 68 years). All patients presented with aneurysmal rupture. Patients presenting with blood in the subarachnoid space (n = 20) were stratified based on the WFNS grading system. Without adjusting for other medical illnesses, 17 patients presented with WFNS grade 1, 3 with grade 2 and none with grade 3 or above.

Headache was the only presenting symptom observed in all the patients, possibly secondary to subarachnoid hemorrhage and hydrocephalus. Examination findings included neck stiffness in 20, cerebellar signs in 4 and lower cranial nerve palsy in 2 patients.

Radiographic Features

Computerized tomographic (CT) scanning: All the patients who presented with acute symptoms suggestive of intracranial bleed underwent CT within 24 to 48 hours after the ictus. In most of the cases there was a delay in patient referral. Intraventricular hemorrhage (IVH) was evident in 22 (81.4%) and intracerebellar hemorrhage was observed in 3 others. Early hydrocephalus was present in 10, of which 2 patients required an external ventricular drain prior to surgery.

Arteriography: Four-vessel cerebral angiography was done in all the patients. In 25 patients the angiogram revealed the aneurysm while in the remaining 2 patients, a second angiogram repeated after 2 weeks detected the aneurysm. 13 patients had aneurysms located at the PICA origin (Figure 1A-D). The rest of the aneurysms were located along PICA, with 2 arising from the anterior medullary segment (Figure 2A-D), 3 from the lateral medullary segment (Figure 3A-D), 3 from the tonsillomedullary segment, 6 from the telovelotonsillary segment (Figure 4A-D) and none from the cortical segment. We had two cases of distal AICA-PICA variant aneurysms, one arising from the telovelotonsillary segment and the other from the tonsillomedullary segment. There were 2 fusi-saccular aneurysms while the rest were saccular with an identifiable neck. Only one aneurysm was giant (>25 mm) in size and 4 aneurysms were large (15 to 25mm).

Operative Procedure

Owing to the referral pattern in this part of the country, none of the ruptured aneurysms could be treated within 48 hours of the ictus. Ten were clipped within 2 to 5 days on a semi-urgent basis, and 17 patients had to wait for longer than 5 days for the procedure. No patient had recurrent hemorrhage upon arrival at our institution. 24 aneurysms were directly clipped without any intraoperative complications. One patient had a large fusi-saccular aneurysm from the lateral medullary segment that was partially thrombosed and calcified. Aneurysmorrhaphy was done and wrapped with muscle tissue. In 2 patients, in view of poor aneurysm configuration for clipping, aneurysmorrhaphy was done with multiple clips. None of the cases required parent vessel occlusion or bypass procedure. Intraoperative temporary parent artery occlusion was performed depending on the complexity of aneurysm dissection and surgeon preference. There was no record of intraoperative aneurysmal rupture.

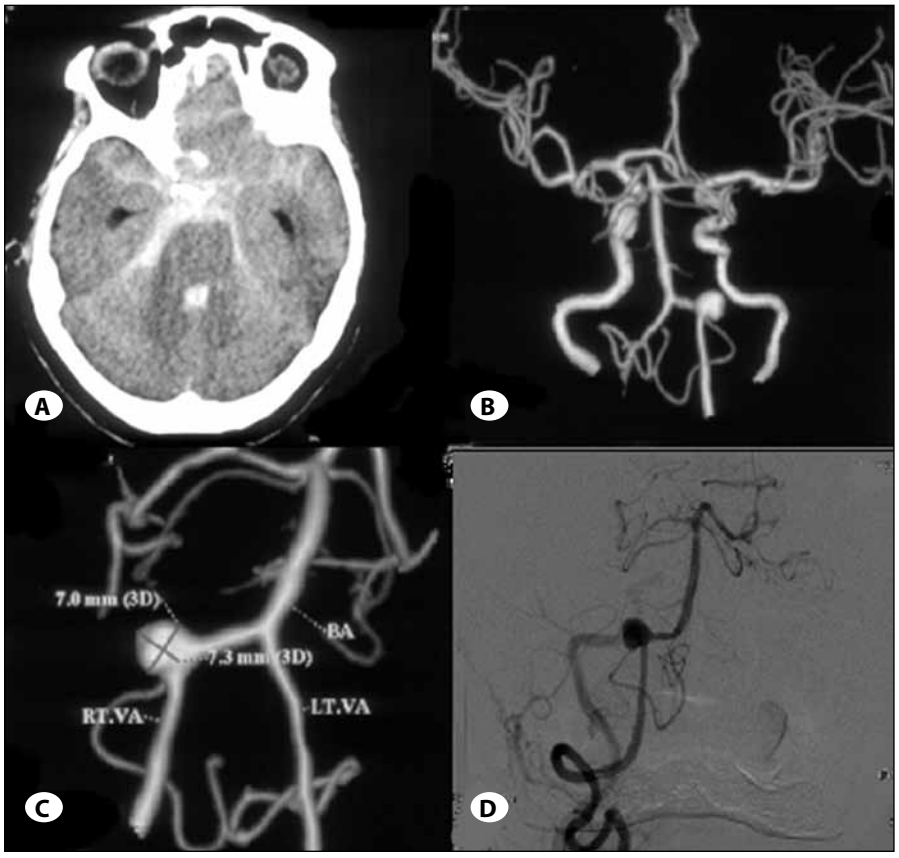

Figure 1: Axial non-contrast CT brain **(A)** showing diffuse SAH with fourth ventricular bleed. CT angiogram **(B,C)** demonstrating an aneurysm from the right PICA origin confirmed by a vertebral angiogram **(D)**. This patient had a stormy post-operative period resulting from transient lower cranial nerve palsy requiring tracheostomy and ventilator support.

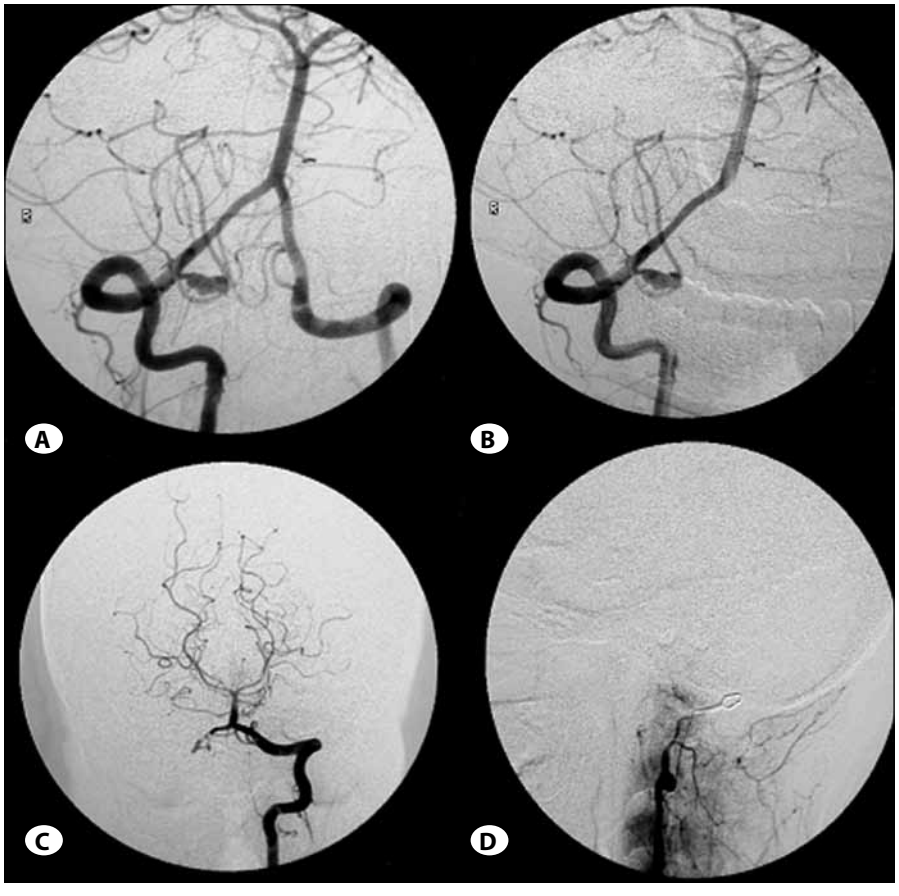

Figure 2: Preoperative vertebral angiograms **(A,B)** demonstrating aneurysm arising from the anterior medullary segment of right PICA that was clipped using a lateral suboccipital approach. Post-operative angiogram **(C,D)** does not reveal any residual aneurysm.

Figure 3: Vertebral angiogram **(A,B)** demonstrating aneurysm arising from the lateral medullary segment of left PICA that was clipped. No evidence of residual aneurysm on post-operative angiogram **(C,D)**.

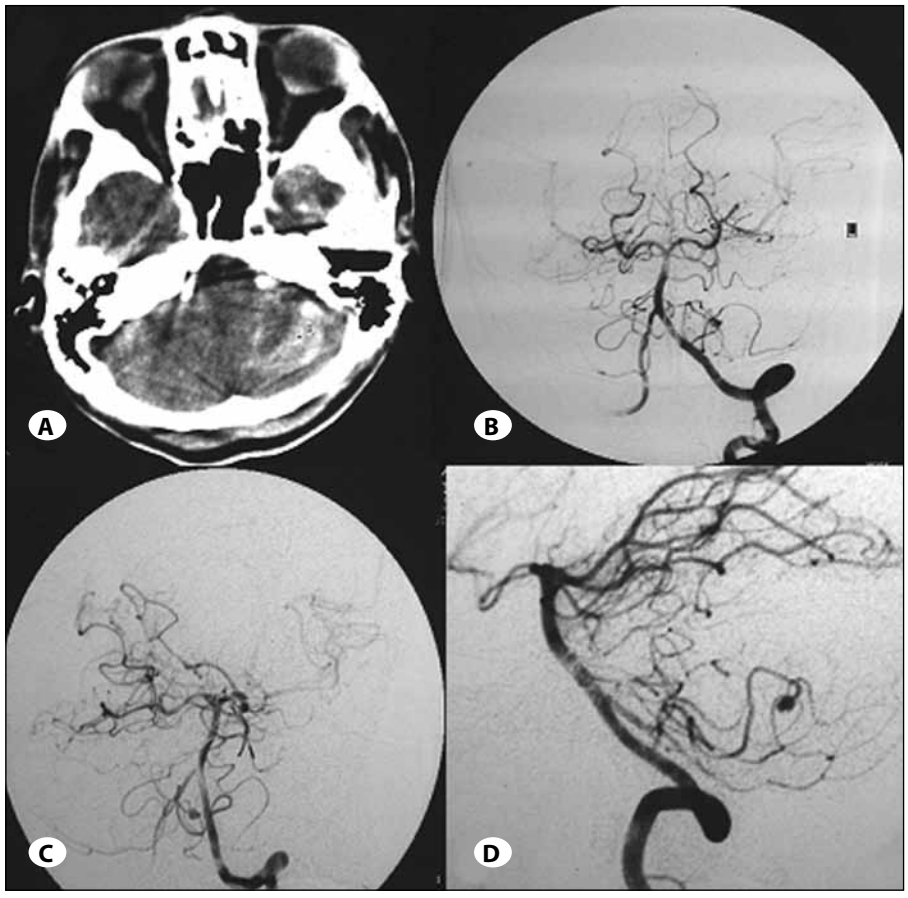

Figure 4: Axial non-contrast CT brain **(A)** showing evidence of left cerebellar hematoma. Left vertebral injection angiograms **(B,C,D)** demonstrating left PICA aneurysm arising from the telovelotonsillary segment responsible for the intracerebellar bleed. This aneurysm was successfully clipped by a midline suboccipital approach.

Complications and Outcomes

At 6 months follow-up, 24 patients were available for review. 88.9% (24/27) of the patients were functionally independent (GOS score of 4 or 5) at the time of discharge. The GOS remained unchanged for the patients seen in the review clinic at 6 months.

The mean duration of hospital stay was 18.4 days (range 9 to 101 days). Twenty-four patients were discharged home, 2 required rehabilitation and 1 died in the hospital. 6 patients developed new postoperative neurological deficits representing neurological complications. Two (7.4%) patients developed vocal cord paralysis requiring tracheostomy; one being transient in nature. Three patients underwent ventriculoperitoneal shunt or endoscopic third ventriculostomy for persisting radiographic hydrocephalus. Three developed postoperative gait ataxia possibly due to ipsilateral cerebellar infarct that was proven by CT imaging in 2 of them. This complication was transient and improved within 3 months. A conventional angiogram / CT angiogram was performed in 16 patients after surgery depending on the surgeon's preference. None of the angiograms revealed any residual aneurysm.

Three patients had poor results necessitating prolonged in-hospital care. One of these patients, operated for a distal AICA-PICA variant aneurysm developed brainstem dysfunction, required prolonged ventilator support and at the time of discharge was in a vegetative state. The second patient had lower cranial palsy necessitating prolonged tracheostomy. Both the above-mentioned patients never returned for follow-up visits. The third patient underwent a ventriculoperitoneal shunt for persistent hydrocephalus 2 days following clipping of PICA aneurysm. A week after surgery she developed myocardial infarction and could not be resuscitated. This was the only mortality in our series that could not be directly attributable to the primary pathology or its management. It would be wise to presume that the first two patients also ultimately added up to the mortality because this is the most likely scenario to be expected in the mid-term range.

DISCUSSION

Historical Perspective

PICA aneurysms are uncommon. Cruvelhier (3) in 1829 described a spherical aneurysm arising from the PICA-vertebral junction. Fernet (7) reported the first case of a distal PICA aneurysm in 1864. The largest review on PICA aneurysms was the series by Peerless and Drake of 146 cases (23). A study on the natural history of aneurysms following SAH revealed that those arising from the vertebrobasilar system were associated with the highest mortality rate (26).

Clinical Features

Patients with PICA aneurysms present at a younger age than those with aneurysms at other sites. In a study by Lewis et al. (19) the mean age reported was 51 years. In a report by Dernbach and colleagues (5), the mean age was slightly lower at 44.7 years. The mean age in our series (44.6 years) was consistent with literature reports.

Overall 74% of our patients presented with SAH. The most common presentation was headache and meningismus without focal deficits. Focal deficits are uncommon although bilateral abducent palsy, hemiparesis and truncal ataxia have been described earlier (6,15). Unilateral cerebellar dysfunction, as seen in few of our patients, can be due to the pressure effect of the aneurysm.

Location of Hemorrhage

The site of bleed on CT imaging helps in the assessment of aneurysm location. Rupture of proximal PICA aneurysms is often evident by the presence of hyperdensity in the ipsilateral basal cisterns, with or without extension into the fourth ventricle. Thirteen of 18 (72.2%) aneurysms located in the proximal PICA segments demonstrated SAH with extension into the ventricular system. Isolated IVH without cisternal SAH is considered a hallmark for distal aneurysmal rupture (33.3% in our series) though not uncommon with proximal PICA aneurysms (11.1% in our series). Aneurysms arising from the tonsillomedullary segment are known to hemorrhage into the fourth ventricle alone (13,16).

Cerebellar parenchymal hematoma suggests rupture of aneurysm along the cortical or telovelotonsillary segment of PICA. This can often extend into the ventricular system. Presence of small peri-ventricular focal clots on imaging suggests this possibility. In our series intracerebellar hematoma was seen in 3 patients of which one was due to a giant aneurysm from the proximal segment.

Angiography

Although arteriography of the dominant vertebral artery reveals the aneurysm, the necessity for direct visualization of each VA and its branches has been repeatedly stressed. One should not depend on contralateral VA washout to provide opposite PICA visualization. Similarly, initial arteriographic studies may miss the aneurysm though the clinical and radiological suspicion may be high. This stresses the need for a repeat angiography until one is satisfied with the anatomical delineation. Two of the aneurysms in our series were missed out on the original study despite a complete absence of vasospasm. It is also important to determine whether the PICA is reduplicated, whether AICA is supplying PICA territory also, whether the opposite artery is missing and whether the posterior communicating arteries are of the fetal type. This information is vital prior to a planned or emergency VA sacrifice.

Management

Though aneurysm size is an important factor in determining risk for hemorrhage, distal PICA aneurysms have a higher propensity to rupture even at smaller sizes probably due to thinner walls (8). Early surgery for ruptured aneurysms prevents rebleeding and allows vasospasm to be treated aggressively. This applies in particular to ruptured PICA aneurysms as rebleeding rates may be as high as 78%. Outcomes following surgical treatment of PICA aneurysms are sparse in recent literature.

Peerless and Drake (23) analyzed 146 cases and classified outcomes as excellent, good, poor and dead. This study lacked a definitive objective score for outcome measurement. Patients in good neurological status at the time of admission had better overall outcome which we would naturally expect regardless of aneurysm location. Hudgins et al. (13) reported on 21 PICA aneurysms presenting with SAH. They also used similar scales for evaluation of outcome and showed that patients with higher Hunt and Hess grades had a greater incidence of poorer outcomes. In a study of 38 patients by Horowitz et al. (12), 66% had new postoperative deficits. Outcomes were projected as GOS scores reducing the bias in observer assessment. 89% of the patients had a GOS score of 1 or 2, one year after surgery indicating excellent prognosis. In our study, the WFNS classification was used as a predictor of patient's prognosis/outcome (GOS), though no statistical conclusion could be drawn as all the patients were in good clinical grade at the time of presentation.

Surgical Nuances

PICA aneurysms have always been a surgical challenge owing to its closeness to the lower cranial nerves and brainstem. Successful dissection and clipping of these aneurysms often results in handling of lower cranial nerves. This often results in transient swallowing difficulty in the postoperative period that can be quite distressing to an otherwise normal patient. Many neurosurgeons, over the years, have improvised in their approaches to minimize cranial nerve traction during dissection especially for the larger aneurysms. One of these has been the far lateral suboccipital approach as first described by Heros (11) in an attempt to minimize postoperative morbidity.

Bertalanffy et al. (2) in their series of VA-PICA junction aneurysms used the lateral suboccipital transcondylar approach. This also included removal of posterior arch of C1. This trajectory proved quite optimal for proximal PICA aneurysms. Postoperatively only 2 patients (29%) had transient lower cranial nerve palsies.

In the description by Ambrosio et al. (4), the incidence of new onset transient vocal cord palsy was 10% with one patient requiring tracheostomy. They suggest excision of posterior arch of C1 and occipital condylar drilling for reaching proximal PICA aneurysms from below the lower cranial nerves rather than working in-between. They do mention an increased risk of CSF leak, 15% in their series, and new postoperative neck pain.

In a study of 13 PICA aneurysms by Liew et al. (20), use of the far lateral approach without condylar resection resulted in an excellent outcome at 6 months. Only one patient developed transient lower cranial nerve palsy and there was no incidence of CSF leak. Salcman et al. (27) in their review on aneurysms of the PICA-VA complex describe that the majority of the patients can be operated in the lateral decubitus or three-quarter prone position employed for retromastoid exploration. Control of the proximal VA can be obtained by far lateral craniectomy without resection of the posterior lip of the foramen magnum and dissection of the arachnoid caudal to the 9th and 10th cranial nerves.

Present Study

The overall outcome in our study was good with 88.9% of the patients evaluated at the time of discharge being independent. Only 6 patients had new postoperative neurological deficits, majority having recovered within 3 months. We were not able to correlate WFNS scores at the time of admission with the GOS scores as almost all patients presented to us in good clinical grades probably due to late referral pattern in our setting.

In our series postoperative morbidity was more related to hydrocephalus than lower cranial nerve dysfunction. Of the series that discuss perioperative morbidity, the incidence of lower cranial nerve deficits ranges anywhere between 20% and 66%. Our incidence of vocal cord paresis at 7.4% was substantially low in comparison to earlier series.

Unlike aneurysms in the anterior circulation, PICA aneurysms have a higher propensity to bleed even if small. Hence we believe that PICA aneurysms should be obliterated whenever they are diagnosed. Though the debate of clipping vs. coiling still continues whenever the subject of intracranial aneurysms are raised, we feel that direct inspection of the aneurysm and its related neurovascular anatomy especially for PICA aneurysms, makes open surgery advantageous. This not only allows for identification of perforators from the parent artery but also, if required, trapping in case of complex and poor configuration aneurysms. Use of Yasargil ring clips or application of clips obliquely across PICA can often avoid the perforating vessels. Surgery also becomes more preferable when there is an associated hematoma that needs evacuation or when there is a variation in the anatomy of the blood supply to PICA region.

A good knowledge of posterior skull base anatomy is essential when approaching PICA aneurysms. The approach could be either a midline or lateral skull base approach depending on the segment of PICA that is involved. One should always be prepared if the need arises, for PICA reconstruction and excision of an associated AVM. The extreme tortuosity of the vertebral and PICA arteries may occasionally influence the laterality of the surgical approach. For aneurysms arising from the first 2 segments of PICA, a far- lateral suboccipital approach provides sufficient VA and proximal PICA exposure to apply temporary and permanent clips. We believe that the resection of the foramen magnum rim without removal of the condyle and posterior arch of C1 provides adequate exposure for proximal PICA aneurysms. Occasionally, for patients who are obese and/or have a short neck, removal of the posterior arch of C1 becomes necessary for widening the space for dissection. This extra bony removal allows one to look rostrally along the brainstem. The amount of cerebellar retraction is less and the working corridor is beneath the lower cranial nerves rather than between them, thus avoiding excessive manipulation. Though several authors advocate

partial drilling of the occipital condyle, we strongly feel that this leads to significant new postoperative neck pain and also increases the chances of CSF leak. Our extremely low incidence of postoperative lower cranial nerve palsy does not justify the need for condylar resection. The retrolabyrinthine transsigmoid approach advocated by Giannotta and Maceri (9) takes the surgeon in front of the lower cranial nerves but we have had no personal experience.

Lesions arising from the distal three segments of PICA are approached by a standard midline/ paramedian suboccipital craniectomy. Aneurysms located beneath the tonsil can be tackled after subpial tonsillar resection rather than mobilizing the tonsil to avoid premature rupture. The PICA can be sacrificed distal to the choroidal point, but if the lesion is more proximal and cannot be clipped, an end-to-end anastomosis or a distal bypass should be performed to preserve blood supply to the deep cerebellar nuclei and brainstem. Aneurysms arising from AICA-PICA variant are extremely rare, though this variant has been commonly described in literature. We had two cases of AICA-PICA variant aneurysms of which one patient had a poor outcome (14). We feel that the poor outcome could partly be due to medullary ischemia secondary to retrograde perforator spasm. There are possibly perforators to the brainstem arising from distal segments of AICA-PICA variant that have to be carefully identified intraoperatively for safe clipping. Further studies are required to understand the exact configuration of the AICA-PICA variant.

In summary, PICA aneurysms, by virtue of their rarity and strategic location pose a unique technical challenge. In treating patients with suspected SAH whose CT imaging is normal, special attention should be given to the fourth ventricle and the possibility of VA-PICA aneurysms. Angiography should be performed with separate injections of each vertebral artery. Occasionally, these aneurysms may be missed on the initial study and therefore the study has to be repeated again after an interval of at least 2 weeks. Surgical planning must take into account the location of the aneurysm, the presence of any anatomical variations of the parent vessel and the need for an anastomosis or bypass procedure. A thorough search for brainstem perforators is essential prior to trapping though it has been claimed to be safe for aneurysms arising distal to the choroidal point. The use of a far lateral approach without condylar resection provides sufficient space for aneurysm dissection without significant manipulation of the lower cranial nerves and avoids the increased morbidity associated with condylar resection. Maintaining a caudal to rostral view beneath the cranial nerves rather than through them has significantly decreased postoperative lower cranial nerve dysfunction that used to be the major cause of morbidity. Our series showed that the majority of PICA aneurysm patients have an excellent outcome after surgical treatment and their presence should not deter the surgeon from clipping them.

REFERENCES

1. Andoh T, Shirakami S, Nakashima T, Nishimura Y, Sakai N, Yamada H, Ohkuma A, Tanabe Y, Funakoshi T: Clinical analysis of a series of vertebral aneurysm cases. Neurosurgery 31: 987–993, 1992
2. Bertalanffy H, Sure U, Petermeyer M, Becker R, Gilsbach JM: Management of aneurysms of the vertebral artery-posterior inferior cerebellar artery complex. Neurol Med Chir (Tokyo) 38(Suppl):93–103, 1998
3. Cruveilhier J: Anatomie Pathologique de Corps Humain. Paris: JB Bailli~re, 1829-1835, Vol 2. Cited in Schwartz HG: Arterial aneurysm of the posterior fossa. J Neurosurg 5:312-316, 1948
4. D'Ambrosio AL, Kreiter KT, Bush CA, Sciacca RR, Mayer SA, Solomon RA, Connolly ES Jr: Far lateral suboccipital approach for the treatment of proximal posteroinferior cerebellar artery aneurysms: Surgical results and long-term outcome. Neurosurgery 55(1):39-50, 2004
5. Dernbach PD, Sila CA, Little JR: Giant and multiple aneurysms of the distal posterior inferior cerebellar artery. Neurosurgery 22: 309–312, 1988
6. Dumas S, Shults WT: Abducens paresis. A rare presenting sign of posterior-inferior cerebellar artery aneurysm. J Clin Neuroophthalmol 2:55–60, 1982
7. Fernet. Bull Soc Anat Paris 39:495, 1864
8. Gács G, Viñuela F, Fox AJ, Drake CG: Peripheral aneurysms of the cerebellar arteries. Review of 16 cases. J Neurosurg 58: 63–68, 1983
9. Giannotta SL, Maceri DR: Retrolabyrinthine transsigmoid approach to basilar trunk and vertebrobasilar artery junction aneurysms. Technical note. J Neurosurg. 69(3):461-466, 1988
10. Gopalakrishnan CV, Menon G, Nair S: Aneurysm of the anterior inferior cerebellar artery-posterior inferior cerebellar artery variant: two case reports and review of literature. Br J Neurosurg 23(5):554-556, 2009
11. Heros RC: Lateral suboccipital approach for vertebral and vertebrobasilar artery lesions. J Neurosurg 64(4):559-562, 1986
12. Horowitz M, Kopitnik T, Landreneau F, Krummerman J, Batjer HH, Thomas G, Samson DS: Posteroinferior cerebellar artery aneurysms: Surgical results for 38 patients. Neurosurgery 43:1026–1032, 1998
13. Hudgins RJ, Day AL, Quisling RG, Rhoton AL Jr, Sypert GW, Garcia-Bengochea F: Aneurysms of the posterior inferior cerebellar artery. A clinical and anatomical analysis. J Neurosurg 58(3):381-387, 1983
14. International Study of Unruptured Intracranial Aneurysms Investigators: Unruptured intracranial aneurysms—risk of rupture and risks of surgical intervention. N Engl J Med 339:1725–1733, 1998
15. Judice D, Connolly ES: Foramen magnum syndrome caused by a giant aneurysm of the posterior inferior cerebral artery. Case report. J Neurosurg 48:639-641, 1978

16. Kallmes DF, Lanzino G, Dix JE, Dion JE, Do H, Woodcock RJ, Kassell NF: Patterns of hemorrhage with ruptured posterior inferior cerebellar artery aneurysms: CT findings in 44 cases. AJR 169:1169–1171, 1997
17. Lee KS, Gower DJ, Branch CL Jr, Kelly DL Jr, McWhorter JM, Bell WO: Surgical repair of aneurysms of the posterior inferior cerebellar artery: A clinical series. Surg Neurol 31:85–91, 1989
18. Lempert TE, Malek AM, Halbach VV, Phatouros CC, Meyers PM, Dowd CF, Higashida RT: Endovascular treatment of ruptured posterior circulation cerebral aneurysms: Clinical and angiographic outcomes. Stroke 31:100–110, 2000
19. Lewis SB, Chang DJ, Peace DA, Lafrentz PJ, Day AL: Distal posterior inferior cerebellar artery aneurysms: Clinical features and management. J Neurosurg 97(4):756-766, 2002
20. Liew D, Ng PY, Ng I: Surgical management of ruptured and unruptured symptomatic posterior inferior cerebellar artery aneurysms. Br J Neurosurg. 18(6):608-612, 2004
21. Lister JR, Rhoton AL Jr, Matsushima T, Peace DA: Microsurgical anatomy of the posterior inferior cerebellar artery. Neurosurgery 10(2):170-199, 1982
22. Mukonoweshuro W, Laitt RD, Hughes DG: Endovascular treatment of PICA aneurysms. Neuroradiology 45:188–192, 2003
23. Peerless SJ, Drake CG: Management of aneurysms of the posterior circulation. In Youmans JR (ed), Neurological Surgery. Vol:3, 4th ed. Philadelphia: W.B. Saunders Co., 1990:1764-1806
24. Peerless SJ, Hernesniemi JA, Gutman FB, Drake CG: Early surgery for ruptured vertebrobasilar aneurysms. J Neurosurg 80:643–649, 1994
25. Peluso JP, van Rooij WJ, Sluzewski M, Beute GN, Majoie CB: Posterior inferior cerebellar artery aneurysms: Incidence, clinical presentation, and outcome of endovascular treatment. AJNR Am J Neuroradiol 29(1):86-90, 2008
26. Richardson AE: The natural history of patients with intracranial aneurysms after rupture. Prog Brain Res 30:269-273, 1968
27. Salcman M, Rigamonti D, Numaguchi Y, Sadato N: Aneurysms of the posterior inferior cerebellar artery-vertebral artery complex: Variations on a theme. Neurosurgery 27:12–21, 1990
28. Wiebers DO, Whisnant JP, Sundt TM Jr, O'Fallon WM: The significance of unruptured intracranial saccular aneurysms. J Neurosurg 66:23–29, 1987