Far-Lateral Approach for Lower Basilar Artery Aneurysms

**Cherukuri Ravi Kumar, M.D.,¹ Prasad Vannemreddy, M.D.,¹
and Anil Nanda, M.D., F.A.C.S.¹**

ABSTRACT

Objectives: Aneurysms of the lower basilar artery are surgically difficult to expose and clip. Various cranial base approaches, which are associated with significant morbidity, have been used to access this region. We have used the far-lateral approach without occipital condyle drilling for clipping of lower basilar junction aneurysms to assess the exposure for adequate visualization and clipping, and to study the complications and outcome. **Design:** Retrospective review of data. **Setting:** Between 1997 and 2001, four patients with lower basilar artery aneurysms were operated on at Louisiana State University Health Sciences Center in Shreveport. The far-lateral approach without drilling of the occipital condyle was used in each procedure. **Participants:** Cases of basilar artery aneurysms. **Main Outcome Measures:** Glasgow Outcome Scale (GOS) score. **Results:** All four aneurysms were clipped successfully. All patients had good outcome (GOS scores of 5 and 4). There were no instances of cerebrospinal fluid leakage or pseudomeningocele. Two patients experienced transient morbidity in the form of voice hoarseness and swallowing difficulty. **Conclusion:** The far-lateral approach without drilling of the occipital condyle adequately exposed the lower basilar artery for successful clipping of aneurysms and was associated with minimal morbidity.

KEYWORDS: Aneurysm, basilar, far lateral

Aneurysms of the basilar artery from the origin of the anterior inferior cerebellar artery (AICA) to the vertebrobasilar (VB) junction are a surgically challenging group of lesions. The depth of exposure, space limited by surrounding bone and the brainstem, ventral location to the neuraxis, and

brainstem proximity make the task of adequate exposure and clipping difficult to accomplish. Early attempts of surgical treatment of these aneurysms have been discouraging with significant mortality and morbidity. Advances in microneurosurgery, anesthesia, critical care, instrumentation, and the

¹Department of Neurosurgery, Louisiana State University Health Sciences Center in Shreveport, Shreveport, Louisiana.

Address for correspondence and reprint requests: Anil Nanda, M.D., F.A.C.S., Professor and Chairman, Department of Neurosurgery, Louisiana State University Health Sciences Center in Shreveport, 1501 Kings Highway, P.O. Box 33932, Shreveport, LA 71130-3932 (e-mail: ananda@lsuhsc.edu).

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Received: March 11, 2008. Accepted: July 18, 2008. Published online: October 30, 2008.

DOI 10.1055/s-0028-1096197. ISSN 1531-5010.

advent of skull base surgery have contributed to decreasing mortality rates in surgical management of these aneurysms. Various complicated cranial base approaches have been described to achieve this goal, including numerous modifications of the transclival,^{1,2} transpetrous,^{3,4} and far-lateral approaches.^{5,6} Removal of the cranial base is advantageous as it reduces brain retraction. However, it may be associated with increased morbidity due to injury to cranial nerves and labyrinth, cerebrospinal fluid (CSF) leakage, occlusion of the eustachian tube, and injury to the vertebral and carotid arteries, and so on. All of these factors have tempered enthusiasm for the cranial base approaches, and the focus is shifting to determine if more conservative cranial base approaches can be as effective in offering adequate exposure for clipping of aneurysms of the lower basilar artery and also to reduce associated morbidity.

PATIENTS AND METHODS

Between 1997 and 2001 at the Department of Neurosurgery, Louisiana State University Health Sciences Center in Shreveport (LSUHSC-S), four patients with aneurysms of the lower basilar artery were operated on using the far-lateral approach without drilling of the occipital condyle. Each case is presented here.

Case 1

A 42-year-old female patient who was previously healthy presented with sudden onset of severe headache followed by loss of consciousness. She had a Glasgow Coma Score (GCS) of 4 with bilateral decerebrate posturing and equal and sluggishly reacting pupils. Computed tomography (CT) scan revealed extensive subarachnoid hemorrhage with blood in the fourth ventricle and moderate hydrocephalus. She was transferred to the LSUHSC-S Neurosurgery Department after an arteriogram revealed left posterior communicating and anterior choroidal artery aneurysms and a proximal basilar artery aneurysm (Fig. 1A). The basilar aneurysm was projecting posteriorly toward the brainstem. She was graded subarachnoid hemorrhage grade V (Hunt and Hess grading system). Her initial management included intubation, sedation, control of blood pressure, and external ventricular drainage. She gradually improved, and 10 days later was operated on using the far-lateral approach. The lower basilar aneurysm was clipped uneventfully (Fig. 1B). She continued to improve and was transferred to a rehabilitation facility with a GCS of 10. She was readmitted 6 months later for elective clipping of the posterior communicating and anterior choroidal artery aneurysms, which was performed uneventfully. At admission, she had a GCS of 15. Her last follow-up was 3 years later and she is well with a Glasgow Outcome Scale (GOS) of 5.

Figure 1 Case 1. (A) Preoperative angiogram shows posteriorly projecting proximal basilar aneurysm. (B) Perioperative angiogram after clipping of the aneurysm.

Figure 2 Case 2. (A) Pre- and (B) postoperative angiograms show successful clipping of a basilar aneurysm arising at the origin of the anterior inferior cerebellar artery.

Case 2

A 48-year-old female patient presented to the emergency room with sudden occipital headache and slurred speech and quickly lapsed into altered sensorium with a GCS of 6 and right hemiplegia. She was immediately intubated and ventilated. Computed tomography scan showed subarachnoid hemorrhage with intraventricular bleeding and moderate hydrocephalus. An external drain was placed and she improved to a GCS of 10 the next day. Angiogram revealed bilateral posterior communicating artery aneurysms and a lower basilar artery aneurysm arising at the origin of the AICA (Fig. 2).

The basilar aneurysm was projecting posteriorly toward the brainstem and was clipped using the far-lateral approach. The patient required placement of a ventriculoperitoneal shunt for hydrocephalus. She was transferred to a rehabilitation facility, and she has gradually improved. At last follow-up 1 year later, she had improved remarkably and her outcome was graded as a GOS of 4 with residual right hemiparesis.

Case 3

A 69-year-old female patient presented with left eye ptosis, dizziness, and ataxia for 6 weeks. On examination, she had left ptosis and mild left-sided weak-

ness. Magnetic resonance imaging (MRI) scan (Fig. 3) showed an enhancing lesion at the lower clivus, and angiogram showed a low basilar artery aneurysm projecting anteriorly toward the clivus (Fig. 4A). She underwent a far-lateral approach and clipping of a basilar aneurysm (Fig. 4B). The patient improved in her preoperative signs. Postoperatively, she developed swallowing difficulty, which resolved within 10 days. At 1-year follow-up, she was well and was graded as GOS 5.

Case 4

A 42-year-old male patient presented with a long history of headaches, which had worsened and were now associated with neck stiffness. He was con-

Figure 3 Case 3. Magnetic resonance imaging scan shows an enhancing lesion at the lower clivus.

Figure 4 (A) Pre- and (B) postoperative angiograms of Case 3 show the clipping of an anteriorly projecting lower basilar aneurysm.

scious, but confused. There were no neurological deficits except neck stiffness. Computed tomography scan revealed blood in the lateral ventricle, and an MRI scan revealed an arteriovenous malformation (AVM) in the medial frontal region on the left side. Arteriogram revealed an AVM of the left frontal region and an aneurysm of the proximal

basilar artery with fenestration of the basilar artery (Fig. 5A,B). The patient underwent a far-lateral approach and clipping of a basilar artery aneurysm (Fig. 5C,D). Postoperatively, he had transient hoarseness of voice, which improved over 1 week. At last follow-up 3 years later, his outcome was graded as GOS 5.

Figure 5 Case 4. (A,B) Preoperative angiogram shows arteriovenous malformation, fenestration of the basilar artery with the aneurysm. (C,D) Postoperative angiogram after clipping.

FAR-LATERAL APPROACH

The far-lateral approach⁷ without drilling of the occipital condyle was used to access the aneurysms in these four cases. Many modifications of the far-lateral approach have been described,⁵ and we have chosen the far-lateral approach without the resection of the occipital condyle based on our previous experience.⁸ The essential steps we have employed are briefly delineated here. The patient is positioned in a lateral position with the head in a pin fixation. A lumbar drain is inserted if the patient did not have a pre-existing ventricular drain. A slightly curved skin incision is made 1 cm behind the mastoid process, and the muscles are divided in the line of the incision to expose the suboccipital bone, foramen magnum, and C-1 arch and transverse process. The vertebral artery (VA) is identified in the suboccipital triangle and traced to the entrance of the dura. A lateral suboccipital craniotomy is performed with exposure of the sigmoid sinus laterally. The foramen magnum rim is removed laterally up to the occipital condyle, followed by the removal of the lateral half of the atlas. The dura is opened, the cisterna magna and the cerebellopontine angle cisterns are opened, and the arachnoid bands around the cranial nerves are sharply divided to let the brain fall back. The ligamentum denticulatum is cut to facilitate neuraxis to fall back for further exposure if necessary. These maneuvers, along with CSF drainage and administration of mannitol, sufficiently slacken the brain to offer adequate space without significant retraction of the brain. The VA is followed superiorly to expose the VB junction and the proximal basilar artery to define the neck of the aneurysm, which is clipped in standard fashion. Moderate intraoperative hypotension to systolic blood pressure of 80 mm Hg helps to reduce the turgor of the aneurysms and facilitates clipping. In all four of the patients, adequate exposure of the proximal basilar artery and the aneurysm neck was achieved. A primary watertight closure of the dura is easily achieved with this approach.

RESULTS

All aneurysms were clipped successfully as demonstrated by the intraoperative or postoperative angiograms. There was no CSF leak or pseudomeningocele. Two patients had transient neurological deficits related to the operative procedure—hoarseness of voice and swallowing difficulty. All of the patients had improved postoperatively and at the time of last follow-up had good outcome (GOS grades 5 and 4).

DISCUSSION

Accounting for less than 1% of all intracranial aneurysms, aneurysms of the lower basilar artery and VB junction are rare.^{9,10} They are usually reported along with the posterior circulation aneurysms. In addition, the majority of reports would group aneurysms along with tumors—both intra- and extradural, which complicates exclusive evaluation of treatment of aneurysms located at the proximal basilar artery. Due to the rarity of these aneurysms, few neurosurgeons have gained significant experience with them and most reports consist of small groups of patients.^{1,9,11–14} Surgical access to these aneurysms is difficult with conventional neurosurgical avenues due to the depth of exposure and the location surrounded by the lower clivus, brainstem, and the cranial nerves. Therefore, these aneurysms have been notorious as the most difficult to treat. Earlier reports of surgical management of posterior circulation aneurysms have been dismal with high morbidity and mortality due to the location and the need to retract the brain or cranial nerves during exposure.^{15,16}

Drake reported increased survival in patients with aneurysms of the posterior circulation including the lower basilar artery, but has emphasized the difficulty of reaching these aneurysms from above via the subtemporal approach and from below by the suboccipital approach, prompting reference to this region as “no man’s land.”¹⁷ Peerless and Drake

advocated more traditional approaches to these aneurysms, namely the subtemporal route with sectioning of tentorium or the suboccipital approach.¹⁶ Using these avenues, they demonstrated extraordinary and unparalleled results with posterior fossa aneurysms comparable with anterior circulation aneurysm. They have determined that the proximal basilar aneurysms lie in a narrow and confined space some distance from either approach. The subtemporal approach has the disadvantages of temporal lobe retraction and injury to fourth, fifth, and sixth cranial nerves. The suboccipital approach carries risk of injury to cerebellum and brainstem in addition to lower cranial nerves, with significant morbidity and some risk of mortality.

The advent of cranial base surgery with its guiding principle of resection of bone to reduce retraction of the brain has facilitated effective exposure of these hitherto uncharted seas. The various complicated cranial base approaches that have evolved over the last few decades access the proximal basilar artery from three principal corridors. They are the anterior-transclival,^{1,2,18} the lateral-transpetrosal,¹¹⁻¹³ and the posterior far-lateral approaches.^{7,12} With the evolution of surgical techniques and instrumentation, operative mortality has considerably reduced, and the operative results have significantly improved when compared with the natural history of these aneurysms. The advantages and disadvantages of these approaches are discussed below.

Anterior Approaches

Obliteration of the midline basilar aneurysms by the transoral transclival route has always seemed the logical approach, as it does not involve manipulation of the brainstem, cranial nerves, or perforating vessels. The transoral approach offers an excellent view of the proximal basilar artery without the need for brain or cranial nerve retraction. However, initial mortality rates were ~50%.² It offers a deep and confined working space, ~1 cm wide and 2.5 cm long, for clipping of the aneurysm.¹ This

narrow space may require a special clip applicator and may cause an additional problem, as the base of the clip may not be retained intracranially. This narrow corridor also hinders a satisfactory dural and mucosal closure, thus predisposing to meningitis. Potential injury to the sixth cranial nerve, velopharyngeal dysfunction, as well as a significant risk of CSF leak and meningitis, and a possible need for posterior craniocervical stabilization, are causes for concern with this approach.^{1,2}

Lateral Approaches

Transpetrosal approaches offer a shallow and more direct corridor of access. However, the transpetrosal approaches are associated with morbidity related to cranial nerves VI to VIII, labyrinth, cochlea, eustachian tube, and CSF leakage.^{11,13,19} Some of these deficits related to inner ear structures are anticipated with translabyrinthine and transcochlear approaches. With transpetrosal approaches, the incidence of facial nerve paralysis is ~30%, abducens paralysis ~7%, and CSF leak ~13% despite extensive cranial base reconstruction.⁴ The exposure requires the expertise of an experienced neuro-otologist. In addition, these approaches expose the aneurysm from the side with the aneurysm sac between the surgeon and the neck, requiring the surgeon to look around the aneurysm dome to see the neck and to shift the aneurysm. In view of these considerations and the limited space available, typically a right-angled clip is required, which makes clip application more technically difficult.¹⁹ The space offered with these approaches may be limited and may not be adequate in large aneurysms and, hence, they are usually preferred for small aneurysms.

Posterior Approaches

The posterior suboccipital approach was the traditional method used for lesions of the anterior foramen magnum and lower clivus. However, it was associated with morbidity and mortality in addition

to incomplete resection in case of tumors;^{8,20} this prompted evolution of modifications of the lateral suboccipital approach with two main variations. The first is the far lateral approach,⁷ which differs from the lateral suboccipital approach in the extent of lateral removal of the bone of the foramen magnum as far as the condylar fossa; and inferior-lateral removal of the arch of atlas toward the exposed VA. The key is the extradural control of the VA and dural opening along the site of the VA entrance to the dura. These steps would ensure the lateral exposure and the inferosuperior trajectory necessary to deal with the intradural lesions at the lower clivus and foramen magnum.

The second major variation is the extended far-lateral approach or the transcondylar approach, which involves resection of some or all of the occipital condyle. It has been further modified to include resection of the C1 superior facet, jugular tubercle, exposure of jugular foramen, and mastoidectomy.^{5,6} The extended far-lateral approach is endowed with ease of proximal control and a lateral and parallel view along the axis of the vertebral and basilar arteries. However, this approach is associated with lower cranial nerve and hypoglossal dysfunction, potential injury to the VA and sigmoid sinus, increased incidence of CSF leak, and it may need occipital cervical junction fusion for stabilization.^{6,12}

Combined Approaches

Some authors have advocated the use of combined supra- and infratentorial approaches with sectioning of the sigmoid sinus to expose the VB junction and the proximal basilar artery.^{9,12,14,21} These exposures involve sectioning of the tentorium and sigmoid sinus, and occasionally the superior petrosal sinus, in addition to the transpetrosal or the far-lateral approach. They offer a panoramic view of the basilar artery. However, extensive cranial base procedures are associated with significant morbidity, increases in operating time and blood loss, and require considerable expertise of a neurosurgeon and neuro-otologist in skull base techniques.^{12,19}

These factors have prompted a recent trend to tailor the approach to the type and size of the aneurysm and seek alternative surgical approaches that reduce the extent of bone removal and correspondingly reduce morbidity rates, while providing adequate surgical exposure to treat these aneurysms.

We have successfully employed the far-lateral approach without drilling of the occipital condyle to access four aneurysms of the proximal basilar artery. We have chosen this approach based on our previous experience with intradural lesions at the foramen magnum and lower clivus substantiated by cadaver studies, which indicated that extensive bone removal may not effectively translate into increased exposure.⁸ All the aneurysms were small to medium-sized (< 2 cm) and had a well-defined neck. Lateral projection of the fundus is not a disadvantage with this approach due to the inferolateral surgical corridor with proximal control rather than a more lateral trajectory offered by the lateral approaches. The key steps of this approach are the lateral exposure of the suboccipital bone at the level of the foramen magnum and sigmoid sinus, lateral C1 arch, and early exposure and control of the VA in the suboccipital triangle. We have used a slightly curved retromastoid incision instead of the incision used by Heros⁷ to reduce the muscle bulk laterally, which is in the direct line of sight. Division of the superficial muscles along the line of incision, in our experience, has not led to an increased risk of pseudomeningocele or CSF leak. It could have contributed to avoiding these complications as medial detachment of the muscles is minimized and it facilitates reapproximation, thus decreasing post-operative muscle atrophy. These two maneuvers have contributed significantly to the reduction in operative time and blood loss and increased the ease of the surgical procedure. Available space is improved by CSF drainage by a lumbar or ventricular drain and extensive dissection of posterior fossa cisterns, arachnoid adhesions, and use of mannitol to slacken the brain. In this procedure, the VA is not transposed, thereby reducing the potential of injury to the artery. As the condyle is not resected, stabilization of the occiput-cervical junction is not

necessary. The exposure obtained was adequate for clipping the aneurysms of the lower basilar artery.

There are a few disadvantages to the far-lateral approach. Blood loss can be significant and troublesome during dissection of the VA. View of the VB junction may be hampered by the jugular tubercle, especially if the procedures outlined above are not strictly followed and the brain is edematous. In such a situation one should be prepared to drill the jugular tubercle to obtain the necessary exposure. The predominant morbidity associated with the far-lateral approach is related to lower cranial nerve dysfunction. This could be due to the fact that the dissection proceeds along the VA and in between the rootlets of the lower cranial nerves. It could be argued that condyle resection might decrease the incidence of this complication; however, this has not been substantiated as lower cranial nerve palsies are reported with extended far-lateral approaches.^{12,19} The risk to the nerves is not due to retraction of the nerves, cerebellum, or the brainstem, as retraction of the brain is not usually necessary with the far-lateral approach with its additional maneuvers as noted above. The direction of the approach would not differ with condyle drilling because of the fact that the VA is ventral to the nerves. Moreover, the condyle resection adds the risk of hypoglossal injury and instability. The lower cranial nerve deficits are temporary and thus should not discourage one from using this approach to a small or medium-sized aneurysm with a well-delineated neck in favor of a more extensive approach with its additional complications. The ease of the surgical approach is also dependent on the direction of the aneurysm fundus and the location of the aneurysm relative to the clivus and midline. The limitation of the approach is that the distal control is not always available, which may be troublesome in larger aneurysms. Some of the large aneurysms, giant aneurysms, and those located higher on the clivus will need an extended far-lateral approach with resection of the condyle and/or combined approaches. We have not used these surgical avenues for the lower basilar aneurysms as

the aneurysms we have encountered were small to medium-sized with a well-defined neck. Giant aneurysms may need further additional space for dissection, and the technique of hypothermic circulatory arrest can amplify the available space as it helps to further slacken the brain and the aneurysm. However, this technique can only be employed at specialized centers and carries a significant risk of complications.¹⁹

Endovascular coiling has an important role to play in the management of lower basilar artery aneurysms. This ability was not refined at our institution for the initial two cases. The latter two cases were discussed with the interventional neuro-radiologist and it was felt that the surgical option was more feasible. The same issues were discussed with the patients who opted for surgery.

Aneurysms of the lower basilar artery present a formidable surgical challenge and are associated with significant mortality with traditional neuro-surgical approaches. With advances in cranial base techniques, extensive petrous and occipital bone resection has been advocated to expose and effectively treat these lesions. Although these techniques have significantly reduced mortality rates, they come with a price in terms of increased morbidity related to cranial nerves, VA and sigmoid sinus, inner ear and middle ear structures, increased incidence of CSF leak, and the need for stabilization of the craniocervical junction. Attempts continue to refine skull base approaches and define the type of aneurysms that could be treated by a minimalistic approach with low risk of morbidity. Our experience has shown that it is possible to clip small or medium-sized aneurysms of the lower basilar artery using the far-lateral approach without drilling of the occipital condyle with a lower risk of morbidity and mortality as compared with the extensive cranial base approaches.

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