Management of anterior inferior cerebellar artery aneurysms: an illustrative case and review of literature

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Aneurysms of the anterior inferior cerebellar artery (AICA) are relatively rare among intracranial aneurysms. They can occur in 1 of 3 regions of the AICA: 1) craniocaudal (high or low riding), 2) mediolateral-premeatal (proximal), and 3) meatal-postmeatal (distal). The management strategies for treatment differ according to the location and configuration of the aneurysm. The existing body of neurosurgical literature contains articles on aneurysms arising from the AICA near the basilar artery (BA), intracanalicular/meatal aneurysms, and distal AICA. Several therapeutic options exist, encompassing microsurgical and endovascular techniques. The authors describe a case of treatment involving a large BA-AICA aneurysm approached via exposure of the prestigmoid dura using a retromastoid suboccipital craniectomy and partial petrosectomy. Treatment of these lesions requires detailed knowledge of the anatomy, and an anatomic overview of the AICA with its arterial loops and significant branches is presented, including a discussion of the internal auditory (labyrinthine) artery, recurrent perforating arteries, subarcuate artery, and cerebellosubarcuate artery. The authors discuss the various surgical approaches (retromastoid, far lateral, subtemporal, and transclival) with appropriate illustrations, citing the advantages and disadvantages in accessing these AICA lesions in relation to these approaches. The complications of these different surgical techniques and possible clinical effects of parent artery occlusion during AICA surgery are highlighted. (DOI: 10.3171/2009.1.FOCUS0915)

Key Words • anterior inferior cerebellar artery • aneurysm • surgical approaches

Case Report

History and Examination. A 58-year-old woman presented with a 6-month history of progressive headaches and dizziness. The results of physical examination were unremarkable. There were no cerebellar signs or motor/sensory deficits. A digital subtraction angiogram of the cerebral circulation demonstrated a 10-mm, right-sided AICA aneurysm beginning 1 cm distal to the vessel origin from the BA (Fig. 2). The supratentorial arterial system was found to be normal, with good filling across the circle of Willis.

Because of the narrow caliber of the AICA in this patient, the sharp angle of its takeoff from the BA, and the aneurysm’s large size with possible thrombus, surgical treatment was recommended.

Operation and Postoperative Course: Step 1. A right retrosigmoid incision was made after infiltration of the area with 1% lidocaine and 1:100,000 epinephrine. This incision was extended anteriorly, and subperiosteal flaps were raised to expose the spine of Henley as well as the root of the zygoma and the mastoid tip. A standard mas-

Abbreviations used in this paper: AICA = anterior inferior cerebellar artery; BA = basilar artery; CPA = cerebellopontine angle; CN = cranial nerve; DS = digital subtraction; IAM = internal acoustic meatus; PICA = posterior inferior cerebellar artery; SCA = superior cerebellar artery.
Mastoidectomy was performed, followed by the skeletonization of the sigmoid sinus, sinodural angle, posterior fossa dura, and osseous posterior canal wall. The horizontal semicircular canal was identified and preserved, as the facial nerve was skeletonized. After removing the mastoid tip, diamond drills were used on the retrosigmoid area to expose the dura behind the sigmoid sinus and to transect the mastoid emissary vein and cauterize it. Bone removal was then performed from over the sigmoid sinus area and the middle fossa, along with the sinodural angle, with exposure of the greater petrosal sinus. The bone was removed to the level of the posterior semicircular canal and the superior semicircular canal. At this point, the sigmoid sinus could be mobilized and completely exposed to facilitate the removal of the retromastoid suboccipital bone.

Operation and Postoperative Course: Step II. Baseline somatosensory evoked potentials were monitored after induction of general anesthesia. After retrosigmoid craniectomy, the dura was opened in a curvilinear fashion. The sigmoid sinus was retracted to the ear, allowing exposure of the right CPA. A self-retaining retractor was used to relax the cerebellar hemisphere. A lumbar drain for CSF drainage was placed to assist brain relaxation. The CN VII-VIII complex was identified and carefully protected, exposing the large proximal AICA aneurysm, which was very broad-necked. Microdissection was carried around the aneurysm until 2 titanium clips were placed across the base of it, isolating it from the circulation (Video).

Limiting factors were the deep corridor, narrow angle of view, and persistent high aneurysm turgor because of difficulty obtaining proximal control and temporary clip occlusion. Indocyanine green videoangiography was used to confirm excellent proximal and distal flow of the AICA vessel. Papaverine was applied around the acoustic-vestibular complex, and the dura was closed primarily. A fat patch was used to close the mastoidectomy using 4-0 nylon covered with Duragen and Tisseel fibro-nerve sealant. Finally, a titanium mesh cranioplasty was performed to cover a 4.5-cm-diameter craniectomy. The patient experienced transient postoperative lower-motor-neuron CN VII paresis and an ipsilateral CN VI paresis. Postoperative angiography showed no evidence of residual aneurysm, although there was evidence of occlusion of the AICA (Fig. 3) considered the result of slow-flow through the parent vessel at the time of surgical clipping, lead-
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Aneurysms of the AICA are exceedingly rare and presentations vary. In a series of more than 3500 saccular aneurysms treated surgically during a 16-year period, Gonzalez and colleagues reported that a mere 34 (1.7%) aneurysms arose from the AICA. Of these, 21 became symptomatic with subarachnoid hemorrhage. Of the 13 unruptured aneurysms, 7 manifested with brainstem compression. Eight aneurysms were giant (> 2.5 cm). Incidences of peripheral AICA aneurysms on dorsolateral and caudomedial branches of the same vessel have been reported. Zager and colleagues have described a patient with a ruptured meatal loop aneurysm in whom 3 prior negative DS angiograms had shown no positive findings. Iwanga and associates have described a peripheral aneurysm that was diagnosed on CT angiography but was previously undetected on 2 DS angiograms; the aneurysm eventually bled. Menovsky and colleagues have reported on AICA aneurysms in association with high-flow lesions, such as arteriovenous malformations fed by the AICA. They performed a lateral retromastoid suboccipital cranietomy and aneurysm clipping, and followed this with the removal of the draining veins. The authors also reported a case of hemangioblastoma associated with AICA aneurysms. Recent publications on case series of distal AICA aneurysms represent postmeatal segments treated surgically or endovascularly, with or without occlusion of the parent artery.

The course of the parent AICA artery is intimately related to the pons, foramen of Luschka, middle cerebellar peduncle, and petrosal surface of the cerebellum. After its origin from the BA, the AICA wraps around the pons near CN VI–VIII and then sends branches to the internal acoustic meatus and choroid plexus of Luschka. The artery then passes around the flocculus on the middle cerebellar peduncle, and petrosal surface of the cerebellum. The AICA gives rise to perforators to the brainstem and choroidal branches to the tela and choroid plexus, as well as giving rise to unique branches, such as recurrent perforators and the internal auditory and subarachnoid artery.

Discussion

Aneurysms of the AICA can be categorized into 3 types: proximal, meatal, and distal (Table 1). Proximal aneurysms arise from the BA-AICA junction or at the premeatal segment, AICA bifurcation, or combined AICA-PICA origin. Meatal aneurysms arise from the meatal loop or segment and are subclassified as Type I, II, or III, based on Yamakawa and colleagues’ classification. The classification depends on the location of the aneurysm with respect to the IAM, which in turn determines the extent of IAM drilling. In Type I (“remote”) lesions, an aneurysm exists on the vascular loop outside the meatus, and is most common (56% of cases) in the CPA/proximal part of the lateral pontine segment; in Type II (“plugged”) lesions, the aneurysm is partly buried in the IAM, with the neck of the aneurysm located to one side; and in Type III (“buried”) lesions, the aneurysm is entirely contained by the IAM. Types II and III are collectively called intracanalicular AICA aneurysms. The surgical implication of these aneurysms lies in the fact that the buried aneurysms are very difficult to treat without extensive drilling of the IAM. Distal AICA aneurysms usually arise from the rostral postmeatal branch.

<table>
<thead>
<tr>
<th>Location</th>
<th>New Classification</th>
<th>Rhoton Classification</th>
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<tbody>
<tr>
<td>proximal (aneurysms arising from the AICA origin to the meatal loop)</td>
<td>vertebrobasilar junction, AICA-PICA origin premeatal segment (CPA)</td>
<td>corresponds to anterior pontine segment</td>
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<tr>
<td>middle (meatal loop)</td>
<td>Type I (aneurysms on the loop, not in the IAM)</td>
<td>corresponds to LPS-premeatal</td>
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<tr>
<td>distal (aneurysms arising from the end of the meatal loop to the distal AICA)</td>
<td>Type II (partially in the IAM)</td>
<td>LPS-meatal</td>
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<td></td>
<td>Type III (fully in the IAM)</td>
<td>LPS-meatal</td>
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<td></td>
<td>postmeatal</td>
<td>flocculopeduncular &amp; cortical segments</td>
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* LPS = lateral pontine segment.

Segments of the AICA: Implications in Management of Aneurysms

Management Options for AICA Aneurysms

Surgical Approaches. Depending on the anatomical features of the aneurysm, various skull base approaches, including the retrosigmoid, far-lateral, middle fossa, transcochlear, translabyrinthine, orbitozygomatic, and combined supratentorial-infratentorial presigmoid approaches, are being used to manage AICA aneurysms. The common surgical approaches for AICA aneurysms that are discussed in the literature include the retromastoid suboccipital approach with or without petrosectomy (posterior lateral), the subtemporal middle fossa approach (lateral), the pterional or orbitozygomatic approach (anterolateral), and, rarely, the anterior approach (transcivial-transfacial).

The unique difficulty associated with clipping AICA aneurysms partially reflects their location near the skull
base and their proximity to multiple CNs. The 2 most important factors in choosing a surgical approach are (a) the craniocaudal location of the aneurysm in relation to the clivus and (b) the mediolateral location, along with the course of the artery (Fig. 4). The development of an adequate corridor between the petrous temporal bone and CPA is critical to adequate visualization of the AICA. High-riding aneurysms may be reached by the orbitozygomatic approach, although using this approach is limited by the need to perform a posterior clinoidectomy (Fig. 5). This may increase complications related to the approach, particularly CN paresis. An alternate method that may be selected for high-riding AICA aneurysms would be a subtemporal middle fossa approach with division of the tentorium combined with a petrosectomy. The subtemporal corridor was popularized by Drake and colleagues, who described its use in the exposure of 32 AICA aneurysms. A limitation of this approach is that it may not offer adequate visualization of the AICA origin. As the AICA-BA aneurysm points anteriorly in most cases, the neck is grasped by forceps and the sac is tipped away during the dissection, defining the pontine segment.

Spetzler used the subtemporal and subtemporal-transtentorial approach only once in the surgical treatment of 41 AICA aneurysms and cited a significant rate of morbidity associated with its use. As a result, it is primarily used in the approach of midclival aneurysms. In addition to the removal of the petrous apex, the use of the subtemporal-transtentorial approach involves opening the tentorial edge, increasing the extent of exposure, and posing a hazard to CN IV, which travels along the tentorial edge. Recent cadaveric studies have not demonstrated an increase in surgical freedom or quantitative exposure to the ventral brainstem and origin of the AICA when comparing the subtemporal-transtentorial approach to the retrosigmoid approach.

The retrosigmoid route affords the greatest versatility in terms of approaches while being the simplest and most straightforward way in which to expose the AICA region. This approach is commonly used for removal of CPA tumors, such as acoustic schwannomas, and microdecompression of AICA branches in hemifacial spasm. As performed in our case, skeletonization and lateral retraction of the transverse-sigmoid junction allows for minimal cerebellar retraction. If additional exposure is desired, a partial petrosectomy may be performed with the opening of the presigmoid dura. While the sigmoid sinus may be sacrificed, this is often unnecessary. Sequential movement of the operating mi-
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crossectomy combined with judicious use of the retractor
allow for adequate visualization of the CPA while mini-
mizing the risk of venous injury or infarction (Fig. 6).6
The premeatal AICA can then be seen between CN VI
and CN VII. During subsequent dissection, care must be
taken because it is easy to injure CN VI. The retrosigmoid
approach offers good access to distal AICA aneurysms
off the meatal and postmeatal segments, the lateral as-
pect of the mid- and lower brainstem below CN V, and
the area near the IAM. The retrosigmoid approach can
be combined with either a medial petrosectomy in high-
riding aneurysms or a far-lateral approach when required
to expose low-lying aneurysms near the vertebrobasilar
junction. Such combined skull base approaches are par-
ticularly helpful in the surgical clipping of giant AICA
aneurysms.11,19

Transpetrosal approaches (transcochlear and trans-
labyrinthine) provide the most direct route to the brain-
stem.29,51-56,59 However, these approaches are associated
with significant morbidity, such as deafness, facial nerve
palsy, and CSF leakage, and they are rarely performed in
the absence of giant AICA aneurysms.5 Rhoton46 com-
pared the middle fossa and translabyrinthine approaches
to the AICA and found notable differences. In the middle
fossa approach to the IAM, only a short segment of the
artery near the meatus is exposed and, often, only if the
artery loops into the meatal porus. The translabyrinthine
approach exposes the AICA at and for a short distance
proximal and distal to the IAM and along the anterior
part of the petrous surface. An obvious drawback of the
translabyrinthine approach is its association with perma-
nent hearing loss.

The supratentorial-infratentorial presigmoid ap-
proach allows various degrees of resection involving the
semicircular canals, vestibule, and cochlea. Transoral-
transfacial approaches to AICA aneurysms have been
reported but are not routinely used because of their high
rates of associated morbidity.41,26,41,49,52

Protection of the cerebellum and brainstem is
achieved by several neuroprotective methods, and the
CNs are protected by judicious use of intraoperative
monitoring. Hypothermic cardiac arrest with barbiturate
cerebral protection is an important adjunct for surgery
of BA and AICA aneurysms.5 Adequate deflation of
the aneurysm during this technique allows further dissec-
tion of the dome away from the brainstem and minimizes
the risks of intraoperative hemorrhage.

Although rare, dissecting aneurysms involving the
AICA have been reported.25 Generally, these lesions pre-
sent with brainstem ischemic symptoms and may be sug-
gested on MR imaging by an evolution of signal char-
acteristics, lesion shrinkage over time, and angiographic
evidence of fusiform dilation with luminal irregularities.
High-flow lesions, such as arteriovenous malformations,
often occur with AICA aneurysms, complicating the
choice of surgical approach.7,17,32,33,44,45,61 Such lesions can
be treated using surgery or endovascular therapy in mul-
tiple stages as a patient’s clinical condition warrants.

Endovascular Options. The treatment of posterior
circulation aneurysms has undergone significant changes
as endovascular treatment options have evolved.21,25,47,54
Because these options eliminate surgical approach–relat-
ed morbidity, they are particularly appropriate for con-
sideration in the treatment of AICA aneurysms. Require-
ments of successful coil embolization are an adequate
aneurysm dome-to-neck ratio and the ability to maneuver
a microcatheter into the dome of the aneurysm. Because
most AICA aneurysms arise proximally, microcatheter
navigation into the aneurysm dome is often feasible. Oc-
casionally, complete obliteration of the aneurysm sac is
impossible without jeopardizing parent vessel patency due
to protruding coil loops. Nevertheless, it is clear that coil
embolization is a valuable treatment option, often consid-
ered first-line management for these lesions.15,36,43,47,54,57

The indications for endovascular treatment of distal
AICA aneurysms are less clear. Not more than 10 re-
ported cases of endovascularly treated distal AICA an-
eurysms appear in the literature, and a common theme in
these reports is that parent artery occlusion is necessary
to achieve adequate aneurysm obliteration.11,57 Saito and
colleagues58 reported that only 58 patients had AICA an-
eurysms in the meatal or postmeatal segments. In their
report of 3 cases, 2 patients underwent surgical trap-
ppling and the remaining patient underwent endovascular coiling due to poor clinical condition. An increase in hearing disturbance was noted in 2 patients, one in either modality of treatment. Dissection as a consequence of embolization has been described and often results in a subarachnoid hemorrhage with an intraventricular extension.

Advances in endovascular techniques have led to increased treatment of even giant AICA aneurysms. In such cases, balloon-assisted techniques with stents placed across the neck of an aneurysm are valuable tools when the aneurysm dome-to-neck ratio is unfavorable. The need for antiplatelet agents in cases requiring stent augmentation increases the risk of hemorrhagic complications; however, it limits the utility of such techniques in cases in which aneurysms have presented in association with a subarachnoid hemorrhage. In cases of large aneurysms that cannot be safely and directly occluded, flow reversal leading to aneurysm thrombosis may be induced following direct vertebral artery or BA occlusion with detachable coils. Such maneuvers are not undertaken lightly because they are associated with significant rates of ischemic complications, and balloon test occlusion should be performed first to identify patients who can tolerate permanent vessel occlusion. In some cases, flow augmentation may be considered via distal extracranial-intracranial bypass.

Parent Artery Occlusion in AICA Aneurysms: a Safe Option?

The case illustrated in our report underscores some of the challenges inherent in managing difficult lesions. Despite attempts to the contrary, the patency of the distal AICA was compromised by surgical treatment, and it may be argued that endovascular management would have been equally effective in treating this particular lesion. In an attempt to preserve hearing, an extensive labyrinthectomy was not performed, although this would have increased the surgical exposure. Sigmoid sinus sacrifice would have afforded additional exposure, but this was not performed because of the large size of the sinus on the affected side without comparably sized contralateral venous drainage. Despite sacrifice of the AICA, there were no associated clinical signs, likely a reflection of the small size of the parent vessel and presence of collateral flow from the posterior cerebral artery and SCA. Although endovascular treatment could have been attempted, AICA canalization would have been hazardous and would not have resulted in complete aneurysm obliteration. However, such assumptions are controversial and highly dependent on institutional biases and the comfort level of the treating physicians with various therapies. Although the initial goal of treatment was preservation of the parent vessel, which influenced the initial decision regarding the recommended treatment modality, clearly endovascular treatment would have offered a potentially equivalent outcome. Such difficulties highlight the challenges inherent in treating these rare lesions.

The occlusion of the AICA can result in syndromes characterized by 4 distinct clinical presentations that are strikingly different from PICA or SCA infarcts. The most common clinical presentation is the classic syndrome described by Adams, which includes vertigo, nausea, vomiting, dysarthria, and tinnitus. Ipsilateral facial palsy, facial sensory loss, and Horner’s syndrome are often observed. Other possible deficits are appendicular dysmetria, contralateral loss of sensation, hearing loss, conjugate lateral gaze palsy, dysphagia, and, in advanced cases, ipsilateral motor weakness. Because several of these signs are similar to Wallenberg syndrome, some may confuse this condition with a PICA infarction. The second most common form is isolated vertigo, often confused with labyrinthitis. Amarenco and colleagues have shown that the vertigo in cases of AICA infarction results from damage to the flocculus, whereas in cases of PICA infarction it is due to a damaged nodulus. A third form in which the patient typically presents with coma, ophthalmoplegia, and quadriplegia is often fatal. A fourth form of AICA infarction, in which the patient presents with minimal cerebellar signs, is probably explained by the adequate collateral circulation from other cerebellar arteries. Suzuki and colleagues have proposed that the AICA could be sacrificed distal to the internal auditory branch because of anastomotic connections with branches of the PICA and the SCA. Hansen has demonstrated that anastomotic vessels from the carotid circulation via the temporal bone can supply blood to the cochlea and labyrinth, but the adequacy of these anastomotic vessels is extremely difficult to assess intraoperatively and during cerebral angiography. Rhoton has reported that the size of the infarction area after AICA occlusion is inversely related to the size of the PICA and the SCA as well as to the extent of anastomoses with these vessels. For example, if the PICA is unusually small and the AICA is large, the collateral circulation is likely to be poor, creating an unfavorable environment in the event of AICA occlusion at surgery.

Akar and colleagues have reported that the branches of the AICA that supply the inferior part of the olive arise 3–18 mm distal to the origin of the AICA, although AICA occlusion causes a lateral inferior pontine syndrome. They have argued that the obstruction of the AICA distal to the internal auditory artery should not produce cerebellar deficits due to anastomoses with PICA branches to the hemisphere. Likewise, Nishimoto and colleagues have attributed the high incidence of CN VII and VIII dysfunction to the ischemic damage, whereas Fisch has described rami nervosum from the internal auditory artery being involved in the vascularization of the CN VII–VIII complex. Andaluz and colleagues have argued that CN VII and VIII palsies can result from vascular injury despite anatomical preservation of the nerve during surgery. A CN VI deficit is relatively uncommon because the nerve is slack as it courses up to gain access to the cavernous sinus and is easily displaced from the neck of the AICA aneurysm.

The exposure of large AICA aneurysms treated with multiple clip applications can be confining. At the critical moment of clip application, the anatomy will be obscured by the clip applicator and clip handle in the surgical field. The occlusion of the BA and perforators often leads to catastrophic consequences, and these can be prevented.
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by verifying the clip position during and after application. Endoscopic assistance may be an option in certain instances, allowing visualization of otherwise hidden anatomical regions.28

Conclusions

Proximal or vertebrobasilar AICA aneurysms lie in a confined narrow space in the prepontine cistern, and several surgical approaches are designed to allow a direct line of sight down the posterior slope of the petrous bone and clivus, from a supratentorial or infratentorial exposure. Distal AICA aneurysms are less favorable lesions for endovascular therapy because of difficulty in navigating catheters and are often best treated surgically. However, coil embolization is preferred in advanced age and poor clinical status of patients with AICA aneurysms. The illustrative case underscores the inherent difficulties of treating these deeply located and rare lesions.

References


