0148-396X/90/2701-0012$02.00/0
NEUROSURGERY

Vol. 27, No. 1, 1990
Printed in U.S.A.

Experimental and clinical studies

Aneurysms of the Posterior Inferior Cerebellar Artery–Vertebral Artery Complex: Variations on a Theme

Michael Salcman, M.D., Daniele Rigamonti, M.D., Yuji Numaguchi, M.D., and Norihiro Sadato, M.D.

The Cerebrovascular Service, Division of Neurological Surgery (MS, DR), and Division of Neuroradiology (YN, NS), University of Maryland School of Medicine, Baltimore, Maryland

Aneurysms of the posterior inferior cerebellar artery–vertebral artery complex are relatively uncommon lesions. They include aneurysms at the origin of the posterior inferior cerebellar artery (PICA-VA), aneurysms on the distal artery (PICA) and aneurysms at the junction of the vertebral and basilar arteries (VA-BA). We have had the opportunity to treat 17 patients and study the radiological records of 9 additional patients in the past 8 years. The aneurysms ranged in size from 3 to 30 mm, with mean values of 10.6, 7.3,and 9 mm for PICA-VA lesions, distal PICA lesions, and VA-BA lesions, respectively. Three of the 4 VA-BA aneurysms were located at the midline, and the mean distance of the PICA-VA aneurysms from the midline was 7.6 to 9.4 mm; 2 aneurysms crossed the midline from their parent VA. The aneurysms were located slightly more often on the left side (left:right ratio, 1:2), were found more frequently in women (2.25:1), and occurred at a mean age of 50 years. Ten aneurysms at the origin of the PICA and 4 VA-BA aneurysms were treated via a lateral suboccipital craniectomy; 3 distal PICA aneurysms were exposed by a midline craniectomy. Surgery was carried out acutely in 5 patients. Tortuousness of the VA required contralateral approaches in 2 patients, an exploratory craniectomy in 1 patient, and an approach toward the dome of 1 patient with a VA-BA aneurysm. Morbidity was primarily due to cranial nerve dysfunction. There were no perioperative deaths. These aneurysms can easily be missed on initial radiographic examination; one appeared only on the second study, one was seen to grow over 16 days, and one was discovered at the level of C1 extracranially. Our radiographic and surgical approach to the treatment of these lesions is presented. (*Neurosurgery* 27:12–21, 1990)

Key words: Aneurysm, Posterior inferior cerebellar artery, Subarachnoid hemorrhage, Vertebral artery

Aneurysms of the posterior inferior cerebellar and vertebral artery complex are relatively uncommon, comprising less than 0.5 to 3% of all aneurysms (23). Yamaura (26) includes three types of aneurysm within this category: 1) lesions that arise at the origin of the PICA from its parent vertebral artery (PICA-VA); 2) aneurysms located at distal locations on the posterior inferior cerebellar artery (PICA); and 3) aneurysms arising at the junction of the vertebral and basilar arteries (VA-BA). The aneurysms of the PICA-VA complex combine a narrow range of clinical presentation with unusual anatomical variability. Their strategic location and the tortuousness of the vertebral arteries require special consideration during diagnostic evaluation and surgical planning. It is sometimes even difficult to pick the side from which the surgical approach should be made, unless the angiographic size and delineation of the aneurysm, its distance from the midline, the general height and shape of the vertebral artery, and the pattern of collateral supply are carefully evaluated. Relatively little guidance is available in the literature in regard to these matters. We would like to share the lessons that we have learned in treating a variety of these lesions during the past few years. The imaging data that we have accumulated from other cases is also presented.

MATERIALS AND METHODS

The clinical series of 17 cases was obtained by a search of all physician and hospital records of patients with a diagnosis of subarachnoid hemorrhage (SAH) or cerebral aneurysm made between January 1, 1982 and March 30, 1989 at the University of Maryland. Every patient with an aneurysm of the posterior inferior cerebellar artery (PICA) or of the vertebral artery (VA) distal to the PICA was identified and the chart reviewed for demographic information, presentation, neuroradiological findings, surgical therapy, and clinical outcome.

Fifteen of the 17 patients were treated at our institution during the last 5 years. On each arteriogram, the largest diameter of the aneurysm and the distance between the neck of the aneurysm and the anatomical midline was measured in millimeters. Nine additional radiographic cases were available in the teaching file of the Division of Neuroradiology and were used for further radiometric analysis and for the study of patient age and sex as well as aneurysm type and laterality. The combined series, therefore, consists of 26 patients, 18 women and 8 men—a female preponderance of 2.25:1. The distribution of the aneurysms by location in this series is presented and compared with that of other reports in Table 1.

RESULTS

Of the 17 patients with an aneurysm of the PICA-VA complex in the clinical series, 3 did not undergo surgery: 1 refused and the other 2 died of subsequent bleeding before definitive treatment. The remaining 14 patients underwent operation. The average age was 50.5 years (range, 36–69 years) and there was a preponderance of female patients (65%). Every patient except one demonstrated the typical signs of SAH. Altered mental status, ranging from drowsiness to coma was present in 10 patients (59%). Focal neurological deficits were found in 6 patients (35%). At admission, the patients were graded according to the Hunt and Hess scale (Table 2).Computed tomographic (CT) scanning detected diffuse SAH in the basal cisterns as well as intraventricular blood in 7 patients (41%). Evidence of intraventricular hemorrhage (IVH) alone was found in 4 patients (23.5%). IVH in the fourth ventricle alone or in combination with SAH was seen in 8 patients (47%). Intracerebral hemorrhage (ICH) was observed in 2 patients (12%), in one as the only finding and in the other in association with IVH. Hydrocephalus was detected in 5 patients (29%). Brain stem displacement by a partially calcified mass with positive enhancement was seen in 1 patient (6%). The CT scan disclosed nothing abnormal in 2 patients (12%). Angiographic examination initially disclosed nothing abnormal in 2 patients and demonstrated multiple aneurysms in 3 patients. The typical radiographic presentation is demonstrated in Figure 1, and one of the initially negative studies is presented in Figure 2.

TABLE 1
Location of Aneurysms of the PICA-VA Complex[a]

Series (Ref. no.)	PICA-VA	PICA	VA-BA
Hudgins et al., 1983 (9)	17	4	
Yamaura, 1988 (26)	46	9	1
Ojemann et al., 1988 (16)	12	4	7
Lee et al., 1989 (12)	10	4	
Salcman et al., 1990 (present series)	18	4	4

[a] PICA-VA, posterior inferior cerebellar artery–vertebral artery; PICA, posterior inferior cerebellar artery; VA-BA, vertebral artery–basilar artery.

TABLE 2
Initial Grade and Final Outcome in 17 Patients with Aneurysms of the PICA-VA Complex, by Hunt and Hess Grade

Hunt and Hess Grade at Admission	Number of Patients (%)	Patient Outcome		
		Independent	Dependent	Dead
1	3 (18)	3		
2	4 (23.5)	4		
3	7 (41)	3	2	2[a]
4	2 (12)	1		1[b]
5	1 (6)			1[c]

[a] One patient died at 3 months of aspiration pneumonia, one patient had a second episode of bleeding and died before surgery.
[b] Died of aspiration pneumonia 6 months after surgery.
[c] Patient had a second episode of bleeding and died before surgery.

Fourteen patients underwent surgical repair of the aneurysm, 5 patients within the first 96 hours from the onset of symptoms, 9 patients after 10 days. Twelve patients underwent primary clipping of the neck of the aneurysm, 1 patient underwent trapping of the vertebral artery because of intraoperative rupture with tearing of the neck of the aneurysm, and 1 patient underwent proximal ligation of the VA by an exteriorized tourniquet. The follow-up period ranged from 3 to 86 months (average, 24 months). The perioperative morbidity is shown in Table 3 and the outcome by admission grade is summarized in Table 2. The results of the radiometric analysis are summarized in Table 4. The PICA-VA aneurysms in the radiographic series had a mean size (5.3 mm) that was half that of the aneurysms in the clinical series (10.6 mm); the mean distance from the midline was similar (7.6 vs. 9.4 mm). Two of the PICA-VA aneurysms in the clinical series were located on the midline, as were 3 of the 4 VA-BA aneurysms. Distal PICA aneurysms appeared to be somewhat smaller (7.3 mm) than aneurysms at the other two sites. In the combined series, aneurysms were only slightly more likely to be located on the left side (12:10).

DISCUSSION

Aneurysms of the posterior inferior cerebellar artery–vertebral artery complex represent only 0.5 to 3% of all aneurysms and 20% of those in the posterior fossa (23). They are more commonly found in women, with a female to male ratio

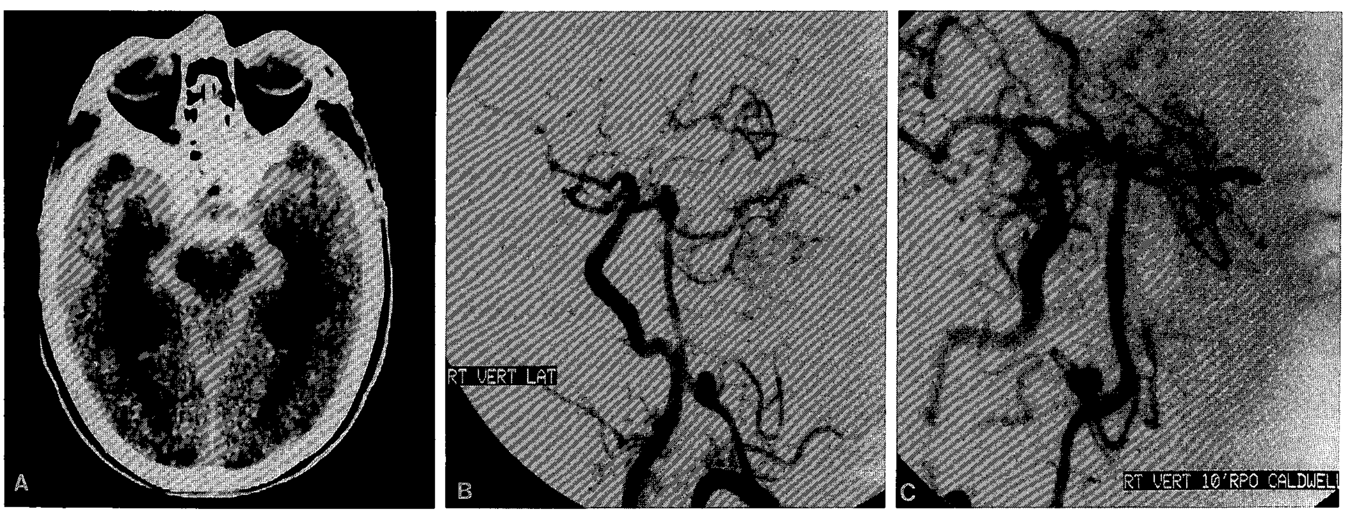

FIG. 1. CT scan and arteriogram of a typical PICA aneurysm. Blood is shown to be in the circumesencephalic cisterns rather than in the suprasellar cisterns on the CT scan (*A*); often, blood is present only in the fourth ventricle. The lateral vertebral arteriogram reveals the origin of the aneurysm in the notch between the VA and the PICA at the forward turn of the VA, with the PICA posterior to the sac (*B*). The special 10° right parieto-occipital Caldwell view (*C*) indicates the aneurysm is mesial to the PICA at its origin.

FIG. 2. Arteriogram of a reappearing large PICA aneurysm. The initial arteriogram (anteroposterior view) reveals only a basilar artery aneurysm (*A*). After clipping, the patient suffered another SAH; a second arteriogram, obtained 11 days after the first study, now demonstrates a large PICA aneurysm on the anteroposterior view (*B*). The lateral view shows the typical origin, with the PICA posterior to the neck and sac (*C*); note the clip at the top of the basilar artery. The PICA aneurysm was successfully clipped at the second procedure.

TABLE 3

Perioperative Morbidity in 14 Patients with Aneurysms of the PICA-VA Complex

Perioperative Morbidity	Number of Patients (%)
Abducens palsy	4 (29)
Facial palsy	3 (21)
Glossopharyngeal-vagal palsy (requiring tracheostomy)	4 (29)
Hemiparesis	2 (14)
Cerebellar ataxia	1 (7)
Meningitis	1 (7)
Hydrocephalus (requiring shunting)	4 (29)

TABLE 4

Size and Location of PICA-VA Aneurysms

Type of Aneurysm	Size (mm)		Distance to Midline (mm)		
	Range	Mean	Range	Mean	N
PICA-VA[a]	5 to 30	10.6	15 to −5	7.6	10
	3 to 10	5.3	20 to −7	9.4	7
PICA	5 to 10	7.3	6 to 7	6.6	3
VA-BA	6 to 18	9	0 to −14	0.0	4

[a] PICA-VA figures are given for both the clinical and radiographic series. Negative numbers refer to the contralateral distance from the midline. The mean distance to the midline does not include contralateral lesions.

of 2.3:1 or 3:1 (9, 26). The latter finding may be related to the fact that in most patients, the left VA is the dominant or larger artery (10). In our combined clinical and radiographic series of 26 cases, the aneurysm was more frequently found on the left, in a ratio of 1.2:1 (12 to 10), and there was a preponderance of female patients in the total series, in a ratio of 2.25:1 (18 to 8). The presenting clinical symptoms of the typical patient with a PICA-VA aneurysm are subarachnoid hemorrhage and, less frequently, brain stem compression.

Because of the proximity of the PICA to the brain stem and to the origin of the lower cranial nerves, impairment of these structures is often manifest when the patient is seen initially (2). Five (29%) of our patients exhibited initial loss of consciousness at the time of bleeding. Three (18%) showed early decerebrate posturing. Cranial nerve dysfunction is not uncommon in these patients and the 6th nerve is the most frequently involved. In our experience, 5 patients presented with ocular findings and 4 of them had damage to the 6th nerve (23.5% of the entire group). Patients who exhibit the sudden onset of bilateral 6th nerve palsies and subarachnoid hemorrhage should be suspected of harboring an aneurysm of the VA-BA junction (6); the junction is often located at the level of these nerves. Our first case of an aneurysm at this site caused just these symptoms, and was found at surgery when the contrast between the white 7th–8th nerve bundle and the yellowed 6th cranial nerve deep to it was noted (Fig. 3).

The radiographic diagnosis of patients with aneurysms of the PICA-VA complex presents its own special difficulties. Blood in the fourth ventricle without blood in the suprasellar, prepontine, and/or circumesencephalic cisterns is said to be the typical CT appearance of bleeding secondary to PICA-VA aneurysms (9), and may lead the unwary to assume that no subarachnoid hemorrhage has occurred (Fig. 1). Intraventricular hemorrhage, most commonly in the fourth ventricle, was noted in 8 of our patients (47%). Some distal PICA aneurysms present with only cerebellar or fourth ventricular hemorrhages (11, 14, 29). Although arteriography of the dominant vertebral artery usually reveals the aneurysm, the necessity for direct visualization of each vertebral artery and its PICA has been repeatedly stressed by all authors. One should not depend on washout down the contralateral VA to provide adequate visualization of the opposite PICA. Less well appreciated is a curious lack of visualization of the aneurysm by initial studies in this location; hence, the need to repeat arteriography until one is completely satisfied with the anatomical delineation. The third and tenth cases of Hudgins et al. (9) were initially missed by arteriography. Two of the aneurysms in our series (Fig. 2) were invisible on the original study despite a complete absence of vasospasm, but were detected on a second study only after additional hemorrhage. The mechanism in this situation is unclear, and may involve the lysis of a clot extending into the neck of the aneurysm. A demonstration of the instability of the aneurysm size is given by the visualiza-

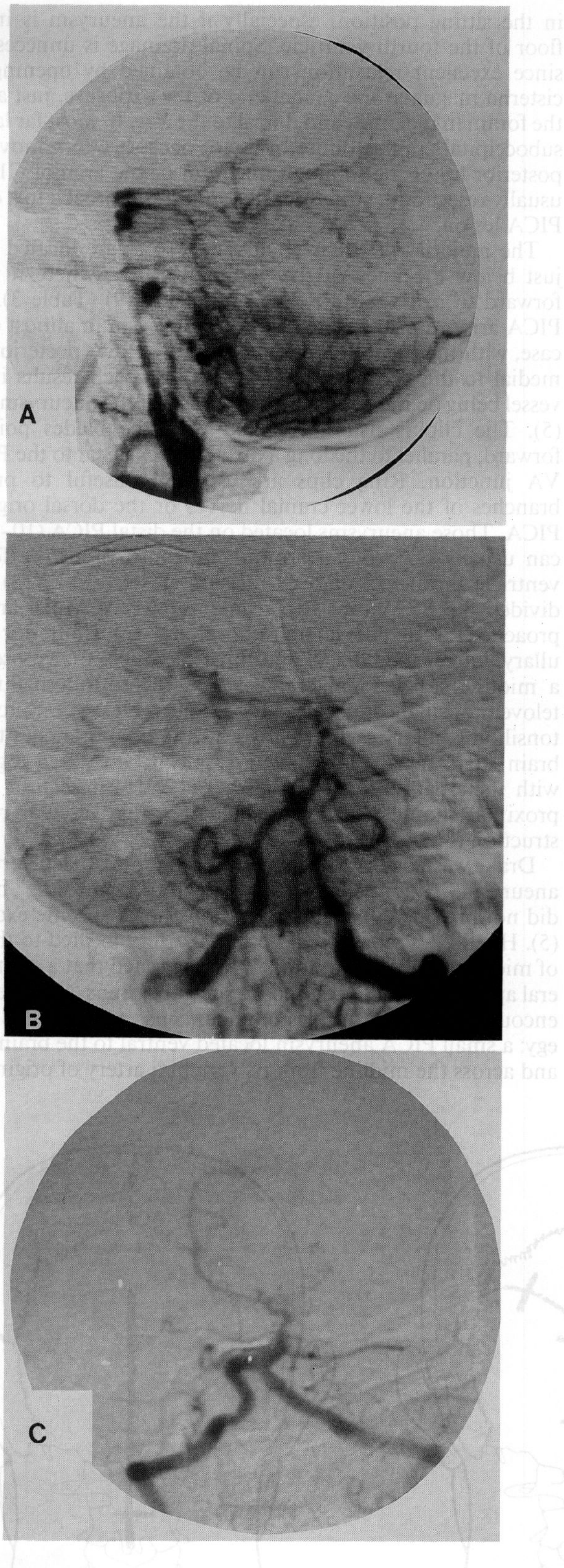

FIG. 3. Arteriogram of a typical aneurysm of the VB junction. The lateral view demonstrates an aneurysm pointing posteriorly toward the brain stem at the junction of both VAs with the basilar artery (*A*). Anteroposterior view shows the high shoulder of the right VA thrusting the dome of the aneurysm toward the right side (*B*). Postoperative anteroposterior view shows the aneurysm was clipped from the dome side with the blades parallel to the shoulder (*C*).

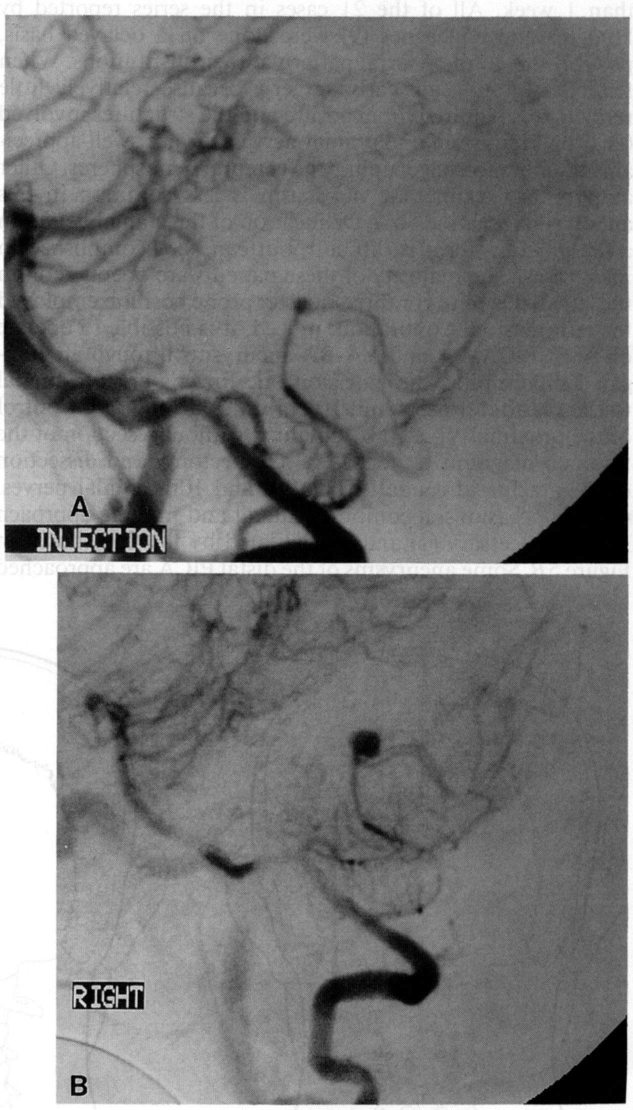

FIG. 4. Arteriogram of a "growing" distal PICA aneurysm. The initial right lateral view demonstrates a seemingly tiny aneurysm at the cephalic loop of the PICA (*A*); surgery was delayed because of severe cardiac instability. A second lateral view obtained 16 days later reveals a much larger aneurysm, presumably after lysis of an intraluminal clot (*B*). The aneurysm was successfully clipped.

tion of an enlarging peripheral PICA aneurysm over the course of 16 days (Fig. 4). One of our patients had a 7-mm extracranial PICA aneurysm located below the level of C1; such a lesion is easily missed on the initial review of the arteriogram, and has been reported on at least two previous occasions (8, 20).

It is also important to determine whether the PICA is reduplicated, whether the opposite artery is present, whether the PICA territory is irrigated by another vessel (e.g., the anterior inferior cerebellar artery), and whether the posterior communicating arteries are present and, if so, whether they are exceptionally large or fetal in nature; all of this information is vital in the event of a planned or emergency vertebral occlusion (10, 18, 24). Large or atherosclerotic aneurysms in this location may require proximal vertebral ligation with a Drake tourniquet or an intravascular balloon (4).

Surgery for aneurysms of the PICA-VA complex has traditionally been carried out at a delay of several days to weeks. Yamaura (26) had no examples operated on within 72 hours of the SAH, and only two operations were performed at less than 1 week. All of the 21 cases in the series reported by Hudgins and colleagues (9) were done on a delayed basis, possibly due to the referral pattern at their institutions. When feasible, we advocate early surgery, because relatively little retraction is required for exposure and the structures involved (i.e., the brain stem and cranial nerves) do not swell appreciably after hemorrhage, unlike the cerebral hemispheres. Other authors also claim that vasospasm is less common in this aneurysmal location (16). Delineation of the cranial nerves in a sea of fresh fibrin is difficult, but can be accomplished in most cases. The majority of these patients are operated on in the lateral decubitus or three-quarter prone position employed for retromastoid exploration; indeed, it is possible to operate on most PICA-VA and VA-BA aneurysms through an elongated suboccipital "tic" incision one finger's breadth mesial to the mastoid process and 10 cm in length (Fig. 5). Control of the proximal VA can be obtained without resection of the foramen magnum by far lateral craniectomy and dissection of the arachnoid caudal to the 9th and 10th cranial nerves. On rare occasions, a combined lateral and midline approach may be necessary (1) and is facilitated by the flap shown in Figure 5*B*. Some aneurysms of the distal PICA are approached in the sitting position, especially if the aneurysm is in the floor of the fourth ventricle. Spinal drainage is unnecessary, since excellent relaxation can be obtained by opening the cisterna magna at the caudal end of the exposure, just above the foramen magnum and dorsal to the VA. In most far lateral suboccipital craniectomies, it is not necessary to remove the posterior lip of the foramen magnum or the arch of C1. We usually resect both structures in a midline approach to a distal PICA lesion.

The majority of PICA aneurysms (76%) are located at or just below the knee of the vertebral artery, where it turns forward to run ventral to the brain stem (9) (Table 3). The PICA arises dorsal or lateral to the aneurysm in almost every case, with the exception of an occasional PICA posterior and medial to the neck; hence, a lateral approach results in the vessel being delineated before dissection of the aneurysm itself (5). The clip is usually applied with the blades pointing forward, parallel to the long axis of the VA distal to the PICA-VA junction. Ring clips are especially useful to protect branches of the lower cranial nerves or the dorsal origin of PICA. Those aneurysms located on the distal PICA (10–20%) can usually be exposed around the tonsil or in the fourth ventricle through a midline incision. Lister et al. (13) have divided the PICA into five segments, two of which are approached through the lateral suboccipital route (anterior medullary, lateral medullary) and three of which are exposed by a midline suboccipital craniectomy (the tonsillomedullary, telovelotonsillar, and cortical segments (Fig. 5*C*). Since the tonsillomedullary segment gives off the final branches to the brain stem, distal PICA aneurysms can be excised together with their parent vessel if needed (17, 19); resection more proximal should be accompanied by microvascular reconstruction (3, 14, 21).

Drake was possibly the first author to report "a left vertebral aneurysm . . . done inadvertently from the right side," but he did not provide either the indications nor a specific example (5). He did describe a right vertebral artery located to the left of midline, and other authors have suggested that a contralateral approach should be used on such occasions (10). We have encountered two examples of aneurysms requiring this strategy: a small PICA aneurysm located ventral to the brain stem and across the midline from its vertebral artery of origin, and

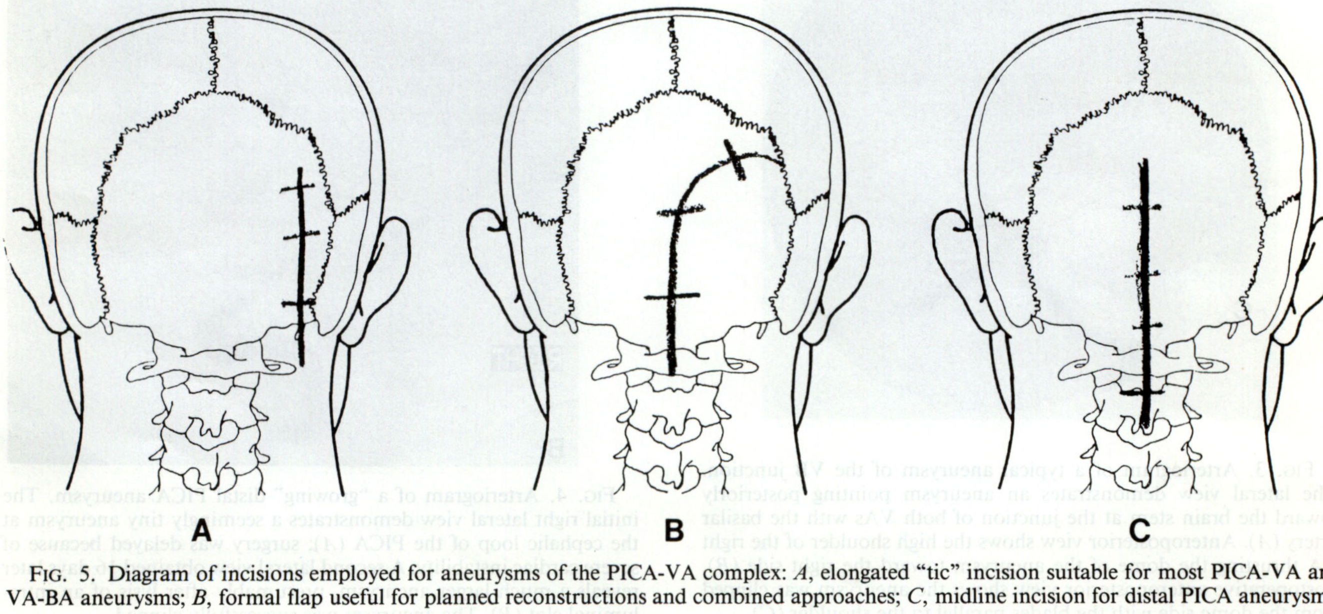

FIG. 5. Diagram of incisions employed for aneurysms of the PICA-VA complex: *A*, elongated "tic" incision suitable for most PICA-VA and VA-BA aneurysms; *B*, formal flap useful for planned reconstructions and combined approaches; *C*, midline incision for distal PICA aneurysms.

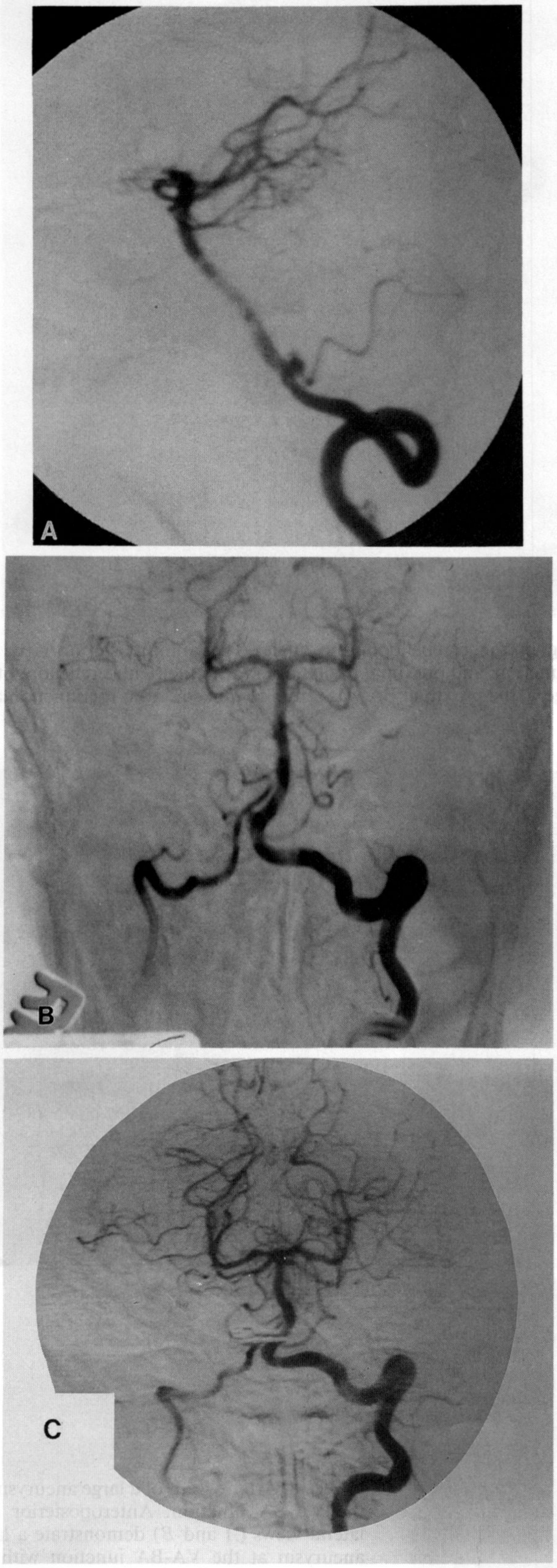

FIG. 6. Arteriogram of a PICA aneurysm clipped from the opposite side. The lateral view (*A*) indicates a typical small PICA aneurysm with the PICA posterior to the sac; however, the anteroposterior view demonstrates that the aneurysm originates from a large and tortuous left VA that has crossed to the right of midline (*B*). Note that the right PICA originates opposite the left PICA and dome of the aneurysm; note also the relation of the left VA to the basilar artery. The postoperative anteroposterior view confirms that the left PICA aneurysm has been clipped from the right side, preserving both PICAs (*C*).

a large aneurysm of the vertebrobasilar (VB) junction forced into the cerebellopontine angle by a vertebral artery that completely crossed the posterior fossa from side to side (Figs. 6 and 7). In using the contralateral approach to a PICA aneurysm, the vertebral artery on the side of the surgery should be traced to its junction with the ipsilateral PICA without any initial regard for the contralateral artery; since the origin of the opposite PICA is often at approximately the same level, retraction of the brain stem can be carried out at this point if necessary and the contralateral aneurysm identified.

Aneurysms of the VB junction are especially treacherous to reach because they are positioned close to the anatomical midline at a relatively high point in the posterior fossa. Yamaura et al. (27) has correlated the risk of serious morbidity for all PICA-VA complex aneurysms with a proximity to the midline of less than 10 mm; another unfavorable prognostic factor is a distance of more than 13 mm from the clivus to the aneurysm. In the latter circumstance, the aneurysm is buried on the ventral aspect of the brain stem and retraction of the medulla may be required to reach it. In both our clinical and our radiographic series, it was somewhat surprising to discover that the mean distance to the midline of PICA-VA aneurysms was less than 9.5 mm, and that three of the four VA-BA aneurysms (as expected) were at the midline (Table 3). In this situation, a tortuous vertebral artery with a high shoulder (Fig. 4) can be helpful, even though the aneurysm must be exposed from the dome side. In dealing with aneurysms of the VB junction, the use of contralateral and translabyrinthine approaches, as well as exposures ipsilateral to the dome, can make distance of the aneurysm to the midline less relevant (7). Experience with VB junction aneurysms is difficult to obtain, owing to their relative rarity. In the most extensive series of aneurysms of the PICA-VA complex, only 1 of 56 saccular lesions was located at the VA-BA junction (26). We have encountered 4 such cases in our clinical series of 17 aneurysms (23.5%), one of which probably arose just proximal to the junction from one of the smaller, unnamed branches of the VA first commented on by Drake (5).

Large and giant aneurysms of the complex are relatively rare; only Drake (4) has a considerable experience with giant aneurysms in this location. In Yamaura's series of 56 saccular cases (26), only 2 were giants; one was a PICA-VA aneurysm and one a VA-BA aneurysm. We have treated one large VA-BA aneurysm (Fig. 8) with four clips and one giant PICA-VA aneurysm with a Drake tourniquet. As of 1988, approximately 10 giant PICA aneurysms had been reported in the literature; one, on the tonsillomedullary segment, was treated by excision and end-to-end anastomosis (14). This technique was first reported by Dolenc (3). Sixty-one aneurysms of the peripheral PICA of any size have been reported as of this writing (11, 14, 15, 25), and we have experience with 3 cases (Fig. 4).

Outcome from surgical repair of PICA aneurysms is reported to be generally good (5, 9, 12, 16, 27, 28) (Table 5). Although we have had no operative deaths, our clinical series has a management mortality of 23.5%. Two patients suffered new bleeding and died before definitive therapy could be instituted, and two others, one a Grade 3 patient and one a Grade 4 patient, died of aspiration pneumonia during the course of their stay at a rehabilitation center, 3 and 6 months after surgery, respectively. One patient is gradually recovering

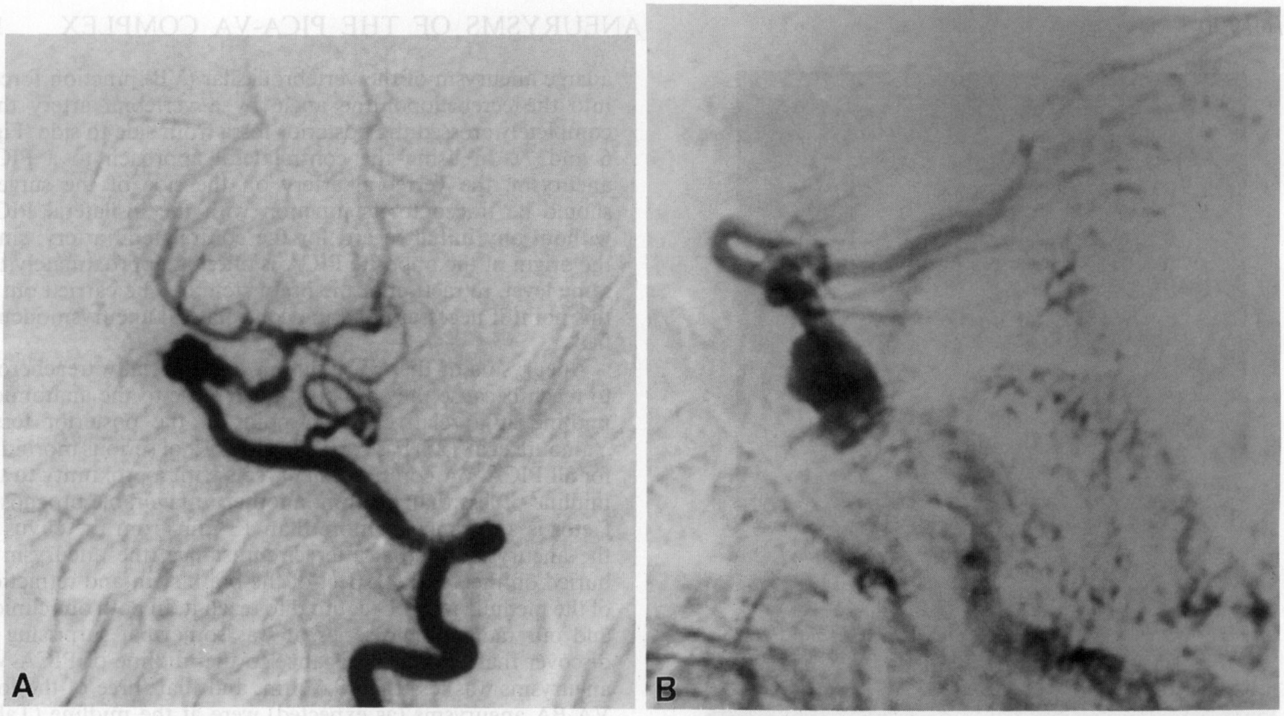

FIG. 7. Arteriogram of an aneurysm of the VA-BA junction presenting in the cerebellopontine angle. The anteroposterior view (*A*) demonstrates that the large and ectatic left VA pushes the aneurysm, VA-BA junction, and proximal basilar artery into the right cerebellopontine angle. The aneurysm and basilar artery overlap on the lateral view (*B*). At surgery, the proximal BA was found to *descend* from the junction and could be mistaken for a VA; the aneurysm was successfully clipped.

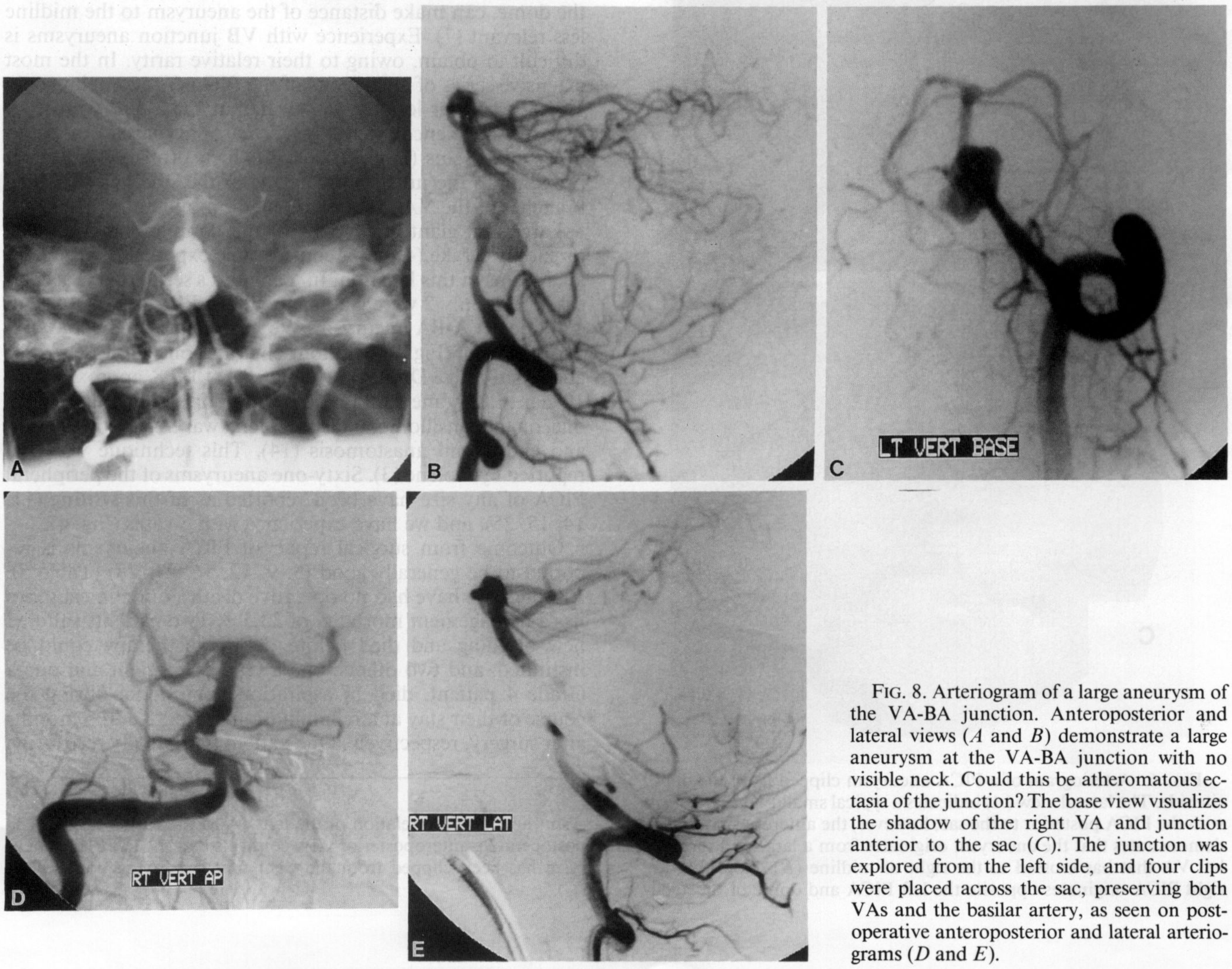

FIG. 8. Arteriogram of a large aneurysm of the VA-BA junction. Anteroposterior and lateral views (*A* and *B*) demonstrate a large aneurysm at the VA-BA junction with no visible neck. Could this be atheromatous ectasia of the junction? The base view visualizes the shadow of the right VA and junction anterior to the sac (*C*). The junction was explored from the left side, and four clips were placed across the sac, preserving both VAs and the basilar artery, as seen on postoperative anteroposterior and lateral arteriograms (*D* and *E*).

TABLE 5
Surgical Outcome

Series (Ref. no.)	Number of Patients	Mortality (%)	Morbidity (%)
Drake, 1979 (5)	65	6.1	
Hudgins, 1983 (9)	21	10	20
Yasargil, 1984 (28)	15		13
Ojemann et al., 1988 (16)	23	13	4.3
Yamaura, 1988 (26)	56	17	
Lee et al., 1989 (12)	14	14	7
Salcman et al., 1990 (present series)	14	14	7

from lower cranial nerve paralysis and hemiparesis secondary to emergency trapping of the vertebral artery after an intraoperative tear of the aneurysm neck. The remaining patients have completely recovered. Our immediate perioperative morbidity (Table 3) and management mortality (Table 2) may reflect the fact that the majority of our patients had aneurysms in Hunt and Hess Grades 3 and 4, a factor associated with higher morbidity and mortality independent of the location of the aneurysm (22).

In summary, aneurysms of the PICA-VA complex, by virtue of their relative rarity, strategic location, and complex anatomy, pose unique diagnostic and technical challenges. In treating patients suspected of subarachnoid hemorrhage whose CT scans are apparently free of abnormalities, special attention should be paid to the fourth ventricle and the possibility of a PICA-VA aneurysm. When the latter is entertained in a new patient or when the initial arteriogram in an SAH suspect is apparently negative, separate injections of each vertebral artery should be made. As compared with aneurysms at other sites, PICA-VA lesions are frequently missed on the initial study and, on rare occasions, must be looked for in extracranial sites. Surgical planning must take into account the observation that the majority of PICA-VA aneurysms are within 7 mm of the anatomical midline and that tortuousness and elongation of the VA may push the aneurysm across the midline. Contralateral approaches to PICA-VA aneurysms should utilize the point of origin of the ipsilateral PICA as an approximate marker to the level of the aneurysm on the opposite side. VA-BA aneurysms can be done through the same elongated "tic" incision as PICA-VA aneurysms, with even more care in the amount of lateral bone removed. VA-BA aneurysms may require gentle retraction of the brain stem for their exposure and can be located by tracing the ipsilateral VA deep to the blood-stained 6th nerve. VA-BA aneurysms should be done on the side of the higher and broader vertebral shoulder, even if this is the dome side of the aneurysm. Preoperative planning for VA-BA aneurysms and large PICA-VA aneurysms should include a contingency plan for possible trapping or vertebral ligation. In this regard, preoperative test occlusions of the VA with an intravascular balloon are especially helpful. In general, the operative results are quite good, and patients should be operated on during the acute phase whenever possible.

Received for publication, October 23, 1989; accepted, January 17, 1990.

Reprint requests: Michael Salcman, M.D., Division of Neurological Surgery, University of Maryland Hospital, 22 South Greene Street, Baltimore, MD 21201.

REFERENCES

1. Beyerl DB, Heros RC: Multiple peripheral aneurysms of the posterior inferior cerebellar artery. Neurosurgery 19:285–289, 1986.
2. Crompton MR: Subtentorial changes following the rupture of cerebral aneurysms. Brain 88:75–84, 1965.
3. Dolenc V: End-to-end suture of the posterior inferior cerebellar artery after the excision of a large aneurysm: Case report. Neurosurgery 11:690–693, 1982.
4. Drake CG: Giant intracranial aneurysms: experience with surgical treatment in 174 patients. Clin Neurosurg 26:12–95, 1979.
5. Drake CG: The treatment of aneurysms of the posterior circulation. Clin Neurosurg 26:96–144, 1979.
6. Fox JL: *Intracranial Aneurysms.* New York, Springer-Verlag, 1983, vols 1 and 2.
7. Giannotta SL, Maceri DR: Retrolabyrinthine transsigmoid approach to basilar trunk and vertebrobasilar artery junction aneurysms. Technical note. J Neurosurg 69:461–466, 1988.
8. Hirschfield A, Flamm ES: Extracranial aneurysm arising from the posterior inferior cerebellar artery. J Neurosurg 54:537–539, 1981.
9. 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 58:381–387, 1983.
10. Krayenbuhl H, Yasargil MG: Variationen der A. Vertebralis, Basilaris und ihrere Äste, in *Die Vaskularen Erkrankungen in Gebiet der Arteria Vertebralis und Arteria Basilaris.* Stuttgart, Thieme Verlag, 1957, p 39.
11. Kusuno K, Yoshida Y, Shibata N, Hayashi T: Three cases of giant aneurysm of the distal posterior inferior cerebellar artery. No Shinkei Geka 14:345–350, 1986.
12. Lee KS, Gower DJ, Branch CL, Kelly DL, McWhorter JM, Bell WO: Surgical repair of aneurysms of the posterior inferior cerebellar artery. A clinical series. Surg Neurol 31:85–91, 1989.
13. Lister JR, Rhoton AL, Matsushima T, Peace DA: Microsurgical anatomy of the posterior inferior cerebellar artery. Neurosurgery 10:170–199, 1982.
14. Madsen JR, Heros RC: Giant peripheral aneurysm of the posterior inferior cerebellar artery treated with excision and end-to-end anastomosis. Surg Neurol 30:140–143, 1988.
15. Nishizaki T, Tamaki N, Nishida Y, Fujita K, Matsumoto S: Aneurysms of the distal posterior inferior cerebellar artery: Experience with three cases and review of the literature. Neurosurgery 16:829–833, 1985.
16. Ojemann RG, Heros RC, Crowell RM: Basilar trunk and vertebral artery aneurysms, in *Surgical Management of Cerebrovascular Disease.* Baltimore, Williams & Wilkins, 1988, ed 2, pp 232–295.
17. Pasqualin A, Pian RD, Scienza R, Licata C: Posterior inferior cerebellar artery aneurysm in the fourth ventricle: Acute surgical treatment. Surg Neurol 16:448–451, 1981.
18. Pelz DM, Vinuela F, Fox AJ, Drake CG: Vertebrobasilar occlusion therapy of giant aneurysms: Significance of angiographic morphology of the posterior communicating arteries. J Neurosurg 60:560–565, 1984.
19. Rizzoli HV, Hayes GJ: Congenital berry aneurysm of the posterior fossa: Case report with successful operative excision. J Neurosurg 10:550–551, 1953.
20. Ruelle A, Cavazzani P, Andrioli G: Extracranial posterior inferior cerebellar artery aneurysm causing isolated intraventricular hemorrhage: A case report. Neurosurgery 23:774–777, 1988.
21. Sundt TM, Piepgras DG, Houser OW, Campbell JK: Interposition saphenous vein grafts for advanced occlusive disease and large aneurysms in the posterior circulation. J Neurosurg 56:205–215, 1982.
22. Sundt TM, Kobayashi S, Fode NC, Whisnant JF: Results and complications of surgical management of 809 intracranial aneurysms in 722 cases related and unrelated to grade of the patient, type of aneurysm, and timing of surgery. J Neurosurg 56:753–765, 1982.
23. Weir B: *Aneurysms Affecting the Nervous System.* Baltimore,

Williams & Wilkins, 1987, pp 489–491.
24. Yamada K, Hayakawa T, Ushio Y, Iwata Y, Koshino K, Bitoh S, Takimoto N: Therapeutic occlusion of the vertebral artery for unclippable vertebral aneurysm: Relationship between site of occlusion and clinical outcome. Neurosurgery 15:834–838, 1984.
25. Yamamoto I, Tsugane R, Ohya M, Sato O, Ogura K, Hara M: Peripheral aneurysms of the posterior inferior cerebellar artery. Neurosurgery 15:839–845, 1984.
26. Yamaura A: Diagnosis and treatment of vertebral aneurysms. J Neurosurg 69:345–349, 1988.
27. Yamaura A, Ise H, Makino H: Radiometric study on posterior inferior cerebellar aneurysms with special reference to accessibility by the lateral suboccipital approach. Neurol Med Chir (Tokyo) 21:721–723, 1981.
28. Yasargil MG: Vertebrobasilar aneurysms, in *Microneurosurgery.* New York, Thieme-Stratton, 1984, vol 2, pp 232–295.
29. Yeh HS, Tomsick TA, Tew JM Jr: Intraventricular hemorrhage due to aneurysm of the distal posterior inferior cerebellar artery. Report of three cases. J Neurosurg 62:772–775, 1985.

COMMENTS

This is a very good review of aneurysms of the posterior inferior cerebellar artery (PICA), distal vertebral artery, and vertebrobasilar junction. It should be noted that the authors have had relatively good results, considering that a significant number of these patients were in poor condition preoperatively.

Some comments in reference to the surgical approach to distal vertebral and vertebrobasilar aneurysms are warranted, not as criticisms, but rather with the intention to supplement the information contained in this paper. I would agree that the majority of aneurysms of the PICA–vertebral artery complex can be approached through a standard lateral suboccipital craniectomy without resection of bone at the foramen magnum. We have found it considerably safer, however, to trace the vertebral artery up from its entrance through the dura, working from below the lower cranial nerves. This can only be accomplished by removing the bone in the region of the foramen magnum and, as we have described, by also removing part of the arch of C1 (1). By working from below, one can follow the vertebral artery through the clot frequently encountered when one comes from a more superior direction. Also, one is less likely to come upon the dome of the aneurysm by following the vertebral artery along its axis by working from below. In addition, by working from below, one can routinely avoid injury to the 7th–8th nerve complex, which occurs with some frequency if one works from a more superior direction. These advantages are particularly important when dealing with more distal vertebral aneurysms and with aneurysms of the vertebrobasilar junction. The closer these lesions are to the midline, the more cerebellar retraction is required if one works from superiorly through a standard lateral suboccipital craniectomy. Also, the 7th–8th nerve complex and the 6th nerve are invariably in the way, and in the immediate direction of clip application when one works from above. By removing the lateral portion of the foramen magnum all the way to the condyle and the arch of C1 all the way to the vertebral artery on the ipsilateral side, one is always working below these sensitive cranial nerves and below the cerebellum, which needs only a minimal amount of medial and upward retraction. It is difficult to avoid some brain stem retraction with midline aneurysms, but again, this can be minimized by coming from below, since the medulla is significantly thinner than the pons.

Using this far lateral inferior suboccipital approach, we did not encounter any instances of permanent cranial nerve damage in a series of 24 patients that included 7 with aneurysms at the vertebrobasilar junction (Ref. 16). We had our share of temporary lower cranial nerve difficulties, which fortunately resolved in time. It is almost impossible to deal with these aneurysms without having to mobilize and dissect free of arachnoid the lower cranial nerves, but fortunately, with good early postoperative respiratory care, most of these patients recover completely. The one approach that may take the surgeon lateral enough to be in front of the lower cranial nerves is the retrolabyrinthine transsigmoid approach advocated by Giannotta and Maceri (Ref. 7). I have had no personal experience with this approach for aneurysms, but I have been impressed enough with the logic of this approach that I will probably try it the next time I encounter one of these lesions at the vertebrobasilar junction.

The authors have made a number of important points with which I agree fully: The diagnosis of these aneurysms can be missed because the hemorrhage is frequently confined to the posterior fossa or fourth ventricle, and therefore, the initial computed tomographic scan may not suggest a typical subarachnoid hemorrhage. Both vertebral arteries must be injected if one is to detect the rare distal PICA aneurysms that the authors describe and that we have recently discussed (Ref. 1). The PICA can be sacrificed distal to the choroidal point, but if the lesion is more proximal and it cannot be clipped, an end-to-end anastomosis or a distal bypass should be performed to save the important supply of the PICA to the deep ganglia of the cerebellum and to the brain stem (Refs. 3 and 14). Early surgery should be considered for all the more peripheral aneurysms of the vertebral artery such as those arising from the area of origin of the PICA and for distal PICA aneurysms; the retraction required for these aneurysms is minimal, and there is no reason to delay surgery. We do delay surgery for aneurysms of the vertebrobasilar junction because they may require some retraction of the brain stem, which is not ideal during the acute stage. It may be that with the retrolaybrinthine approach, early operation should be considered, since there is little need for brain stem retraction.

Once again, this is an excellent review of this subject, and our minor differences in surgical approach indicate only that these lesions are rare enough that the surgical approach to them has not yet been standardized.

Roberto C. Heros
Minneapolis, Minnesota

1. Heros RC: Lateral suboccipital approach for vertebral and vertebro-basilar artery aneurysms. J Neurosurg 64:559–562, 1986.

The authors are to be congratulated on an excellent review of their experience with aneurysms of the posterior inferior cerebellar artery–vertebral artery complex. The series demonstrates well the complex problems associated with managing these lesions. Even excluding the two patients who had new episodes of bleeding and died prior to definitive treatment, the overall treatment, morbidity, and ultimate mortality rate serve to emphasize the challenge associated with treating aneurysms in this location. Undoubtedly, a majority of these patients will have initial transient postoperative cranial neurological deficits. Fortunately, the vast majority of those deficits will clear over the subsequent 4 to 6 weeks. The bibliography submitted with the article allows an excellent review and supplement to the authors' paper. I would especially urge anyone preparing to approach an aneurysm in this region who has not operated on a number of these lesions recently to review in detail several of the papers mentioned.

The authors make an especially good point in noting how often these aneurysms are not adequately appreciated during the initial workup. Indeed, it is common to require additional angiographic study for the final precise preoperative delineation of these lesions, since so often one under-appreciates the size and complexity on the initial study. Moreover, since many of these lesions are associated with multiple aneurysms, they will occasionally change in appearance and size following treatment of another symptomatic aneurysm more distally. We recently had a case in which a smaller, almost insignificant, asymptomatic PICA aneurysm seemingly enlarged significantly and became multilobular over a 2-week period after successful clipping of a ruptured aneurysm of the basilar artery bifurcation.

The admonition given eloquently by Dr. Drake in his talk concerning aneurysms in this region, in which he deals with the necessity of careful dissection and separation of the clip from the frequently adjacent and often covering cranial nerves, cannot be stressed too highly if permanent deficits are to be avoided. It is so easy during aneurysm clipping in this region inadvertently and permanently to injure the adjacent cranial nerves. As the authors point out, use of the Sugita or Yasargil ring clip is especially helpful with aneurysms of the PICA-VA complex, even in the absence of giant aneurysms, since these clips add so much flexibility to clipping of an awkward, almost fusiform type aneurysm.

Again, the authors are to be congratulated on an informative review of their series of cases of aneurysms in this location. Although we commonly think of aneurysms of the the basilar artery bifurcation and trunk aneurysms as being more difficult, some of the PICA region aneurysms can be incredibly difficult and challenging.

Eugene D. George
Washington, District of Columbia