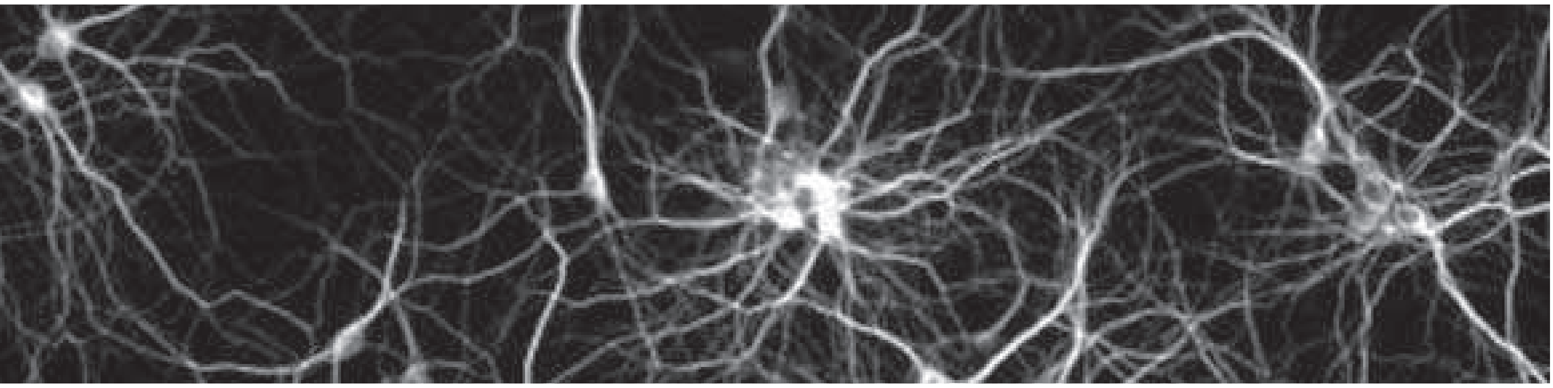

Vertebrobasilar junction aneurysm: surgical treatment *via* far lateral transcondylar approach

D. Štimac, N. Koruga, [1]L. N. Sekhar

ABSTRACT - *Aim of the study:* To present a case of successful microsurgical clipping of the aneurysm within the fenestrated vertebrobasilar junction *via* far lateral transcondylar approach.
Background: Surgical treatment of low basilar aneurysm and vertebrobasilar (VB) junction remains one of the most challenging and most difficult procedures in neurosurgery. Saccular aneurysms of the VB junction are often associated with a fenestration of the basilar artery. Endovascular procedures are performed for the treatment of such aneurysms, but may be difficult in some cases.
Case description: A case is presented of a 53-year-old patient with VB junction aneurysm that was microsurgically clipped successfully *via* far lateral transcondylar approach. The patient was discharged from the hospital fully recovered 10 days after the surgery.
Conclusion: The far lateral approach adequately exposed the VB junction aneurysm for successful clipping of the aneurysm and was associated with no morbidity. It should be considered as a good alternative to endovascular treatment. In developing countries, the microsurgical procedure may be given preference because it is less expensive and does not require preoperative intra-arterial digital subtraction angiography or follow up.

Key words: vertebrobasilar junction aneurysm, far lateral transcondylar approach, transbasal approach, skull base approach, microneurosurgery

INTRODUCTION

Aneurysms of posterior circulation account for 8% to 10% of all intracranial aneurysms. One half of these are located at the basilar tip, and the rest at other locations of the posterior circulation. Aneurysms of the vertebrobasilar (VB) junction account

University Department of Neurosurgery, Osijek University Hospital Center, School of Medicine, Osijek, Croatia
[1]Department of Neurological Surgery, Harborview Medical Center, University of Washington, Seattle, WA, USA

for 1%-2% of all intracranial aneurysms (1,2). These lesions are surgically challenging for the following reasons: the depth of exposure, the space limited by surrounding bone and brainstem, ventral location to the pontomedullary junction, and the arterial anatomy that often includes a fenestration of the basilar artery, with difficulties in getting proximal and distal control, make the task of adequate exposure and clipping difficult. Early attempts at surgical treatment of these lesions have been discouraging, associated with significant mortality and morbidity. Advances in microneurosurgery, anesthesia, critical care, instrumentation, and the 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 (3,4), transpetrous (5,6), and far-lateral approaches (7-10). 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, labyrinth, cerebrospinal fluid (CSF) leakage, occlusion of the eustachian tube, and cosmetic deformities.

CASE REPORT

A 53-year-old man, previously healthy, presented for the onset of severe headache, vertigo, nausea, vomiting, back pain and right-sided weakness followed by the loss of consciousness. He was admitted to Department of Infectious Diseases for suspected meningitis. Computed tomography (CT) scan revealed extensive subarachnoid hemorrhage and hemorrhage into the fourth ventricle, but without hydrocephalus. Computed tomography angiography (CTA) demonstrated a saccular VB junction aneurysm 7 mm in diameter with a 5-mm neck. The aneurysm projected ventrally toward the clivus (Fig. 1 A,B). The associated fenestration was not clearly apparent on initial angiogram. The patient was diagnosed as having subarachnoid hemorrhage grade IV (Hunt and Hess grading system) and was transferred to Department of Neurology. His initial management included sedation and control of blood pressure. Nimodipine was administered parenterally. He gradually improved and 10 days later, he was transferred to Department of Neurosurgery and underwent surgery for aneurysm clipping *via* far lateral transcondylar approach. The VB junction aneurysm was clipped uneventfully. Postoperatively there was no CSF leak or pseudomeningocele.

Far lateral transcondylar approach

The far lateral transcondylar approach was used to access the aneurysm in this case. The essential steps employed are briefly delineated below.

Positioning and skin incision: The patient was placed in lateral position and the head was held in three-point pins with the neck slightly flexed, the vertex angled slightly down, and the face rotated slightly ventrally, so that the ipsilateral external auditory meatus and the mastoid bone were the highest point. Positioning the head in this manner allowed for better exposure of the occipito-cervical region

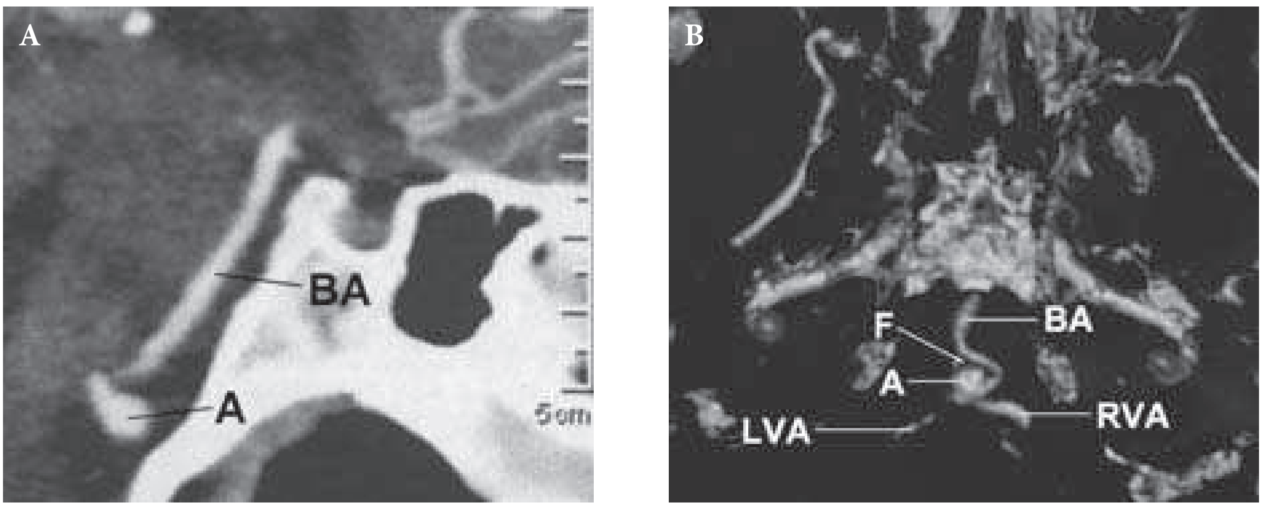

Fig. 1. *(A) Preoperative CT angiography: saccular aneurysm of the VB junction pointed ventrally towards the clivus; BA, basilar artery, A, aneurysm; (B) ventrally projected aneurysm of the vertebrobasilar junction. Note that the aneurysm is within the proximal portion of the fenestration. Fenestration of basilar artery was not clearly visible; BA, basilar artery; A, aneurysm; LVA, left vertebral artery; RVA, right vertebral artery; F, fenestration.*

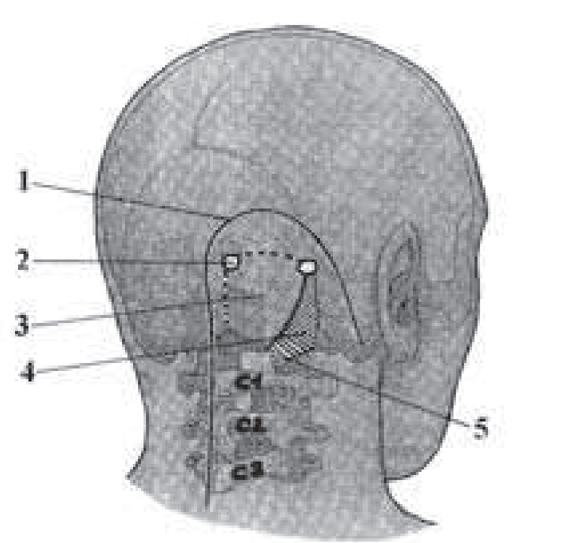

Fig. 2. *Drawing showing plan for surgical procedure: 1 – 'hockey stick' skin incision started from the mastoid tip; 2 – burr holes placed just below the superior nuchal line; 3 – a "tear drop" bone flap after osteoplastic craniotomy; 4 – the area where osteoclastic craniotomy was performed; 5 – medial and posterior 1/3 of the occipital condyle was removed.*

and improved the inferior-to-superior viewing angle for the surgeon. An axillary roll was placed and the patient's contralateral arm rested on a Krauss armrest. The elevated arm was distracted inferiorly toward the foot of the table to provide more room for the surgeon to maneuver above the shoulder. All pressure points were carefully padded with gel pads. The patient was carefully secured to the operating table to allow for safe rotation of the table during the operation when needed to improve the surgeon's line of sight. Intravenous glucocorticoid agents, antibiotic drugs, and mannitol were administered at the time of skin incision.

A retroauricular 'hockey stick' skin incision started approximately 1 cm above the mastoid tip, continued superiorly to the level of superior nuchal line, then turned vertically towards the midline, and extended to the level of the spinous process of C4 vertebra (Fig. 2). The skin and the muscle layer were elevated in one layer and rolled laterally. The muscle layer consisted of the trapezius and sternocleidomastoid muscle, splenius capitis, longissimus capitis and semispinalis capitis, and in the deepest layer of rectus capitis posterior major, inferior oblique and superior oblique muscles. The suboccipital triangle, which involves the dorsal ramus of the C-1 nerve root and the horizontal segment of VA (V3), was opened by detaching the insertions of the superior and inferior oblique muscle from the transverse process of C-1 and reflecting them posteriorly. Then the C-1 lamina and VA became more apparent. The VA was covered by venous plexus (sometimes referred to as the suboccipital venous sinus) (11).

Exposure of the extradural VA: Exposure and control of the extradural VA is important and was achieved by identifying its extradural course from the foramen transversarium of C-2 to the occiput. The ventral ramus of the C-2 nerve root, which was found between the laminae of C-1 and C-2, was traced laterally until it crossed dorsally to the vertical segment of the VA, coursing between the foramen transversarium of C-2 and C-1 (7,12,13). As the VA exits the foramen transversarium of C-1, it was encased in a venous plexus and coursed posteriorly behind the lateral mass of C-1 in the vertebral groove, then turned medially to pierce the atlanto-occipital membrane and dura mater. Several muscular branches and the posterior meningeal artery arise from the horizontal segment of the VA, which can be safely coagulated. In rare cases, the posterior spinal artery and posterior inferior cerebellar artery can arise extradurally and can potentially be injured (7,14). Subperiosteal dissection of the VA from the vertebral groove reduced bleeding from the venous plexus by leaving the periosteal sheath around the artery intact (15). However, venous bleeding from the vertebral or epidural plexus can be controlled by the injection of fibrin glue (16). The atlanto-occipital membrane was sharply divided to expose the underlying dura mater.

Suboccipital craniectomy and C-1 hemilaminectomy: Lateral suboccipital craniectomy was initially performed with a high-speed drill and rongeurs (Fig. 2). The craniectomy extended toward the midline medially and to the inferior nuchal line superiorly, to the posterior rim of the foramen magnum inferiorly, and up to the occipital condyle laterally (Fig. 3 A,B). To prove more superior access to the CPA, the craniectomy was extended up to the transverse-sigmoid junction. The sigmoid sinus and jugular bulb were exposed with rongeurs and high-speed drill. The posterior condylar emissary vein was encountered as it travels from the jugular bulb and exits the condylar fossa through the condylar canal to join the extradural venous plexus. Hemostasis was achieved by packing the vein with Surgicel. Ipsilateral hemilaminectomy of C-1 improved the dural exposure inferiorly.

Transcondylar resection: Extradural resection of the occipital condyle is one of the key maneuvers in maximizing exposure to the ventral aspect of the craniovertebral junction while avoiding brainstem

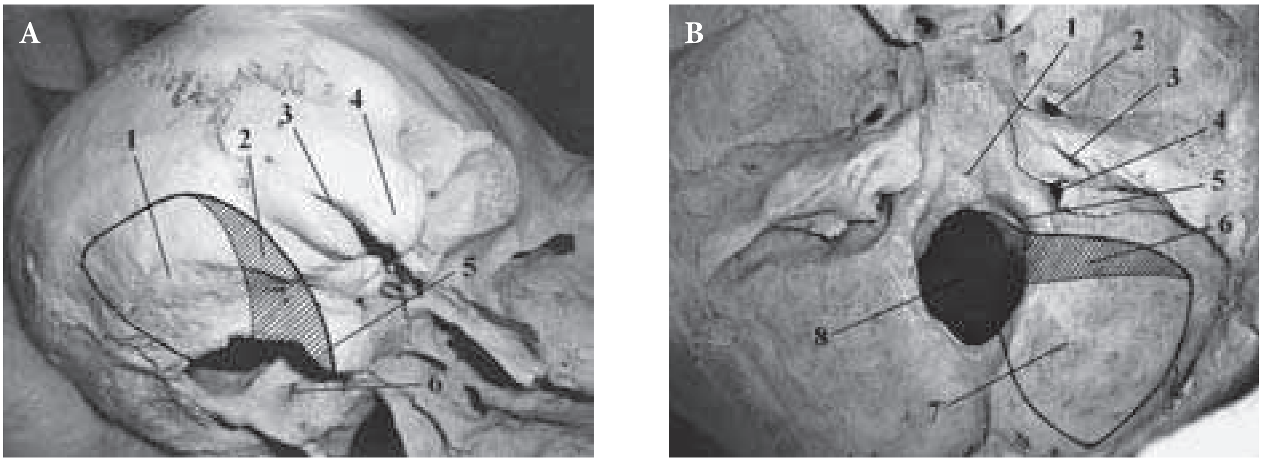

Fig. 3. *(A) Anatomical drawings: surface anatomy and landmarks for the far lateral transcondylar approach. View of the outer surface of the skull: 1 – a "tear-drop" osteoplastic craniotomy; 2 – craniotomy was extended laterally and ventrally by using high-speed drill and rongeurs; 3 – mastoid notch; 4 – right mastoid tip; 5 – partially resected right occipital condyle; 6 – hypoglossal canal on the contralateral side; (B) view of the inner surface of the skull: 1 – location of the aneurysm in our patient; 2 – oval foramen; 3 – internal auditory meatus; 4 – jugular foramen; 5 – right hypoglossal canal; 6 – area of the osteoclastic craniotomy, which included removal of medial 1/3 of the right condylar process; 7 – the area of "tear-drop" osteoplastic craniotomy; 8 – foramen magnum.*

retraction. Partial condylar resection increases the angle of exposure, the working space at the level of the foramen magnum, and visualization of both the ventral and ventrolateral aspects of the craniovertebral junction and the contralateral aspects of the inferior clivus (10,17-24). For intradural lesions, resection of a third to half of the condyle is adequate (8,20,25-30). We removed the posterior and medial third of the condyle. If 50% or more of the condyle is resected or has been destroyed by the lesion, the instability of the craniovertebral junction increases and occipito-cervical stabilization should be strongly considered (31). Although extradural and intraduaral resection of the jugular tubercle aids in maximizing the intradural exposure across the anterior surface of the brainstem and mid-clivus, this maneuver was not necessary in our case.

Intradural exposure: A curvilinear incision of the dura mater was made several millimeters posteriorly to the sigmoid sinus, extending inferiorly toward the C-2 lamina, staying posterior to the VA where it approaches the dura. A dural cuff was preserved around the VA for later watertight closure. The anterior leaflet of dura mater was reflected laterally and held with tacking sutures for maximal exposure. Adequate reduction of the occipital condyle should provide a straight surgical trajectory to the craniovertebral junction in parallel to the intracranial course of the VA (10,17,32,33). The ligamentum denticulatum was cut in order to facilitate the spinomedullary junction to fall back for further exposure if necessary. These maneuvers, along with CSF drainage and administration of mannitol, sufficiently slackened the brain to offer adequate space without significant retraction of the brain. Sharp arachnoid dissection was performed and the following structures were visualized: the

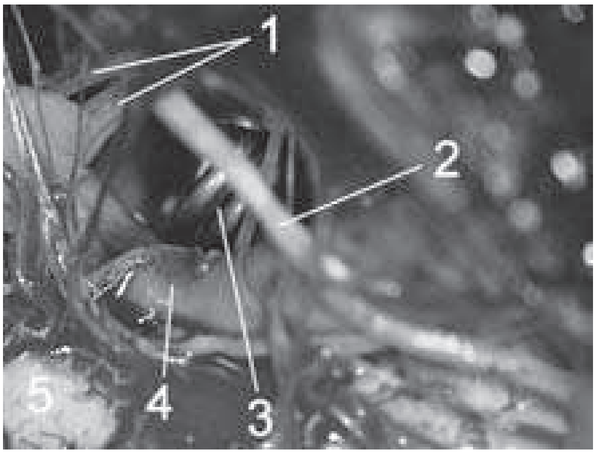

Fig. 4. *Intraoperative microphotography: with the condyle partially drilled, the intradural exposure is much more flat and direct. The first dentate ligament is being divided to uncover the intradural vertebral artery; 1 – roots of the glossopharyngeal and vagus nerve; 2 – spinal root of the right accessory nerve; 3 – titanium vascular clip (spring) in place; 4 – right vertebral artery; 5 – brainstem. Hypoglossal rootlets emerging anteriorly to the olive and coursing toward the hypoglossal canal, located just above the occipital condyle. Note the wide triangular surgical space between the eleventh and ninth/tenth nerve complex.*

Fig. 5. *On postoperative day 3, the patient was able to feed himself; one day later the patient started to walk with the nurse's help, and on postoperative day 5, he walked independently.*

Fig. 6. *Postoperative CT angiography shows gross complete occlusion of the aneurysm and fenestration of the basilar artery; BA, basilar artery; F, fenestration of the basilar artery; LVA, left vertebral artery; RVA, right vertebral artery.*

fifth through 12th cranial nerves; the basilar artery; the VA; the VB junction; the posterior inferior cerebellar artery (PICA); and the anterior inferior cerebellar artery (AICA). The VA was followed superiorly to expose the VB junction and the proximal basilar artery to define the neck of the aneurysm. The aneurysm arose at the site of a fenestration of the basilar artery. Once the aneurysmal neck was identified, the right VA was temporally clipped for 3 minutes. Complete occlusion of the aneurysm neck was performed by use of straight titanium vascular clip, with strict adherence to microsurgical technique and preservation of all cranial and spinal nerves and vascular structures (Fig. 4).

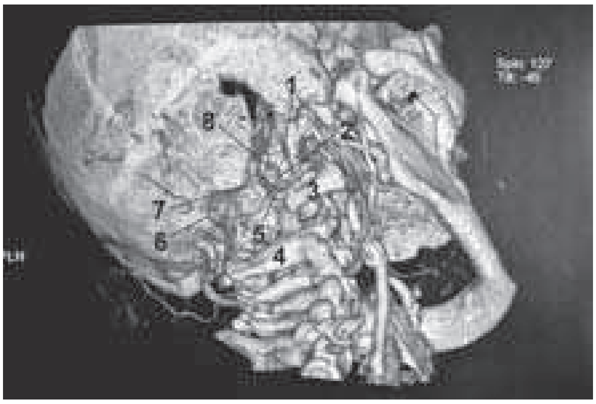

Fig. 7. *Postoperative 3D CT scan of the skull:*
1 – partially resected right occipital condyle;
2 – titanium vascular clip (spring) in place;
3 – resected posterior arch of the C1 vertebra;
4 – lamina of the C2 vertebra; 5 – right (dominant) vertebral artery; 6 – posterior rim of the foramen magnum; 7 – left (non-dominant) vertebral artery;
8 – basilar artery fenestration.

Wound closure: A primary watertight closure of the dura mater was performed. An autologous pericranial graft was harvested from the neck wound. This was supplemented with autologous fat and fibrin glue. The exposed mastoid air cells were closed with bone wax. The muscle layers were carefully reapproximated to avoid postoperative cerebrospinal fluid leakage. The patient continued to improve and on postoperative day 10 he was transferred to a rehabilitation facility with a GCS 15 (Fig. 5). The patient remained asymptomatic at 6-month clinical follow up, fully recovered, without any neurologic deficit. On follow up CT and MR angiography, there was no sign of aneurysm. The basilar artery fenestration was clearly visible (Figs. 6 and 7).

DISCUSSION

Aneurysms of the lower basilar artery and VB junction are uncommon but when present, they often are associated with a fenestration of the basilar artery. They account for 1%-2% of all intracranial aneurysms (1,2). Vertebrobasilar junction aneurysms are frequently associated with fenestration (34). The typical origin of the VB junction aneurysm is at the proximal portion of the fenestration (35-38). The incidence of fenestration when a vertebrobasilar junction aneurysm is present is reported to be 35.5% (39). The complex hemodynamics that exists within these aneurysms makes them difficult for endovascular treatment. Endovascular treatment is frequently associated with residual aneurysm and thrombosis in the limb of fenestration (39,40). The complex anatomy of this region includes multiple small perforating arteries to the brain stem and multiple lower cranial nerves. Due to the rarity of these aneurysms, few neurosurgeons have gained significant experience with them and most reports consist of small groups of patients (1,3,41-44). 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 cranial nerves. Therefore, these aneurysms have been notorious as the most difficult to treat. The suboccipital approach carries the risk of injury to the 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. These are the anterior-transclival (3,4), the lateral transpetrosal (41-43), and the posterior far-lateral approaches (10,17,42). With the evaluation of surgical techniques and instrumentation, operative mortality has been considerably reduced, while operative results have significantly improved when compared with the natural history of these aneurysms.

Cost considerations

In patients who are treated in developing countries, the cost of treatment should also be taken into account. Endovascular aneurysm treatment requires a sophisticated biplane angiography suite, and personnel trained to operate and maintain that unit. Additionally, the coils used for aneurysm treatment are more expensive than aneurysm clips. Patients who undergo endovascular treatment require pretreatment intra-arterial digital subtraction angiography (IADSA) and follow up studies, usually at 6 months and 18 months, when further treatment may be needed. In contrast, nowadays, microsurgical treatment can be rendered in many patients without IADSA, when a good quality CT angiography is available. Additionally, the recurrence rate after complete microsurgical aneurysm occlusion is very low, and follow up by CTA is adequate to evaluate for recurrences. If the microsurgical treatment can be provided with good outcome and in a cost-effective manner, it has some advantages over endovascular techniques.

CONCLUSION

Aneurysms of the VB junction present a formidable surgical challenge and are associated with significant mortality with traditional neurosurgical approaches. Among the skull base approaches, the extreme lateral partial transcondylar approach (with jugular tubercle resection as needed) carries lower morbidity while providing excellent exposure, and a low risk of CSF leakage. Attempts continue to refine skull base approaches and define the type of aneurysms that could be treated by the minimalistic approach with a low risk of morbidity. Vertebrobasilar junction aneurysms are frequently associated with fenestration. The complex hemodynamics that exists within these aneurysms makes them difficult for endovascular treatment, which may be more expensive in developing countries. Our experience has shown that it is possible to clip small or medium-sized aneurysms of the VB junction *via* the far lateral transcondylar approach with a low risk of morbidity and mortality.

ACKNOWLEDGMENT

The first author (D.Š.) expresses great appreciation to Professor Ivo Jeličić, MD, PhD, pioneer of microneurosurgery in Croatia and former Yugoslavia, for his review of the article and useful suggestions.

REFERENCES

1. Hamilton MG, Fleetwood IG, Spetzler RF. Surgical management of midbasilar and lower basilar aneurysms. In: Schmidek HH, Roberts DW, eds. Operative Neurosurgical Techniques. 5th ed. Philadelphia: Saunders Elsevier, 2006,1192-1208.
2. Locksley HB. Report on the cooperative study of intracranial aneurysms and subarachnoid hemorrhage. Section V, Part 1. Natural history of subarachnoid hemorrhage, intracranial aneurysms and arteriovenous malformations. Based on 6368 cases in the cooperative study. J Neurosurg 1996; 25: 219-39.
3. Crockard HA, Sen CN. The transoral approach for the management of intradural lesions at the craniovertebral junction: review of 7 cases. Neurosurgery 1991; 28: 88-98.

4. Archer DJ, Young S, Uttley D. Basilar aneurysms: a new transclival approach via maxillotomy. J Neurosurg 1987; 67: 54-8.

5. Miller CG, van Loveran HR, Keller JT, Pensak M, El-Kalliny M, Tew JM. Transpetrosal approach: surgical anatomy and technique. Neurosurgery 1993; 33: 461-9.

6. Spetzler RF, Hamilton MG, Daspit CP. Petroclival lesions. Clin Neurosurg 1994; 41: 62-82.

7. Rhoton AL. The far-lateral approach and its transcondylar, supracondylar, and paracondylar extensions. Neurosurgery 2000; 47 suppl 1: 195-209.

8. Sen CN, Sekhar LN. An extreme lateral approach to intradural lesions of the cervical spine and foramen magnum. Neurosurgery 1990; 27: 197-204.

9. Bertalanffy H, Seeger W. The dorsolateral, suboccipital, transcondylar approach to the lower clivus and anterior portion of the craniocervical junction. Neurosurgery 1991; 29: 815-21.

10. Sekhar LN, Kalavakonda C. Cranial base approaches to aneurysms. In: Sekhar LN, Fessler RG, eds. Atlas of neurosurgical techniques. 1st ed. New York- Stuttgart: Thieme, 2006, 193-211.

11. Arnautović KI, Al-Mefty O, Pait TG, Krisht AF, Husain MM. The suboccipital cavernous sinus. J Neurosurg 1994; 86: 315-16.

12. Al-Mefty O, Borba LA, Aoki N, Angtuaco E, Pait TG. The transcondylar approach to extradural nonneoplastic lesions of the craniovertebral junction. J Neurosurg 1996; 85: 735-6.

13. Fukushima T, Day JD, Hirahara K. Extradural total petrous apex resection with trigeminal translocation for improved exposure of the posterior cavernous sinus and petroclical region. Skull Base Surg 1996; 6: 95-103.

14. Wen HT, Rhoton AL Jr., Katsuta T, Oliveira ED. Microsurgical anatomy of the transcondylar, supracondylar, and paracondylar extensions of the far-lateral approach. J Neurosurg 1997; 87: 555-85.

15. Kawashima M, Tanriover N, Rhoton AL Jr, Ulm AJ, Matsushima T. Comparison of the far lateral and extreme lateral variants of the atlanto-occipital transarticular approach to anterior extradural lesions of the craniovertebral junction. Neurosurgery 2003; 53: 662-75.

16. Sekhar LN, Natarajan SK, Manning T, Bhagawati D. The use of fibrin glue to stop venous bleeding in the epidural space, vertebral venous plexus, and anterior cavernous sinus: technical note. Neurosurgery 2007; 61 suppl 3: E51.

17. Sekhar LN, Tzortzidis F, Salas EJ. Extreme lateral retrocondylar and transcondylar approaches and combined approaches. In: Sekhar LN, De Oliveira E, editors. Cranial microneurosurgery – approaches and techniques. 1st ed. New York: Thieme, 1997, 464-81.

18. Ziyal IM, Salas E, Sekhar LN. The surgical anatomy of six variations of extreme lateral approach. Turk Neurosurg 1999; 9: 105-12.

19. Dowd GC, Zeiller S, Awatashi D. Far lateral transcondylar approach: dimensional anatomy. Neurosurgery 1999; 45: 95-100.

20. Spektor S, Anderson GJ, McMenomey SO, Horgan MA, Kellogg JX, Delashaw JB Jr. Quantitative description of the far-lateral transcondylar transtubercular approach to the foramen magnum and clivus. J Neurosurg 2000; 92: 824-31.

21. Wanebo JE, Chicoine MR. Quantitative analysis of the transcondylar approach to the foramen magnum. Neurosurgery 2001; 49: 934-43.

22. Gonzales-Portillo G, Coscarella E, Heros RC, Morcos JJ. Vertebrobasilar junction and vertebral artery aneurysm. In: Sekhar LN, Fessler RG, eds. Atlas of neurosurgical techniques. 1st ed. New York-Stuttgart: Thieme, 2006, 181-92.

23. Hakuba A, Tsujimoto T. Transcondyle approach for foramen magnum meningiomas. In: Sekhar LN, Janecka IP, eds. Surgery of Cranial Base Tumors. 1st ed. New York: Raven Press, 1993, 671-8.

24. Hammon WM, Kempe LG. The posterior fossa approach to aneurysms of the vertebral and basilar arteries. J Neurosurg 1972; 37: 339-47.

25. Babu RP, Sekhar LN, Wright DC. Extreme lateral transcondylar approach: technical improvements and lesions learned. J Neurosurg 1994; 81: 49-59.

26. Nanda A, Vincent D, Vannereddy PSS, Baskaya MK, Chanda A. Far-lateral approach to intradural lesions of the foramen magnum without resection of the occipital condyle. J Neurosurg 2002; 96: 302-9.

27. Salas E, Sekhar LN, Ziyal IM, Caputy AJ, Wright DC. Variations of the extreme-lateral craniocervical approach: anatomical study and clinical analysis of 69 patients. J Neurosurg 1999; 90: 206-19.

28. Sen C. The transcondylar approach to the lower clivus, foramen magnum and C1-C2. Clin Neurosurg 1996; 43: 113-26.

29. Vishteh AG, Crawford NR, Melton MS, Spetzler RF, Sonntag VK, Dickman CA. Stability of the craniovertebral junction after unilateral occipital condyle resection: a biomechanical study. J Neurosurg 1999; 90: 91-8.

30. Sen CN, Sekhar LN. Surgical management of anteriorly placed lesions at the craniocervical junction – an alternative approach. Acta Neurochir (Wien) 1991; 108: 70-7.

31. Day JD, Fukushima T, Giannotta SL. Cranial base approaches to posterior circulation aneurysms. J Neurosurg 1997; 87: 544-54.

32. Osborn RE, Kirk G. Cerebral artery fenestration. Comput Radiol 1987; 11: 141-5.

33. Becker DH, Hamilton RD. Saccular aneurysm associated with fenestrated basilar artery: case report. Neurosurgery 1979; 5: 695-7.

34. Drake CG. The surgical treatment of aneurysms of the basilar artery. J Neurosurg 1968; 29: 436-47.

35. Graves VB, Strother CM, Weir B, Duff TA. Vertebrobasilar junction aneurysms associated with fenestration: treatment with Guglielmi detachable coils. AJNR 1996; 17: 35-40.

36. Hoffman WF, Wilson CB. Fenestrated basilar artery with associated saccular aneurysm. J Neurosurg 1979; 50: 262-4.

37. Cloft HJ, Dion JE. Endovascular technique of treating aneurysms. In: Sekhar LN, Fessler RG, eds. Atlas of neurosurgical techniques. 1st ed. New York-Stuttgart: Thieme, 2006, 222-8.

38. Matricali B, van Dulken H. Aneurysm of fenestrated basilar artery. Surg Neurol 1981; 15: 189-91.

39. Kawase T, Toya S, Shiobara R, Mine T. Transpetrosal approach for aneurysms of the lower basilar artery. J Neurosurg 1985; 63: 857-61.

40. Sekhar LN, Kalia KK, Yonas H, Wright DC, Ching H. Cranial base approaches to intracranial aneurysms in the subarachnoid space. Neurosurgery 1994; 35: 472-83.

41. Giannotta SL, Maceri DR. Retrolabyrinthine transsigmoid approach to basilar trunk and vertebrobasilar artery junction aneurysms. J Neurosurg 1988; 69: 461-6.

42. Solomon RA, Fink ME, Lennihan L. Early aneurysm surgery and prophylactic hypervolemic hypertensive therapy for the treatment of aneurysmal subarachnoid hemorrhage. Neurosurgery 1988; 23: 699-704.

43. Fox JL. Obliteration of midline vertebral artery aneurysm via basilar craniectomy. J Neurosurg 1967; 26: 406-12.

44. Heros RC. Lateral suboccipital approach for vertebral and vertebrobasilar artery lesions. J Neurosurg 1986; 64: 559-62.

Address for correspondence: Prof. Dinko Štimac, MD, PhD, Klinika za neurokirurgiju Kliničkog bolničkog centra Osijek Medicinskog fakulteta Sveučilišta „J. J. Strossmayer“, J. Huttlera 4, 31000 Osijek, Hrvatska; e-mail: dinkostimac@hotmail.com