Extreme Lateral Approach to Ventral and Ventrolaterally Situated Lesions of the Lower Brainstem and Upper Cervical Cord

C.V. Ravi Kumar, M.Ch.,¹ Satish Satyanarayana, M.Ch.,¹
B. Ravi Mohan Rao, M.Ch.,¹ and Ravikanth S. Palur, M.Ch.¹

ABSTRACT

Lesions situated ventrally and ventrolaterally to the lower brainstem and upper cervical spinal cord test the skills of neurosurgeons. We present our experience with eight such patients who underwent the extreme lateral craniocervical approach. The pathologies encountered include three distal vertebral aneurysms, one prepontine epidermoid, one anterior foramen magnum meningioma, and three high cervical dumbbell neurofibromas. All lesions were treated effectively. Postoperatively, the patients improved significantly. Complications included transient lower cranial nerve paresis in three patients, meningitis in one patient, and a pseudomeningocele in two patients. All complications improved with therapy. We conclude that the extreme lateral approach offers excellent visualization and access with minimal neural retraction for treating these difficult lesions.

KEYWORDS: Extreme lateral approach, clivus, cervical spine, dumbbell tumor, vertebral artery aneurysm, operative technique, skull base

Lesions situated ventrally and ventrolaterally to the brainstem and upper cervical cord were treated using the extreme lateral craniocervical approach in eight patients. The pathological entities encountered included distal vertebral artery aneurysms, an anterior foramen magnum meningioma, a prepontine epidermoid, and upper cervical dumbbell neurofibromas. Earlier, surgical management of these lesions was associated with significant

morbidity and mortality and incomplete removal.^{1,2} The extreme lateral approach has gained popularity as an alternative to suboccipital craniectomies, transpetrosal, transoral, and transcervical approaches or laminectomies to deal with these lesions.^{1,3,4} The extreme lateral approach offers wide and shallow exposure along with a direct trajectory to these lesions thereby minimizing brain retraction.^{4,5} The transfacetal approach has been used for

Skull Base, volume 11, number 4, 2001. Address for correspondence and reprint requests: C.V. Ravi Kumar, M.Ch., 3737 Beaubien # 900, Detroit MI 48201. E-mail: ravikumarcv@yahoo.com. ¹Department of Neurosurgery, Sri Venkateswara Institute of Medical Sciences, Tirupati, India. Copyright © 2001 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1(212) 584-4662. 1531-5010,p;2001,11,04,265,276,ftx,en;sbs00239x.

the same reason to treat ventral or ventrolateral upper cervical lesions.^{1,4,6} We present our experience using this approach for various pathologic processes at the lower clivus and upper cervical region.

CLINICAL MATERIAL AND METHODS

Between 1997 and 1999, eight patients (five males and three females) with lesions anterior and an-

terolateral to the lower brainstem or upper cervical cord underwent the extreme lateral craniocervical approach at Sri Venkateswara Institute of Medical Sciences, Tirupati, India (Table 1). The patients' ages ranged from 26 to 55 years. The patients with aneurysms were evaluated with computed tomography (CT) and pre- and postoperative angiography. Patients with tumors were evaluated with pre- and postoperative magnetic resonance (MR) imaging. The Glasgow Outcome Scale was used to assess outcomes.

Table 1 Clinical Summary of Eight Patients Undergoing the Extreme Lateral Approach

Case No.	Diagnosis	Location	Clinical Features	Surgery	Complications	Glasgow Outcome Scale
1	Vertebral aneurysm	Distal	Gr. IV SAH* Rt. hemiplegia	Clipping	9th and 10th CN paresis	5
2	Vertebral aneurysm	Distal	Gr. IV SAH* Lt. hemiplegia; similar episode 20 yrs ago	Clipping	Meningitis 9th and 10th CN paresis	3
3	Vertebral aneurysm	Distal	Gr. II SAH*	Clipping	Pseudomenigocele 9th and 10th CN paresis	5
4	Epidermoid	Prepontine	Chemical meningitis; bilateral 6th & lt. 7th nerve palsy; cerebellar signs	Total excision		5
5	Meningioma	Anterior foramen magnum	Quadriplegia; C2 sensory loss	Total excision		5
6	Recurrent neurofibroma	C2-C4	Rt. hemiparesis; pain; spasticity; breathing difficulty; laminectomy 12 yrs and 1 yr ago	Subtotal excision	Pseudomenigocele	5
7	Neurofibroma	C2-C3	Rt. hemiparesis; lt. retroauricular swelling; spasticity	Total excision		5
8	Neurofibroma	C1-C2	Rt. spastic hemiparesis; neck pain	Total excision		5

*Hunt and Hess Grade, SAH, subarachnoid hemorrhage; CN, cranial nerve.

Figure 1 Case 1. Preoperative angiogram (A) AP and (B) lateral views showing the distal vertebral artery aneurysm. (C) Postoperative AP angiogram showing obliteration of the aneurysm.

VERTEBRAL ANEURYSMS

The three patients with vertebral aneurysms presented with subarachnoid hemorrhage. Two patients (Cases 1 and 2) were in Hunt and Hess grade IV and had dense hemiplegia. The third patient (Case 3) was in grade II at presentation. CT at the time of the ictus showed blood in the fourth ventricle in all patients. In each case, the aneurysm arose from the distal vertebral artery near the verte-brobasilar artery junction close to midline (Fig. 1A,

B and Fig. 2). The fundus of the aneurysms pointed medially in two patients, making clipping more difficult. In Case 2, both internal carotid arteries were blocked and the aneurysm arose from the dominant vertebral artery supplying the supratentorial cerebrum (Fig. 2). The extreme lateral approach was used in all three patients, and the aneurysms were clipped successfully as evidenced by postoperative angiography (Fig. 1C). The neurological condition of the three patients had improved by discharge. The second patient had grade 3/5 hemiparesis at

Figure 2 Case 2. Preoperative (A) AP and (B) lateral angiograms showing the distal vertebral artery aneurysm. Note the supratentorial opacification due to bilateral occlusion of the internal carotid artery.

discharge and remained the same at follow-up. Complications included postoperative meningitis in one patient and a pseudomeningocele in another. The meningitis was treated with appropriate antibiotics and the pseudomeningocele improved after repeated lumbar cerebrospinal fluid (CSF) drainage. All three patients had transient unilateral lower cranial nerve (9th and 10th) palsy that had resolved by discharge.

EPIDERMOID

Case 4

A 27-year-old female patient presented with a 20-day history of fever associated with headache, two episodes of seizures, and gait ataxia. Neurological examination revealed bilateral abducent nerve palsy, left lower motor neuron facial nerve palsy, and left-sided cerebellar signs. CT failed to show the lesion clearly, probably due to beam-hardening artifacts. The CSF analysis was suggestive of chemical meningitis. Angiography was normal. MR imaging showed a prepontine epidermoid, which was excised totally using the extreme lateral approach.

FORAMEN MAGNUM MENINGIOMA

Case 5

A 35-year-old male presented with a history of progressive weakness associated with numbness in all four limbs. He had been bedridden for the past year. On examination, he had spastic quadriplegia and sensory loss below the C2 dermatome. MR imaging showed an anteriorly situated foramen magnum meningioma (Fig. 3A), which was excised using the extreme lateral approach (Fig. 3B). Postoperatively, the patient regained normal power in all four limbs and could walk without support at discharge. He returned to work in 3 months.

DUMBBELL NEUROFIBROMAS

Case 6

A 51-year-old male presented with a 2-year history of weakness in the right upper limb with pain and a burning sensation in his right limbs, stiffness in all four limbs, and difficult breathing. He had undergone excision of a C2–C3 dumbbell neurofibroma 10 years earlier. Examination revealed spasticity in all four limbs with brisk deep tendon reflexes and grade 4/5 power in the right upper and lower limbs. MR imaging showed a dumbbell tumor from C2 to C4 with erosion of the vertebral body (Fig. 4A,B,C). He underwent re-exploration of the laminectomy, but only limited decompression could be achieved because of dense postoperative adhesions. His symptoms have not resolved and postoperative imaging showed persistent spinal cord compression.

As an alternative, an extreme lateral trans-facet approach was used for tumor decompression. Part of the tumor was left due to adhesions, extensive erosion of the vertebral body, and encasement of the vertebral artery. The patient had a pseudomeningocele that subsided with repeated lumbar CSF drainage. Postoperative MR imaging showed adequate decompression of the thecal sac (Fig. 4D). His symptoms were relieved completely by discharge and he returned to work. At his 2-year follow-up examination, he was asymptomatic.

Case 7

A 28-year-old male presented with a 2-month history of right upper and lower limb weakness and numbness. He had a 2-year history of left retroauricular swelling. On examination, he had right upper and lower limb weakness (grade 3/5) with bilateral spasticity and pyramidal signs. He had no neurocutaneous signs. MR imaging showed a dumbbell tumor at C2–C3 and a retropharyngeal tumor (Fig. 5A). At surgery, a large laterally situated intra-

Figure 3 Case 5. (A) Contrast-enhanced sagittal MRI of anteriorly situated meningioma at the foramen magnum. (B) Postoperative enhanced MRI showing total excision of the tumor.

and extradural tumor at C2–C3 was excised (Fig. 5B). Another small intradural tumor was also excised. The retropharyngeal tumor required a second-stage anterior cervical surgery at a later date. There were multiple tumors in the cervical region and small remnants were seen on postoperative MR imaging. The patient has improved and has returned to work.

Case 8

A 26-year-old male patient presented with right upper limb stiffness associated with weakness for 2 months along with neck pain. On examination, he had grade 4/5 right upper limb weakness, bilateral pyramidal signs, and impaired posterior col-

umn sensation in both upper limbs. MR imaging showed a C1–C2 dumbbell tumor (Fig. 6A), which was excised using the extreme lateral approach (Fig. 6B). The patient recovered completely and has returned to work.

OPERATION

The operative technique is well described in the literature.^{4,7–9} The essential steps are outlined below. All patients were placed in the lateral position. We prefer the lateral inverted L-shaped retro-mastoid incision, which curves medially at the superior nuchal line. The muscles attached to the mastoid and the occiput are detached and reflected

Figure 4 Case 6. (A) Contrast-enhanced, sagittal MRI showing a recurrent dumbbell tumor at C2-C4. (B) Contrast-enhanced CT showing the extent of vertebral body erosion. (C) Enhanced MRI after laminectomy showing the residual tumor and significant spinal cord compression. (D) Enhanced MRI after the extreme lateral approach showing adequate decompression of the spinal cord. Note the residual tumor.

to expose the occiput, suboccipital triangle, lateral C1 arch, and C2 lamina. The vertebral artery is identified after dissecting along the superior border of C1 and followed until it enters the dura. A retro-mastoid suboccipital craniectomy is performed and the mastoid tip is drilled. The sigmoid sinus is unroofed inferiorly and followed to the posterior aspect of the jugular foramen. The lateral rim of the foramen magnum and the lateral C1 arch are removed. The dura is opened longitudinally to offer a lateral perspective to the brainstem and upper cervical cord with minimal brain retraction.

For the upper cervical tumors below C1, the transfacetal variation of the extreme lateral approach is used.^{1,4,8} The lateral aspect of the vertebra is exposed by dividing the attached muscles to the posterior tubercle of the transverse process. The posterior two-thirds of the superior and inferior articular facets and the adjacent laminae of the vertebra are drilled away to expose the lateral aspect of the dura. The extradural portion is excised, followed by the intradural portion.

The extent, location, and nature of the lesion dictated the variations in the operating procedure.

Figure 5 Case 7. (A) Preoperative enhanced MRI: Sagittal (left), coronal (middle), and axial (right) images showing the dumbbell and retropharyngeal tumor. (B) Postoperative enhanced MRI: Sagittal (left), coronal (middle), and axial (right) images showing the extent of tumor decompression.

The occipital condyle was partially drilled (30 to 40%) in only two patients to allow more anterior access ventral to the foramen magnum. An occiput-to-cervical fusion was not performed in those patients because the condyle was partially drilled. The vertebral artery was mobilized medially in only one patient. In patients with the dumbbell neurofibromas with a wide intervertebral foramen, adjacent facets are partially removed and a limited laminectomy is sufficient for tumor resection.

RESULTS

All three distal vertebral aneurysms were successfully clipped as confirmed by postoperative angiography. In one patient with a recurrent dumbbell neurofibroma, the tumor was partially excised. He had undergone two previous surgeries before the extreme lateral approach. Another patient with a dumbbell neurofibroma tumor required second-stage surgery for a different tumor anterior to the

Figure 6 Case 8. (A) Preoperative enhanced MRI: Sagittal (left), coronal (middle), and axial (right) showing the dumb-bell tumor. (B) Postoperative enhanced MRI: Sagittal (left) and axial (right) images showing total excision of tumor and collection of cerebrospinal fluid.

vertebral body. The remaining tumors were totally excised. Postoperatively, all patients showed significant neurological improvement. Complications included transient partial lower cranial nerve (9th and 10th cranial nerves) paresis in three patients, a pseudomeningocele in two patients, and meningitis in one patient. Fortunately, all complications resolved within 2 to 3 weeks.

DISCUSSION

The lower clivus is the site of various intra- and extradural tumors and vertebrobasilar aneurysms. The surgical access routes to this region include the transoral, transcervical, transthemoid, bifrontal transbasal, infratemporal, transpetrosal, and retromastoid approaches.^{3,10} The classic retromastoid

approach may be all that is necessary to deal with some of these lesions.^{3,4} However, some lesions located ventrally or ventrolaterally to the brainstem require significant brainstem retraction for adequate exposure, necessitating alternative operative avenues. The anterior approaches have the disadvantage of a narrow and deep operative corridor with limited lateral exposure. They traverse a contaminated field and are associated with a greater likelihood of CSF leakage.^{2,4,5} The transpetrosal approaches offer a direct lateral trajectory but are useful for smaller lesions and may necessitate sacrifice of the sigmoid sinus.³ Customarily, a neuro-otologist must participate in obtaining the exposure.

As an alternative, lateral approaches have been developed to manage these lesions.^{5,10} The far lateral was initially proposed by Heros and further developed as an extreme lateral approach to access lesions at the anterior aspect of the clivus and fora-

men magnum.^{1,3,4} This approach decreases the brainstem, cerebellar, and upper cervical cord retraction required to visualize the lower clivus and anterior foramen magnum. It also improves the depth and the width of exposure and avoids a contaminated field. The other distinct advantage of this approach is the early proximal control of the vertebral artery, which is useful in treating vertebrobasilar aneurysms and vascular tumors supplied by arterial branches. The extreme lateral approach has been proposed as a single approach to address pathologies from the lower clivus to C5.⁴

A growing number of clinical reports has described this approach along with a critical analysis of its advantages and disadvantages.^{1,3,6,8} Many anatomical extensions of the approach have been studied using cadaveric dissections.^{2,8} Many authors have recommended tailoring this approach to manage specific lesions located along the craniovertebral axis.^{1,2,8,11}

The extent of occipital condyle resection required to improve the angle of surgical perspective to the lower clivus has been discussed in the literature. Condylar resection improves the angle of approach but is not necessary in all cases.^{1,2,8,11} The tumor itself may create extra space in the posterior fossa, pushing the brainstem posteriorly and obviating the need for condylar resection. We have partially drilled the occipital condyle in only two patients and have not performed occipitocervical fusion.

Although vertebral artery control is essential in all cases, vertebral artery mobilization also may be required, depending on the relationship of the tumor to the lower clivus and anterior foramen magnum. The anterolateral and superior lesions do not require mobilization.^{5,8} Many authors caution against unnecessary handling of the vertebral artery to prevent complications. During dissection of the vertebral artery to attain proximal control, variations in the course of the loop of vertebral artery and displacement of the artery by tumors at C1 and C2 must be kept in mind to prevent injury. The vertebral venous plexus is another source of potential complications during surgery.²

Aneurysms of the vertebrobasilar junction and the distal vertebral artery pose problems when treated by the traditional suboccipital route. Other skull base approaches are used to manage them surgically, namely, the retrolabyrinthine-transigmoid approach and the extreme lateral approach. The former is used for small aneurysms when angiography demonstrates the potential for adequate collateral outflow to the ipsilateral sigmoid sinus. The latter is used for large lesions involving the vertebral artery, the vertebrobasilar junction, and the lower basilar artery.^{3,4} We have used this approach to treat three distal vertebral artery aneurysms, which were near midline and the vertebrobasilar junction. Two of the aneurysms were large and two pointed medially, increasing the technical challenge of clipping. All three patients had transient postoperative lower cranial nerve (9th and 10th) paresis. This complication may be unavoidable with this approach due to the need to work through the network of lower cranial nerves.³ We also have used this approach to completely excise a prepontine cistern epidermoid with good results.

Anterior and large anterolateral tumors at the upper cervical cord comprise another surgically challenging group of patients. The approaches usually employed are laminectomy and suboccipital craniectomy or anterior routes through a transoral or transcervical approach. Each approach has limitations in effectively managing broad-based anterior lesions and recurrent tumors that often have dense adhesions.^{4,12} The lateral approach described by Verbiest or its modifications are alternatives but these approaches are often unfamiliar to neurosurgeons and risk injury to the phrenic and accessory nerves, sympathetic plexus, and vertebral artery. Furthermore, intraspinal access is limited.^{5,12} Sen and Sekhar⁴ used the extreme lateral approach to access the cervical spine, especially for anterior intradural tumors, to minimize spinal cord retraction. Dumbbell tumors have contiguous intraspinal, extraspinal, foraminal, and extraforaminal components. As a group, these tumors are hard to manage due to difficulty exposing the entire tumor,

the proximity of the vertebral artery, the potential for spinal instability, and the risk of injury to upper extremity nerve roots. These tumors often require more than one exposure—the standard posterior laminectomy may be insufficient.^{6,12} McCormick has described the modified posterior approach with good results.¹²

We have adopted, with good results, the extreme lateral approach to deal with large anterolateral dumbbell (intra- and extraspinal) tumors associated with intradural extension. This approach, through the articular pillars and the mastoid process, exposes the spinal canal, foramen magnum, and lower clivus from a lateral perspective. The lateral trajectory offers direct access to the tumors and, as the neural foramen is widened in these patients, the amount of lateral laminectomy or facetectomy is minimized.^{1,4,8} With the patient in the lateral position, after the extradural portion of the tumor is removed, durotomy is performed to excise the intradural portion in a single stage. The vertebral artery in the transverse foramen is not at risk below C2 as it is anterior to the neural foramen. At C1 and C2 the vertebral artery must be dissected carefully, as it is displaced by the tumor.

We have used this approach for the first time to access the upper cervical spine. This case, number 6, was after a prior attempt via laminectomy, which was inadequate for removing the recurrent dumbbell tumor due to the large extraspinal extension and surgical adhesions. Surgery was easier with the extreme lateral approach because the trajectory was direct and the adhesions were minimal. The spinal cord could be well decompressed but some residual tumor was left in the vertebral body and encasing the vertebral artery. The difficulty of excision and the risk of morbidity associated with recurrent tumors have been noted by Sen and Sekhar.⁴ Our experience with Case 6 illustrates this point yet again. Nevertheless, the patient improved after undergoing the extreme lateral approach and is free of symptoms after 2 years of follow-up. This encouraging result prompted us to use this approach in the other two patients with large dumb-

bell neurofibromas, also with good results. We now consider the extreme lateral approach for all dumbbell upper cervical tumors with significant extraspinal extension as a primary single-stage operative procedure.

CONCLUSION

We have reported the successful management of eight patients with lesions located anteriorly or anterolaterally to the lower clivus and upper cervical spine using the extreme lateral craniocervical approach. The lesions were various pathologies situated at various locations along the craniospinal axis. The extreme lateral approach provided adequate access, and the minimal need for brain or spinal cord retraction resulted in satisfactory outcomes with minimal morbidity. Our experience has been particularly gratifying with respect to large cervical dumbbell neurofibromas, where a single-stage operative procedure was possible.

ACKNOWLEDGMENTS

The authors gratefully acknowledge Ms. V. Sobhana for preparing the manuscript and Dr. G. R. Chandrashekar and Dr. Satyendra Kumar for reviewing the manuscript.

COMMENTS FOR PUBLICATION

This article adds to the accumulating body of literature that describes surgical experience with the extreme lateral approach to the lower clivus and upper cervical spinal cord. The eight cases operated on through this approach represent typical pathologies encountered in the appropriate use of this approach: distal vertebral aneurysms, prepontine epidermoid lesions, anterior foramen magnum meningiomas, and high cervical neurofibromas. Traditionally, the location of these lesions has created problems with surgical access and visualization to which the skull base community responded

by developing the extreme lateral transcondylar and transjugular approaches. George et al.¹⁻⁵ and Sen et al.^{6,7} have written and published extensively on this subject.

This series demonstrates two major features of this approach. First, the approach does, indeed, offer excellent visualization and access for the treatment of difficult lesions in this region. Second, complications are frequent and occasionally severe. They tend to include lower cranial nerve pareses with attendant pneumonia, meningitis due to a CSF fistula, or both. Cervical instability can also develop with significant condylar resection. The paper is an honest and fairly typical report of the experiences of even technically gifted surgeons with this approach. Careful and repeated cadaveric dissection is essential before attempting this approach in patients. Vigilant postoperative care is required to detect early infections such as pneumonia and meningitis, which can be life-threatening. Nevertheless, this approach offers hope for a surgical cure in patients with what are normally benign lesions that otherwise would prove fatal because of their critical location.

Gail Rosseau, M.D.
Chicago, Illinois

1. George B, Tran PB. Surgical resection of jugulare foramen tumors by juxtacondylar approach without facial nerve transposition. *Acta Neurochir (Wien)* 2000;142(6):613-620
2. George B, Lot G, Boissonnet H. Meningioma of the foramen magnum: a series of 40 cases. *Surg Neurol* 1997;47(4):371-379
3. George B. Management of the vertebral artery in excision of extradural tumors of the cervical spine. *Neurosurgery* 1995;37(4):844-845
4. George B, Lot G, Tran Ba Huy P. The juxtacondylar approach to the jugular foramen (without petrous bone drilling). *Surg Neurol* 1995;44(3):279-284
5. George B, Lot G. Neurinomas of the first two cervical nerve roots: a series of 42 cases. *J Neurosurg* 1995;82(6):917-923
6. Sen C. The transcondylar approach to the lower clivus, foramen magnum, and C1-C2. *Clin Neurosurg* 1996;43:113-126

7. Sen C, Eisenberg M, Casden AM, Sundaresan N, Catalano PJ. Management of the vertebral artery in excision of extradural tumors of the cervical spine. *Neurosurgery* 1995;36(1):106-116

REFERENCES

1. Babu RP, Sekhar LN, Wright DC. Extreme lateral transcondylar approach. Technical improvements and lessons learned. *J Neurosurg* 1994;81:49-59
2. Wen HT, Rhoton AL, Katsuta T. Microsurgical anatomy of the transcondylar, supracondylar and paracondylar extensions of the far-lateral approach. *J Neurosurg* 1997;87:555-585
3. Day JD, Fukushima T, Gianotta SL. Cranial base approaches to posterior circulation aneurysms. *J Neurosurg* 1997;87:544-554
4. Sen CN, Sekhar LN. An extreme lateral approach to intradural lesions of the cervical spine and foramen magnum. *Neurosurgery* 1990;27:197-204
5. George B, Dematons C, Cophignon J. Lateral approach to the anterior portion of the foramen magnum. Application to surgical removal of 14 benign tumors: technical note. *Surg Neurol* 1988;29:484-490
6. El-Mahdy W, Kane PJ, Powell MP, Crackard HA. Spinal intradural tumors: part I-extramedullary. *Br J Neurosurg* 1999;13:550-557
7. Banerji D, Behari S, Jain VK, Pandey T, Chabra DK. Extreme lateral transcondylar approach to the skull base. *Neurol India* 1999;47:22-31
8. 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 (Spine 2)* 1999;90:206-219
9. Samii M, Cheatham ML, Becker DP. Lateral approach to the craniocervical junction. In: Samii M, Cheatham ML, Becker DP. *Atlas of cranial base surgery*. Philadelphia: WB Saunders Co; 1995:54-61
10. Bertalanffy H, Seeger W. The dorsolateral, suboccipital, trancondylar approach to the lower clivus and anterior portion of the craniocervical junction. *Neurosurgery* 1991;29:815-821
11. Dowd GC, Zeiller S, Awasthi D. Far lateral transcondylar approach: dimensional anatomy. *Neurosurgery* 1999;45:95-100
12. McCormick PC. Surgical management of dumbbell tumors of the cervical spine. *Neurosurgery* 1996;38:294-300