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Far-Lateral Approach for Foramen Magnum Meningioma: An Anatomical Study with Special Reference to Bulbopontine Junction

Nathan Beucler[1,2] Christelle Haikal[3] Aurore Sellier[1] Adrien May[4] Mikael Meyer[4] Stéphane Fuentes[4,5]

[1] Neurosurgery Department, Sainte-Anne Military Teaching Hospital, Toulon Cedex 9, France
[2] Ecole du Val-de-Grâce, French Military Health Service Academy, Paris Cedex 5, France
[3] Department of Radiology, Timone University Hospital, Assistance Publique, Hôpitaux de Marseille (APHM), Marseille, France
[4] Neurosurgery Department, Timone University Hospital, APHM, Marseille, France
[5] Chief of Spine Unit, Timone University Hospital, APHM, Marseille, France

Address for correspondence Nathan Beucler, MD, Neurosurgery Department, Sainte-Anne Military Teaching Hospital, 2 Boulevard Sainte-Anne, 83800 Toulon Cedex 9, France (e-mail: nathan.beucler@neurochirurgie.fr).

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Abstract

Intracranial meningiomas are sometimes located anteriorly to the foramen magnum and can cause disabling long tract symptoms. The far-lateral approach has been developed to provide an extensive view over the bulbopontine junction and the surrounding lower cranial nerves and upper spinal nerves with a good control on the vertebral artery, allowing the safe resection of such tumors. It is the report of a case with anatomical study before and after the removal of the meningioma. The use of the far-lateral approach allowed us to (1) control the vertebral artery in its V3 (Atlantic extradural) and V4 (intradural) portion (2) have an optimal visibility on the lower cranial nerves, the upper spinal nerves, and the bulbopontine junction, and (3) perform a Simpson 2 resection of the tumor that was inserted between the lower clivus and the upper odontoid process. Beyond its interest for the safe resection of tumors located anteriorly to the foramen magnum, the far-lateral approach is of particular anatomical interest. It allowed us to review the anatomy of the craniocervical junction.

Keywords
- ► Foramen magnum
- ► meningioma
- ► brainstem

Introduction

Neurosurgeons have to deal with the challenging anatomy of the craniocervical junction and its surrounding neurological and vascular structures.[1] Meningioma is the most common intradural tumor of the foramen magnum (FM).[2,3] Its growth induces mass effect on vascular and nervous structures and modifies the surgical anatomy of this region. Once a patient suffers from neurological symptoms related to the mass effect, the neurosurgeon has to perform a challenging surgical resection. The main goal of this functional-sparing surgery is the stabilization or the improvement in existing neurological symptoms without compromising neurovascular structures. What is more, there is no place for technical

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challenge anymore as the exhilaration of gross total resection must be balanced with the possibility of postoperative radiotherapy or simply long-term follow-up.

Case Presentation

A 67-year-old female patient, treated with hormone replacement therapy by nomegestrol,[4] was referred for gait disturbance and lower limbs pain. Clinical examination showed a tetrapyramidal syndrome with Babinski sign, Hoffmann sign, and hyperactive reflexes, and a posterior cord syndrome with proprioceptive ataxia and a Romberg sign, a thermoalgesic anesthesia, distal tingling, and numbness. There was a left lower limb weakness ranked 4/5 on the modified Medical Research Council scale. Magnetic resonance imaging of the brain revealed a meningioma measuring 31 mm (craniocaudal) × 23 mm (anteroposterior) × 16 mm (lateral) inserted on the anterior and lateral left part of the FM, between the lower clivus and the upper half part of the odontoid process (►**Fig. 1**). The medulla oblongata was displaced backward on the right and the left vertebral artery (VA) was completely displaced superiorly.

The patient was operated on in a right park-bench position, the head being slightly rotated on the right to better expose the left side of the posterior fossa and the upper spine. A left far-lateral approach (FLA) was used to expose a bone window with a suboccipital craniectomy passing through the FM, the removal of the posterior arch of the atlas from the posterior tubercule to the vertebral groove to expose the V3 segment (extradural) of the VA, and the superior part of the lamina of the axis. The dura matter was opened in a hockey stick fashion. A dural slot was cut until the opening of the transdural passage of the VA for optimal vascular control. The cisterna magna was opened, then the arachnoid was loosened around the medulla oblongata. This allowed a complete visualization of the meningioma. The left VA in its V4 segment (intracranial) was displaced superiorly and externally. The lower cranial nerves (LCN) (CN IX, X, cranial XI, and XII) were not seen at first. The spinal accessory nerve (CN XI) was stretched laterally by the tumor and running directly against it. Finally, C2 nerve root was stretched by the inferior pole of the tumor (►**Fig. 2**).

Because of the firmness of the tumor, the ultrasonic surgical aspirator was of limited support. We performed a progressive tumoral fragmentation between the different cervical roots of CN XI; we were lucky enough to find an arachnoid cleavage plane that helped to preserve this cranial nerve. This allowed the resection of a large portion of the center of the tumor and the loosening of tension against the medulla oblongata. Then, we could gently isolate the posterior wall of the meningioma from the medulla oblongata by following the arachnoid cleavage plane; we did not find any particular tumoral adherence either. The surgical excision was not impeded by excessive bleeding. Another main surgical concern was the wide insertion of the tumor from the lower clivus to the upper part of the odontoid process. We had a proper vision on the lower part of the insertion. For the upper part, we had to tilt the operative microscope to remove small tumoral portions through the suboccipital craniectomy within a thin corridor limited by the LCN anteriorly, the cerebellum superiorly, and the VA loop from V3 to V4 segment posteriorly and inferiorly. The opening of the transdural passage of the VA allowed us to displace the artery safely to better expose this remote part of the insertion of the tumor. The whole tumor insertion was eventually coagulated leading to a Simpson 2 resection.[5] Pathology report was consistent with a grade 1 transitional meningioma with a proliferation index (Ki67) of 3%.

The complete removal of the meningioma led to a proper visualization of the major structures of the bulbopontine junction. The left LCN appeared during their course to join the jugular foramen.[6] The left VA was seen in its intracranial V4 portion. Its first branch, the posterior inferior cerebellar artery (PICA), was also visualized. Because of the remaining footprint of the tumor on the medulla oblongata, the contralateral VA and the contralateral dura mater were visible. A large portion of spinal CN XI was seen with its roots arising from C1, C2, and C3. In the same way, the ventral root of C2 was loosened (►**Figs. 3** and **4**).

The dura mater was closed in a watertight fashion using individual stitches completed with biological glue, then the wound was closed layer by layer. The postoperative course was uneventful, and the patient was sent to neurological rehabilitation.

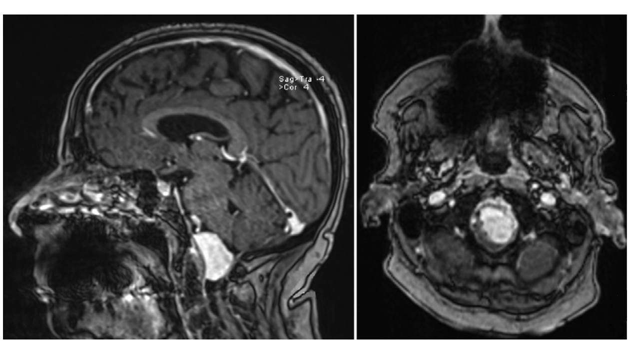

Fig. 1 Preoperative postcontrast T1-weighted magnetic resonance imaging shows the meningioma inserted on the anterior and lateral left part of the foramen magnum. The medulla oblongata is displaced backward on the right, and the left vertebral artery is displaced externally and superiorly.

Discussion

The Far-Lateral Approach: Historical Considerations

Historically, the surgical removal of anteriorly-inserted FM meningiomas was considered as a life-saving procedure.[7] The surgical technique has evolved over time from a posterior or medial approach that forced the surgeon to retract noble structures and leave some tumor anteriorly, to a lateral approach[8] and finally a FLA that led to a better control on the VA and an easier access to the anterior insertion of the tumor.[9] This rethinking of the surgical corridor allowed a precise analysis of the relation between the tumor, the medulla oblongata, the VA, and the LCN.[10] The surgeon

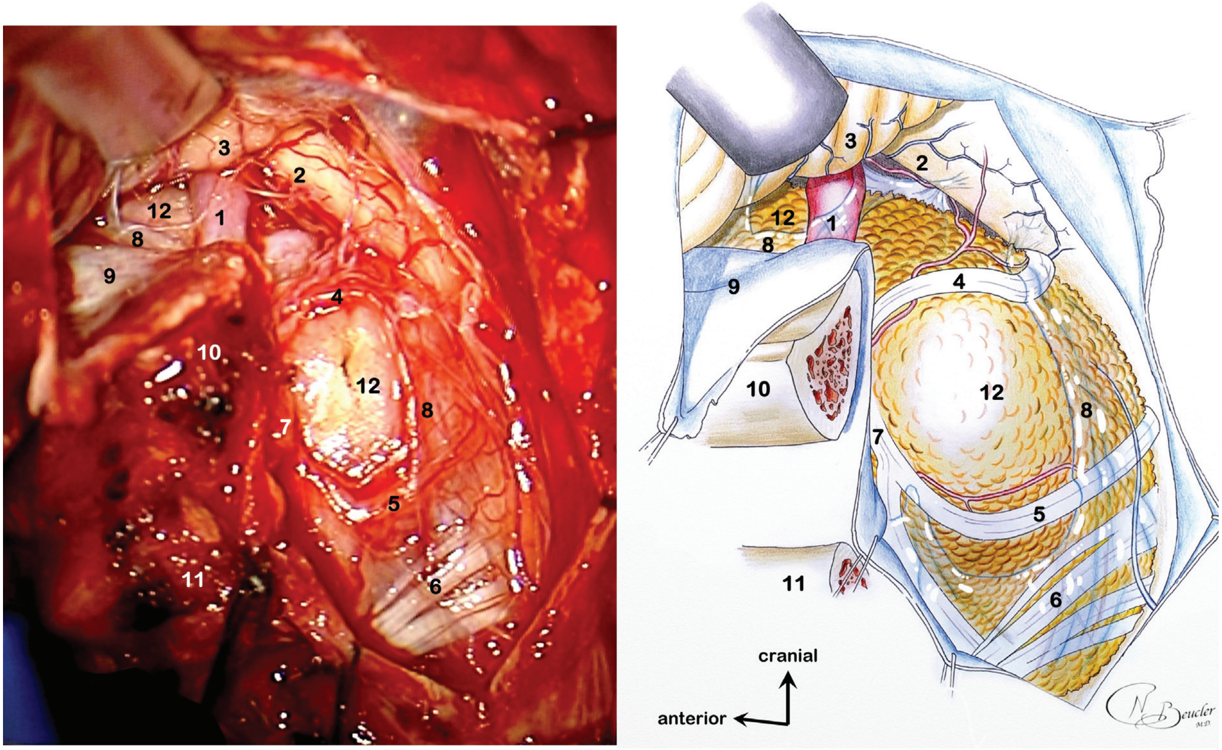

Fig. 2 Intraoperative view using a left far-lateral approach before the resection of the meningioma. (*1*) Vertebral artery; (*2*) medulla oblongata; (*3*) cerebellum; (*4*) C1 root of spinal accessory nerve; (*5*) C2 root of spinal accessory nerve; (*6*) ventral root of C2; (*7*) spinal accessory nerve; (*8*) arachnoid membrane; (*9*) dura mater; (*10*) posterior arch of the atlas; (*11*) lamina of the axis; (*12*) meningioma. (Pencil drawing created by Nathan Beucler.)

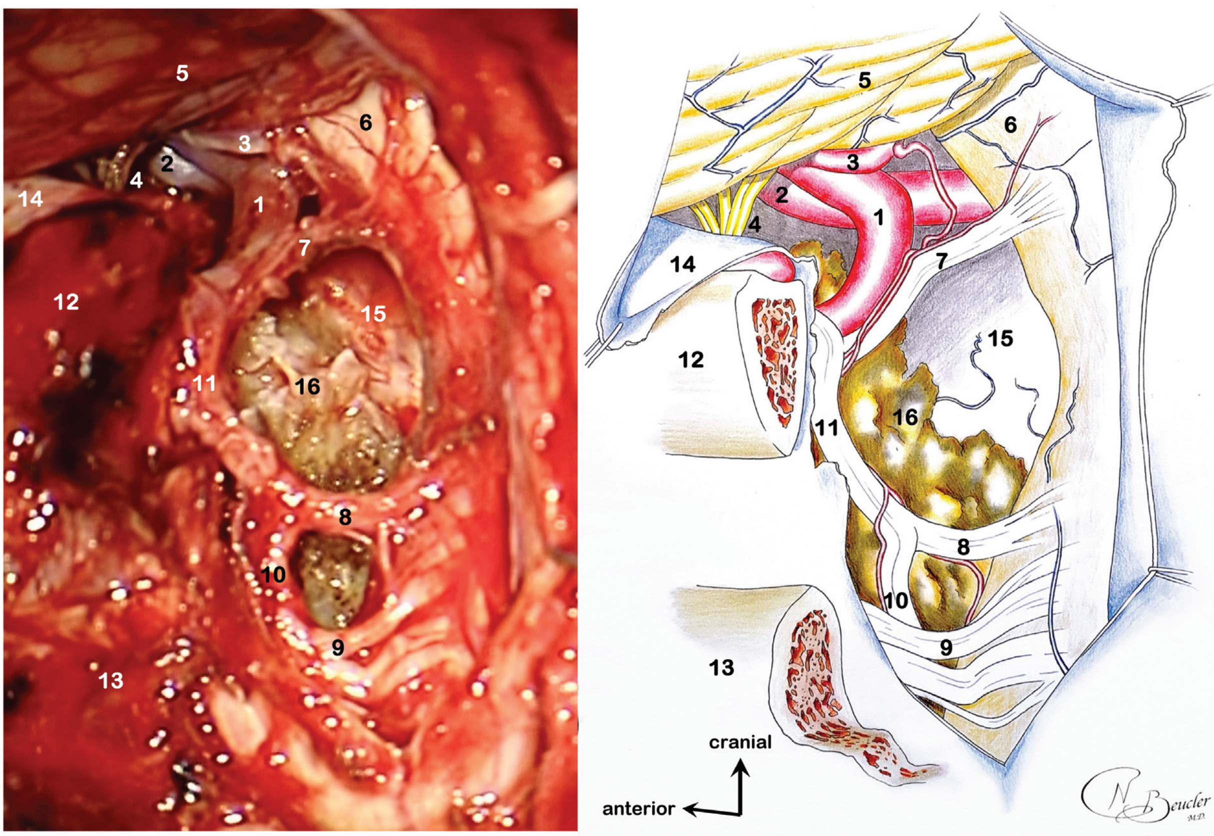

Fig. 3 Intraoperative view using a left far lateral approach after the resection of the meningioma. (*1*) Left vertebral artery; (*2*) right vertebral artery; (*3*) left posterior inferior cerebellar artery; (*4*) lower cranial nerves; (*5*) cerebellum; (*6*) medulla oblongata; (*7*) C1 root of spinal accessory nerve; (*8*) C2 root of spinal accessory nerve; (*9*) ventral root of C2; (*10*) C3 root of spinal accessory nerve; (*11*) spinal accessory nerve; (*12*) posterior arch of the atlas; (*13*) lamina of the axis; (*14*) dura mater; (*15*) contralateral dura mater; (*16*) insertion of the meningioma coagulated. (Pencil drawing created by Nathan Beucler.)

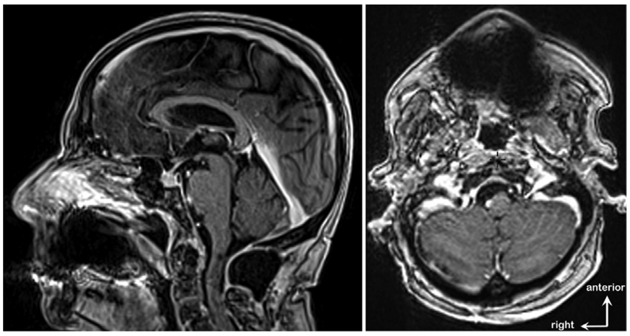

Fig. 4 Postoperative postcontrast T1-weighted magnetic resonance imaging shows gross total resection of the meningioma. Note the remaining footprint of the tumor on the medulla oblongata. The axial slice exposed here is situated in the lower aspect of the clivus at the superior part of the tumor. Thus, it is different for that of ►**Fig. 1** that was situated at the level of the odontoid process, which explains that the medulla oblongata is not displaced backward on the right as it could be expected.

was given the possibility to perform gross total resection (GTR) whenever possible, or to leave a few tumoral remnants in case of tumor adherence to nervous structures, with a thought of functional-sparing procedure.[11]

The Far-Lateral Approach: Surgical Advantages

The FLA provides a particular three-quarters backside view over C1 lateral mass, C2 articular process, and the trajectory of the VA in its V3 and V4 segments (►**Fig. 5**). Although the FLA has scarce indications, it is the ideal opportunity to understand the relations between the atlas, the axis, and the VA. In the case of FM meningiomas, the challenge for the operator is to perform a precise subarachnoid dissection between the tumor, the main vascular structures, and the LCN. It is the same issue in the case of anteriorly located epidermoid cysts of the cerebellopontine angle, or clival chordomas. This approach is also particularly adapted for microsurgical clipping of PICA aneurysms, because PICA lateral medullary segment is to be found right after the opening of the dura mater.[12] Finally, the FLA can be used for the microsurgical resection of cavernous malformations located laterally to the lower brainstem.[13]

In a way, the FLA for the resection of tumors of the anterior part of the upper cervical spine canal is comparable to Georges' oblique transcorporeal approach to the lower cervical spine.[14]

Perspectives Regarding the Surgical Approach

Nowadays, neurosurgeons work in facilities that provide sufficient medical and material support to perform extremely demanding skull base procedures. With this in mind, the surgical approach should be planned to obtain the sufficient exposure for the safe resection of the tumor with minimal retraction over noble neurovascular structures, and without compromising the stability of craniocervical junction. For lesions located anteriorly to the FM, the choice between the FLA and the extreme far-lateral transcondylar approach depends on the tumor's insertion on the clivus, the jugular foramen, and the contralateral portion of the FM. For such lesions, an extreme FLA may sometimes be required, but the operator must keep in mind that the surgical exposure takes longer and can theoretically induce instability of the craniocervical junction depending on the portion of occipital condyle that is drilled. Also, the extreme FLA suffers from higher postoperative complication rates (LCN deficits and especially CN XII, infection, cerebrospinal fluid leak) compared with the FLA.[15,16]

Conclusion

In the modern surgery era, even with the advent of minimal invasive procedures, some tumors located anteriorly to the FM still require large opening for proper exposure and safe resection with minimal retraction over neurovascular structures. Indeed, the surgical paradigm for such tumors has evolved over 50 years from a life-saving procedure to a functional-sparing surgery. The FLA provides an exceptional view over the VA in its V3 and V4 segment, the bulbopontine

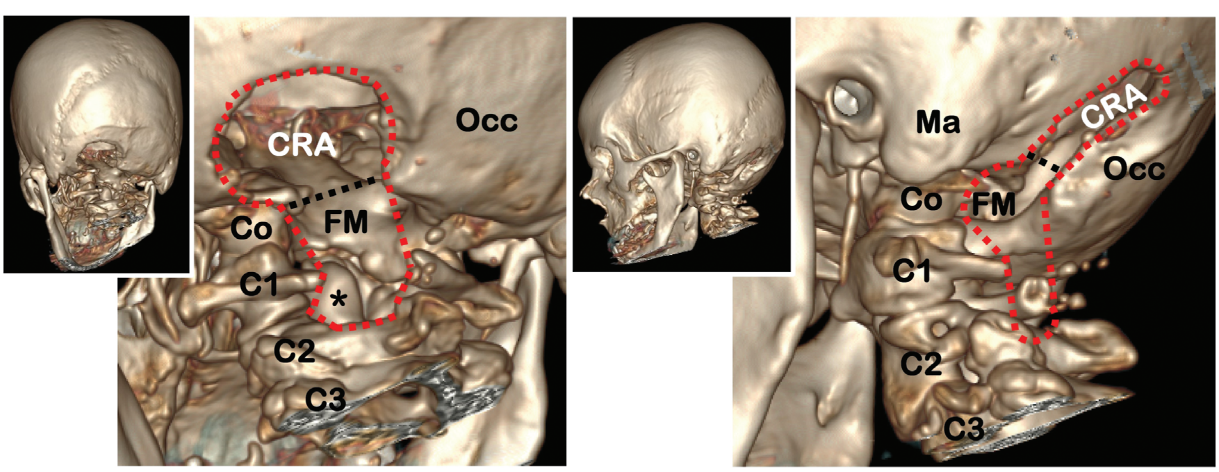

Fig. 5 Postoperative three-dimensional computed tomography scanner in lateral view and three-quarters backside view illustrating the bone window in the far lateral approach. (C1) atlas; (C2) axis; (C3) third cervical vertebra; (CRA) suboccipital craniectomy; (Co) occipital condyle; (FM) foramen magnum; (Ma) mastoid process.

junction, and the LCNs. Beyond its interest for the safe resection of lesions located anteriorly to the FM, this approach is an anatomical lesson.

Conflict of Interest
None declared.

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