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Neurosurgery

FAR LATERAL APPROACH - A SURGICAL GATEWAY FOR ANTERIOR FORAMEN MAGNUM LESIONS

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ABSTRACT Tumours located in the anterior part of foramen magnum are difficult to approach through the usual anterior or posterior approaches.These lesions are best approached by far lateral approach or its modifications. In this article, we are sharing our institutional experience of this approach and a review of the literature . 4 cases were operated in our institution using far lateral approach in 2018 .Three of them were anterior foramen magnum meningiomas and other is a case of vertebral A - PICA aneurysm.

KEYWORDS : anterior foramen magnum , far lateral approach, Foramen magnum meningiomas

Illustrative Case 1

55 yr old male was brought to our department with spastic quadriparesis and neck muscle weakness with decreased sensation for all modalities below the level of C2 with no e/o cerebellar,cranial nerves or extrapyramidal involvement.

MRI brain - T1 hypointense,T2 hyperintense lesion at anterior part of foramen magnum with homogenous contrast enhancement suggestive of foramen magnum meningioma.

Lesion was approached through far lateral approach with condylar drilling and near total excision of lesion was accomplished(Simpsons grade 2).

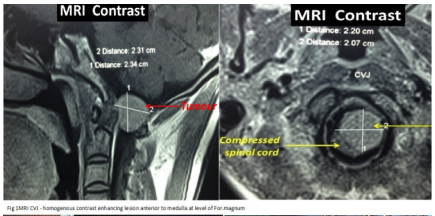


Fig 1MRI CVJ - homogenous contrast enhancing lesion anterior to medulla at level of For.magnum

Fig 2 -Images showing the 3 quarter prone positioning and marked skin flaps and raised skin

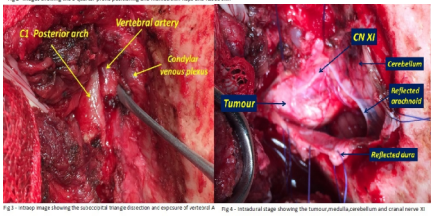


Fig 3 - Intraop image showing the suboccipital triangle dissection and exposure of vertebral A Fig 4 - Intradural stage showing the tumour,medulla,cerebellum and cranial nerve XI

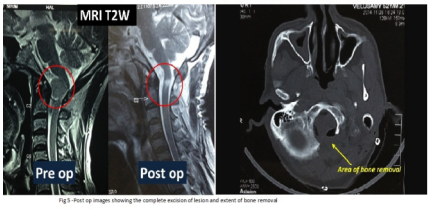


Fig 5 -Post op images showing the complete excision of lesion and extent of bone removal

Illustrative Case 2

55 yrs female presented with sudden onset head ache, altered sensorium and Paucity of movements on right side

GCS E3V3M5 - 11/15

Hunt and Hess grade - 4

WFNS - 4

Modified fisher scale - 4

CTbrain - showed basal cisternal SAH

CT Angio - showed left Vertebral Artery - PICA complex aneurysm

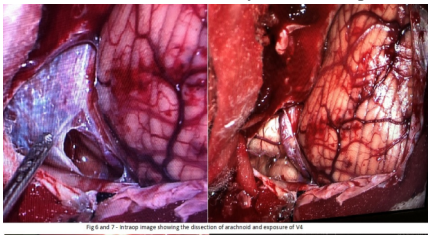


Fig 6 and 7 - Intraop image showing the dissection of arachnoid and exposure of V4

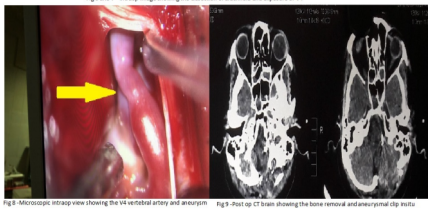


Fig 8 -Microscopic intraop view showing the V4 vertebral artery and aneurysm Fig 9 -Post op CT brain showing the bone removal and aneurysmal clip insitu

Vertebral artery (V4)Aneurysm was clipped with 9mm permanent curved titanium clips using far lateral approach.

Discussion

Foramen magnum is a bony channel bounded

Anteriorly - clivus, C1 anterior arch, dens process

Laterally - jugular tubercles, occipital condyles and lateral mass of C1

Posteriorly - opisthion, posterior arch of C1,first 2 intervertebral space.[1]

The foramen magnum enclose the cervicomedullary junction, tonsils, vermis lowermost part of fourth ventricle , vertebral arteries with meningeal branches,anterior and posterior spinal artery ,venous plexus and cranial nerves 9,10,11, 12 and c1 c2 spinal nerve roots.

Most common pathologies at the level of foramen magnum are tumours and aneurysms.Common neoplasms are meningioma, neurinomas ,chondromas and chordomas(4).Pathologies anterior to foramen magnum are difficult to approach by conventional anterior and posterior approaches. Anterior approach are associated with limited exposure and contamination by oral bacteria. Posterior midline approaches are limited by inability to retract the cervicomedullary junction.These limitations were overcome by the far lateral approach and its variations.

Far lateral approach

In far lateral approach ,the lesions are approached through the surgical corridor between the cervicomedullary junction and the lateral wall of

foramen magnum .This approach is useful for small anteriorly placed lesions.Larger lesions may displace the cervicomedullary junction and are accesible through the standard midline approaches.Side of approach depends on the location of lesion,dominance of vertebral arteries and venous drainage patterns.

Positioning

Patient is placed in three quarter prone position with head turned to the contralateral side (less than 45 degrees) to prevent vertebral artery kinking and laterally flexed to 30 degrees towards the floor and slight flexion to avoid jugular venous compression so that the mastoid bone becomes the prominent part . The contralateral arm is placed outside the table with axillary roll with adequate padding under pressure points.This positioning helps the cerebellum to fall away and bring the anterior parts in line with the surgeons view.

Skin incision

Skin is incised in a inverted hockey stick incision from the C2 spinous process to inion and then turned horizontally along the superior nuchal line, turning inferiorly along the mastoid process to the sternocleidomastoid muscle upto 5 cms below the mastoid tip.

Muscular stage

There are three main steps in muscular dissection:

A) elevation of the superfcial muscles along with the skin flap to expose the suboccipital triangle
B) dissection of the suboccipital triangle to expose the VA
C) transposition of the VA if needed .

First step in muscle dissection is to reflect the trapezius,sternomastoid muscles (first layer) inferiorly along with the skin flap to expose the semispinalis capitis,splenius capitis and longismus capitis (second layer) .The suboccipital triangle is opened by reflecting the rectus capitis posterior major inferiorly and medially, the superior oblique laterally and the inferior oblique medially.

The suboccipital triangle is limited by three muscles - above and medially by the rectus capitis posterior major, above and laterally by the superior oblique, and below and laterally by the inferior oblique .The triangle is covered by a layer of dense fibrofatty tissue. The floor in the depth of the triangle is formed by the posterior atlanto-occipital membrane and the posterior arch of the atlas .

The structures in the triangle are the vertebral artery and its venous plexus and the C1 nerve, both of which lie in a groove on the upper surface of the lateral part of the posterior arch of the atlas.

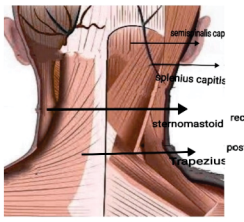


Fig 1 - showing posterior neck muscles .first layer on left and second layer to the right

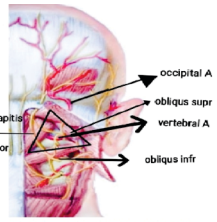


Fig 2 - diagram showing the subocipital triangle and its contents

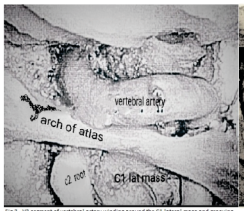
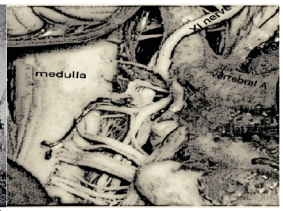


Fig 3 - V3 segment of vertebral artery winding around the C1 lateral mass and grooving the posterior arch of C1



Cranial nerve XI ascending posterior to vertebral A Fig 4- showing V4 segment traversing between medulla and occ.condyle to reach premedullary cistern

The triangle deep to these muscles is covered by a layer of dense fibrofatty tissue. The floor in the depth of the triangle is formed by the posterior atlanto-occipital membrane and the posterior arch of the atlas .The structures in the triangle are the vertebral artery and its venous plexus and the C1 nerve, both of which lie in a groove on the upper surface of the lateral part of the posterior arch of the atlas.

The VA is divided into four segments. V1 is the segment that runs from the origin of the artery at the subclavian artery and ends at the vertebral foramen of C6. V2 runs within the vertebral foramina from C6 through C1. V3, which is the horizontal segment of the vessel, begins at the transverse foramen of the atlas, runs through a groove on the upper surface of the posterior arch of the atlas and ends by passing below the lower, arched border of the posterior atlantooccipital membrane, which transforms the sulcus into an osseofibrous casing that may ossify, transforming it into a complete or incomplete bony canal surrounding the artery.The artery pierces the dura of the posterior fossa, medial to the OC.

V3 segment of Vertebral artery is covered by the semispinalis capitis muscle in suboccipital triangle. The posterior meningeal artery arises from the posterior surface of the vertebral artery as it passes behind the lateral mass or above the posterior arch of the atlas or just before penetrating the dura in the region of the foramen magnum, but it may also have an intradural origin .vertebral artery gives rise to muscular branches in the suboccipital triangle.The first and largest is the anterior VAs, which passes through the suboccipital triangle to reach the muscles of the posterior neck.Some of the muscular branches may need to be divided to mobilize and transpose the vertebral artery. Care should be taken not to coagulate a posterior inferior cerebellar artery (PICA) or a posterior spinal artery that arises extradurally from the V3. V4,the intradural segment of the vertebral artery, after emerging from the fibrous dural tunnel,traverses anterior to spinal accessory nerve and dentate ligament, ascends in front of the rootlets of the hypoglossal nerve to reach the front of the medulla oblongata where it unites near the junction of pons and medulla with its mate to form the basilar artery. Before reaching the lower border of pons, the vertebral artery gives off the PICA, which courses backward around the lateral surface of the medulla and between the rootlets of glossopharyngeal, vagus and accessory nerves.

The first cervical nerve courses on the lower surface of the artery between the artery and the posterior arch of atlas.

The venous system of the posterior neck is divided into two connected plexuses: (1) the suboccipital venous plexus and (2) the plexus around the Vas.

The suboccipital venous plexus is superfcial and is located in a space formed by the splenius capitis muscle superiorly and the longissimus capitis, semispinalis capitis muscles inferiorly.dissectionand manipulation of the venous plexus around the VAs,which is sometimes referred to as the suboccipital cavernous sinus, is needed. The suboccipital cavernous plexus is connected to the suboccipital plexus through the suboccipital triangle via the anterior vertebral vein.

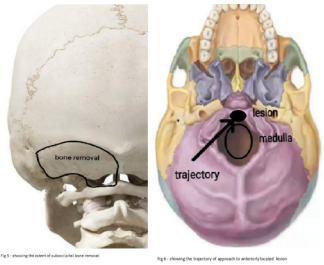
Reflecting the superior oblique muscle laterally exposes the rectus capitis lateralis, a short, flat muscle that is an important landmark in identifying the jugular foramen . It arises from the upper surface of the transverse process of the atlas and attaches above to the rough, lower surface of the jugular process of the occipital bone behind the jugular foramen.The jugular process is a plate of occipital bone extending laterally from the posterior half of the occipital condyle .

The occipital artery passes between the rectus capitis lateralis and the posterior belly of the digastric and then between the superior oblique and the posterior belly of the digastric where it courses in the occipital groove medial to the mastoid notch.After exiting the area between the superior oblique muscle and the posterior belly of the digastric, it courses medially,being related to the longissimus capitis and semispinalis capitis .

Extradural stage

Osseous Stage: Suboccipital Craniectomy and posterior arch removal The target points of the osseous stage of the approach are (1) exposure of the borders of the sigmoid and transverse sinuses, (2) resection of the ipsilateral margin of the FM, (3) resection of the squama of the occipital bone to the midline, and (4) resection of the ipsilateral border of the posterior arch of C1. If additional lateral space is needed, the OC can be removed in a subsequent step. The landmarks for orientation of the craniotomy are (1) the asterion, (2)the superior nuchal line the (3) the inion (4)midline and (5) posterior margin of mastoid. This retrosigmoid point is the keyhole to the lateral suboccipital approach and exposes the posterolateral border of the cerebellar hemisphere. Small tumors

without rostral extension require small craniectomy.



Condylar stage

The amount of condyle that can be safely removed is controversial. However, biomechanical studies showed that the removal of more than 50% of the condyle leads to considerable hypermobility of the craniocervical junction, in which case fusion is indicated.

Removal of the posterior root of the transverse foramen C1 will permit the artery to be displaced downward and medially away from the atlanto-occipital joint to expose the occipital condyle. The average distance between the posterior edge of the occipital condyle and the posterior border of the intracranial end of the hypoglossal canal is 8.4 mm (range, 6–10 mm) .Drilling of this bone exposes the lateral aspect of the intracranial portion of the hypoglossal canal. This landmark is approximately at the limit of the posterior third of the condyle. The hypoglossal canal is surrounded by cortical bone. The contents of the hypoglossal canal are the hypoglossal nerve, a meningeal branch of the ascending pharyngeal artery, and the venous plexus of the hypoglossal canal, which communicates the basilar venous plexus with the marginal sinus that encircles the foramen magnum.

Intradural stage

The dural incision begins behind the sigmoid sinus and extends behind the vertebral artery into the upper cervical area. The upper extent of the dural opening depends on how much of the cerebellopontine angle is to be exposed.The dura is opened parallel to the sigmoid sinus, crossing the circular sinus at the FM. Extreme care must be taken when opening the circular sinus.The arachnoid is opened and kept in place to facilitate the dissection or identifcation of the following neurovascular structures: the VAs and PICA, the anterior spinal artery and the cranial nerves (spinal division of the XI, IX, X, and XII cranial nerves. Section of the upper two triangular processes of dentate ligament will increase access anterior to the spinal cord.

The basic far-lateral approach without drilling of the occipital condyle may be all that is required to reach some lesions located along the anterolateral margin of the foramen magnum .

Variants

The **transcondylar** exposures can be categorized into several variants. An atlanto-occipital transarticular approach, in which the adjacent posterior parts of the occipital condyle and the superior articular facet of C1. The occipital transcondylar variant is directed above the atlanto-occipital joint through the occipital condyle and below the hypoglossal canal to access the lower clivus and the area in front of the medulla.

The **supracondylar** approach directed above the occipital condyle directed above the occipital condyle to the hypoglossal canal or both above and below the hypoglossal canal to the lateral side of the clivus.

In the **transtubercular** variant of the supracondylar approach, the prominence of the jugular tubercle that blocks access to the area in front of the glossopharyngeal, vagus, and accessory nerves is removed extradurally to increase visualization of the area in front of the brainstem and to expose the origin of a PICA.

In **transjugular** variant, the exposure is directed lateral to the condyle through the jugular process of the occipital bone to the posterior surface of the jugular bulb. excellent landmark for identifying the jugular process is the rectus capitis lateralis, which extends upward from the transverse process of the atlas to attach to the jugular process behind the jugular bulb.

Lazy FLA - VA is reflected together with its periosteal sheath and surrounding dura mater, providing a safe and suffcient route to the anterior foramen magnum and area of the lower clivus.(3).

Minimal access far lateral approach - A 30-mm vertical incision centered over the craniovertebral junction is made 35mm lateral to midline (5).

Surgical manipulations may lead to permanent or transitory defcits, such as swallowing and airway protection. Patients must remain intubated after surgery, and removal of the tube is performed only after functional studies of the larynx and pharynx are completed. Tracheostomy is indicated in cases that exhibit several lower cranial nerve defcits. Instability can occur in cases with bone tumors that require extensive bone removal; in these instances,dynamic studies should be performed as soon as possible .

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