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HOW I DO IT -NEUROSURGICAL ANATOMY

The midline suboccipital subtonsillar approach to the cerebellomedullary cistern: how I do it

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Abstract
Background Lesions lateral to the lower brainstem in an area extending from the foraminae of Luschka to the foramen magnum are rare and include different pathologies. There is no consensus on an ideal surgical approach.
Method To gain access to this area, we use the midline suboccipital subtonsillar approach (STA). This midline approach with unilateral retraction of the cerebellar tonsil enables entry into the cerebellomedullary cistern.
Conclusions The STA offers excellent access with a panoramic view of the cerebellomedullary cistern and its structures and therefore can be useful for a number of different pathologies in the lower petroclival area.

Keywords Cerebellomedullary cistern · Suboccipital subtonsillar approach · Lower cranial nerves

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Relevant surgical anatomy

The cerebellomedullary cistern borders the cerebellopontine cistern cranially, the prepontine cistern anterior-medially and the foramen magnum caudally. It is covered dorsally by the cerebellar tonsils and parts of the suboccipital cerebellar surface. The lower cranial nerves (CN IX, X and the medullary portion of XI and XII) originate medially from the brainstem and lead through the cistern to reach the jugular foramen or hypoglossal canal, respectively. The lateral recess of the fourth ventricle enters the cistern via the foramen of Luschka. The lower cisternal part is entered by the ascending accessory nerve as well as the vertebral artery. Before reaching the premedullary cistern, the posterior inferior cerebellar artery (PICA) originates from the vertebral artery and courses posteriorly between the rootlets of the lower cranial nerves into the cerebellomedullary fissure (telo-velo-tonsillar part of the PICA) between the cerebellar tonsils and the medulla to reach the cisterna magna.

Description of the technique

The approach can be performed in the prone (Concorde) or semi-sitting position with a neutral head position and anteriorly flexed cervical spine. A midline vertical skin incision from the inion to the spinal process of the axis is performed, followed by detachment of the neck muscles in the midline. After subperiostal dissection and lateralisation with a retractor the occipital bone and arch of C1 are exposed. Two burr holes are placed below the external occipital protuberance with a trepan whereas smaller burr holes with a drill are an option especially in children. Starting from the burr holes a heart-shaped craniotomy is performed towards the foramen magnum. Depending on the pathology a C1 laminectomy can be

helpful to gain a better access and working angle. Dural opening is Y shaped with accentuation on the side of pathology (Fig. 1a). After dural opening and tenting suture placement the cerebellar tonsils are exposed under the arachnoid layer. Now a sharp dissection of the arachnoid layer in the cisterna magna and around the relevant tonsil is necessary with caution regarding the telo-velo-tonsillar segment of the posterior inferior cerebellar artery (PICA) (Fig. 1b). Extensive arachnolysis and release of cerebrospinal fluid (CSF) open access to the cerebellomedullary fissure with the PICA and the corresponding vein of the cerebellomedullary fissure. Now the ipsilateral tonsil can be slightly elevated and retracted medially to enter the caudal part of the cerebellomedullary cistern. This opens the view to the dural entrance and intracisternal course of the vertebral artery, the spinal root of the accessory nerve laterally as well as the hypoglossal nerve with the hypoglossal canal and the origin of the PICA medially. Dissection of the jugular foramen and the course of the upper accessory (CN XI), vagal (CN X) and glossopharyngeal (CN IX) nerves through the cerebellomedullary cistern becomes possible with further retraction (Fig. 1c–e, Video 1). Medially, the retraction exposes the lateral recess of the fourth ventricle with the foramen of Luschka. Depending on the size and type of pathology a microsurgical tumour resection is performed between the rootlets of the lower cranial nerves with debulking and dissection from the surrounding nerval structures. Aneurysm clipping of distal PICA aneurysms can be performed with good proximal control via the dural entrance of the vertebral artery. In all these procedures neuromonitoring including MEPs and SSEPs of extremities and lower cranial nerves is mandatory. After the intradural procedure a direct watertight dural closure is performed. Dural dehiscence demands closure with autologous material such as muscle patches with fibrin glue as well as fibrin sealant patches to prevent CSF leakage.

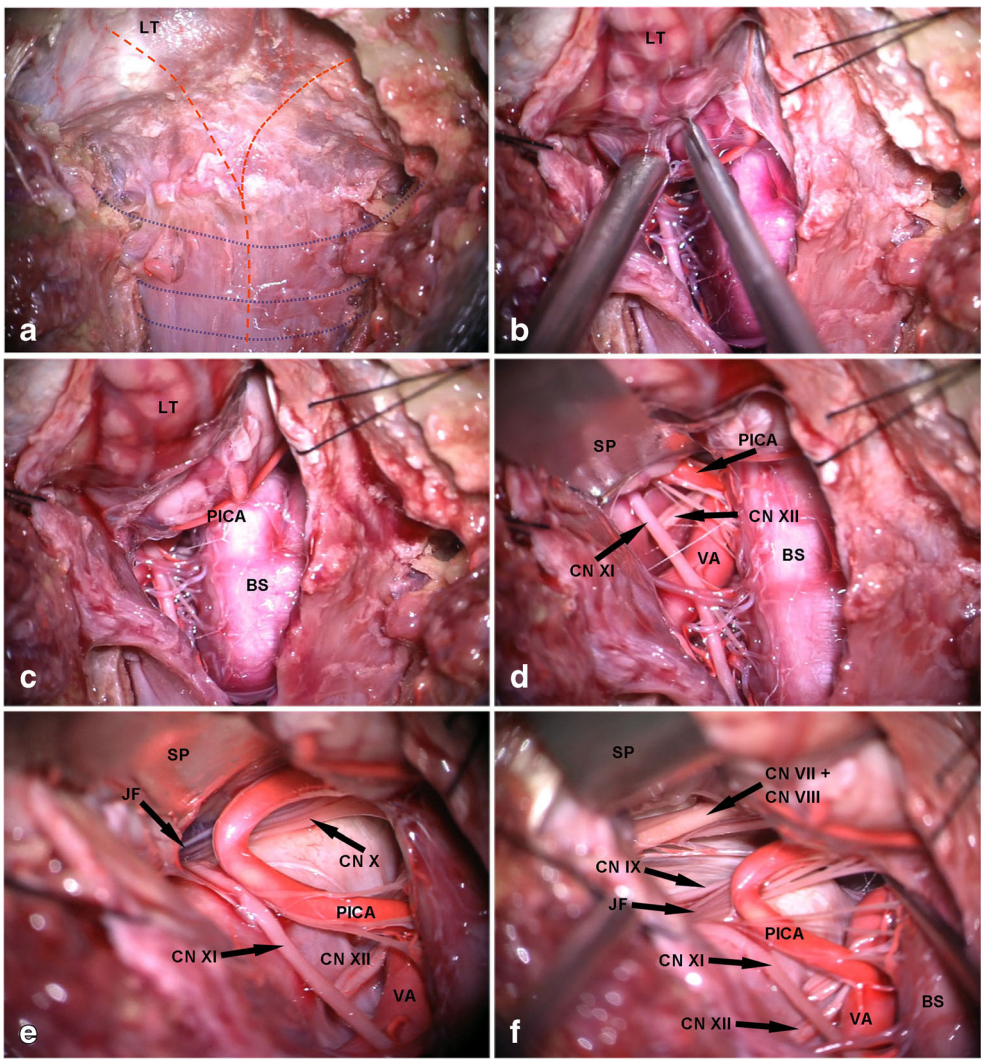

Fig. 1 Left-sided STA in semi-sitting position: anatomical dissection. **a** Y-shaped dural incision (red line), projected border of the foramen magnum and C1 arch (blue lines). **b** Sharp arachnoid dissection around the ipsilateral cerebellar tonsil. **c** View without tonsillar retraction. **d** Cerebellomedullary cistern and its structures with moderate tonsillar retraction. **e** Jugular foramen. **f** Inner auditory canal with CN VII + VIII. LT, left tonsil; BS, brainstem; PICA, posterior inferior cerebellar artery; SP, spatula; CN, cranial nerve; JF, jugular foramen; VA, vertebral artery

Indications and limitation

As described earlier the STA [3, 6, 8] offers excellent access to the cerebellomedullary cistern with a panoramic view of the intracisternal course of the lower cranial nerves, hypoglossal canal, foraminae of Luschka and rostral middle cerebellar peduncle. For this reason the STA can be an excellent and straightforward approach for a number of different intradural pathologies in the lower petroclival area [3, 4, 6–8, 10] (Fig. 2, Video 2). The STA can provide a sufficient and time-sparing access to the cerebellomedullary cistern and the lateral premedullary region without the risk of long-term instability of the craniocervical junction as described in the far lateral, transcondylar or transcondylar fossa approaches [9]. Anatomical data indicate that moderate retraction of cerebellar tonsils is sufficient (0.3–2.4 cm) to gain vision of relevant structures even in the cerebellopontine cistern [3] (Fig. 1f). Furthermore tonsil displacement by slow-growing pathologies helps sparing spatula pressure and opens more space for surgery and sufficient tumour resection. Patient positioning, additional C1 laminotomy and craniotomy size can further influence the extent of tonsillar retraction enabling a better viewing angle. With endoscopic assistance visualisation can be extended to the cerebellopontine as well as the premedullary cistern [3]. Endoscopy-assisted surgery therefore can be helpful to complete tumour resection when the microscopic viewing angle is limited. Additionally the STA opens good access to the distal segments of the PICA and therefore can be suggested as an ideal approach to the distally located PICA and proximal intradural vertebral artery aneurysms, providing good vessel control and minimal approach-related morbidity [3, 7] (Video 3).

However the STA shows limitations concerning the viewing angle. Pathologies extending far superior to the inner auditory canal or to the contralateral side may lead to poor visualisation and cause the risk of subtotal resection. Posteriorly displaced cranial nerves may further influence resection because of the necessity to work in between their sensitive rootlets (Fig. 3). Proximal PICA and basilar trunk aneurysms are not suitable for the STA technique [1, 5].

How to avoid complications

We suggest the STA as a straightforward approach to the cerebellomedullary cistern with low morbidity. Nevertheless a temporary increase of preoperatively existing deficits might be possible because of the manipulation and stretch on sensitive structures [3]. A semi-sitting position and additional C1 laminotomy can enhance the surgical exposure and viewing angle. An extensive arachnoid dissection and the release of CSF can help to increase tonsil mobility and reduce spatula pressure additionally. To cope with visual limitations or with high-rising tumours bilateral arachnoid dissection or incision of the medullary velum can further increase the tonsillar retraction potential. Cerebral mutism has been described using the telo-velar approach to the fourth ventricle. Unilateral tonsillar retraction however may avoid these problems [2]. Postoperative cerebellar symptoms are dependent on the extent and time of tonsillar retraction as well as vascular impairment. Intermittent retraction, extensive arachnoid dissection and clear visualisation of the PICA are mandatory to minimise the risk. Unilateral dural opening can facilitate primary watertight dural closure thus preventing CSF leakage.

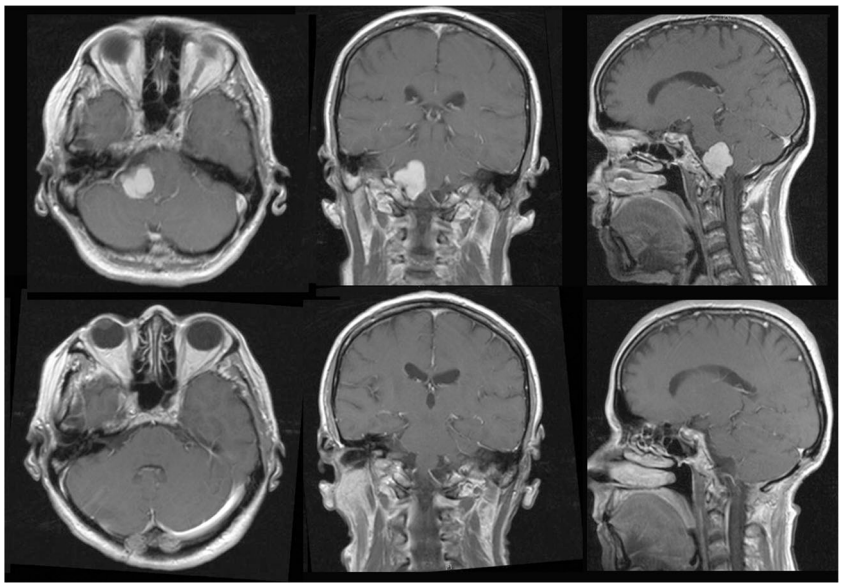

Fig. 2 Pre- (upper row) and postoperative (lower row) contrast-enhanced MRI scans of a WHO grade I meningeoma located in the cerebellomedullary cistern

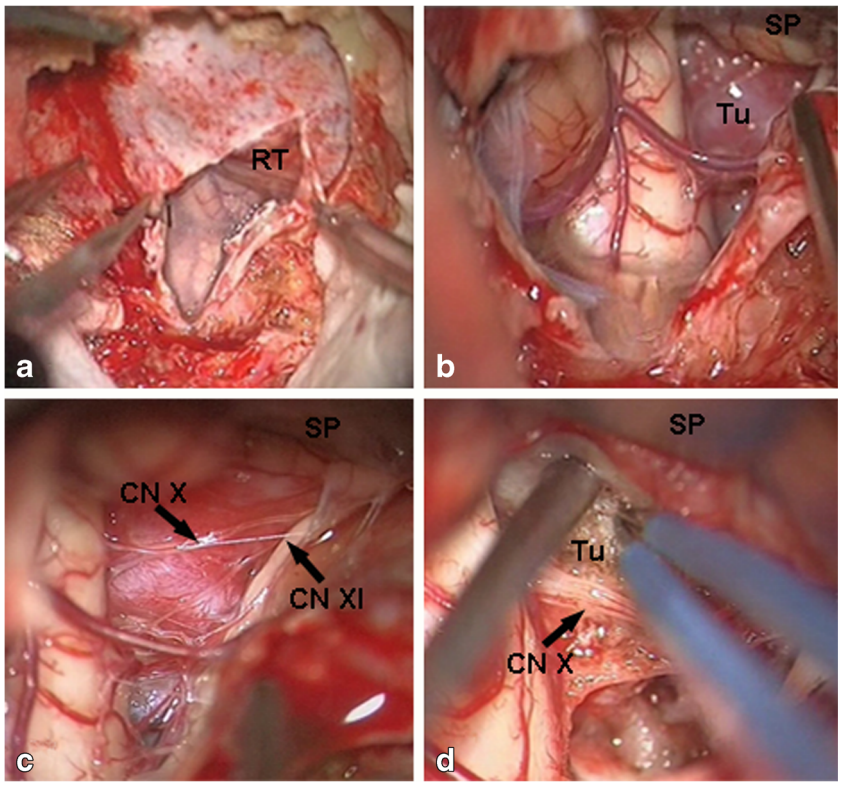

Fig. 3 Intraoperative pictures of a right-sided STA in meningioma surgery. RT, right tonsil; SP, spatula; Tu, tumour; CN, cranial nerve

Specific peri- and postoperative considerations

Depending on preoperatively existing lower cranial nerve deficits a peri- or postoperative tracheotomy and PEG-tube insertion must be considered because approximately half of the patients temporarily decrease in function [3]. Intraoperative neurophysiological monitoring (IOM) of the lower cranial nerves is absolutely mandatory to reduce the risk of permanent deficits. The postoperative ICU with prolonged respiratory assistance might additionally become necessary in patient cases of severe lower cranial nerve involvement along with early logopaedic and physiotherapeutic training.

Specific information to give to the patient about the surgery and potential risks

The STA is an easy-to-perform and straightforward procedure with very low approach-dependent morbidity. However the close relation of different pathologies to the lower cranial nerves may influence the clinical outcome. In case of lower cranial nerve involvement information about permanent or temporary loss of lower cranial nerve function is mandatory including the necessity of PEG or nasogastral tube insertion and tracheotomy. Nevertheless in our series only two patients required tracheotomy and five patients received PEG or a nasogastric tube to treat postoperative swallowing disturbances lasting more than 3 days [3].

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Key points

- The STA is a fast, straightforward and easy-to-perform approach to structures of the cerebellomedullary cistern
- Semi-sitting position and C1 laminotomy may improve the viewing angle, facilitating bimanual microsurgical dissection and avoiding tonsillar retraction
- Careful arachnoid dissection around the tonsils and cisterns enables panoramic view of the cerebellomedullary cistern
- Mild and intermittent tonsil retraction can be sufficient in the majority of the cases
- Endoscope assistance enhances the overview thus helping to achieve total tumour resection or aneurysm closure
- For distal PICA aneurysms the approach enables good proximal vessel control of the proximal intradural vertebral artery
- Electrophysiological monitoring of the lower cranial nerves is absolutely recommended
- Depending on pathology a temporary decrease of lower cranial nerve function may be expected
- Postoperative complications and risks are mainly dependent on pathology but not the approach
- Major limitations of the approach consist of pathologies expanding into the cerebellopontine and/or premedullary cistern as well as strong adhesions to the ventral parts of the brainstem