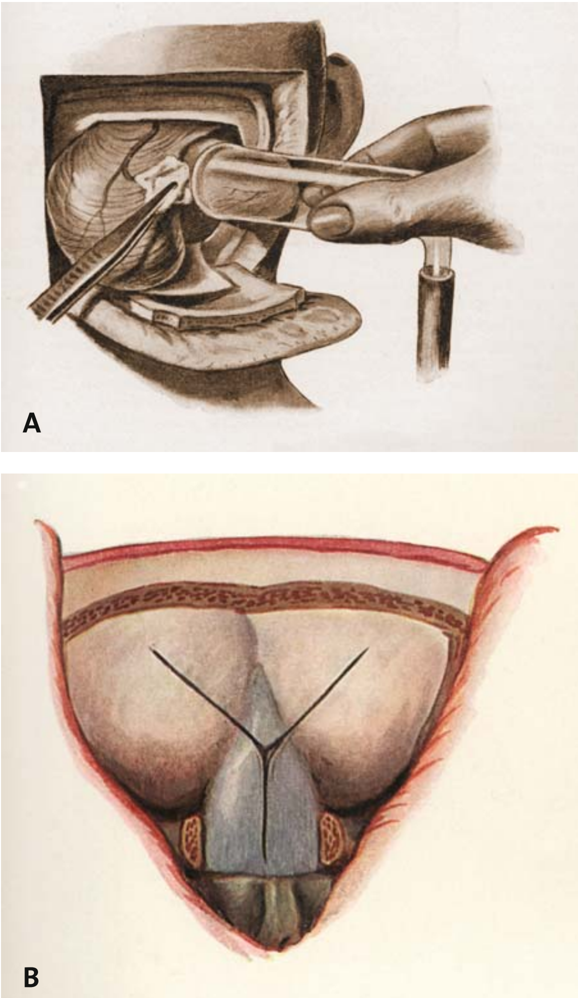


Fig. 5.0.1

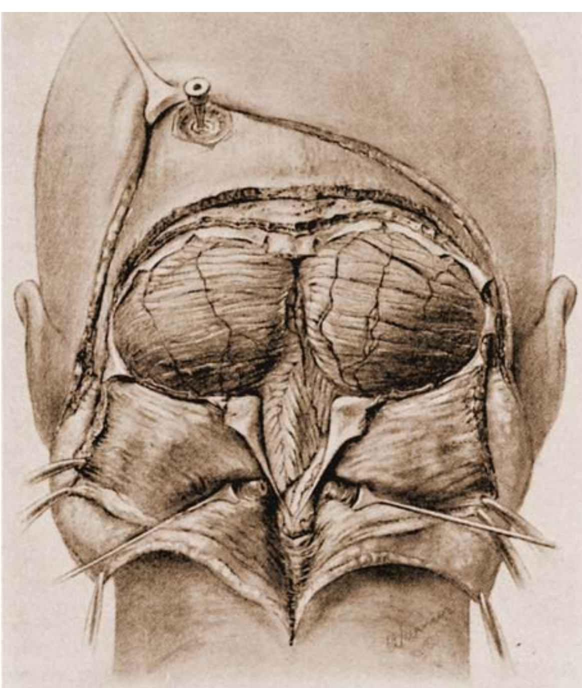


Fig. 5.0.2

5.0 Suboccipital approach

History of the median suboccipital approaches

During the early period of neurosurgery, operative treatment of space-occupying lesions within the posterior fossa was characterized by an extremely high mortality rate. Due to inaccurate preoperative assessment and crude surgical techniques for tumor removal, the treatment failed so frequently that surgeons were reluctant to undertake these operations (Fig. 5.0.1 A). In 1893, Allen Starr published 15 cases of cerebellar tumors with only one patient surviving with neurological recovery [Starr 1893]. On account of these frustrating results, Hermann Oppenheim classified cerebellar lesions as inoperable, reporting a greater than 70% mortality [Oppenheim 1902].

Fedor Krause in 1913 published different approaches to cerebellar tumors describing a broad bilateral exposure of the posterior fossa (Fig. 5.0.1 B). However, only a minority of patients survived this treatment, resulting in a mortality rate ranging from 67% to 88% [Krause 1913].

Wide exposure of the entire suboccipital area was commonly used to approach the posterior fossa. Victor Horsley in 1904 and Harvey Cushing in 1905 reported the *"bilateral exposure of the cerebellar hemispheres through a crossbow incision"* [Horsley 1904, Cushing 1905]. These extended approaches avoided brain stem compression during surgery and allowed posterior fossa decompression after incomplete tumor removal and brain swelling (Fig.5.0.2).

Fig. 5.0.1 *In the early days of neurosurgery, space-occupying lesions were usually removed by blunt finger dissection between the sensitive neurovascular structures. Treatment of cerebellar lesions was often unsuccessful because of the crude surgical techniques. To achieve a nontraumatic dissection, especially within the posterior fossa, Krause in 1909 published a new method using vacuum suction of the tumor mass (A). Note Krause's median suboccipital approach exposing the posterior fossa. He carried out a broad laminectomy of the atlas allowing decompression of the craniocervical region and the dura was opened in a "Y" form (B).*

Fig. 5.0.2 *Cushing's posterior fossa surgery using a bilateral suboccipital approach. Cushing described an "extreme foraminal herniation in a case in which tension was so great as to necessitate removal of the laminae of the atlas and carrying the dural incision to the atlas before respiratory embarrassment was relieved". Note the puncture of the left lateral ventricle.*

On the basis of his experience, Horsley pointed out that a large amount of the cerebellar tissue could be sacrificed and removed with a minor or no demonstrable loss of neurological function. The common approach to lesions of the fourth ventricle was obtained by splitting the vermis on the suboccipital surface, and in some cases, removing the medial part of the cerebellar hemisphere as recommended by Walter E. Dandy and Ludwig G. Kempe [Dandy 1938, Kempe 1970] (Figs. 5.0.3, 5.0.4).

The introduction of microsurgical techniques provided a marked improvement in surgical efficiency. With less invasive approaches as reported by Robert W. Rand and M. Gazi Yasargil, surgical mortality and morbidity could be successfully minimized [Rand 1968, Yasargil 1970]. In particular, the precise dissection within the subarachnoid spaces of the posterior fossa and approaching the fourth ventricle through anatomical pathways offered a significant development in surgical results (Fig. 5.0.5).

In the following the importance of these anatomical considerations is discussed in full.

Fig. 5.0.3 *Exploration of a partial cystic tumor of the posterior fossa through a median suboccipital approach as described by Dandy. The patient suffered from severe headaches caused by a consecutive obstructive hydrocephalus. Note the intraoperative use of monopolar coagulation allowing a safe surgical dissection.*

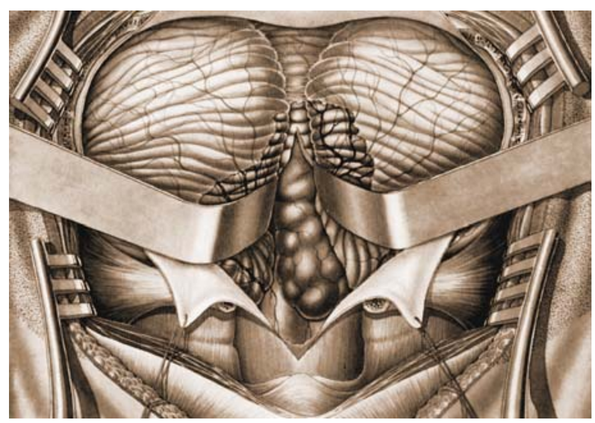


Fig. 5.0.4 *Kempe's macrosurgical posterior fossa exploration published in 1968 in his comprehensive neurosurgical textbook. Note the broad bilateral exploration and sectioning of the inferior vermis for approaching the tumor within the fourth ventricle.*

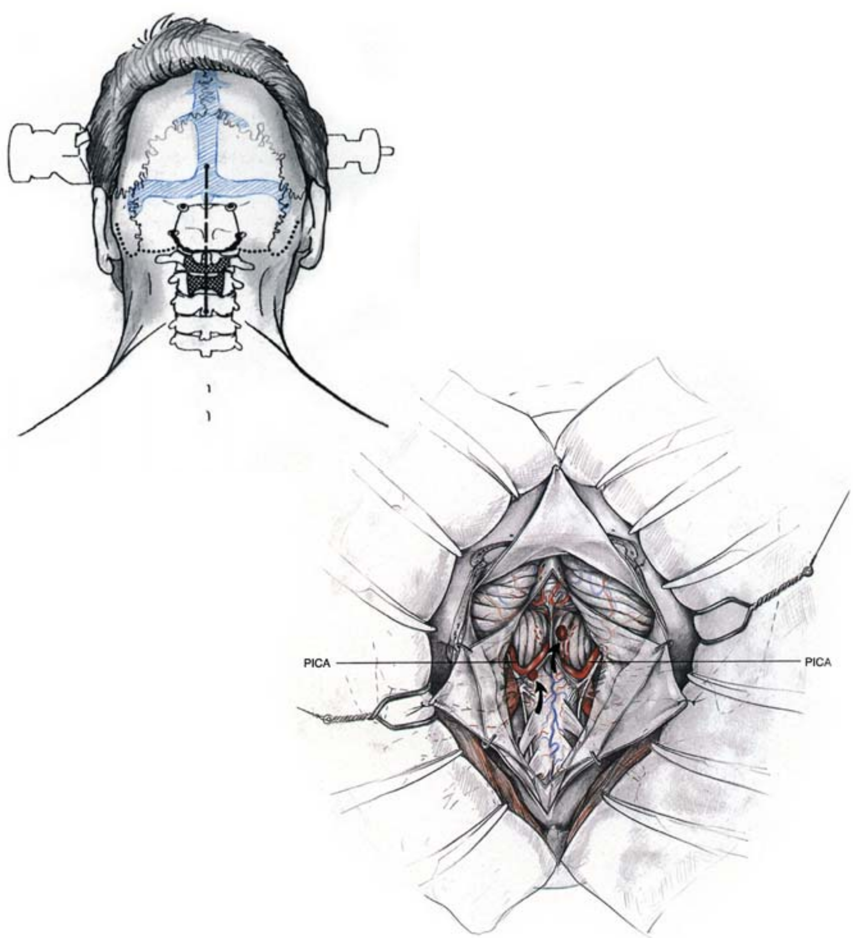


Fig. 5.0.5 *The median suboccipital approach using microsurgical techniques described by Yasargil for distally situated aneurysms of the PICA.*

General anatomical construction of the surgical corridor to the fourth ventricular region

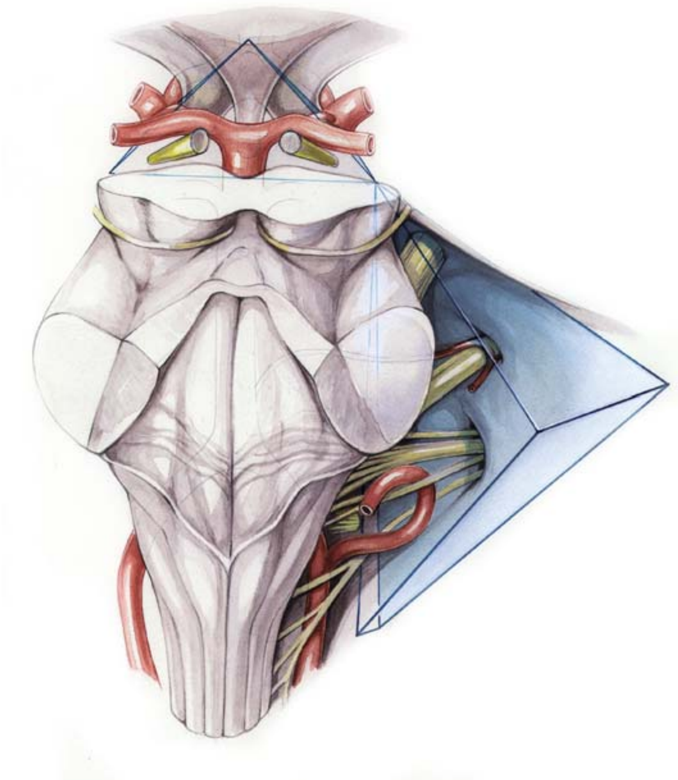


Fig. 5.0.6 *Artistic illustration of the fourth ventricle, rhomboid fossa and the surrounding anatomical structures.*

The posterior cranial fossa is the deepest of the three cranial fossae containing the most complex intracranial anatomy with structures of the cerebellum, brain stem, ten pairs of cranial nerves, and complex arterial and venous relationships. The posterior fossa extends from the tentorial incisura to the foramen magnum between the supratentorial and intraspinal spaces. It is surrounded by the occipital, temporal, parietal, and sphenoid bones. In its narrow space, which consists of only approximately one-eighth of the intracranial volume, are the most important vital pathways regulating consciousness, cardiorespiratory and other autonomic functions, motor activities and sensory reception, and centers for controlling balance and gait.

Operative approaches to the fourth ventricle and most cerebellar tumors are commonly directed around and through the suboccipital area of the posterior fossa. According to the falx cerebelli, the suboccipital surface of the cerebellum is divided by the posterior cerebellar incisura into right- and left-sided hemispheres. The vermis cerebelli is folded into this incisura and forms a type of cortical surface within the incisura. The suboccipital cerebellar surface is divided horizontally by the suboccipital fissure into superior and inferior parts. This suboccipital fissure has a vermian and a hemispheric part. The vermian part separates the tuber and the pyramid and is termed the prepyramidal fissure. In the hemispheric part, the prebiventral fissure separates the biventral and inferior semilunar lobules of the cerebellar hemispheres. The tonsils and the uvula are situated inferomedial from the lobulus biventral and pyramid covering the access to the caudal part of the fourth ventricle.

Via the suboccipital approach, access is gained to the fourth ventricular chamber through a triangle-formed space between the two tonsils, the so-called vallecula, and through the cerebellomedullary fissure, the narrow space between the tonsils and the medulla oblongata. The vallecula communicates through the foramen of Magendie with the chamber of the fourth ventricle (Fig. 5.0.6). Surgical exposure of the ventricle requires dissection of the foramen of Magendie and opening of the caudal part of the ventricular roof. This caudal roof of the fourth ventricle is formed by the inferocaudal part of the vermis with the uvula and nodulus and the inferior medullary velum covering the tonsils of both cerebellar hemispheres. The tela choroidea stretches between the inferior medullary velum and the taenia of the medulla oblongata forming the choroid plexus of the fourth ventricle with branches of the posterior inferior cerebellar artery.

In the past, operative access to the fourth ventricle was obtained by splitting the cerebellar vermis and, in some cases, by removing the medial part of the cerebellar hemisphere. However, careful microsurgical dissection of the vallecula and the cerebellomedullary fissure provides a broad exposure of the caudal entrance into the ventricle. Opening the foramen of Magendie and tela choroidea will provide adequate exposure of the full length of the floor of the ventricle without splitting of the vermis or removing neural tissue (Fig. 5.0.7). This maneuvre can be compared with the transchoroidal enlargement of the foramen of Monro. In addition, by opening the inferior medullary velum, one can approach the entire ventricular chamber including the fastigium, the lateral recesses toward the foramen of Luschka and the aqueduct of Sylvius. It is important to note that there are no reports of deficits following separate opening of the velum and tela compared with possible severe gait disturbances and ataxia after splitting of the vermis.

In the following, the basic surgical technique of the median suboccipital infracerebellar approach is described.

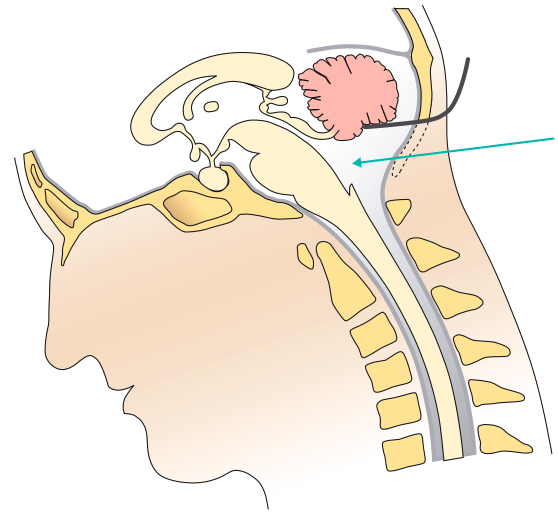


Fig. 5.0.7 *Operative exposure of the fourth ventricle using the median suboccipital approach. Note that careful retraction of the nodulus and uvula after dissection of the cerebellomedullary fissure provides a broad approach to the ventricular chamber without splitting the inferior vermis.*

Craniocervical junction	Fourth ventricle
Posterior circumference of the foramen magnum Marginal sinus, occipital sinus Suboccipital surface of the cerebellar hemispheres Cerebellar tonsils, lower vermis, vallecula Inferior medullary velum Choroid plexus of the fourth ventricle Foramen of Magendie Cervicomedullary junction Posterior surface of the medulla oblongata First denticulate ligaments CN XII, CN XI, CN X, CN IX, first cervical root VA, PICA, incl. perforators	Choroid plexus of the fourth ventricle Rhomboid fossa Foramen of Luschka Fastigium Superior medullary velum Aqueduct Posterior third ventricle

Table 5.0.1 *Anatomical structures which can be reached through the median suboccipital approach.*

Surgical technique

1. Patient positioning

Surgery of the posterior fossa including the fourth ventricle can be performed with the patient in the sitting or the prone position. As a main advantage, the sitting position improves the venous drainage of the posterior fossa and allows blood, CSF, and irrigating solutions to drain from the operative field. However, the sitting position carries a very severe anesthesiological risk with danger of cardiopulmonary instability, air embolism, severe pneumocephalus or ventricular collapse caused by an enormous loss of CSF. In addition, exposing the fourth ventricle in the sitting position requires retraction of the cerebellar hemispheres against gravity, resulting in contusion of the cerebellar tissue. In our department, we use the prone position for exposing the posterior fossa via the median suboccipital approach. Advantages of this positioning are the simplicity of the technique and comfort for the patient. With an adequate positioning of the head, the cerebellum falls away from the brain stem surface opening the subvermial surgical corridor. At the same time, the perpendicular direction of surgical dissection provides an efficient working position with optimal visualization of the operating field.

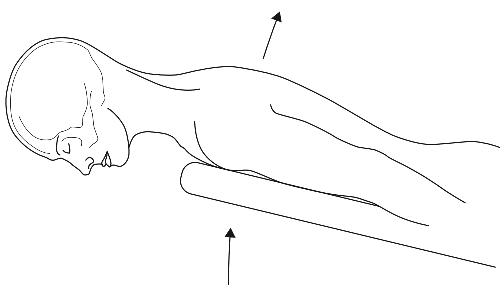


Fig. 5.0.8

Step 1

As a first step of positioning, the body and the head are elevated ca. 20° to 30° as in an anti-Trendelenburg position. This elevation is necessary to bring the head above the level of the thorax offering optimal venous drainage (Fig. 5.0.8).

Fig. 5.0.9

Step 2

In a second step, the head may be anteroflected about 45° in order to bring the tentorium in a perpendicular plane. This so-called Concorde position provides an efficient working position for the surgeon dissecting toward the inferior cerebellar surface and within the fourth ventricle. However, special care should be taken not to compress the ventilation tube and the larynx. Excessive anteflection can also cause venous congestion due to compression of the jugular veins (Fig. 5.0.9).

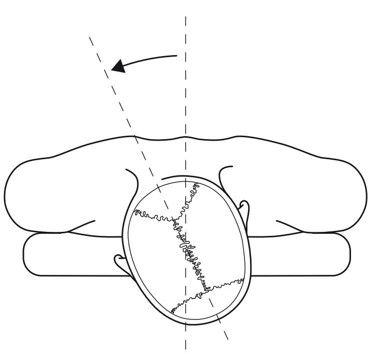


Fig. 5.0.10

Step 3

For lesions located mainly in the midline, rotation of the head is not necessary. However, mediolaterally situated lesions require a slight rotation of 5°–15° (Fig. 5.0.10).

2. Anatomical landmarks and orientation

For preoperative orientation, the important anatomical landmarks of the posterolateral osseous skull and spine, such as the external auditory meatus, mastoid process, the highest nuchal line, the external occipital protuberance, the foramen magnum and the spinous process of C2 are precisely determined (Fig. 5.0.11). Special attention should be given to the course of the transverse sinus as the border of the posterior fossa, and definition of the midline structures.

After exact orientation, the borders of the craniotomy are marked with a sterile pen. Usually, the craniotomy is placed median or slightly paramedian extending from the foramen magnum to the inferior nuchal line with a diameter of about 3 cm. In some cases, the superior rim of the posterior arch of C1 can additionally be removed, allowing optimal exposure of the cervicomedullary junction.

After defining the craniotomy, the hair is shaved and carefully disinfected according to the midline skin incision of 6 to 8 cm in length (Fig. 5.0.11).

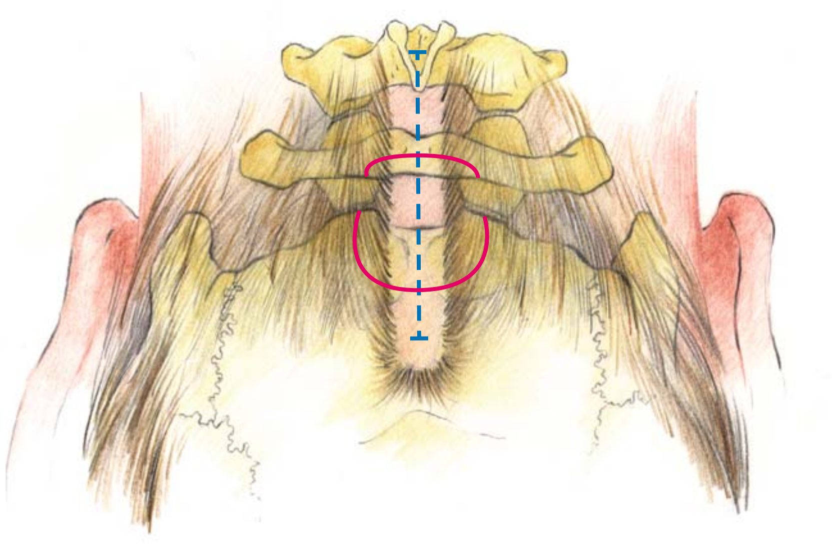


Fig. 5.0.11 *Definition of the craniotomy according to the anatomical landmarks of the posterior craniocervical region. The midline skin incision should reach the easily palpable C2 spinous process.*

3. Craniotomy and dural opening

Step 1

After patient positioning and anatomical orientation, the skin is prepared with alcohol solution. To begin the suboccipital exposure, a straight midline incision is made extending from the inion to the well palpable spinous process of C2 (Fig. 5.0.12).

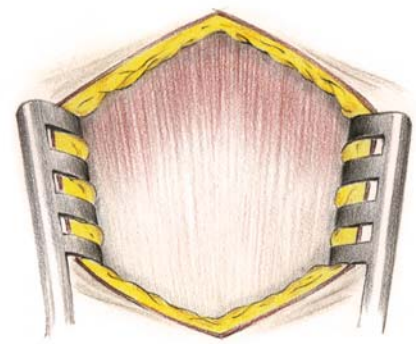


Fig. 5.0.12

Step 2

After retraction of the skin, the ligamentum nuchae is precisely defined and split according to the midline. Soft tissue dissection and separation of the suboccipital muscles should be made strictly in the midline through the ligamentum nuchae, thus avoiding misguiding into the highly vascular paramedian muscles (Fig. 5.0.13).

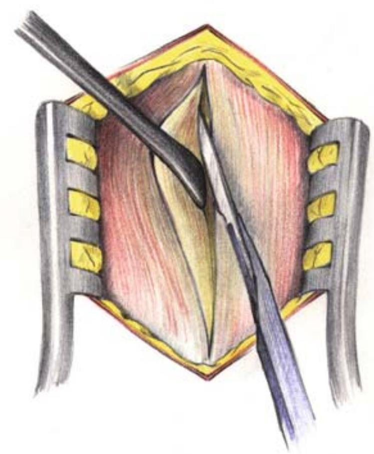


Fig. 5.0.13

Step 3

A low profile, self-retaining retractor is then used to hold back the thick suboccipitial muscle layers, e.g., the trapezius, splenius and semispinalis capitis muscles. The rectus capitis posterior minor is dissected from the tubercle on the posterior arch of the atlas exposing the suboccipital area with the foramen magnum and the posterior arch of C1. Local hemostasis needs to be performed rapidly and precisely. After retraction of the muscles, two paramedian burr hole trephinations are performed exposing the dura mater of both cerebellar hemispheres (Fig. 5.0.14).

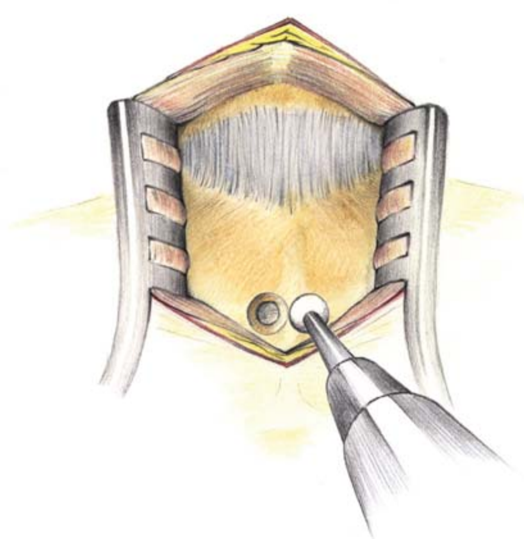
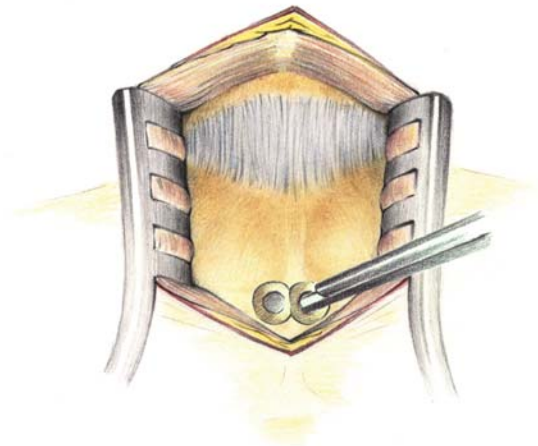


Fig. 5.0.14

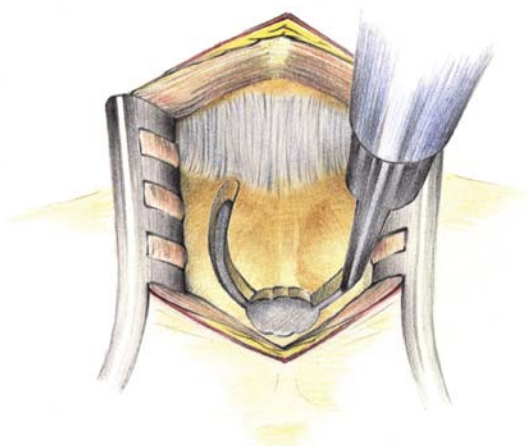
Fig. 5.0.15



Step 4

Next, the paramedian burr holes are connected using fine punches with removal of the internal occipital crest, avoiding damage to the occipital sinus (Fig. 5.0.15).

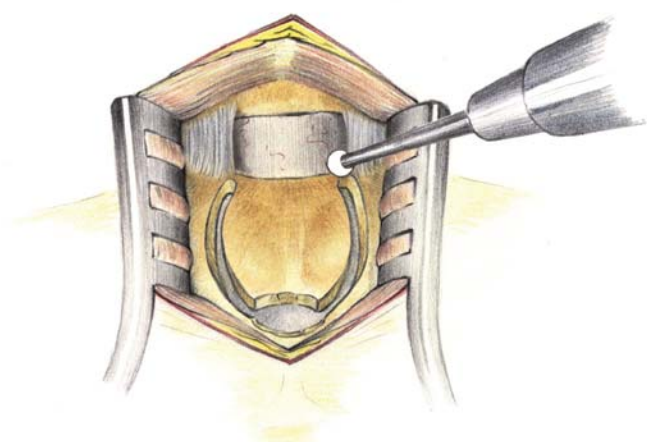
Fig. 5.0.16



Step 5

After careful exposure of the dura mater and the occipital sinus, an osteoplastic craniotomy is performed using a high-speed craniotome. From the burr hole trephinations, curved lines are sawed on both sides to the posterior margin of the foramen magnum (Fig. 5.0.16).

Fig. 5.0.17



Step 6

According to the craniotomy lines, the thick posterior margin of the foramen magnum is then removed using a high-speed drill, avoiding injury to the dura mater of the lateral craniocervical junction. Note avoiding surgical injury to the vertebral artery (Fig. 5.0.17).

Step 7 A

Observing the vallecula and the fourth ventricle, the bone flap should be elevated with a blunt dissector. Using this "open-door" technique, the flap is retracted caudally without detaching from the atlantooccipital ligament and fixed temporarily on the nuchal ligament. Nevertheless, this suboccipital keyhole does not offer adequate exposure of the cervicomedullary junction (Fig. 5.0.18 A).

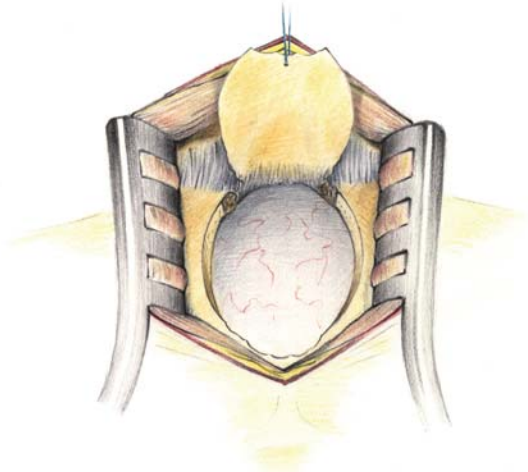


Fig. 5.0.18 A

Step 7 B

If visualization of the upper cervical spine is required, an extended suboccipital craniotomy must be performed. After removal of the bone flap, the superior border of the posterior arch of the atlas should also be additionally removed. This partial removal of the posterior arch without C1 laminectomy allows additional exposure of the craniocervical region, and after dural opening, open visualization of the cervicomedullary junction (Fig. 5.0.18 B).

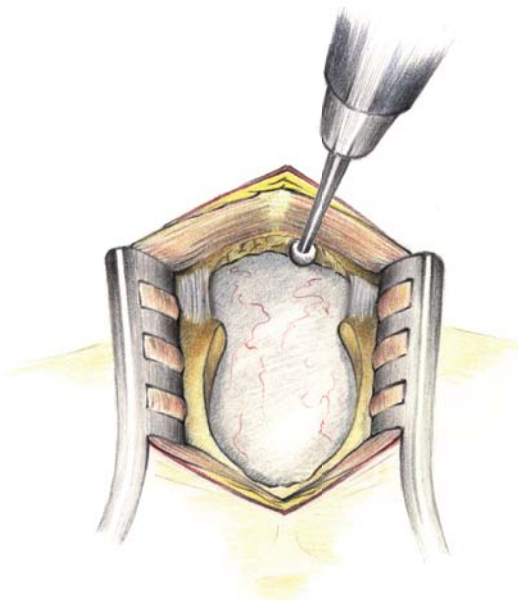


Fig. 5.0.18 B

Step 8

The dura is opened in a reverse Y-shaped fashion extending toward the foramen magnum and the free dural flaps are fixed with holding sutures. In young children, the dura may be full of venous channels and a prominent marginal sinus may be present in the region of the foramen magnum. This may bleed excessively upon dural opening and hemoclips or sutures should be used for hemostasis (Fig. 5.0.19).

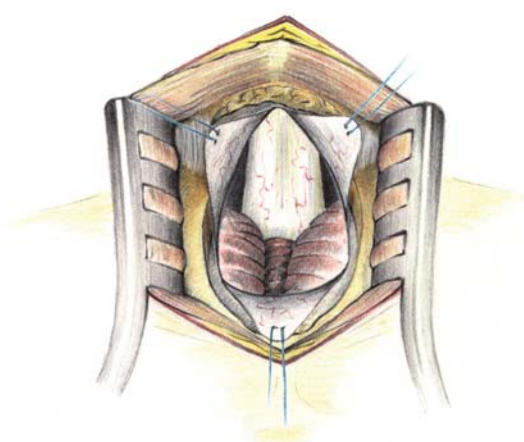


Fig. 5.0.19

4. Intradural dissection

Step 1

Dissection performed on a fresh human cadaver. The vessels are prepared with colored latex solution. After opening the dura mater, the intact arachnoid membranes of the great cerebellomedullary cistern can be seen. The first step is the sufficient drainage of CSF by opening the arachnoid sheet. This helps further relaxation of the brain by releasing CSF and will initiate dissection of the cerebellar tonsils, the vermian peg, and the floor of the fourth ventricle (Fig. 5.0.20).

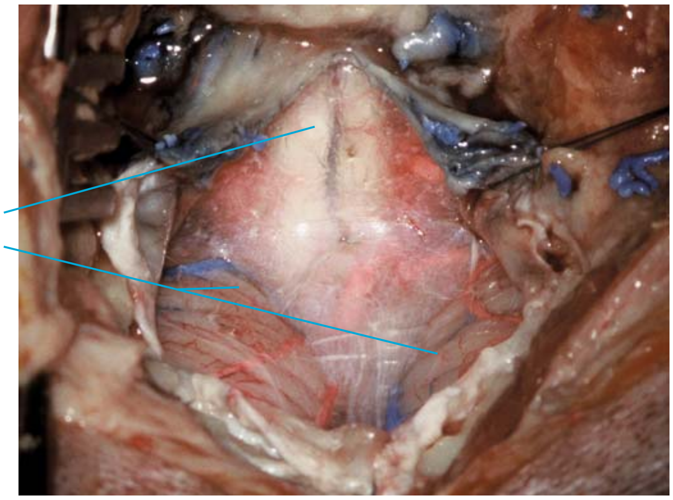


Fig. 5.0.20

Step 2

After opening and retraction of the arachnoid, the cervicomedullary junction is seen and, in part, the suboccipital surface of the cerebellum. Note the lobulus biventer and the cerebellar tonsils hiding the view into the fourth ventricle. The vertebral arteries can be observed on both sides of the medulla; the PICA disappears into the cerebellomedullary fissure (Fig. 5.0.21).

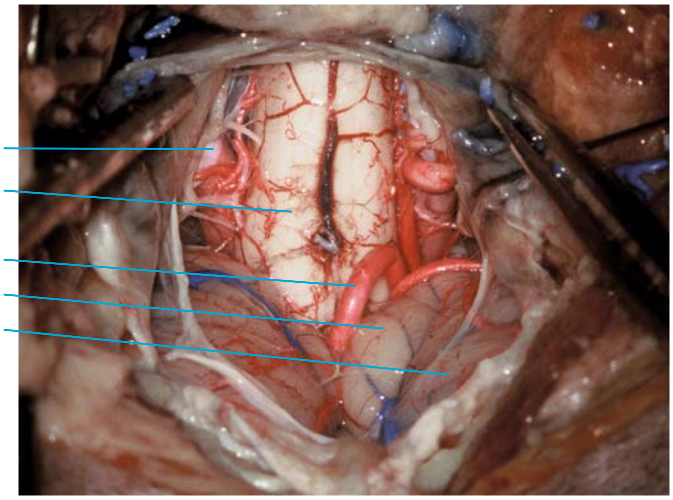


Fig. 5.0.21

Step 3

Dissecting more laterally, the entrance of the right VA into the intracranial space can be observed. Note the cervical root of the CN XI and the first denticulate ligament. Note the arachnoid membrane of the great cerebellomedullary cistern (Fig. 5.0.22).

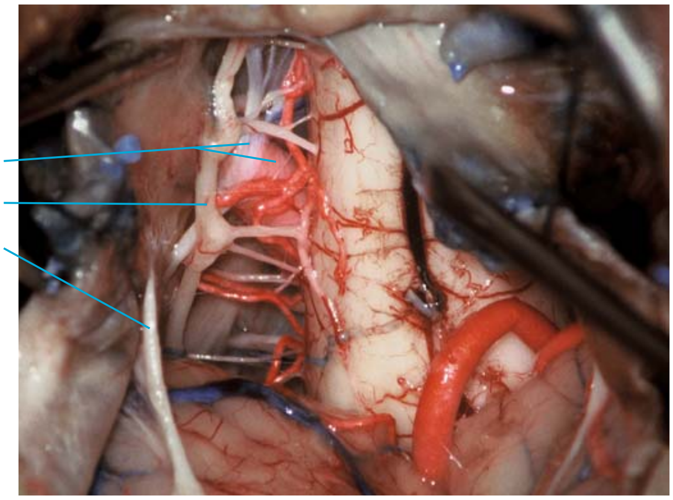


Fig. 5.0.22

Step 4

After careful retraction of the brain stem, the entrance of the CN XII into the hypoglossal canal can be seen. Note the right VA and the CN XI (Fig. 5.0.23).

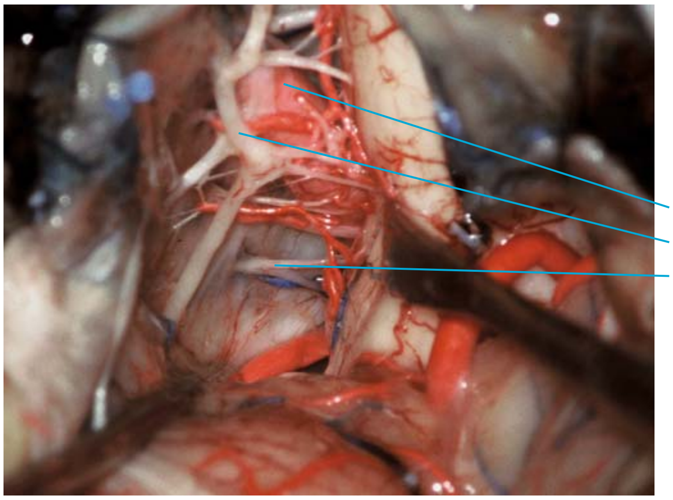


Fig. 5.0.23

Step 5

After mobilization of the cerebellum, the CN X and Bochdalek's choroid plexus of the fourth ventricle can be observed. Note the first loop of the PICA close to the caudal cranial nerves (Fig. 5.0.24).

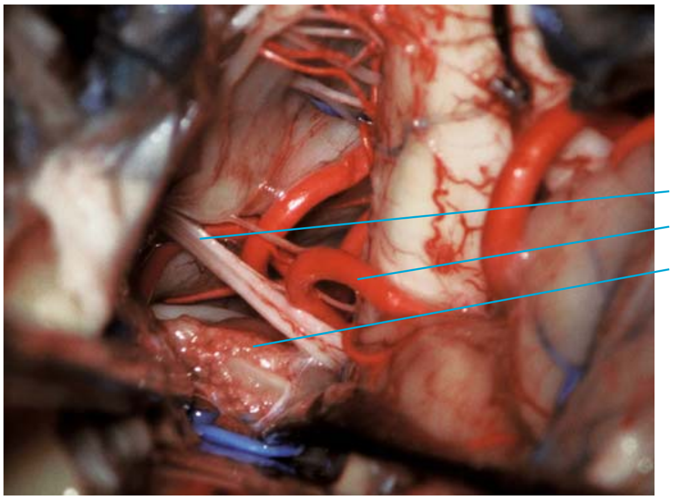


Fig. 5.0.24

Step 6

Focusing more medially, the right tonsil is retracted. Both posterior cerebellar arteries disappear into a triangle-formed chamber between the two tonsils, the so-called vallecula. Note the cerebellomedullary fissure, the narrow space between the tonsils and the medulla oblongata (Fig. 5.0.25).

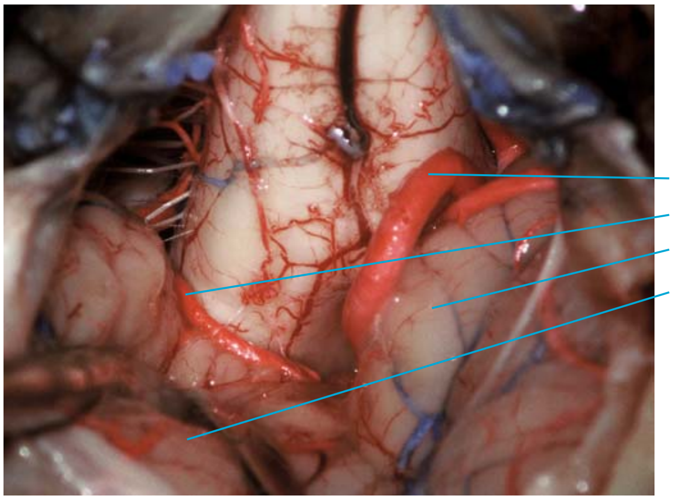


Fig. 5.0.25

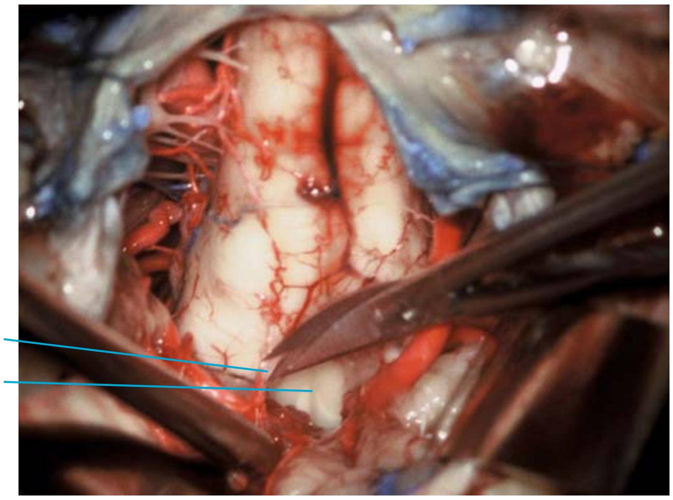


Fig. 5.0.26

Step 7

To expose the chamber of the fourth ventricle, the tonsils should be moved away from the medulla, taking care not to damage the posterior inferior cerebellar arteries. The tela choroidea is carefully dissected from the taenia of the medulla oblongata, enlarging the foramen of Magendie. Note the caudal part of the fourth ventricle (Fig. 5.0.26).

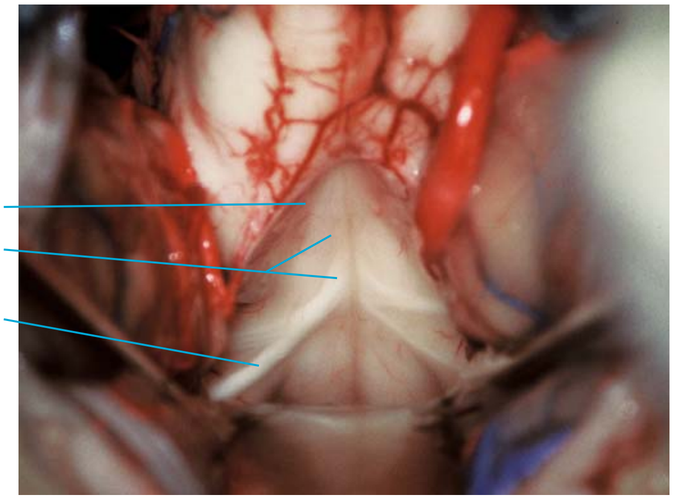


Fig. 5.0.27

Step 8

After opening the foramen of Magendie and dissection of the tela choroidea away from the taenia of the medulla oblongata, the inferior medullary velum and the vermis are gently retracted, providing a broad view of the fourth ventricle. The caudal part of the rhomboid fossa appears with the trigone of the hypoglossal and vagus nerve. The area postrema, a triangular field caudal to the trigone of the vagus nerve with strongly vascularized reddish glia-rich tissue, can also be well observed. Note the white tissue of the medullary striae (Fig. 5.0.27).

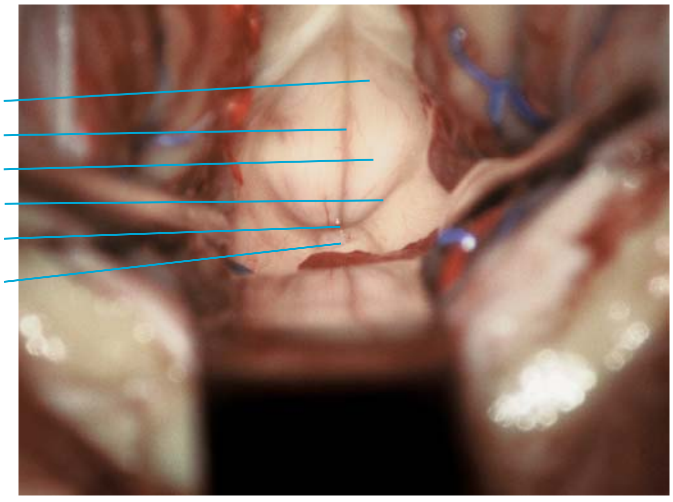


Fig. 5.0.28

Step 9

Using adequate head positioning and careful surgical dissection, exposure of the cranial part of the fourth ventricle is possible without incision and splitting of the vermis, thus avoiding severe postoperative ataxia. The facial colliculus appears cranial from the medullary striae according to the genu of the facial nerve. Note the median eminence between the median and limiting sulcus. Note the cerebral aqueduct and the superior medullary velum (Fig. 5.0.28)

Step 10

Dissecting more laterally within the ventricular chamber, the vestibular area and the lateral recess of the fourth ventricle can be observed. Note the medullary striae, facial colliculus and the limiting sulcus of the rhomboid fossa (Fig. 5.0.29)

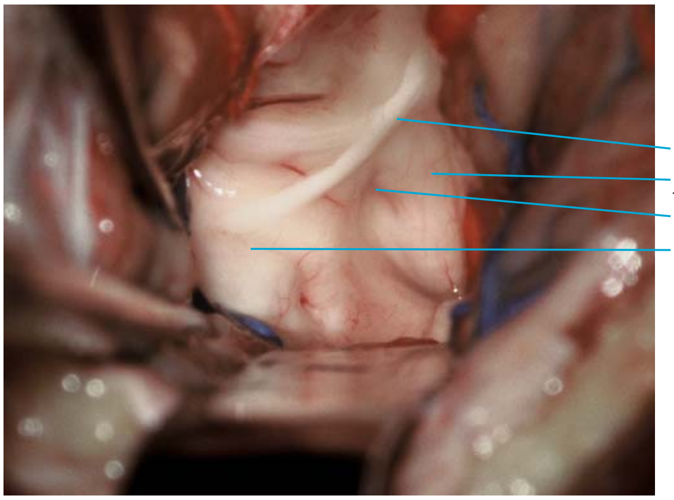


Fig. 5.0.29

Step 11

Observing again the craniocervical junction, the dural entrance of the left vertebral artery can be seen. Note the first denticulate ligament. The spinal root of the CN XI crosses the intracranial VA and the CN XII disappears into the hypoglossal canal (Fig. 5.0.30)

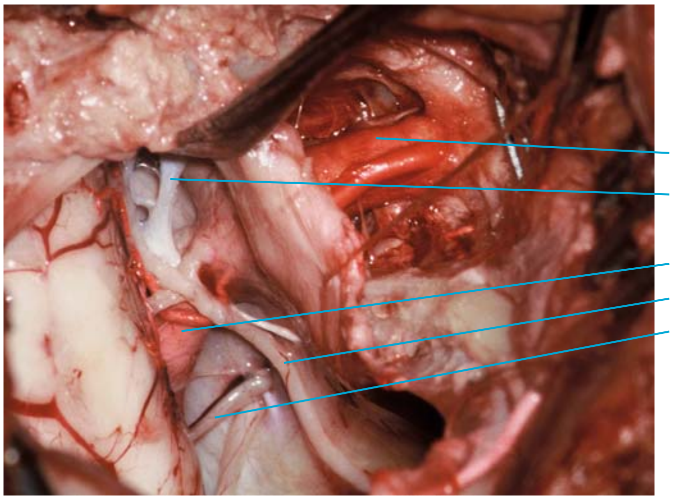


Fig. 5.0.30

Step 12

Dissection shows the intra- and extradural course of the VA, the blunt dissector points to the first cervical root after removal of the posterolateral dura of the craniocervical junction. Note the spinal part of the CN XI (Fig. 5.0.31)

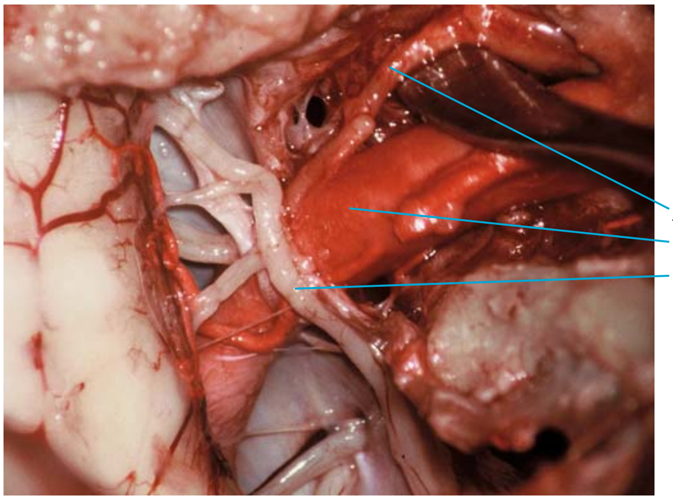


Fig. 5.0.31

5. Dura, bone and wound closure

Closure of midline posterior fossa exposures must be performed meticulously. After completion of the intracranial procedure, the intradural space is filled with Ringer solution at body temperature. The dural incision is closed with interrupted sutures. If shrinkage has developed in the dural plane, which is a frequent problem, a small piece of muscle can be sewn into the dural closure. In other cases, an artificial dural graft can be used. After watertight dural closure, a plate of gelfoam is placed extradurally. The bone should be reattached using titanium plates. After final verification of hemostasis, the muscles should be closed in anatomical layers. The subcutaneous layer is closed with interrupted sutures and the skin with running or interrupted sutures. Suction drainage is not required.

Potential errors and their consequences

- Poor preoperative planning with poor exposure of the target region and significant deterioration in efficiency of surgically excising the lesion. Planning is the most important part of surgery and the task of the surgeon!
- Inadequate positioning of the patient with insufficient exposure of the target.
- Loss of the midline, dissecting the deep suboccipital muscles. This can cause unwarranted bleeding, inadequate exposure of the bony surface and postoperative discomfort.
- Injury to the occipital sinus after burr hole trephination or injury to the marginal sinus after craniotomy with excessive venous bleeding.
- Inadequate removal of CSF at the first stage of the intracranial dissection with subsequent injury to the cerebellar surface.
- Need to split the inferior vermis after inadequate preoperative planning, poor patient positioning or inadequate craniotomy.
- Injury to sensitive neurovascular structures of the cervicomedullar region and cerebellomedullary fissure with postoperative neurological sequelae.
- Injury to the rhomboid fossa during tumor removal with subsequent severe cranial nerve disorders.
- Postoperative hydrocephalus due to incomplete tumor removal or intraventricular blood clot. In such cases, endoscopic third ventriculostomy should be performed with temporary implantation of a ventricular drain.

Fig. 5.0.32

Fig. 5.0.33

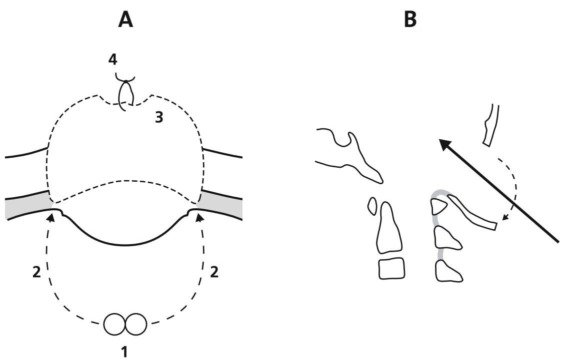


Fig. 5.0.34

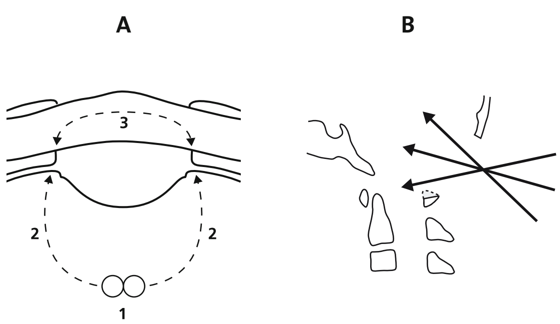
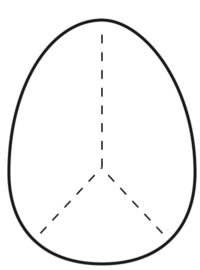


Fig. 5.0.35



- Inadequate dural closure with postoperative CSF fistula.
- Inadequate positioning and fixation of the bone flap.
- Inadequate hemostasis causing postoperative soft tissue hematoma.

Tips and tricks

- Take time for preoperative planning and positioning of patients. The result is an excellent overview of the target area and an efficient working position during surgery.

- Make a careful anatomical orientation and use the three steps of marking with a sterile pen: 1. osseous structures and superficial neurovascular structures; 2. placement of craniotomy; 3. skin incision.

- Using a Concorde prone position, cerebellar retraction and splitting of the inferior vermis can be effectively avoided (Fig. 5.0.32).

- Stages of the suboccipital "open-door" keyhole craniotomy (Fig. 5.0.33 A, B): 1. two paramedian burr holes and removal of the internal occipital crest; 2. craniotomy using a high-speed craniotome; 3. elevation of the bone flap and 4. temporary fixation on the nuchal ligament

- Stages of craniotomy (Fig. 5.0.34 A, B): 1. two paramedian burr hole trephinations; 2.median suboccipital craniotomy; 3. due to partial removal of the posterior arch of the atlas without laminectomy the exploration of the cervico-medullary junction can be extended.

- The dura should be opened in a reverse "Y"-shaped fashion avoiding injury to the occipital sinus. In young patients and children, extensive sinusoid vessels around the foramen magnum may be present which should be occluded with hemoclips or sutures (Fig. 5.0.35).

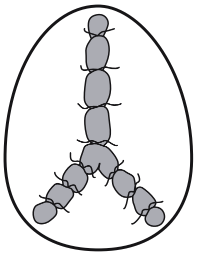
- The first step of the intradural dissection should be the opening of the cerebellomedullar cistern and sufficient CSF drainage.

- After finishing the intracranial procedure, the dural opening should be closed watertight using interrupted or running sutures.

If tension has developed, which is not uncommon, a small piece of muscle can be sewn into the dural closure. In other cases an artificial dural graft should be used (Fig. 5.0.36).

- After dural closure, the bone flap should be tightly fixed with a titanium plate.
- The deep suboccipital muscles should be meticulously closed in anatomical layers. This also helps to avoid postoperative CSF leakage.
- Suction drain should not be used to avoid postoperative CSF leak.

Fig. 5.0.36



5.1 Caudal variation of the median suboccipital approach

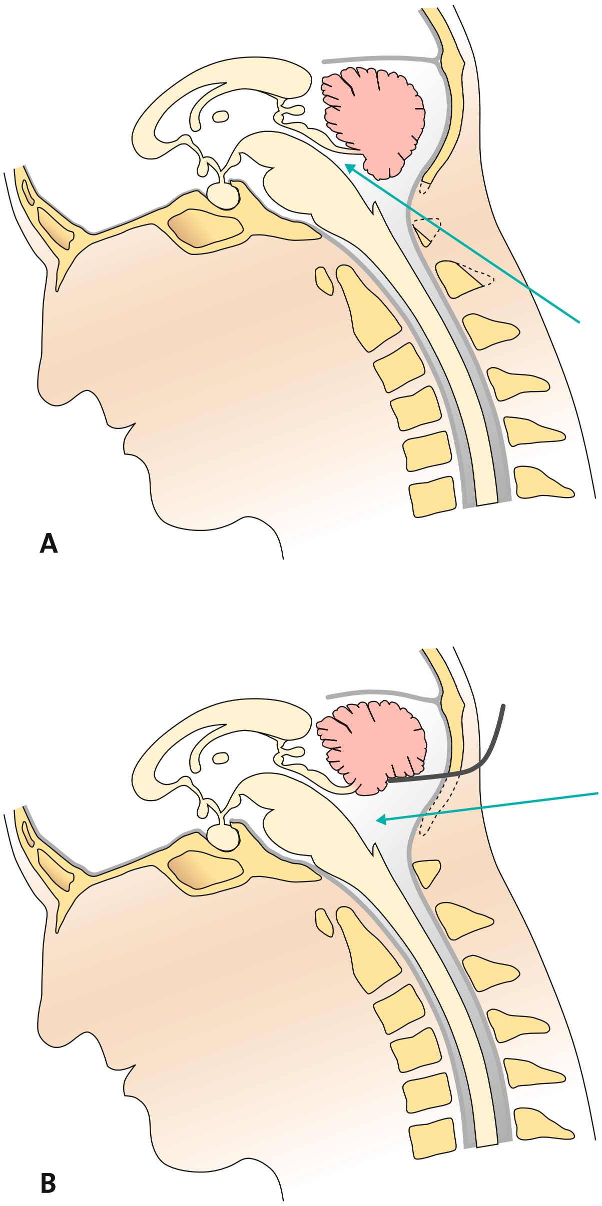


Fig. 5.1.1 *Caudal variation of the median suboccipital approach after partial removal of the posterior arch of C1 and the spinous process of C2 (A). Compared with the basic suboccipital exposure (B) the caudal variant avoids retraction of the cerebellum exposing the Sylvian aqueduct.*

The median suboccipital infracerebellar approach allows visualization of the main part of the fourth ventricle. In some cases, however, the cranial part of the ventricular chamber can be approached only after excessive retraction or even partial sectioning of the inferior vermis, resulting in postoperative coordination disturbances and ataxia. To avoid destruction of sensitive neural tissue, exposure of the cranial fourth ventricle and the Sylvian aqueduct should follow the plane of the rhomboid fossa, placing the dural opening as caudally as possible.

The essence of the caudal variation of the median suboccipital approach is exposure of the upper part of the fourth ventricle through the foramen magnum from a caudal direction. After a craniocervical midline skin incision and soft tissue dissection, the posterior arch of the atlas and the spinous process of the axis are partially removed, revealing the posterior craniocervical region and foramen magnum. After a limited dural opening, the rhomboid fossa of the fourth ventricle including the Sylvian aqueduct can be observed (Fig.5.1.1).

Craniocervical junction	Fourth ventricle	Third ventricle
Posterior and posterolateral circumference of the foramen magnum Posterior arch of the atlas Spinous process of the axis Marginal sinus Cervicomedullary junction Posterior surface of the medulla oblongata Cerebellar tonsils Lower vermis Vallecula Inferior medullary velum Choroid plexus of the fourth ventricle Foramen of Magendie PICA	Choroid plexus of the fourth ventricle Rhomboid fossa Fastigium Superior medullary velum Cerebral aqueduct	Posterior chamber of the third ventricle

Table 5.1.1 *Anatomical structures reached by the caudal variation of the median suboccipital approach.*

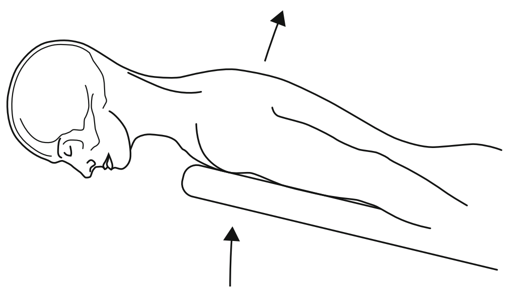


Fig. 5.1.2

Fig. 5.1.3

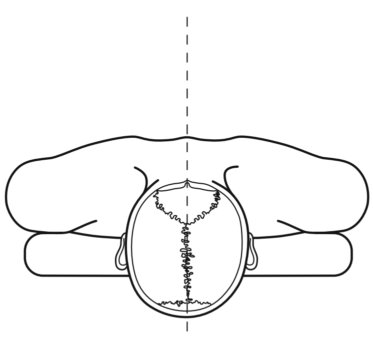


Fig. 5.1.4

Surgical technique

1. Patient positioning

Similar to the median suboccipital approach, the patient is brought into the prone position. Goal of the positioning is the maximal inclination of the head, allowing surgical dissection parallel to the plane of the rhomboid fossa.

Step 1

After fixing in the three-pin head holder, the body and the head are elevated ca. 20° to 30° on the operating table. This elevation is necessary to bring the head above the level of the thorax allowing optimal venous drainage (Fig. 5.1.2).

Step 2

In a second step, the head may be maximally anteroflected. This extreme Concorde position allows an efficient working direction according to the plane of the rhomboid fossa. Special attention should be given to avoid severe compression of the larynx with the ventilation tube and the main cervical vessels (Fig. 5.1.3).

Step 3

As the target of the approach is the mid-located fourth ventricle and aqueduct, rotation or lateroflexion of the head is not necessary (Fig. 5.1.4).

2. Anatomical landmarks and orientation

For preoperative orientation, the important anatomical landmarks of the posterolateral osseous skull and spine, e.g., the external occipital protuberance, foramen magnum, mastoid process, and the spinous processes of C2 to C4 are precisely determined (Fig. 5.1.5).

After exact orientation, the hair of the suboccipital area should be combed or shaved according to the suboccipital midline skin incision (Fig. 5.1.5). The skin is disinfected meticulously.

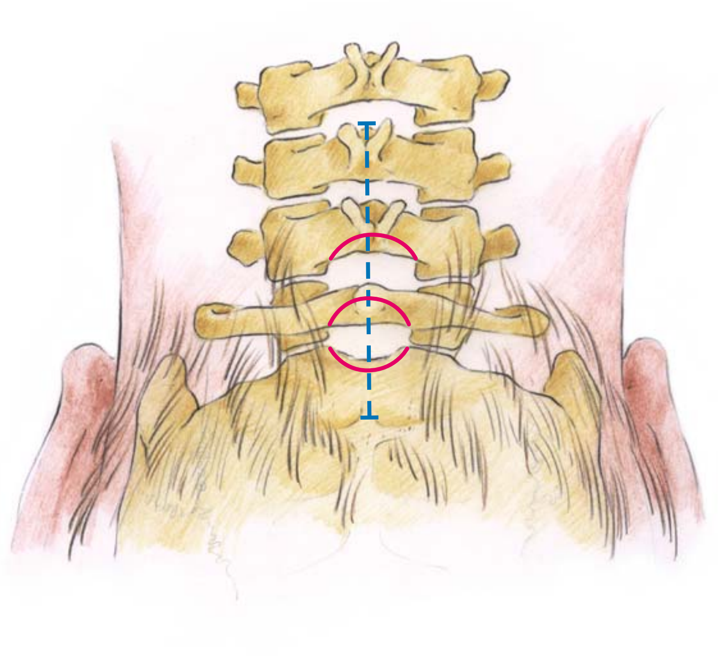


Fig. 5.1.5 *Definition of the surgical approach according to the anatomical landmarks of the posterior craniocervical region. The midline skin incision should extend from the easily palpable C3 spinous process up to the foramen magnum.*

3. Craniotomy and dural opening

Step 1

After patient positioning and anatomical orientation, the skin is prepared with alcohol solution. A straight midline incision is then made extending from the foramen magnum to the spinous process of C3. After retraction of the skin, the ligamentum nuchae is precisely defined according to the midline. Similar to the median suboccipital approach, soft tissue dissection and separation of the suboccipital muscles should be done strictly in the midline avoiding cutting into highly vascular muscular tissue (Fig. 5.1.6).

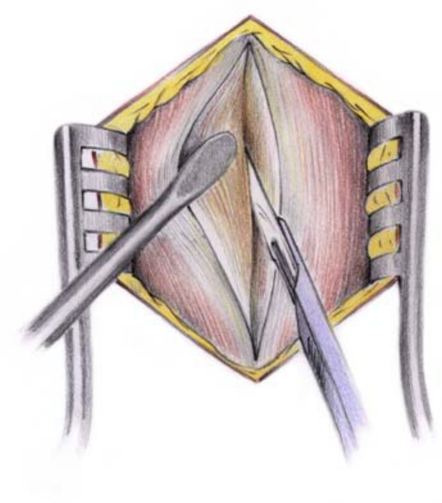


Fig. 5.1.6

Step 2

A self-retaining retractor is used to hold back the thick muscular layer, e.g., the trapezius, splenius and semispinalis capitis muscles, exposing the posterior craniocervical junction. The rectus capitis posterior major arises with a pointed tendon from the spinous process of the axis, the rectus capitis posterior minor on the posterior tubercle of the atlas. Both muscles are dissected from their insertion and retracted laterally, observing the foramen magnum, posterior arch of C1 and the spinous process of C2. Avoiding a complete laminectomy, the top of the spinous process of the axis is removed using a high-speed drill (Fig. 5.1.7).

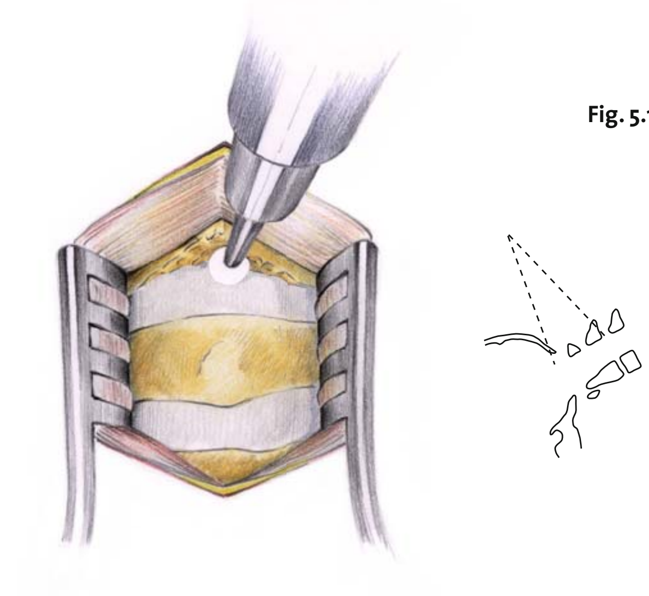


Fig. 5.1.7

Step 3

Thereafter, the superior part of the posterior arch of the atlas is removed enlarging the foramen magnum (Fig. 5.1.8).

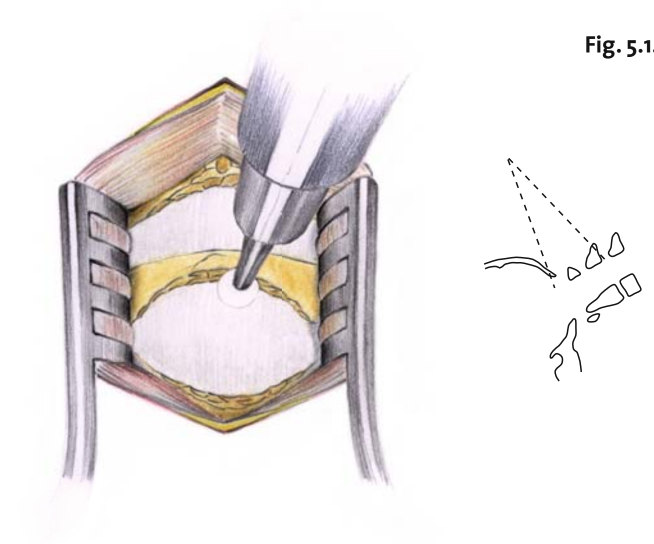
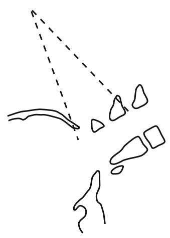
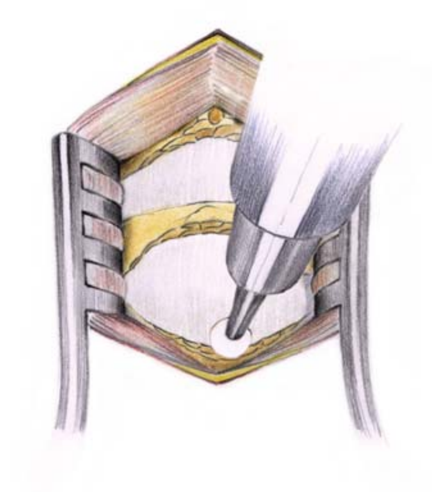


Fig. 5.1.8

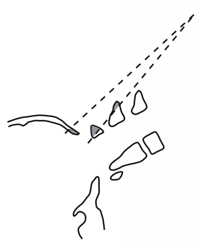
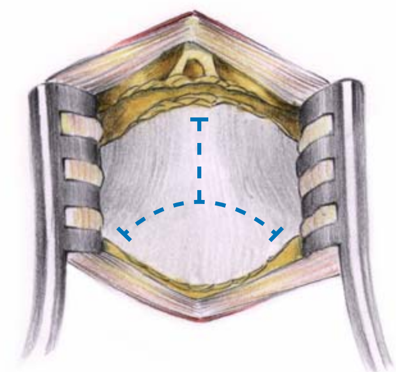
Fig. 5.1.9

Step 4

Thereafter, the posterior margin of the foramen magnum is removed exposing the posterior atlanto-occipital membrane. Rapid and precise local hemostasis is necessary (Fig. 5.1.9).

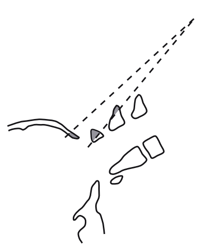
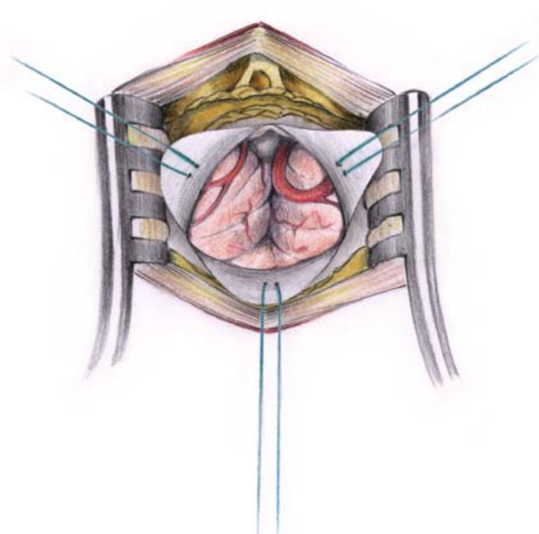
Fig. 5.1.10

Step 5

After bone removal, the direction of view is changed (note schematic picture on the left), observing the posterior margin of the foramen magnum from a caudal aspect. The posterior atlanto-occipital membrane is partially removed or incised according to the dural opening (Fig. 5.1.10).

Fig. 5.1.11

Step 6

The dura is opened in a straight or reverse Y-shaped fashion and the free dural flaps are retracted with holding sutures. When prominent sinusoid vessels are present, particularly in young children, hemoclips or sutures should be used for sufficient hemostasis (Fig. 5.1.11).

4. Intradural dissection

Step 1

Dissection performed on a fresh human cadaver. Note the red arterial and blue venous vessels. After opening the dura mater, the intact arachnoid membranes of the great cerebellomedullary cistern can be seen. Sufficient drainage of CSF by opening the arachnoid membranes offers immediate decompression of the posterior fossa. Note the cerebellar tonsils and the caudal loop of the PICA appearing through the arachnoidal layers (Fig. 5.1.12).

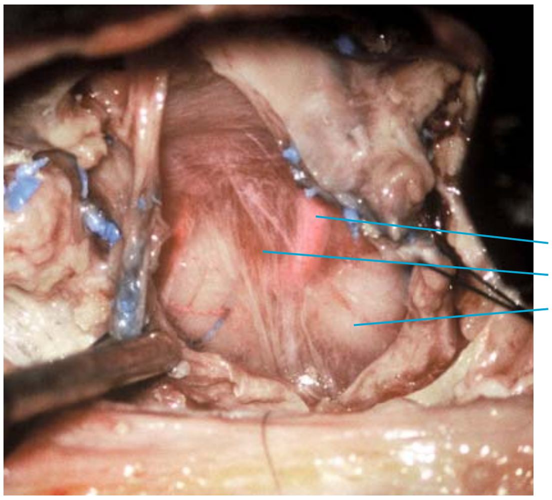


Fig. 5.1.12

Step 2

After opening the arachnoid of the cerebellomedullary cistern, the region of the vallecula is observed. Note the medial aspect of both tonsils according to the limited dural opening. The PICA disappears into the vallecula (Fig. 5.1.13).

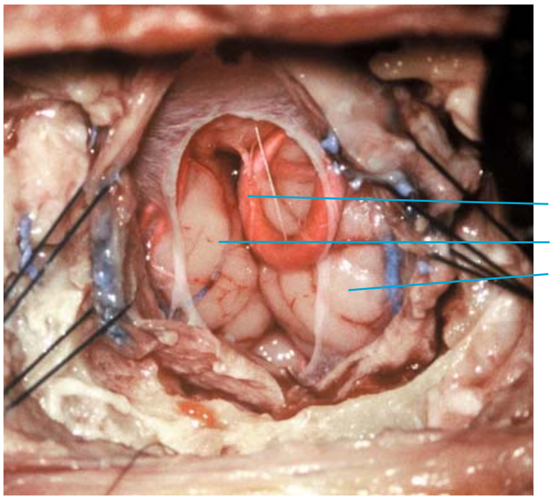


Fig. 5.1.13

Step 3

After opening the foramen of Magendie, the tonsils and the inferior vermis with the choroid plexus are gently retracted exposing the chamber of the fourth ventricle. The special surgical view allows visualization of the superior medullary velum. Note the rhomboid fossa and the cerebral aqueduct (Fig. 5.1.14).

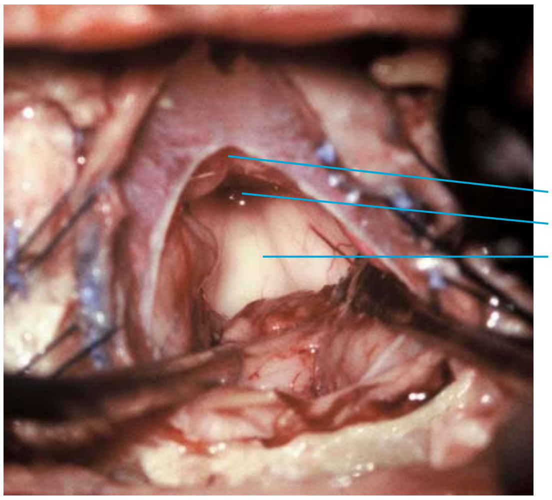


Fig. 5.1.14

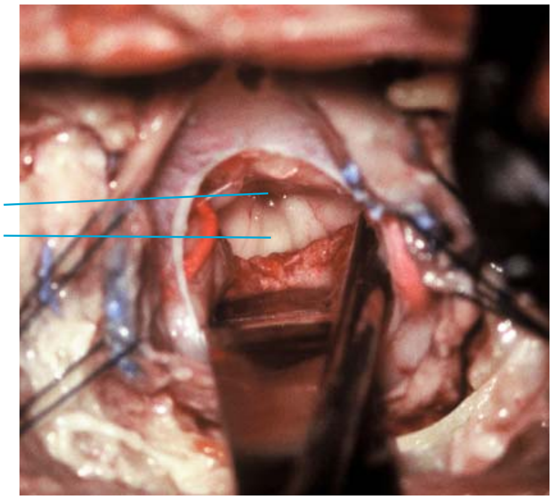


Fig. 5.1.15

Step 4

When observing the cranial part of the fourth ventricle, note the superior medullary velum and the caudal part of the cerebral aqueduct (Fig. 5.1.15).

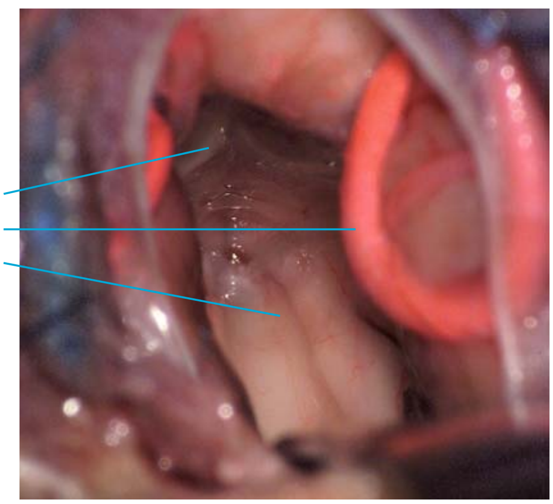


Fig. 5.1.16

Step 5

The entrance of the cerebral aqueduct visualized from the fourth ventricle. Note the rhomboid fossa with the medullary striae and the superior medullary velum (Fig. 5.1.16).

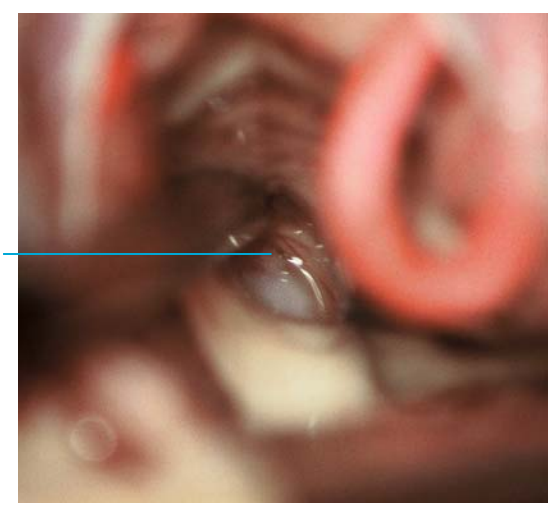


Fig. 5.1.17

Step 6

With a gentle dissection, the aqueduct is enlarged allowing a limited view into the posterior third ventricle (Fig. 5.1.17).

5. Dura, bone and wound closure

After completion of the intracranial procedure, the intradural space is filled with Ringer solution at body temperature. The dural incision is closed meticulously with interrupted sutures. If tension has developed in the dural plane, a small piece of muscle can be sewn into the dural closure; in other cases, an artificial dural graft should be used. After watertight dural closure, a plate of gelfoam is placed extradurally and the suboccipital muscles are closed in anatomical layers. The subcutaneous layer is closed with interrupted sutures and the skin with running or interrupted sutures. Suction drainage is not required.

Potential errors and their consequences

- Inadequate preoperative planning with consequent inadequate exposure of the target region and significant deterioration in surgical exposure. Planning of the procedure must be performed by the surgeon!
- Dissection of the deep suboccipital muscles should be performed in the midline according to the nuchal ligament. Misguiding may cause extensive bleeding from the highly vascular tissue, inadequate exposure of the bony surface and postoperative neck pain with headache.
- Poor positioning of the patient may cause inadequate exposure of the fourth ventricle requiring retraction or even splitting of the inferior vermis. The surgeon should perform patient positioning himself.
- Injury to the dura during craniotomy. Dural reconstruction with dural material may be necessary.
- Inadequate removal of CSF from the cerebellomedullary cistern with subsequent injury to the cerebellar surface due to spatula pressure.
- Injury to sensitive neurovascular structures of the cervicomedullar region, cerebellomedullary fissure and fourth ventricle with postoperative neurological sequelae.
- Postoperative occlusive hydrocephalus due to closure of the cerebral aqueduct by tumor tissue or intraventricular blood clot. In this emergency situation, endoscopic third ventriculostomy should be performed immediately with temporary implantation of a ventricular drainage.
- Inadequate dural closure with postoperative CSF fistula.
- Inadequate hemostasis causing postoperative intracranial or extracranial soft tissue hematoma.

Tips and tricks

- Take time for preoperative planning and positioning of patients. The result is an excellent overview of the target area and an efficient working position during surgery.
- Make a careful anatomical orientation and use the three steps of marking with a sterile pen: 1. osseous structures; 2. definition of the approach; 3. skin incision.
- Using a Concorde prone position, cerebellar retraction and splitting of the inferior vermis can be effectively avoided (Fig. 5.1.18 A). Note the extreme inclination of the head (Fig. 5.1.18 B).
- For optimal exposure of the fourth ventricle, the spinous process of C2 and posterior arch of C1 should be partially removed; thereafter the foramen magnum is enlarged approaching the dura mater of the posterior craniocervical junction (Fig. 5.1.19).
- The dura should be opened in a straight or reverse "Y"-shaped fashion avoiding injury to the occipital sinus. In young patients and children, extensive sinusoid vessels around the foramen magnum may be present which should be occluded with hemoclips or sutures (Fig. 5.1.20).
- The first step of the intradural dissection should be the opening of the cerebellomedullar cistern and sufficient CSF drainage.
- After finishing the intracranial procedure, the dural opening should be closed watertight using interrupted or running sutures. If tension has developed, which is not uncommon, a small piece of muscle can be sewn into the dural closure. In other cases, an artificial dural graft should be used (Fig. 5.1.21).
- The deep suboccipital muscles should be meticulously closed in anatomical layers without using a suction drain. This also helps to avoid postoperative CSF leakage.

Fig. 5.1.18 A

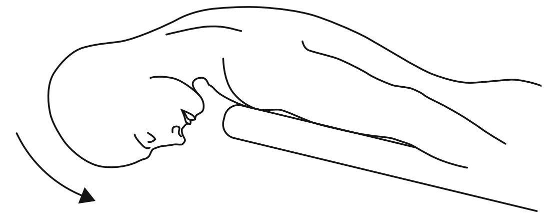


Fig. 5.1.18 B

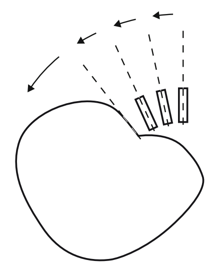


Fig. 5.1.19

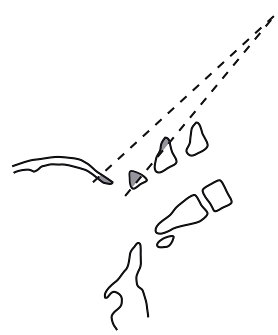


Fig. 5.1.20

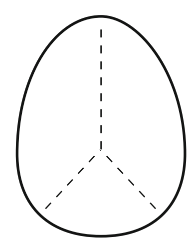


Fig. 5.1.21