Endoscopic anatomy of the fourth ventricle

Laboratory investigation

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Object. Microsurgical anatomy of the fourth ventricle has been comprehensively addressed by masterly reports providing classic descriptions of this complex region. Neuroendoscopy could offer a new, somewhat different perspective of the “inside” view of the fourth ventricle. The purpose of this study was to examine from the anatomical point of view the access to the fourth ventricle achieved by the endoscopic transaqueductal approach, to enumerate and describe the anatomically identifiable landmarks, and to compare them with those described during microsurgery.

Methods. The video recordings of 52 of 75 endoscopic explorations of the fourth ventricle performed at the authors’ institution for different pathological conditions were reviewed and evaluated to identify and describe every anatomical landmark. According to the microsurgical anatomy, at least 23 superficial structures are clearly identifiable in the fourth ventricle, and they represent the comparative basis of parallel endoscopic anatomy of the structures found during the fourth ventricle navigation.

Results. The following anatomical structures were identified in all cases: median sulcus, superior and inferior vela medullare, choroid plexus, inferior fovea, hypoglossal and vagal triangles, area postrema, obex, canalis medullaris, lateral recess, and the foramina of Luschka and Magendie. The median eminence, facial colliculus, striae medullaris, auditory tubercle, and inferior fovea were seen in the majority of cases. The locus caeruleus could never be seen.

Conclusions. On the whole, 20 anatomical structures could consistently be identified by exploring the fourth ventricle with a fiberscope. Neuroendoscopy offers quite a different outlook on the anatomy of the fourth ventricle, and compared with the microsurgical descriptions it seems to provide a superior and detailed visualization, particularly of the structures located in the inferior triangle. (DOI: 10.3171/JNS/2008/109/9/0530)

Key Words • anatomy • aqueduct • fourth ventricle • neuroendoscopy • neuronavigation

Endoscopic anatomy of the fourth ventricle has been reported infrequently in the literature, mainly based on laboratory experiences or, more rarely, in accounts of caudocranial suboccipital surgical approaches.3,4,6,12,16,19 Even neurosurgeons familiar with flexible endoscopes have scarcely taken advantage of the extraordinary versatility of their instruments to achieve complete visual control of all the ventricular cavities.7 Nonetheless, the transaqueductal approach to the fourth ventricle performed with flexible scopes has been demonstrated to be safe and technically feasible.1,9,11,14,17

Our endoscopic practice has provided a consistent series of different pathological conditions in which transaqueductal navigation has been successfully performed. This gave us the opportunity to attempt to revisit the anatomical structures approached during the endoscopic navigation of the fourth ventricle to compare them with those classically described in microsurgical studies.

Methods

Between August 1994 and August 2006, 385 endoscopic procedures were performed at our institution; in 75 of these cases, complete transaqueductal endoscopic navigation of the fourth ventricle was accomplished. A description of this patient series was the subject of 2 other papers, which were mostly focused on technical data.9,10 Because this report is strictly anatomical, we have only briefly summarized the pathological entities leading to endoscopy in Table 1.

We reviewed our cases by retrieving data from both our clinical and video database. Of 75 cases of transaqueductal endoscopic exploration of the fourth ventricle, 23 video recordings were discarded due to the poor quality of the images. In fact, a consistent number of cases in-
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volve intraventricular hemorrhages, for which we use the endoscope to evacuate acutely. In these cases the view is rarely clear due to the presence of blood, and they are thus scarcely suitable for providing sufficiently defined anatomical landmarks. Therefore, the great majority of the considered cases is represented by patients affected by different conditions of hydrocephalus. According to the most cited texts and papers on human anatomy and central nervous system microsurgery, at least 23 landmarks may be recognized in the fourth ventricle. All of these structures were searched while reviewing the videotapes of the selected cases, to identify them and to compare the quality of the endoscopic perspective with that provided by microsurgery.

Technical Endoscopic Aspects and Precautions During the Fourth Ventricle Navigation

The surgical approach to the fourth ventricle is through the usual frontal bur hole, 2 cm anterior to the coronal suture and 1.5–2 cm from the midline. The direction of the trajectory is toward the foramen of Monro. The frontal horn is first cannulated with a 14 Fr peel-away catheter, and then the flexible endoscope is introduced in the third ventricle and deflexed posteriorly toward the aditus of the aqueduct (Fig. 1). The endoscopic visualization offered to the neurosurgeon exploring the fourth ventricle must take into account the fact that the posterior stirring of the endoscopic tip turns the videoendoscopic images upside down. Therefore the dorsal and ventral anatomical structures are projected in the monitor downward and upward, respectively. In that way, for instance, when the floor of the rhomboid fossa appears above, the fastigium is seen below (Figs. 2–4). Also, the tela choroidea with the affixed plexus is visible in the downward position of the videoendoscopic monitor. These nuisances could seem quite obvious, but if not taken in account they may be the cause of dangerous disorientation. Furthermore, once inside the aqueduct, irrigation is stopped because the instrument itself occupies and shuts the aqueduct with its own volume. Therefore, further increments of liquid could overload the fourth ventricle, which in this particular phase could become completely trapped, leading to threatening bradycardia.

In all of our cases neuroendoscopic navigation of the fourth ventricle was successfully performed; we recorded only 4 episodes of bradycardia and 2 cases of small and clinically irrelevant ependymal contusions of the aditus ad aqueductum cerebri.

Results

Cerebral Aqueduct

When the tip of the endoscope moves toward the aqueductal entrance (aditus ad aqueductum cerebri), the observer is impressed by the morphological variability, with the only constant appearance being that of a circular shape that commonly occurs in pathological conditions of the aqueduct. After the aditus has been crossed, 2 strictures with a lumen enlargement between them, the so-called ampulla aqueducti, are noted. The first stricture is caused by the intraluminal protrusion of the superior colliculi whereas the second one (narrower accord-

FIG. 1. Artist’s drawings showing the trajectory to the fourth ventricle. The endoscopic view is perpendicular to the inferior triangle. cmc = centromedullary canal; LL = left Luschka foramen; LP = left plexus; M = foramen of Magendie; RL = right Luschka foramen; RP = right plexus.
ing to some authors) is due to the inferior colliculi. Ven-
trally, a trace of a sulcus is visible continuing in the fourth
ventricle.

Roof of the Fourth Ventricle

Once the rhomboid fossa is reached, the superior ve-
lum medullare is immediately faced because this struc-
ture is on the trajectory of the tip of the scope. The velum,
however, is obliquely positioned and therefore the scope
may be gently advanced by sliding it along the velar wall.
In that way the tip of the scope navigates along the roof
of the fossa rhomboidea far from the brainstem. The fas-
tigium can be inspected with gentle down-stirring move-
ments; the inferior velum medullare is so smooth that the
vermian structures (nodule) become clearly visible, par-
ticularly when the ventricle is dilated. Paired on the mid-
line, the longitudinal portions of the choroid plexus are
soon visible and often well separated. According to the
description by Rhoton, the choroid plexus of the fourth
ventricle may be compared with 2 inverted symmetrical
L-shaped fringes that arise on the ventricular surface of
the tela choroidea and are located on each side of the mid-
line on the roof of the ventricle (Figs. 2 and 4). Thus the
double plexi are conjoined in the medial line and located
in the roof of the ventricle. The horizontal portion of the
plexi starts at the level of the foramen of Magendie, and
then they deviate in opposite directions along the lateral

![Diagram](image)

**Fig. 2.** Artist’s drawing showing orientations of endoscopic views of the inferior triangle. Letters (a–c) correspond
to the endoscopic views and anatomical drawings in the right panel. at = acoustic tubercle; fc = facial colliculus;
ht = hypoglossal triangle; if = inferior fovea; mf = median fissure; ob = obex; sf = superior fovea; T = taenia; vt =
vagal triangle.

![Endoscopic views and anatomical drawings](image)

**Fig. 3.** Endoscopic views and anatomical drawings of the fourth ventricle. ap = area postrema; L = foramen of
Luschka; s = acoustic striae.
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recesses, parallel to the telovelar junction until the fora-
men of Luschka, where they emerge in the cerebellopon-
tine angles.

Floor of the Fourth Ventricle and the Inferior Triangle

The floor of the fourth ventricle (fossa rhomboidea) has a symmetrical rhomboid shape, and it is classically divided into 3 parts: 1) a superior or pontine, 2) an intermediate or junctional, and 3) an inferior or medullary part. Generally the anatomical structures of the inferior triangle (also called calamus scriptorius) offer the best endoscopic images because the edges of the rhomboid fossa are lifted up by tela choroidea and therefore the view of the endoscopic tip turns from parallel to perpendicular and straight (Figs. 2–4). If the inferior triangle resembles an ink pot (calamus), the tip of the flexible scope may lay on resembling a pen. It must be added that once the tip of the scope has reached the inferior part of the fourth ventricle, it can be freely stirred from one side to the other without danger of damaging the aqueduct, because the maneuver is simply done by spinning the instrument.

Identifications of anatomical structures are summarized in Table 2. The following anatomical structures of the fourth ventricle were identified in all cases: fastigium, median sulcus, superior and inferior medullary velum, inferior fovea, vermian inferior structures, hypoglossal triangle, vagal triangle, area postrema, choroid plexus, obex, canalis medullaris, lateral recess, foramina of Luschka and Magendie, and PICAs. The median eminence, striae medullaris, auditory tubercle, facial colliculus, and inferior fovea were seen in the majority of cases; the superior fovea and sulcus limitans could sometimes be clearly identified; whereas the locus caeruleus could never be seen. We therefore were able to identify clearly and consistently, on the whole, 20 anatomical landmarks (Table 2).

Discussion

Although experiences with endoscopic exploration of the fourth ventricle have seldom been reported, and therefore this issue does not represent an absolute

Fig. 4. Endoscopic views of the lateral recess (A and B), Magendie region (C), and global view of the inferior triangle (D). F = fastigium; IMV = inferior medullary velum; ME = median eminence; N = nodule; sm = sulcus medianus; SMV = superior medullary velum.
novelty, to our knowledge no investigator has focused on
the endoscopic identification of the structures encoun-
tered during fourth ventricle navigation. Many theoretical
objections to the transaqueductual navigation of the fourth
ventricle could be raised, but in practice it proves rela-
tively easy and harmless; the clinical aspects of the ap-
proach have been discussed elsewhere.9,11 In many cases
the exploration of the fourth ventricle was an important
procedure was thereafter routinely included in all our
operations, and indeed some other cases of unexpected
closure were seen, allowing us to avoid in some instances
a ventriculoperitoneal shunt, because hydrocephalus due
to outlet closure is a blocked hydrocephalus that can be
treated with third ventriculocisternostomy.

In an anatomical endoscopic description one should
be aware not only that, as outlined before, the posterior
stirring of the endoscopic tip turns the videoendoscopic
images upside down, but also that the advancement of
the scope in the fourth ventricle is parallel to the floor;
therefore the brainstem is mostly viewed at an angle and
not perpendicularly as in microsurgery (Figs. 2–4). These
general aspects account for the particularities of this type
of endoscopic navigation. The upper two-thirds of the
ventricle are inspected with parallel light, suitable to en-
hance even a small inequality of the surface of the floor,
as for example in the median fissure, median eminence,
and particularly the colliculi and related fossae. Con-
versely, the best panoramic view results for the inspection
of the inferior third part of the ventricle (inferior trian-
gle), where we assert a remarkable superiority of the vi-
sion compared with the classic microsurgical description.
The visual control of the structures encompassed from
one of the foramina of Luschka to the opposite one (thus
the inferior edges of the triangle) can be described. The
more external parts of the inferior triangle come to an
end through the lateral recess in the funnel-like foramen
of Luschka, coming out with their fringes of choroidal
plexus into the pontocerebellar cistern. The contours of
the foramen of Luschka are delimited by the lateral por-
tion of the acoustic area and by the cranial nerve VIII and
inferior cerebellar peduncles. All the structures surround-
ing the foramen of Magendie are prime sites for neuroen-
doscopy, which can give details superior to microsurgery.
The very end of the foramen of Luschka may be inspected
only in conditions of a dilated fourth ventricle. Orienta-
tion toward the foramen of Luschka is always led by the
horizontal portion of the choroid plexus. The latter may
be so abundant as to fill up the foramina themselves like
clusters of grapes in a cornucopia.15 The calamus scripto-
rius constitutes the apex of the inferior triangle enclosing
important landmarks such as the hypoglossal trigona, va-
gal trigona, and area postrema, which are distinctly seen,
together with the centromedullary canal, and can always
be examined with great accuracy.

According to many neuroanatomists,15,20 beneath the
inferior fovea and between the trigonum hypoglossi and
the lower part of the area acustica, there is a triangular
dark field, the ala cinerea, which corresponds to the sen-
sory nucleus of the vagus and glossopharyngeal nerves.
The lower end of the ala cinerea is crossed by a narrow
translucent ridge, the funiculus separans, and between
this funiculus and the clava is a small tongue-shaped ar-
ea, the area postrema. Sections show that the funiculus
separans is formed by a strip of thickened ependyma, and
the ala cinerea, which corresponds to the sen-
sory nucleus of the vagus and glossopharyngeal nerves.

### Table 2

<table>
<thead>
<tr>
<th>Landmark</th>
<th>Endoscopic Visualization</th>
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<td>aqueduct</td>
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<td>obex</td>
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<td>PICAs</td>
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area postrema is noticed because it shows as a pale orange spot compared with the white structures around it, whereas we could never visualize the aforementioned funiculus separans. The canalis centromedullaris was found endoscopically in all cases, whereas in microsurgical approaches this structure is veiled posteriorly by the obex itself (Figs. 2 and 3). At its inferior end the calamus scriptorius is called the obex, and is usually covered by a subtle band of tissue. The obex is a landmark not so precisely delimited; Milhorat and Miller considered it to be the band of gelatinous tissue connecting the clava at the inferior pointed end of the fossa rhomboidea, constituting the floor of the ventricle (Figs. 2 and 3). At its inferior end the calamus scriptorius is called the obex, and is usually covered by a subtle band of tissue. The obex is a landmark not so precisely delimited; Milhorat and Miller considered it to be the band of gelatinous tissue connecting the clava at the inferior pointed end of the fossa rhomboidea, constituting the floor of the ventricle (Figs. 2 and 3).

Conclusions

Neuroendoscopy offers a quite different perspective on the anatomy of the fourth ventricle and, compared with the microsurgical description, it seems to provide a superior and detailed visualization, particularly of the structures located in the inferior triangle. Most of the structures of the inferior triangle, in fact, such as the median sulcus, inferior medullary velum with the vermal inferior structures, choroidal plexus, auditory tubercle, inferior fovea, hypoglossal triangle, vagal triangle, area postrema, obex, canalis medullaris, recessus lateralis, foramen of Luschka, foramen of Magendie, and PICAs can all be easily identified during endoscopy.

Disclaimer

The authors do not report any conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

References


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