Endoscopic transventricular third ventriculostomy through the lamina terminalis

Technical note

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Object. Endoscopic third ventriculostomy (ETV) has become a well-accepted option for obstructive hydrocephalus. However, standard ventriculostomy at the floor of the third ventricle might not be feasible under certain conditions. Here, the authors report in detail on their initial experience with an alternative option of endoscopic ventriculostomy through the lamina terminalis via a transventricular route.

Methods. Endoscopic third ventriculostomy through the lamina terminalis from a transventricular transfornaminal route was evaluated in 4 cadaveric human heads and in 4 clinical cases.

Results. In all 4 human cadavers, an opening of the lamina terminalis via a transventricular approach could be achieved without injury to either the optic chiasm or the anterior cerebral arteries. In the 4 clinical cases, an accurate and reliable ventriculostomy was performed at the lamina terminalis. The bur hole was placed directly at the coronal suture 2 cm lateral from the midline. After identifying the optic chiasm and the anterior cerebral arteries, a blunt perforation was made just anterior to the optic chiasm by using perforation forceps and a balloon catheter. After the opening, the stoma was inspected with a 0° and 30° rod lens endoscope, and its patency as well as the preservation of vessels and optic nerves was checked. No complications occurred, although all patients suffered from a clinically silent fornical contusion at the foramen of Monro.

Conclusions: Endoscopic opening of the lamina terminalis via a transventricular transfornaminal route appears to be feasible. No complications were observed. Although no conclusions on the clinical success rate can be drawn, the reliable anatomical opening and known success rate for anterior subfrontal approaches suggest that the technique represents an alternative in a small subgroup of patients in whom a standard ETV cannot be performed.

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Key Words • lamina terminalis • endoscopic ventriculocisternostomy • neuroendoscopy

During the last 25 years, ETV via a precoronal bur hole, a transfrontal trajectory, and an approach through the foramen of Monro and the floor of the third ventricle to the prepontine cistern has become a well-established surgical technique. In many forms of obstructive hydrocephalus, ETV has become the treatment option of first choice.¹⁰,¹¹,¹³,²⁰–²⁴ Although ETV at the floor of the third ventricle represents a simple and well-described technique that is almost always possible with a low complication rate,²³ ETV to the prepontine cistern might not be possible in a small subpopulation of patients. For this subgroup, various alternative options of internal shunting have been described as alternatives to VP shunting, and sometimes those techniques are much older than the current concept of ETV. In particular, Sir Walter Dandy pioneered this area and described a ventriculocisternostomy via a subtemporal craniotomy⁷ and an anterior subfrontal approach.⁵,⁶ Others introduced microsurgical ventriculocisternostomy,³⁰ stereotactic ventriculocisternostomy,⁴,¹⁵,²⁹ fluoroscopic ventriculocisternostomy,¹² microsurgical opening of the lamina terminalis,³¹ reconstruction of or stent placement in the aqueduct,¹⁸ and endoscopic aqueductoplasty.²⁵ Selecting the ideal candidate for each treatment modality is an old problem neurosurgeons have been confronted with for many decades.²⁵ Here the authors present another alternative to ETV: placing the endoscopic stoma at the lamina terminalis of the third ventricle via a standard transfrontal transventricular transfornaminal approach.

Abbreviations used in this paper: ACoA = anterior communicating artery; ETV = endoscopic third ventriculostomy; VP = ventriculoperitoneal.
**Methods**

**General Study Design**

This study is divided into 2 segments. In the first part, the feasibility of an ETV from the third ventricle through the lamina terminalis was analyzed in 4 formalin-fixed human cadaveric heads. Particular reference was given to the preservation of the optic nerve and anterior cerebral arteries as well as the fornix at the level of the foramen of Monro. In the second part of the study, our endoscopic database was investigated for ETV procedures through the lamina terminalis via a transventricular approach. All of our intracranial endoscopic procedures have been collected in this database since January 1993. All patients were prospectively followed. After identifying the patients, the frequency, indication, results, risks, and complications of the ventriculostomy through the lamina terminalis were evaluated. All endoscopic laminotomies were further analyzed based on videotape recordings.

**Endoscopic Equipment and Follow-Up**

We used a standard endoscopic system consisting of a rigid endoscope, a high-resolution digital camera, a Xenon cold light source, a digital recording system, and other effective instruments such as perforation forceps, bipolar diathermy probe, and grasping forceps. To enlarge the stoma, a Fogarty balloon catheter (3 Fr or 4 Fr) could be applied. Postoperatively, the patients were followed up at 3 and 6 months after the procedure and then on a yearly basis.

**Results**

**Cadaveric Dissection**

Four cadaveric, formalin-fixed human heads were subjected to a right-sided approach. The bur hole was placed 2 cm lateral from the midline directly at the coronal suture. After durotomy, the work sheath with the trocar of the endoscopic system was introduced into the right lateral ventricle (GAAB I, Karl Storz Company). Under a 0° endoscopic view, the work sheath was forwarded through the foramen of Monro into the third ventricle. Landmarks at the anterior part of the third ventricle were identified, for example, the mammillary bodies, infundibular recess, optic chiasm, and lamina terminalis. After switching to the working optics, the perforation was conducted using the perforation forceps at the lamina terminalis directly anterior to the optic chiasm. After the perforation, parts of the lamina were resected with the grasping forceps, and the stoma was inspected using the 0° and 30° diagnostic scope. A free opening to the subarachnoid space was achieved in all cases without signs of injury to the optic chiasm. In all cases, both anterior cerebral arteries could be identified without signs of injury. On withdrawal of the endoscope, mild contusion of the fornix at the 12 o'clock position was seen in all 4 cases. An exemplary case is featured in Fig. 1 and Video 1.

**Surgical Procedure**

All procedures were performed with patients under general anesthesia. Each patient was placed supine with his or her head slightly anteflexed in Mayfield 3-pin fixation, except for 1 patient whose head was fixed with bandages. Antibiotics were routinely administered. The surgical field was prepared and draped. A 3-cm skin incision and a 10-mm bur hole were made directly at the coronal suture 2 cm lateral from the midline on the right side. After opening the dura mater, the operating sheath was introduced into the third ventricle through the foramen of Monro. In all cases, the standard site for ETV at the floor of the third ventricle was inspected. If feasible, a standard ETV at the floor of the third ventricle was performed. Only if a successful ETV at the standard site could not be achieved, a ventriculostomy through the lamina terminalis was made. Additionally, the ideal location for ETV at the lamina terminalis was evaluated on transversal MR images (Fig. 2f).

**Clinical Results**

Out of more than 800 endoscopic intracranial procedures and more than 400 ETVs, an ETV through the lamina terminalis was performed in only 4 cases by 1 of the authors (J.M.K.O., H.W.S.S., W.W., and M.R.G.).

**Preoperative Evaluation**

Endoscopic third ventriculostomy was always considered the first option in all cases of obstructive hydrocephalus (Fig. 2a–c). If there was close contact between the floor of the third ventricle and the basilar artery and the clivus so that restoration of sufficient CSF circulation through a standard ETV at the floor of the third ventricle could not be achieved, a ventriculostomy through the lamina terminalis was considered (Fig. 2d). The ideal trajectory for lamina terminalis perforation reaches from almost the premotor cortex through the lateral ventricle and the foramen of Monro to the lamina terminalis (Fig. 2e). Because of the risk of injury to the premotor area and the impossibility of performing a standard ETV via a more posterior bur hole, the ideal straight trajectory for ETV through the lamina terminalis is not feasible. Consequently, a compromise between the standard ETV trajectory and the ideal trajectory for endoscopic ventriculostomy of the lamina terminalis was made. Additionally, the ideal location for ETV at the lamina terminalis was evaluated in 4 formalin-fixed cadaveric human heads. Particular reference was given to the preservation of the optic nerve and anterior cerebral arteries as well as the fornix at the level of the foramen of Monro. In the second part of the study, our endoscopic database was investigated for ETV procedures through the lamina terminalis via a transventricular approach. All of our intracranial endoscopic procedures have been collected in this database since January 1993. All patients were prospectively followed. After identifying the patients, the frequency, indication, results, risks, and complications of the ventriculostomy through the lamina terminalis were evaluated. All endoscopic laminotomies were further analyzed based on videotape recordings.

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**Video 2.** Clinical endoscopic ventriculostomy through the lamina terminalis. Click here to view with Windows Media Player. Click here to view with Quicktime.

The optic chiasm and anterior cerebral arteries were identified (Fig. 3b). After switching to the 6° working optics, a blunt perforation was made between the anterior arteries and anterior to the optic chiasm (Fig. 3c). After a small perforation was made (Fig. 3d), the flaccid lamina was coagulated (Fig. 3e) and the opening was further enlarged with perforation forceps (Fig. 3f) and a balloon catheter (Fig. 3g and h). Special attention was directed at avoiding any injury to even small vessels given the proximity of...
the anterior circulation complex and to avoid any injury to the optic chiasm. In all procedures, only a blunt bipolar probe (as in Fig. 3e) preset at 5 W was used. Coagulation was only performed with this very low power and under direct visualization so that injury to vessels and to the optic chiasm through the application of bipolar diathermy could always be avoided. However, a clinically silent small contusion of the optic chiasm occurred in 1 case through the application of the perforation forceps (Fig. 3c). Final inspection of the ventriculostomy was performed using the 0° and 30° diagnostic optics to identify the optic nerve and/or the anterior cerebral arteries (Fig. 3i and j). The work sheath was withdrawn. A small contusion of the fornix at the foramen of Monro occurred in all cases (Fig. 3k). No bleeding from the corticotomy was observed (Fig. 3l). All procedures were performed using a rigid rod-lens endoscope.

Patients and Follow-Up

The patients consisted of 2 females (39 and 5 years) with obstructive hydrocephalus due to membranes at the foramen of Magendie and the foramina of Luschka, a 15-month-old male infant with multiloculated hydrocephalus, and a 12-year-old boy with aqueductal stenosis. Details of the patients are given in Table 1. The patient in Case 1 was a 15-month-old boy suffering from multicystic hydrocephalus and shunt infection. This patient was subjected to 4 endoscopic surgeries including 3 revisions within 2 months because of recurrent ETV closure and new cyst development. At the fourth surgery, an endoscopic opening of the lamina terminalis was undertaken. Cyst size decreased and the patient clinically improved but remained shunt dependent. The patient in Case 2 was a 5-year-old girl who had undergone standard ETV for obstructive hydrocephalus due to closure of the foramen of Magendie and foramina of Luschka 2 years earlier. This child returned with progressive ventricular enlargement. Endoscopic inspection revealed an open ETV so that intraoperatively we decided to make an opening of the lamina terminalis. After initial improvement with the subsidence of clinical symptoms, the patient received a shunt after 2 weeks. The patient in Case 3 also suffered from membranous obstruction of the foramen of Magendie and the foramina of Luschka with subsequent obstructive hydrocephalus. This patient underwent standard ETV, but intraoperatively the ETV was considered to be insufficient because of a dense membrane covering the prepontine cistern and basilar artery. Opening of the lamina terminalis was performed. The patient improved clinically and radiologically and has remained symptom free for 4 months (Fig. 4). The patient in Case 4 suffered from aqueductal stenosis with cephalgia because of VP shunt dysfunction. Intraoperatively the anatomy at the floor of the third ventricle was disturbed, and we decided on an
opening of the lamina terminalis. The patient’s headaches resolved, and he has been symptom free for 5 years. No complications were noted in any of the patients. No patient presented clinically with any visual disturbances, although no formal visual field testing was performed. The fornical contusion at the foramen of Monro remained clinically silent in all cases. Details of the patient data are given in Table 1.

Discussion

Endoscopic third ventriculostomy currently represents the gold standard for noncommunicating hydrocephalus, and reports on successful treatment with this technique are frequent. Despite significant effort to improve the success rate and reduce the number of failures by the introduction of new techniques, such as waterjet dissection or endoneurosonography, the success rate of the standard ETV averages around 70%–80% depending on the underlying pathology and the study cited. This leaves about 20%–30% of cases that do not benefit from ETV despite noncommunicating hydrocephalus. Usually patients in such cases are subsequently assigned to VP shunting. However, there are many complications related to shunt dependency. The majority of the complications are shunt infections, but there are also mechanical difficulties, such as late shunt malfunction, which can occur after even decades. Thus, research on new sites and techniques for an “internal shunt” without foreign body implantation as an alternative to a standard ETV, if not feasible, is ongoing.

Reasons for a nonfunctioning ETV might include reocclusion of the stoma by newly formed membranes or tumor progression, which is particularly seen in slow-growing low-grade gliomas of the midbrain and pons, or insufficient CSF circulation due to blockage of the CSF pathway directly at the prepontine stoma. Furthermore, slit ventricles in shunt malfunction might make a standard ETV impossible. Alternative endoscopic strategies for ventriculostomy have been reported depending on the position of the third ventricle floor, including opening of the lateral recess of the floor next to the posterior cerebral artery and perforation of the floor between the basilar artery trunk, superior cerebellar artery, and dorsum sellae. Additionally, several authors have addressed supplementary surgical techniques such as a subfrontal endoscopic approach, microsurgical lamina terminalis fenestration, and fenestration at the suprapineal recess. In particular, opening of the lamina terminalis from a subfrontal or pterional approach has been frequently investigated. Most of the studies address its value in procedures related to ruptured aneurysm surgery, but reports that exclusively approach the lamina for the treatment of noncommunicating hydrocephalus are also present.

Fig. 2. Preoperative axial (a), coronal (b), and sagittal (c) T2-weighted MR images demonstrating obstructive hydrocephalus with enlarged ventricles due to a membrane at the foramen of Magendie (arrowhead). Preoperative midsagittal T2-weighted MR image (d) revealing an obstructed foramen of Magendie (white arrowhead), a very narrow prepontine space with the floor of the third ventricle very close to the basilar artery (arrow), and the lamina terminalis (gray arrowhead). Sagittal T2-weighted MR image (e) showing ideal trajectories for an ETV (white line) and an endoscopic stoma at the lamina terminalis (gray line). White dotted line indicates the compromise of both approaches directly at or just behind the coronal suture. Axial T2-weighted MR image (f) showing the optic chiasm (arrow) and the ideal place for a stoma at the lamina terminalis (arrowhead).
Endoscopic ventriculocisternostomy of the lamina terminalis

lamina terminalis is a valuable and sufficient treatment option in obstructive hydrocephalus, which could represent an alternative to the standard ETV. Anatomically, the anterior wall of the third ventricle extends from the foramina of Monro above to the optic chiasm below. The part of the anterior wall visible on the surface is formed by the optic chiasm and the lamina terminalis. The lamina terminalis is a thin sheet of gray matter and pia mater that attaches to the upper surface of the chiasm and stretches upward to fill the interval between the optic chiasm and the rostrum of the corpus callosum. A so-called organum vasculosum lamina terminalis is only rudimentarily (if at all) developed and not present at the potential location for lamina terminalis opening directly anterior to the optic chiasm. When viewed from within, the boundaries of the anterior wall of the third ventricle, superior to inferior, are formed by the columns of the fornix, foramina of Monro, anterior commissure, lamina terminalis, optic recess, and optic chiasm. Anterior to the lamina terminalis are located the arterial complex of the anterior cerebral artery and its branches.

In most cases, the ACoA is situated just anterior to the lamina terminalis. The A1 segment courses above the optic chiasm or nerves to join the ACoA. The A2 (infra- callosal) segment begins at the ACoA, passes anterior to the lamina terminalis, and terminates at the junction of the rostrum and genu of the corpus callosum. The perforating branches arising from the A1 segment terminate, in descending order of frequency, in the anterior perforated substance, the dorsal surface of the optic chiasm or supra-chiasmatic portion of the hypothalamus, the optic tract, the dorsal surface of the optic nerve, or the sylvian fissure between the cerebral hemispheres and lower surface of the frontal lobe. The ACoA also frequently gives rise to perforating arteries that terminate in the superior surface of the optic chiasm or above the ACoA. The A1 segment is also the site of origin of perforating branches terminating in the anterior perforated substance, dorsal optic chiasm, supra-chiasmatic area, and adjacent frontal lobe. A detailed review of the peculiar anatomy of this region is provided by Rhoton.

In the current study we report on the endoscopic

Fig. 3. Endoscopic ventriculostomy at the lamina terminalis. a: Anterior guidance of the endoscope passing the infundibular recess (IR). b: Identification of optic chiasm (OC) and anterior cerebral arteries (A1). c: Blunt perforation of the lamina terminalis with the perforation forceps between the anterior arteries (A1) and anterior to the optic chiasm (OC). d: Initial small perforation. e–h: Bipolar coagulation and further enlargement of the stoma using perforation forceps and a balloon catheter. Note the small contusion of the optic chiasm. i and j: Final inspection of the ventriculostomy with the 0° diagnostic scope and identification of the anterior artery (A1) and optic nerve (ON). k: Small contusion of the fornix at the foramen of Monro at 12 o’clock. l: No bleeding from the corticotomy is observed.
opening of the lamina terminalis via a transventricular transforaminal approach in 4 cadaveric heads and 4 patients. In contrast to the opening of the lamina anteriorly or rostrally, this transventricular transforaminal approach has not been described in detail. The only presentation known to us is a brief picture summary between other CSF restoration procedures described by Schroeder et al. However, the peculiarities of this approach have never been addressed. In all cadavers and in all clinical cases, a reliable anatomical opening resulted without any complications or injury to vessels and optic structures in particular. Our results allow for the assumption that a reliable and anatomically accurate opening of the lamina terminalis just anterior to the optic chiasm can be achieved with the endoscope via a transventricular route despite the dense vessel supply of this region. The stoma directly above the optic chiasm has been suggested to represent the ideal location for perforation.

Ideally, the definition of distinct anatomical criteria would allow for preoperative identification of patients unsuitable for a standard ETV but well suited for an endoscopic transventricular opening of the lamina terminalis. Unfortunately, our very limited experience with 4 clinical cases in more than 15 years and therefore the lack of information on the reliability of the restoration of CSF circulation and on the complication rate in comparison with a standard ETV prohibit our defining any criteria. Nevertheless, formal visual field testing should be added to the standard follow-up evaluation to objectively exclude any visual disturbances.

From an anatomical standpoint, the technique is feasible and reliable. Clinically, the small patient numbers and diverging results do not allow one to draw conclusions about the clinical success rate of the technique so far. It must be remembered that the technique was applied only when ETV was thought to be unsuccessful; thus, a success rate lower than that with pristine obstructive hydrocephalus cases must be considered. In rare distinct indications, such as in patients with slow-growing low-grade gliomas of the midbrain and the pons, this technique might very well give superior options since a blockage of the CSF circulation by narrowing of the prepontine space, including the site of ETV, might be avoided for a longer time period. In comparison with the more frequently applied microsurgical opening of the lamina terminalis anteriorly, the transventricular route has the immense advantage that within this endoscopic procedure the status of the floor of the third ventricle and earlier ETVs can be checked and reopened. If this is not possible, the surgeon can proceed to an opening of the lamina terminalis.

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age, Sex</th>
<th>Symptoms</th>
<th>Reason for Laminotomy</th>
<th>Pathology</th>
<th>Outcome</th>
<th>FU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15 mos, M</td>
<td>increased head circumference, shunt infection, recurrent cyst development</td>
<td>nonfunctioning ETV (in 4th revision for shunt infection &amp; cyst size increase)</td>
<td>complex case w/ multicystic hydrocephalus, shunt infection, new cyst development, &amp; 4 endoscopic revision surgeries w/in 3 mos</td>
<td>cyst size decreased, ventricles remained large, remained shunt depended</td>
<td>foreign patient from abroad, only 1 mo FU, thereafter lost</td>
</tr>
<tr>
<td>2</td>
<td>5 yrs, F</td>
<td>cephalgia, increased ventricle enlargement</td>
<td>open ETV (from 2 yrs earlier)</td>
<td>obstructive hydrocephalus w/ closed foramina of Luschka &amp; foramen of Magendie (ETV 2 yrs earlier)</td>
<td>clinical symptoms resolved</td>
<td>became shunt dependent after 2 wks FU</td>
</tr>
<tr>
<td>3</td>
<td>39 yrs, F</td>
<td>cephalgia, nausea, vomitus, visual disturbances</td>
<td>1st ETV, considered to be insufficient because of very narrow prepontine space covered by dense membrane</td>
<td>obstructive hydrocephalus w/ obstruction at foramen of Magendie</td>
<td>symptom free, ventricle enlargement resolved</td>
<td>4 mos</td>
</tr>
<tr>
<td>4</td>
<td>12 yrs, M</td>
<td>cephalgia</td>
<td>disturbed anatomy of floor of 3rd ventricle, ETV technically difficult</td>
<td>aqueductal stenosis, VP shunt dysfunction</td>
<td>headaches resolved</td>
<td>5 yrs</td>
</tr>
</tbody>
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* There were no complications in any of the patients. Abbreviation: FU = follow-up.
approach, such as that shown in Fig. 2, must be discussed since the avoidance of injury to the anterior columns of the fornices with such an approach might be possible. However, in all 4 clinical cases, the final decision for opening the lamina terminalis was made during the procedure itself. Thus, a more posterior approach would require a second bur hole and a second corticotomy. Moreover, this approach may have an additional potential for injury to the structures at the posterior foramen of Monro (that is, thalamostriate and internal cerebral veins). Additionally, injuries to the anterior column of the fornices are frequently reported in endoscopic procedures and almost
always remain clinically silent. Thus, at present, we cannot recommend a more posterior bur hole until further data are acquired.

Nevertheless, the preoperative selection of candidates for opening of the lamina terminalis via a transventricular route by using a posterior bur hole remains appealing. If further study data allow for the preoperative selection of patients in the near future and if the application of such an unusual and unfamiliar posterior approach is planned, the use of stereotactic guidance in the approach should be understood.

Instead of using a more posterior bur hole, the application of a steerable flexible endoscope could permit the avoidance of any damage to the anterior fornices. However, this value must be weighed against the much poorer image quality with such endoscopes. At present, we have not performed any procedures with this alternative technique and cannot share any experience.

**Conclusions**

In all, endoscopic opening of the lamina terminalis via a transventricular transfornaminal route appears to be feasible. No complications—in particular, no injury to the optic chiasm or anterior cerebral arteries—occurred. Although the present study is limited by its small patient numbers and because no conclusion on the success rate of this procedure can be drawn, the reliable anatomical opening and known success rate for anterior subfrontal approaches suggest that the technique could represent an alternative to a standard ETV for a small but distinct subgroup of patients when a standard ETV cannot be performed.

**Disclosure**

Drs. Gaab, Oertel, and Schroder are consultants for Karl Storz Company.

Author contributions to the study and manuscript preparation include the following. Conception and design: Oertel, Konerding. Acquisition of data: Oertel, Vulcu, Schroeder. Analysis and interpretation of data: Oertel, Vulcu. Drafting the article: Oertel. Critically revising the article: Oertel, Wagner, Gaab. Reviewed final version of the manuscript and approved it for submission: all authors. Administrative/technical/material support: Oertel. Study supervision: Oertel.

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