Endoscopic third ventriculostomy in adults: a technique for dealing with the neural (opaque) floor

Clinical article

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Object. An opaque (neural) floor of the third ventricle is considered an obstacle to safe penetration of the floor of the third ventricle in endoscopic third ventriculostomy (ETV). The direct technique of endoscopic coring (“cookie cut”) of the opaque (neural) floor of the third ventricle is described in 41 cases among a total of 101 consecutive adult ETVs.

Methods. A 0° endoscope in a 4.6-mm irrigating sheath was used to press and core (“cookie cut”) a section of the tuber cinereum, thereby exposing the underlying membranes and vasculature. Thereafter, the endoscopic apparatus was used to penetrate the membrane into the preoptic space.

Results. Among 101 consecutive ETVs performed in adults, there were 41 instances of an opaque floor in which the coring technique was used. The basilar artery (BA) complex was in the intended path of penetration in 13 cases. There were no perioperative deaths or vascular injuries. No cases were aborted because of the opaque floor or the configuration of the BA complex. The clinical success rate in the opaque floor group was 80% (33 of 41 patients).

Conclusions. An opaque (neural) floor is frequently seen in adults during ETV. Removing the floor by the core (“cookie cut”) method is a safe means of revealing the underlying BA complex and membranous structures prior to penetration into the preoptic cistern. On occasion, the BA complex may be in the path of penetration, and one can maneuver the endoscope to displace the vasculature to successfully accomplish the ETV.

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Key Words • basilar complex • endoscopic coring (cookie cut) technique • endoscopic third ventriculostomy • opaque floor • neural floor

Abbreviations used in this paper: BA = basilar artery; ETV = endoscopic third ventriculostomy; VP = ventriculoperitoneal.
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falo General Hospital and Millard Fillmore Gates Hospital (Buffalo, New York) between 1999 and 2010. Clinical success was determined by improvement in preoperative symptoms or signs with or without reduction in ventricular size on CT or MR imaging. Insertion of a VP shunt was considered a failure of ETV.

Surgical Technique

A bur hole is placed approximately 13 cm from the nasion, 3 cm lateral to the midline and 1 cm in front of the coronal suture. Stereotactic navigation is not routinely used unless the ventricles are small or distorted. A ventricular catheter (Integra LifeSciences) is introduced into the ventricle, and confirmation of ventricular fluid is obtained. The depth to the ventricle is measured preoperatively on a coronal MR image and is not exceeded in the ventricular tap by more than 1 cm. After confirmation of CSF flow, a 0° 2.7-mm endoscope in a 4.6-mm irrigating sheath (Minop, Aesculap) follows the ventricular catheter under video guidance into the lateral ventricle. The endoscopic apparatus is then passed into the third ventricle.

If an opaque floor is encountered (Fig. 1A), the endoscope is pressed against the floor of the third ventricle to outline a core (“cookie cut”) of neural tissue (from the tuber cinereum) midway between the anterior mammillary bodies and the infundibulum in the midline (Fig. 1B). Care is taken to determine the margins of the walls of the third ventricle by drawing an imaginary line between the lateral mammillary bodies and the posterior rim of the infundibulum (Fig. 2). The endoscope is withdrawn after the first impression to ensure that the penetration point is appropriately centered. The endoscope is then reapplied over the same “cookie cut” template multiple times without penetrating the underlying membranes but eventually dislodging the opaque (neural) floor. At times, the opaque floor may be quite vascular, but these vessels are relatively small, and oozing of blood stops with irrigation or pressure exerted with the endoscope. We have not found it necessary to coagulate the edges of the open floor. The removal of the “core” creates a translucent or transparent membrane and allows visualization of the basilar complex, particularly if the complex is in the corridor of the penetration point of the underlying prepontine cistern. The endoscope is then passed through the floor of the third ventricle and the membrane of Liliequist into the prepontine cistern (Fig. 1 A–F). Depending on the configuration of the BA, the endoscopic penetration can be tailored safely to produce a stoma that insinuates itself around the contour of the basilar complex. At times, the smooth contour of the posterior endoscopic sheath can be used to gently displace the BA or the P¡ segments to facilitate entry into the prepontine cistern. The “cookie cut” technique can also be used to debride and expose the edge of the dorsum sellae in cases of a very narrow corridor in the prepontine cistern when the BA is juxtaposed to the dorsum and clivus (Fig. 3 A and B). If there is not an opaque floor, the endoscope is used for penetration through the membranous structures, as described above.

Classification of Third Ventricle Floor

If the intended penetration point was opaque, the floor was classified as opaque, even if there was translucency in front of the mammillary bodies. In addition, the cases reported as opaque were only those in which a “core” of neural tissue was obtained by the “cookie-cut” technique described above, including the removal of neural tissue over the dorsum sellae to increase exposure. In essence, an opaque floor was equivalent to a neural floor in this series.

Results

A total of 101 cases of ETV were performed in adults at our 2 institutions during the study period. Based on review of operative reports and/or video records of the procedures, an opaque (neural) floor was identified in 41 (40%) of these cases. The patient group comprised 21 men (age range 25–89 years, average age 59 years) and 20 women (age range 21–84 years, average age 56 years), with a mean follow-up of 2.4 years (range 3 months–6 years). The preoperative diagnoses in the 41 cases were aqueductal stenosis in 8 patients, posterior fossa mass with obstruction in 9 patients, third ventricular mass with obstruction in 2 patients, communicating hydrocephalus (no clear-cut obstruction) in 12 patients, subarachnoid hemorrhage in 4 patients, intraventricular hemorrhage in 2 patients, failed VP shunt of long duration with suspected aqueductal stenosis in 1 patient, and head trauma in 3 patients.

The overall ETV clinical success rate was 80% (33 of 41 cases). In 13 instances (32%), the vascular structures uncovered by the removal of the opaque floor during ETV were in the path of the previously intended penetration route midway between the infundibulum and the anterior edge of the mammillary bodies.

Discussion

Management of the Ventricle Floor in ETV

There are varied techniques described for penetration of the floor of the third ventricle in ETV. These include blunt probe with balloon expansion, direct use of the endoscope, laser perforation and dissection of the floor, and variations on the application of coagulation of the floor. Brockmeyer alluded to the use of the endoscope as a “dissecting tool” in a staged penetration of the floor of the third ventricle. With a transparent or translucent floor, direct assessment of the underlying cistern and basilar complex is possible. However, when the floor is opaque, penetrating the floor directly into the interpeduncular cistern or prepontine cistern in one step, either with a blunt instrument or an endoscope, is a “blind action.” If the neural tissue is first removed and the floor is converted to translucent or transparent, visibility and anticipation of the surrounding vascular anatomy and prepontine space are greatly improved. Penetration can be particularly hazardous when the underlying basilar complex or perforators are in the intended penetration route (Fig. 4). No totally reliable CT or MR imaging study exists with which to determine preoperatively the configuration or thickness of the floor of the third ventricle.
tion, there is no totally reliable way of determining the configuration of the basilar complex and its relationship to the floor of the third ventricle. More importantly, the neuroendoscopist must have not only a knowledge of the thickness and contour of the third ventricle floor but also of the relationship to the basilar complex and perforating vessels.

One of the most common anomalies at endoscopy is a thickened third ventricle floor. At times, one can assess the position of the BA in relationship to the dorsum and clivus or visualize a grossly thickened floor on a sagittal MR image. Moreover, even extensive experience might not protect against BA perforation. Sacko et al. reported 1 fatal BA rupture among 368 ETVs during which a monopolar thermal technique with balloon dilation was used. Other instances of fatal and near-fatal penetration of the basilar complex have been reported. Virtual MR imaging endoscopy was assessed with respect to determining the contour of the third ventricle floor and was found to have low reliability. There was some success in visualizing the basilar configuration but no reliability in determining the thickness of the floor.

Riegel et al. described the management of an opaque floor by intraoperative neuronavigation and guidance of the endoscope through the thickened neural third ventricle floor. Although they took into account the BA

**Fig. 1.** Endoscopic views showing a neural (opaque) floor (A), the first impression of the endoscope “cookie cut” (B), loosening of the core with the second and third impressions (C), partial exposure of the underlying bulbous BA (D), full exposure of the bulbous BA at the stoma (E), and a clear view into the prepontine cistern (F). The midsection of the BA comes into view as the endoscope slides over the more proximal bulbous portion.

**Fig. 2.** Endoscopic view showing the edges of the walls of the third ventricle (arrows) and the entry point in the tuber cinereum (yellow circle). Notice the triangular shape of the floor.
configuration based on “dynamic MR imaging” preoperatively, their approach involved a single-trajectory navigation entry and included coagulation of the floor and no inspection of the prepontine cistern, instead relying on intraoperative ventriculography. We have found little value in using navigation to assess the opaque (neural) floor or to localize and abrade the dorsum sellae. In 4 of the 41 ETVs in our series, navigation was used only to enter the lateral ventricle. These 4 cases included 1 case of trauma with mass shift of the hemisphere, 2 cases of simultaneous biopsy of a posterior third ventricle mass and third ventriculostomy with 2 bur-hole sites, and 1 case of small ventricles in a patient with an acute obstructed VP shunt.

Burtscher et al.3 used virtual neuroendoscopy in anatomical specimens and could strip the floor of the third ventricle to show the basilar complex below. However, there was artifact at times, with false images or hidden anatomical structures. Information was gained, but their conclusion was that “spatial resolution of the MR images and the calculated virtual endoscopic images is inferior compared to the real endoscopic view.” A microvascular Doppler probe has also been used to determine the position of the BA complex by passing it through a working channel and selecting a “safe zone” of penetration through an opaque floor. This method gives real-time information. A further modification has been virtual neuroendoscopy that is based on 3D ultrasonography.14 Localization of the basilar complex and the relationship to the floor of the third ventricle was considered quite reliable. Paladino et al.19 used an ultrasonic contact microprobe to perforate the floor of the third ventricle and serve as a guide to avoid the basilar complex simultaneously. The perforation was then widened by balloon dilation. Indirect methods of determining the thickness of the third ventricle floor have been tried with high-resolution MR imaging and measuring the distance between the mammillary bodies.13 A water jet device18 and a special spreading forceps33 have been used for graded, stepwise penetration of the neural floor and as a means to reveal the underlying vascular structures.

The endoscopic “cookie cut” coring technique for dealing with an opaque (neural) floor that is described in the present report has certain advantages. No special 3D reconstruction of the floor of the third ventricle and basilar complex is required nor is any special navigation alignment needed.27 One creates a window in the neural floor to reveal the underlying membranous structures and can directly visualize the configuration of the basilar complex, including the relative proximity of the BA to the dorsum and clivus. It is a “see-as-you-go” procedure. Once the basilar complex configuration is assessed, one can maneuver the endoscope into the appropriate trajectory to safely penetrate the membrane of Liliequist and thereafter directly inspect the preoptic cistern. If the space is confined, the endoscope, with its smooth posterior design, can slide atraumatically over the BA or P1 segment, even at times actively displacing the vessels to open the cistern. The dorsum can also be denuded when the distance from the mammillary bodies to the infundibulum is very short (Fig. 3A) or the BA is revealed to be closely applied to the clivus (Fig. 3B). The endoscope is used to palpate the bony dorsum sellae and, in a sliding motion, posteriorly tears the membrane of Liliequist, thus allowing a view into the tight prepontine space. In addition, even if there is a wide expanse between the mammillary bodies and infundibulum, the BA may be closely applied to the dorsum and clivus (Fig. 5 A and B). A posteriorly displaced BA under the mammillary bodies

![Fig. 3. Endoscopic views. A: The dorsum sellae is denuded (double asterisks) by pressure from the endoscope. Notice the very confined and short distance between the mammillary bodies and dorsum. B: The membranous floor and Liliequist membrane are torn from the posterior edge of the dorsum to reveal a BA against the clivus.](image-url)
still may produce a hazard with a loop of a P1 segment. Perforators alone may underlie a neural floor at what appears to be the appropriate penetration point. In addition, long-standing hydrocephalus (with aqueductal stenosis) is no guarantee of a thin floor of the third ventricle. Eight patients in our series of 41 had longstanding aqueductal stenosis.

**Success Rate of ETV in the Presence of a Neural (Opaque) Floor**

Sufianov et al. estimated the occurrence of a neural floor in 33.3% of procedures in 42 children under the age of 2 years undergoing ETV and reported an increased failure rate of ETV in those patients. Feng et al. reported 58 ETVs among patients with a mean age of 35 years and advised that “in most cases of obstructive hydrocephalus, the floor [was] translucent.” Amini and Schmidt reported ETV in 36 adults, with 39% having basilar complex “anomalies” in relation to the floor of the third ventricle. The overall frequency of an opaque floor was 53%, with 19% having an opaque floor combined with an anomaly of the basilar complex. The success rate was 61%. Kadri et al. reported 203 ETVs, with a failure to achieve perforation of the ventricle floor in 9.3%. The reasons for failure included “thickening of the ventricle floor.” However, unlike the present series, only 21% of the patients in that series were over the age of 30 years. Tisell et al. analyzed a series of ETVs in adults with aqueductal stenosis; they reported a 50% long-term failure rate but did not mention an opaque floor as a factor. In the current series of ETV with 41 instances of an opaque floor, the success rate was 80% (33 of 41 patients). Our success rate in these 41 ETVs is higher than generally reported in most series. Eight of the patients with opaque floors in our series had long-term untreated aqueductal stenosis, which emphasizes that the presence of a membranous floor cannot be assumed even with chronic obstructive hydrocephalus. Among the 41 cases in the series reported here, there were 13 cases (32%) of the basilar complex in the path of the intended penetration route (average age of the 13 patients in these cases was 64 years). A successful ETV result was obtained in 10 of the 13 (77%). Seven cases involved the basilar trunk; 5 involved the P1; and 1 involved the perforators. In 3 cases, perforators could be seen accompanying the P1 (Fig. 6). There were no cases in which the ETV was aborted because of a neural floor or the vascular configuration. In all 41 cases of an opaque (neural) floor, the subsequent membranous floor was successfully penetrated by the endoscope, and the prepontine cistern was inspected to confirm proper communication of the third ventricle with the cistern of Liliequist.

**Significance of the Tuber Cinereum**

“The tuber cinereum is an eminence of grey matter, situated between the optic tracts and extending from the corpora albicantia (mammillary bodies) to the optic commissure, to which it is attached; it is connected with the surrounding parts of the cerebrum, forms part of the floor of the third ventricle, and is continuous with the grey substance in that cavity. From the middle of its under surface, a conical tubular process of grey matter, about 2 lines [sic] in length, is continued downwards and forwards to be attached to the posterior lobe of the pituitary body. This is the infundibulum, and its canal, which is funnel shaped, communicates with the third ventricle.”

The “cookie cut” or coring technique removes only one portion of the tuber cinereum, in its central and anterior location (Fig. 1B). In our experience, a truly opaque portion of the floor was composed of neural tissue. On 2 occasions, we were able to retrieve the core and obtain histological confirmation of tuber cinereum tissue (gray matter). However, one must be mindful of the margins of the walls of the third ventricle, which are continuous with the gray matter of the tuber cinereum. A “mind’s eye” line can be drawn from the lateral edge of the mammillary bodies to the posterior rim of the infundibulum, which will define the margins of the walls of the third ventricle (Fig. 2). Notice that this compartment is triangular in shape. Brockmeyer described this compartment as square, and this is at variance with our observation. Injury to the wall may be an explanation for cases of diabetes insipidus because we did not encounter any instance of diabetes insipidus in the 41 neural floor ETVs. Assessing the floor, as opposed to the transition to the walls of the third ventricle, is particularly important when the third ventricle is very narrow. It is also important to reapply the endoscope for the core over exactly the same template of the first impression. For this reason, it is crucial to withdraw the endoscope to view the mammillary bodies and floor to ensure that the first and all subsequent pressure points are in the midline and centered. With each application of the endoscope, the walls of the third ventricle tend to move laterally. The basilar complex will come into view as the neural floor sloughs off, exposing the un-
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derlying translucent membrane (Fig. 1D). One can press
the endoscope against the membrane and at times see the
silhouette of the basilar complex. At this point, one can
slowly penetrate the membrane with the basilar complex
continuously in view and subtly maneuver the endoscope
in a safe direction as one tears through the membrane of
Liliequist.

Experimentally, the tuber cinereum has been linked
to dopaminergic neuronal activity and prolactin surge and regulation of
docrine-specific protein factors. Diffuse anatomical connections of the tuber cinereum have
been demonstrated in the mouse, including connections
to the amygdala. In the current series of adult patients,
there were no postoperative overt clinical signs of hypo-
thalamic or pituitary dysfunction. However, preoperative
and postoperative pituitary hormone levels were not eval-
uated; certainly, this is a future area to be studied. Fritsch
et al. evaluated endocrine function in 20 children who
had undergone ETV and found elevated prolactin levels
in 8; abnormal parameters were found in 3 other children
as well—decreased levels of follicle-stimulating hormone
and luteinizing hormone in 1, increased thyroid-stimulat-
ing hormone level in 1, and decreased levels of insulin-like
growth factor-1 and insulin-like growth factor-binding
protein-3 in the other. However, they determined that no
clinical significance was associated with these changes.
To evaluate the endocrine effect of damage to the tuber cinereum in ETV, one would have to determine pre- and postoperative hormone values in all patients undergoing ETV to sort out the influence of removing part of the neural floor. We did not encounter diabetes insipidus or any other clinical manifestation of an endocrinopathy in any of the 41 patients in our series. Further study on this point would be worthwhile. Bradycardia has been reported in association with putting traction on the floor of the third ventricle while penetrating into the prepontine cistern during ETV. We previously encountered transient bradycardia in 2 cases of ETV, but neither involved an opaque floor.

Conclusions

Endoscopic coring (“cookie cut”) of the floor of the third ventricle is an effective way of dealing with the uncertainties and dangers of penetrating the opaque (neural) floor of the third ventricle during ETV. The core-exposure removal of the opaque floor effectively and safely exposes the translucent membrane on the floor of the third ventricle and allows visualization of the basilar complex and its relationship to the floor and surrounding structures. The dorsum sellae can also be stripped in cases of a narrow prepontine window. One can then maneuver the endoscope around the vasculature and safely enter the prepontine cistern. In all 13 cases of partial vascular obstruction of the stoma, the ETV was completed. Postoperative clinical success was obtained in 77% of that ETV subgroup. No special MR imaging studies or special navigation systems are required. Moreover, special trajectories are not required. The endoscope is used partially as an instrument in clearing the way, and it is a “see-as-you-go” procedure. One has to obtain the experience and learn the feel and subtleties of pressing the endoscope with the proper pressure against the various structures. Other authors have described techniques to perform an ETV and to deal with the opaque floor, and many have reported excellent results. In our hands, the coring (cookie cut) technique has worked well. This technique is a good addition to the armamentarium of the experienced neuroendoscopist and is one method of performing an ETV and dealing with the opaque (neural) floor.

Disclosure

Dr. Grand has received honoraria for participating in a lecture series and practical courses sponsored by Aesculap.

Dr. Leonardo has no relationship to disclose.

Author contributions to the study and manuscript preparation include the following. Conception and design: both authors. Acquisition of data: both authors. Analysis and interpretation of data: both authors. Drafting the article: Grand. Critically revising the article: both authors. Reviewed final version of the manuscript and approved it for submission: both authors. Study supervision: Grand.

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