Dorsum Sellae as Key Landmark in ETV With Disminished Prepontine Cistern: Technical Note and Case Series

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BACKGROUND AND OBJECTIVES: One of the key aspects in the surgical technique of endoscopic third ventriculostomy (ETV) is the perforation of the floor of the third ventricle because of the high risk of injuring vital structures located in that region. According to the standard technique, this perforation should be performed in the midline halfway between mammillary bodies and the infundibular recess to avoid damage to the structures. This can be performed without excessive complications when the diameter of the prepontine cistern is wide. However, in situations where the diameter is reduced (defined in the literature as having a prepontine interval [PPI] ≤1 mm), the probability of complications increases exponentially.

In this article, we propose using dorsum sellae as a key point to safely perform ETV in patients with a decreased PPI, guiding the trajectory and its marking using neuronavigation.

METHODS: A review was conducted on the latest 100 ETV procedures performed by our team in the past 5 years. The measurement of the PPI was conducted using archived preoperative MRI imaging studies, specifically between the dorsum sellae and the basilar artery. In cases where the PPI was ≤1 mm and, therefore, the use of the dorsum sellae was applied as a reference point, the technical results and procedural functions were documented.

RESULTS: In the cohort, 7 patients with a PPI ≤1 mm were identified. In all 7 cases, fenestration of the tuber cinereum was successfully performed without causing vascular damage or associated complications. ETV was successful in 6 patients, with only one experiencing ETV failure necessitating the placement of a ventriculoperitoneal shunt.

CONCLUSION: The utilization of the dorsum sellae as a reference point to perform ETV in reduced PPI constitutes a safe alternative to the classical technique.

KEY WORDS: Dorsum sellae, Hydrocephalus, Endoscopic third ventriculostomy

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Noncommunicating obstructive hydrocephalus is one of the main pathologies treated using endoscopic third ventriculostomy (ETV).[1-3] Since its introduction to the present day, both the technique for its implementation and the associated complications have been thoroughly described.[4,5] Unlike classical ventricular shunt techniques, which are associated with a high number of complications, the morbidity and mortality associated with endoscopic techniques are low.[2] Among the possible complications of the technique, the most complex and challenging to treat are injuries to the vascular structures located beneath the tuber cinereum, primarily the basilar artery and its branches.[6] According to the classical technique, to avoid damaging these structures, the perforation of the floor of the third ventricle should be performed in the midline halfway between mammillary bodies and the infundibular recess.[7] This is relatively straightforward when the prepontine interval (PPI) is wide and thinned, allowing us to visualize the underlying structures through transparency. However, in certain cases, this intervale is diminished, increasing the technical complexity of the procedure. The literature includes studies that present mechanisms to attempt to reduce the risk of vascular injury using preoperative MRI, intraoperative Doppler ultrasound, or 3-dimensional planning.[7-11] Similarly, there have been studies analyzing whether the complication rates increase in these cases.[12] However, these studies have not delved into the technical concepts to reduce the possibility of complications. Therefore, our team

ABBREVIATIONS: A, artery; **DS,** dorsum sellae; **ETV,** endoscopic third ventriculostomy; **IR,** infundibular recess; **MB,** mammillary bodies; **PPI,** prepontine interval; **TC,** tuber cinerum.

presents in this work the use of the dorsum sellae as a reference point for performing neuronavigated ETV in patients with a decreased PPI, where the possibility of injuring the structures underlying the tuber cinereum increases if the principles of the classical technique are followed.

The main objective of this article was to provide tools to the neurosurgical community to safely perform ETV in complex situations where the use of the classical technique may not be recommended because of the high risk of complications, such as in cases with a decreased PPI.

METHODS

All patients consented to the procedure, and the patient in the figures consented to the publication of his image. This study was approved by the institutional review board. A retrospective review was conducted on the cases performed by our team in the past 5 years, including the latest 100 cases of ETV. Among them, patients were identified who exhibited a PPI ≤1 mm on preoperative MRI. This was defined as the distance between the dorsum sellae and the basilar artery. This measurement was obtained using an automated linear measurement tool.

Technical success was defined as the successful creation of a surgically induced fenestration without any resulting patient morbidity. Functional success was determined by the absence of the need for any additional cerebrospinal fluid (CSF) diversionary procedure within a period of 6 months after ETV.

All patients underwent a postoperative MRI performed at 72 hours after surgery. To determine the success rate of the technique, patients were followed for a minimum of 1 year.

ILLUSTRATIVE CASE

History and Examination

A 75-year-old woman with no relevant medical history presented to the emergency department of our hospital, reporting a 1-month history of memory impairment, gait instability, and headache. In the past few days, her symptoms had worsened and were accompanied by behavioral changes. During the neurological examination, the patient was conscious but disoriented and exhibited disinhibited behavior. Cranial nerve examination revealed no abnormalities. She had a left-sided gait disturbance. Laboratory tests showed no significant alterations. The family provided a privately obtained MRI scan from the previous days, which revealed a large contrast-enhancing lesion in the pineal region, resulting in obstruction of the Sylvian aqueduct and anterior displacement of the upper part of the brainstem, causing a decrease in the PPI (Figure 1A and 1B) (Video). These findings indicated enlargement of the lateral and third ventricles in the context of noncommunicating obstructive hydrocephalus. Given the findings in the imaging tests and the patient's clinical situation, it was decided to perform a two-stage combined approach using neuronavigation guidance. On one hand, an ETV will be performed, and on the other hand, a biopsy of the pineal lesion will be taken.

Technique

1. How is a decreased prepontine cistern space defined?

In the literature, there is no consensus on how to define a decreased prepontine space. However, some studies have established a cut-off point to consider it as such when there is a distance between the upper portion of the basilar artery and the dorsum sellae equal to or less than 1 mm (this measurement is known as the PPI).

2. Why use the dorsum sellae as a reference point in ETV with decreased prepontine space?

One of the main challenges of ETV lies in avoiding damage to vital vascular structures during the perforation of the floor of the third ventricle. In ideal situations, where the tuber cinereum has a wide diameter, the chances of damage are reduced as there is enough space to perform the perforation away from the basilar artery and its branches. However, when this space is decreased, the risk and technical difficulty increase (Figure 2A and 2B). To avoid this situation, we believe that using the dorsum sellae as a reference point is highly useful. First, it is a nonvital structure. Second, it is not affected by variations that may occur during the procedure. Third, it provides haptic feedback during the perforation with instruments as it is a solid structure. There may be some counterarguments against its use. The most common one would be the potential damage we could cause to the pituitary stalk and the corresponding gland if we accidentally enter the sella. However, this can be avoided in 2 ways. First, with a technical maneuver that involves, once the dorsum sellae is referenced, sliding through a trajectory parallel to the posterior edge of the clivus and through the use of neuronavigation.

3. First step: Analyzing the imaging studies.

In an ideal situation, it would be optimal to have both MRI and computed tomography scan to assess both the neural/vascular structures and the bony elements. However, in certain urgent situations, only access to a computed tomography scan may be available. The next step would be to analyze the ventricular anatomy and determine the presence of a decreased prepontine space (Figure 1A-1D).

4. Second step: Establishing a surgical trajectory.

Our team believes that neuronavigation (Medtronic StealthStation S8) is an essential element in rigid instrument endoscopy (LOTTA, Karl Storz). Having a guided straight trajectory to our target helps us reduce the rate of complications and avoid disorientation in the ventricular system. To achieve this, we trace a trajectory before surface registration, with the target located on the dorsum sellae. Subsequently, we can dynamically modify the cranial entry point based on the patient's characteristics.

5. Third step: Navigation through the ventricular system.

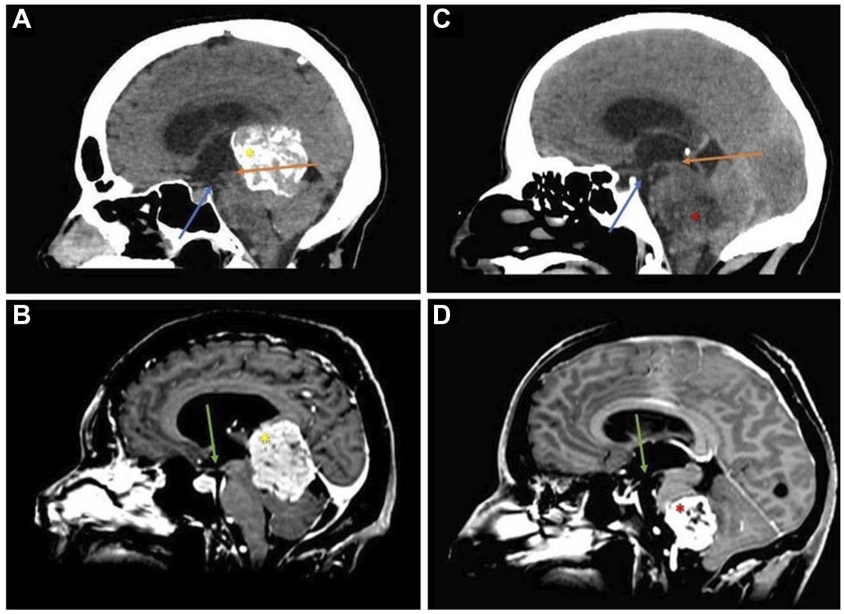

FIGURE 1. *Preoperative and postoperative imaging studies.* **A**, *Preoperative Cranial CT showing a patient with a space-occupying lesion in the pineal region (yellow asterisk), causing displacement of the upper third of the brainstem, obliterating the prepontine cistern and resulting in a decrease in its space.* **B**, *Postoperative MRI after the performance of ETV with perforation of the floor of the third ventricle (green arrow).* **C**, *Preoperative Cranial CT of a patient with a space-occupying lesion in the lower third of the brainstem (red asterisk), which, due to its location, unlike the previous case, does not lead to a reduction in the prepontine cistern.* **D**, *Postoperative MRI after the performance of ETV with perforation of the floor of the third ventricle (green arrow). The blue arrows indicate the prepontine space, where the difference in diameter between patients can be observed. The orange arrows refer to the position of the mesencephalic region, indicating whether there is displacement or not. CT, computed tomography; ETV, endoscopic third ventriculostomy.*

Typically, in patients with noncommunicating obstructive hydrocephalus, this stage is not highly complex because the ventricular size usually has wide diameters due to its pathophysiology. However, the use of neuronavigation is helpful because it allows us to effectively guide our trajectory and identify all our anatomic landmarks within the ventricular system in a linear and progressive manner (Lateral Ventricle-Septal Vein-Thalamostriate Vein-Choroid Plexus-Monro's Foramen-Third Ventricle-Tuber Cinereum-Dorsum Sellae). Our team performs atraumatic entry using the trocar provided with the endoscope. Once we confirm entry into the ventricular system through both the tactile feedback on breaking the ependyma and the navigation guidance, we introduce the endoscope through the trocar and then guide it to our target in the third ventricle: the dorsum sellae.

6. Fourth step: Identification of the dorsum sellae and perforation of the tuber cinereum.

Finally, we reach the key point of the procedure, which represents the main modification proposed in this article. Instead of attempting to perforate the floor of the third ventricle using the classical technique, our team seeks to identify and create the initial opening on the dorsum sellae. To achieve this, visual identification is the first step. The dorsum sellae is typically observed as a horizontal yellowish lamina through the gray matter, contrasting with the more grayish tone of the tuber. It is intimately related to the infundibular recess.

After visual inspection, we proceed with tactile inspection. Using a blunt instrument, we perforate the point where we believe our target is located. To avoid entering the sella turcica, our manual technique involves directing the instrument as if we were trying to slide through the posterior wall of the clivus (this is performed by modifying the direction of the instrument tip from a more angled position to a straighter one).

Once we reach the desired point, if we are in the correct location, we will feel as if we are touching a rigid structure that does not allow further advancement. This is the dorsum sellae, which becomes easily identifiable once the membrane of the third ventricle floor is disrupted. After this step, we conclude the ETV procedure following the classical technique of enlarging the stoma with a Fogarty catheter (Figure 3A-3D).

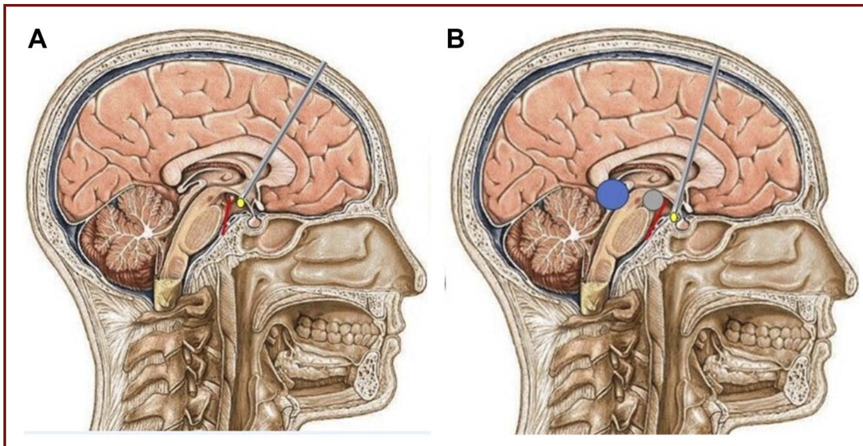

FIGURE 2. *Schematic representation of ETV in relation to the prepontine space.* **A**, *In this scenario, we encounter a patient with a wide prepontine cistern, and the classic technique is performed by making a perforation in the floor of the third ventricle along the midline, between the mammillary bodies and the infundibular recess. If the basilar artery complex and its branches do not present anatomic anomalies and considering the ample space, the risk of injury is low. The direction of the endoscope is perpendicular to the Liliequist membrane.* **B**, *In this other scenario, we have a patient with an occupation in the pineal cistern (blue circle) causing obliteration of the prepontine space (gray circle) with displacement of the vascular structures. To prevent injury during ETV, the direction of the endoscope in this case should be directed toward the dorsum sellae, taken as a reference point. Next, we would slide along the posterior aspect of the clivus to proceed with the opening of the Liliequist membrane. ETV, endoscopic third ventriculostomy.*

Additional Inquiries

1. Is the technique applicable in cases of reduced transparency in the tuber cinereum?

Yes, it is possible. When dealing with a tuber cinereum exhibiting reduced transparency, the technical complexity of ETV increases due to the inadvertent risk of injury to vascular structures in the prepontine cistern. In fact, in such situations, the use of the dorsum sellae as a reference point for perforating the floor of the third ventricle should be considered as one of the measures to reduce the risk of complications. To safely perform this procedure, a series of measures are required.

First, an attempt should be made to identify the dorsum sellae in relation to the infundibular recess. It is usually identified as a yellowish line contrasting with the grayish color. Sometimes, because of reduced transparency, this is not

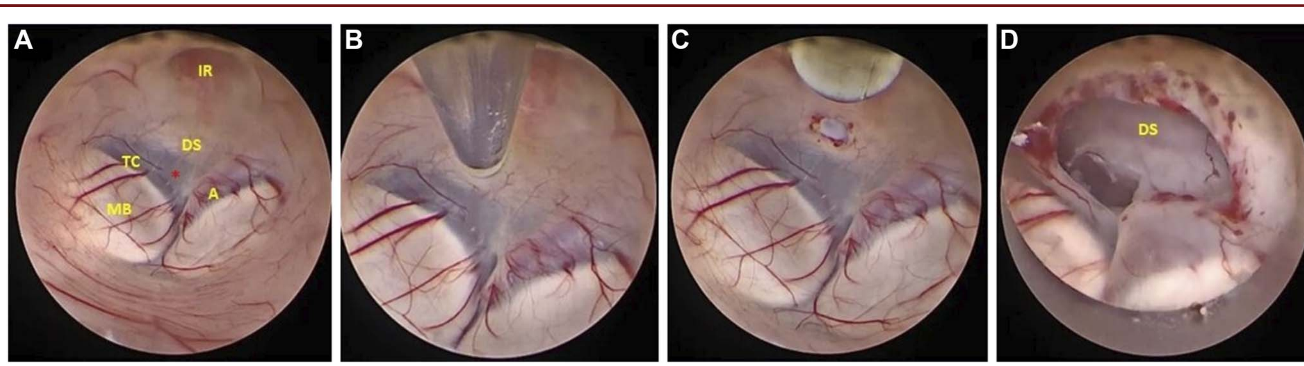

FIGURE 3. *ETV in diminished PPI.* **A**, *Identification of the structures present on the floor of the third ventricle. The red asterisk refers to the point that would traditionally be used for perforating the membrane.* **B**, *Palpation maneuver of the dorsum sellae to confirm its location.* **C**, *Identification of the dorsum sellae.* **D**, *Enlargement of the ostomy with visualization of the dorsum sellae, proceeding along the posterior aspect of the clivus. There are no vital structures in this location that would be at risk during the maneuver. A, artery; DS, dorsum sellae; ETV, endoscopic third ventriculostomy; IR, infundibular recess; MB, mammillary bodies; PPI, prepontine interval; TC, tuber cinerum.*

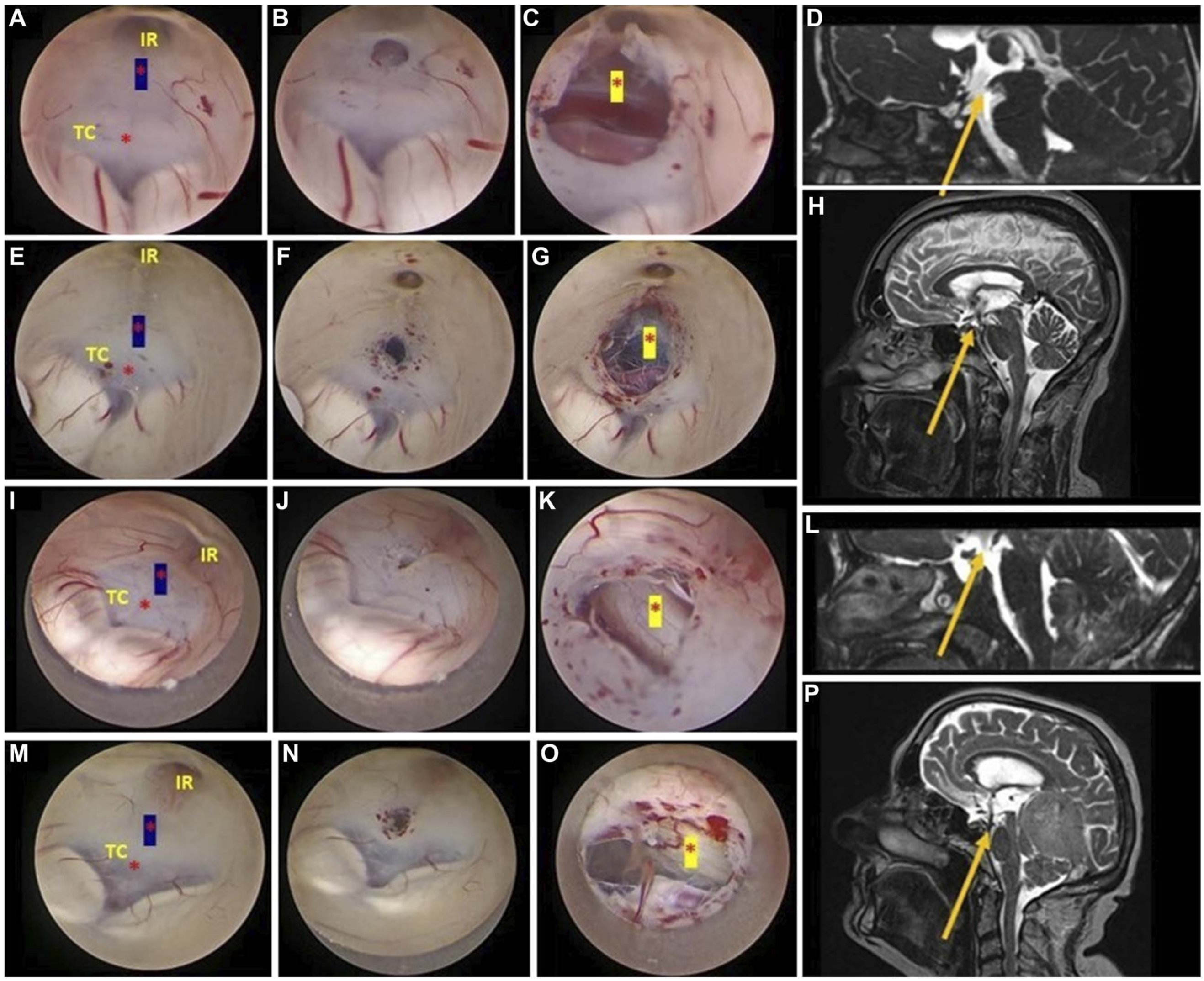

FIGURE 4. *ETV with diminished PPI in other contexts.* **A-D**, *Pediatric patient with diminished PPI and obstructive hydrocephalus due to posterior fossa rupture arteriovenous malformation lesion. The main determinant is the incomplete formation of the dorsum sellae due to the patient's age. In this case, our direction should be directed toward the posterior aspect of the clivus to avoid entering the sella turcica.* **E-H**, *The patient with obstructive hydrocephalus in the context of shunt malfunction, presenting a diminished PPI. In this case, the limiting factor is the opacity of the tuber, which does not allow clear identification of the dorsum. By using the techniques described in the article, we can safely perform ETV.* **I-L**, *Pediatric patient with decreased PPI due to a posterior fossa tumor causing obstructive hydrocephalus.* **M-P**, *The patient with space-occupying lesion in the pineal cistern leading to a decrease in PPI and obstructive hydrocephalus. In all of them, the red asterisk on the blue background marks our entry zone. The red asterisk marks the entry zone in a classic ETV. The red asterisk on the yellow background marks the dorsum sellae. In addition, postoperative MRI control is provided, demonstrating ostomy patency. ETV, endoscopic third ventriculostomy; PPI, prepontine interval; TC, tuber cinereum.*

possible. Second, the use of neuronavigation can be employed for assistance. Another option is to perform a technical maneuver to identify it through visual/haptic feedback. This involves performing small palpations with a blunt instrument from the anterior (near the infundibular recess) toward the posterior until visually identifying and/or feeling a solid element corresponding to the bony structure. To avoid inadvertent entry into the sella turcica, it is crucial to establish a vector of direction of the blunt instrument parallel to the posterior part of the clival region (Figure 4E-4H).

2. Can this technique be applicable even in the absence of a diminished prepontine space?

The use of the dorsum sellae as a reference point to perform ETV may be applicable in other situations following the

TABLE. Characteristics of Patients With Decreased PPI in Whom the Use of the Dorsum Sellae Was Applied as a Reference Point for ETV

Cases	Sex	Age	Origin of obstructive hydrocephalus	PPI (mm)	Vascular complication/ morbidity	Follow-up (yo)	ETV failure
Patient 1	Male	8 mo	Rupture AVM Posterior Fossa	0.75	No	1	Yes
Patient 2	Male	54 yo	Silvio's Aqueduct Stenosis. Shunt Malfuction	0.8	No	2	No
Patient 3	Female	75 yo	Pineal Tumor	0.6	No	2	No
Patient 4	Female	9 yo	Posterior Fossa Tumor	0.9	No	1.5	No
Patient 5	Female	62 yo	Falcotentorial Meningioma	0.85	No	4	No
Patient 6	Male	50 yo	Posterior Fossa Tumor	0.8	No	3	No
Patient 7	Male	45 yo	Posterior Fossa Tumor	0.7	No	3	No

AVM, arteriovenous malformation; ETV, endoscopic third ventriculostomy; mo, months; PPI, prepontine intervale; yo, years old.

guidelines described in this article. Although the patient may not present a diminished prepontine space, they may exhibit other technical peculiarities that increase the risk of complications (eg, distorted vascular anatomy).

3. Is it safe to perform it in children in whom the sella turcica has not yet fully developed?

The technical complexity of this maneuver in pediatric patients is greater because many of them have not yet fully developed the sella turcica. However, the fact that it poses a greater technical challenge does not mean that it is contraindicated. Such patients have the posterior part of the clivus that may not serve as an anatomic reference, making it difficult to determine the direction of our perforation (Figure 4A-4D).

4. Are there any contraindications for performing the procedure?

The only absolute contraindication for the technique is when the size of the lateral ventricles/III ventricle is insufficient to accommodate the endoscopy system. As a relative contraindication, the only significant one to highlight would be inexperience in performing the specific technique under consideration here.

5. What were the difficulties encountered during the initial implementation of the technique?

At the beginning of applying the technique to the target patients, we did not encounter significant difficulties. This was due to the fact that the different steps (use of neuronavigation, identification of the dorsum sellae, navigation through the ventricular system) were performed in more favorable situations for our team (eg, good transparency of the tuber cinereum, absence of decreased prepontine space, etc.). These favorable conditions contributed to a smoother initial application of the technique and facilitated successful outcomes.

RESULTS

Out of the 100 reviewed cases of ETV, preoperative MRI data allowing us to determine the prepontine space were available for 60 cases (60%). The age range of the identified patients varied from 8 months to 75 years (mean age of 42 years). Among them, 7 patients (11.6%) (Figure 1A and 1B) (Figure 2A and 2B) were identified with a prepontine space ≤1 mm. In all cases, a successful stoma creation was achieved during ETV (100% technical success). There was no evidence of vasculonervous injury during the procedure and postoperatively. During the follow-up period, only 1 patient (14.28%) required a secondary CSF diversion procedure due to ETV failure. The patients' characteristics are summarized in Table.

DISCUSSION

The implementation of ETV for the treatment of noncommunicating obstructive hydrocephalus revolutionized the management of these patients.[1-3] Over the years, the possible complications associated with the technique and their frequency have been described.[4,5] Despite being a complex procedure, the percentage of complications is low. One critical aspect for achieving good outcomes is the accurate perforation of the floor of the third ventricle. In the prepontine cistern, vital structures such as the basilar artery complex and its branches, as well as the brainstem, are encountered.[6] Some patients present anatomic characteristics that hinder the performance of the endoscopic ostomy. One of these peculiarities is the presence of a diminished PPI, which increases the risk of complications. According to the classical technique, the perforation should be performed with a blunt instrument in the midline between the mammillary bodies and the infundibular recess.[13] However, the presence of a small cistern makes it challenging to perform the procedure. To attempt to reduce the risk of structural damage, different measures have been proposed.[7-10] Among them, our team suggests using the dorsum sellae as a reference point for the procedure. We believe it is a safe, nonvital, and unalterable structure that provides a fixed anatomic reference for safely performing the technique. However, it is necessary to have a deep understanding of how to perform it, as improper application can also lead to the appearance of other associated risks.

Limitations

It is important to emphasize the limitations of the current study. Although it is a technical note, both the number of patients analyzed and the follow-up time are low. Future research would be valuable to assess the long-term success of the technique.

CONCLUSION

The utilization of the dorsum sellae as a reference point to perform ETV in reduced PPI constitutes a safe alternative to the classical technique. The comprehension and technical implementation of this procedure will enable less experienced neuroendoscopy groups to perform ETV on this type of patients with increased safety.

DECLARATIONS—COMPLIANCE WITH ETHICAL STANDARDS

The authors declare that this manuscript has not been previously published in whole or in part or submitted elsewhere for review.

ETHICS APPROVAL

All procedures performed in the studies involving human participants were in accordance with ethical standards of the institutional and national research committee and with the 1964 Declaration of Helsinki and its later amendments.

CONSENT TO PARTICIPATE AND CONSENT FOR PUBLICATION

Informed consent to participate and for publication was obtained from all individual participants included in the study. Written informed consent was obtained from the parents as legal guardians.

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Disclosures

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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VIDEO. Operative video. Dorsum sellae as key landmark in disminished prepontine interval.

COMMENTS

In this current report, the authors describe a technique for performing an endoscopic third ventriculostomy (ETV) under unfavorable anatomic conditions, namely a prepontine interval of less than 1 mm in which injury to vital underlying structures is of greater concern than in cases of more favorable anatomy. While this is not the first report to discuss the possibility of still performing successful ETVs in these patients, this is indeed the first report to focus primarily on the procedural details and discuss how a surgeon can optimize his or her approach for successful fenestration of the tuber cinereum in these cases. The authors should be commended for their work, as their descriptions are well formulated and detailed enough to allow the reader to follow the protocol for success with their own patients. The readership may have elected for other CSF diversion options in these patients historically, and this article opens the possibility for a more technically aggressive approach to these patients via a minimally invasive surgical corridor, precluding the need for shunt placement. By shifting our collective limitations/concerns/contraindications for this procedure, we can enter into new discussions and build larger series which evaluate the safety and outcomes in patients with small prepontine intervals. Of course, the reader and the surgeon must be aware of the greater risk for vascular injury in these cases, and discuss this with their patients preoperatively, but with care and caution as described in this report, less invasive options for CSF management even in patients with unfavorable anatomy are become more possible and more commonplace among our community. In the future, we can build further on this series and obtain longer follow up for these patients to determine whether there are differences in long term outcomes for these individuals, which would be factors used for better patient selection and risk stratification moving forward. I commend the authors again for their work and will likely integrate the methodology into my practice even in patients with small prepontine intervals not necessarily below 1 mm but approaching this size, as this methodology only increases the safety of this procedure for our patients.

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