Ventricular Catheter Insertion on the Occipital and Parietooccipital Bone: A Nonmetric Complementary Technique

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Abstract

Background and Study Aim Hydrocephalus is a common disease of the pediatric population, with cerebrospinal fluid diversion as the management of choice. All current insertion techniques require craniometrics calculation that may not be applicable for pediatric patients, due to significant variation in head circumference. We describe a complementary method of inserting ventricular catheters, devoid of craniometrics.

Materials and Methods The insertion site is based on two imaginary lines on the sagittal plane (superior and inferior limits) and four imaginary lines on the axial plane of a computed tomography/magnetic resonance imaging. The insertion point is chosen based on the shortest location from the outer table of the bone to the ventricle. The length of catheter insertion is calculated based on the distance between the calvarial outer table and the foramen of Monro.

Results Two case examples of ventricular catheter insertions, in pediatric patients with noncommunicating hydrocephalus, are described. External ventricular drain and ventriculoperitoneal shunt were inserted using this technique, with no required craniometrics measurements.

Conclusion This complementary method of inserting ventricular catheters can be easily tailored and implemented by junior neurosurgical residents to senior neurosurgeons as it precludes the measurement of the catheter insertion points.

Keywords
- ventricular catheter insertion
- ventriculoperitoneal shunt
- hydrocephalus

Introduction

Ventricular catheter insertion to divert cerebrospinal fluid (CSF) is one of the most common and fundamental neurosurgical procedures in managing hydrocephalus. Hydrocephalus is considered the most common indication for ventricular catheter procedures in the pediatrics population, with an annual approximately 39,900 admissions, approximately 430,000 hospital days, and total hospital cost of $1.4 to 2.0 billion.[1] Therefore, many ventricular approaches with

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different entry points and techniques have been described.[2] We propose a complementary technique of accessing and inserting a ventricular catheter through the parietooccipital or occipital bone without the use of fixed craniometrics parameters.

Materials and Methods

We describe the step-by-step approach to plan and insert the ventricular catheter on the parietooccipital or occipital sites.

First Step

Determine the superior and inferior level of the burr hole (►Fig. 1A):

- Patient is positioned with the head rotated to the contralateral side (►Fig. 1B).
- Use the superior orbital ridge as a mark for skull base level as shown by the measuring tape above the superior orbital ridge (►Fig. 2A).
- Use the vertex as a mark for the top of the head as shown by the measuring tape on the midline of the skull (►Fig. 2A).
- The lines should be parallel to the lateral ventricles.
- Burr hole level should be on the junction between the middle and lower thirds (►Fig. 2B).

Second Step

Determine the anterior and posterior location of the burr hole (►Fig. 3A):

- Divide the axial computed tomography/magnetic resonance imaging (CT/MRI) cut (where the ventricles are maximally dilated) into four quadrants.
- The location of the parietooccipital or occipital burr hole is located between the P and R points for right-sided insertions and P and L points for left-sided insertions.
- Correlate the curvature of the patient skull with a CT axial cut bone curve to choose the best burr hole location, which is usually midway between P and R points for the right side or P and L points for the left side. The shortest distance between the outer table of the skull and ventricular wall is a desired location for the burr hole.

Third Step

Determine the trajectory of insertion (►Fig. 3A)

- Landmark sticker (►Fig. 3B), such as electrocardiograph (ECG) lead sticker applied 1 cm above the glabella in the

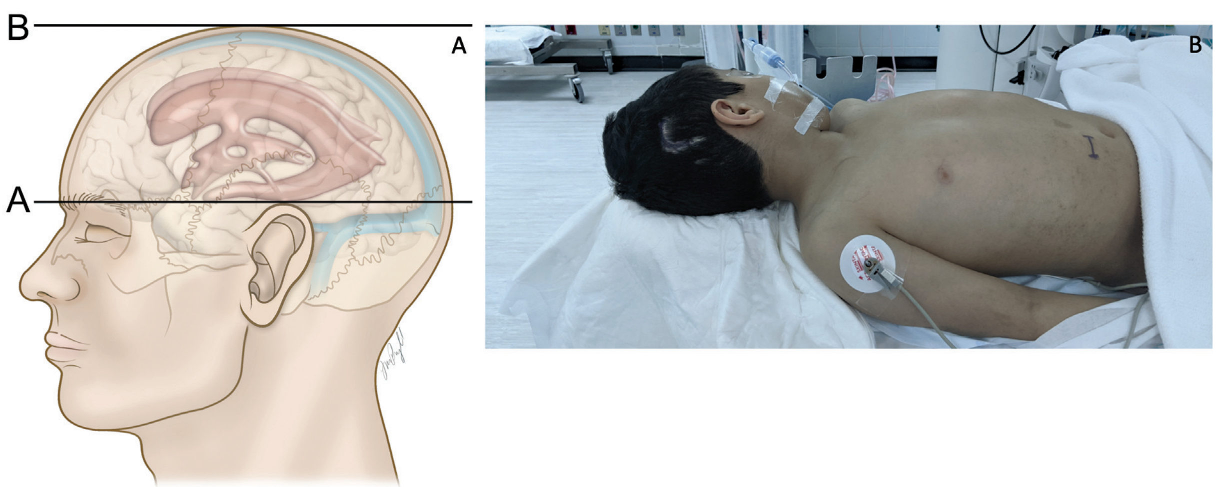

Fig. 1 Sagittal depiction of the inferior (point A at the superior orbital ridge) and superior (point B at the vertex) limits of the ventricular catheter insertion (►Fig. A). Positioning of patients undergoing parietooccipital ventriculoperitoneal shunt or external ventricular drain insertion. The head is rotated to the contralateral side (B).

Fig. 2 Measuring tape applied to the patient's head for marking the skull base (left) and vertex (right). Note that no measurement is performed (A). Three lines are depicted to bisect the area between the vertex and skull base into three quadrants. The insertion point is at the junction of the middle and lower third quadrants (B).

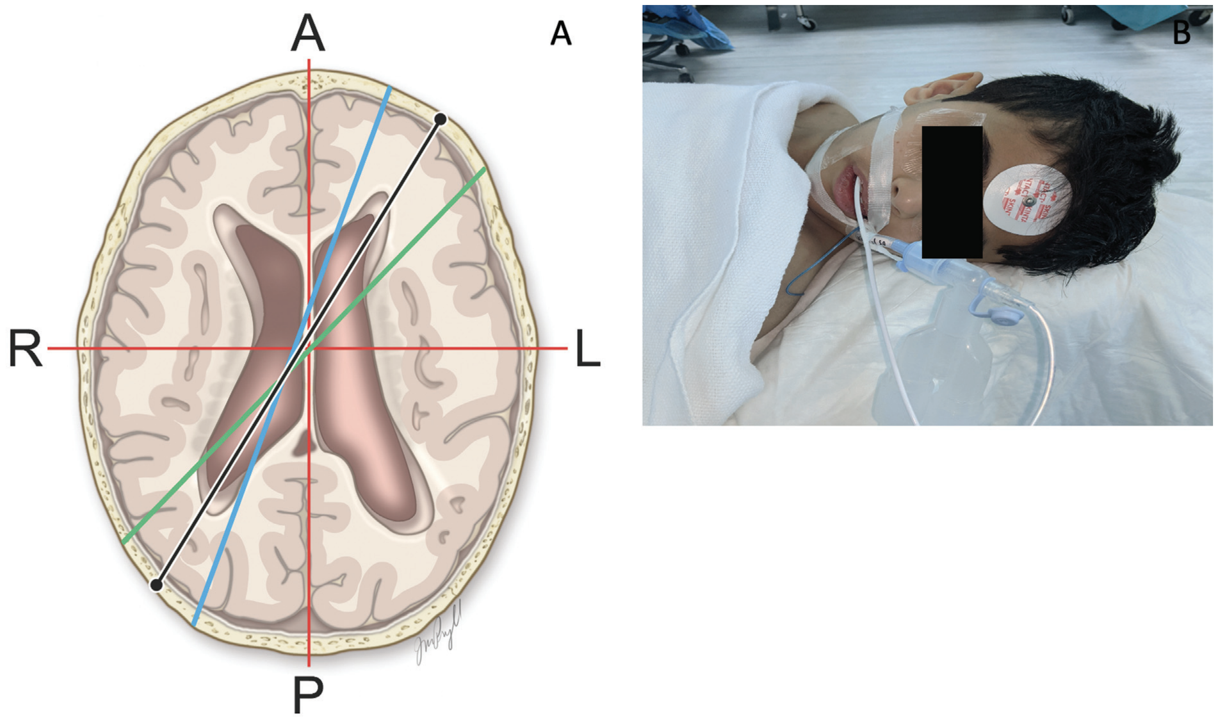

Fig. 3 Axial depiction of the entry point and trajectory of the ventricular catheter. The entry point is chosen based on the shortest distance between the outer table of the bone and the ventricle, between point P and R (right side) and point P and L (left side). The green, black, and blue lines are different trajectory points based on the entry point. A landmark sticker is applied 1 cm above the glabella to aid in the insertion trajectory at the sagittal plane intraoperatively. The length of the catheter inserted depends on the distance calculated between the bony outer table and the foramen of Monro (**A**). Landmark sticker, such as an electrocardiograph sticker, applied 1 cm above the glabella to aid in intraoperative insertion in the axial plane (**B**).

midline to assist intraoperatively for the accuracy of catheter trajectory in the axial plane.

- A trajectory is chosen based on a line starting from the burr hole point, to the ventricular wall, and the frontal bone in the opposite direction.
- Measure the length of the ventricular catheter that will be inserted in the ventricular by measuring the distance between the outer table of the bone of the insertion site to the foramen of Monro.

Results

Case 1

The patient is a 2-year-old girl who was referred to our tertiary center after she was found to have a cerebellar mass lesion in a local hospital. Her parents noticed gait ataxia 2 weeks prior to her transfer, and progressive vomiting and lethargy 4 days before her transfer. On the same day of transfer, the patient underwent emergency insertion of right frontal external ventricular drain (EVD) due to ventriculomegaly. Two days postadmission, she underwent suboccipital craniotomy and gross total resection of the cerebellar mass. Pathology revealed a large-cell/anaplastic type medulloblastoma.

The pediatric oncology team was involved; chemotherapy was scheduled after EVD is removed. Therefore, the patient underwent EVD removal and ventriculoperitoneal (VP) shunt insertion on the right occipital side (►**Fig. 4**). Despite finishing her chemotherapy regimen, there was a progression of her disease with craniospinal dissemination 2 months post-VP shunt insertion, and she died as a result.

Case 2

The patient is a 9-year-old girl who was transferred to our center due to the diagnosis of suprasellar mass, causing ventriculomegaly. One month prior to transfer, the patient started to notice a decrease in her visual acuity (worse on the left eye) and gait ataxia. Three days prior to transfer, she started to have progressive vomiting and headache. Immediately upon arrival, the patient underwent right occipital EVD insertion. Two days later, a ventricular endoscopic-guided biopsy revealed a diagnosis of germinoma. The patient was started on radiation therapy two days later.

Thirteen days postadmission, the patient underwent EVD removal and insertion of left occipital VP shunt (►**Fig. 5**). The patient's overall condition improved markedly and was discharged after 27 days of hospital stay with a remaining decreased visual acuity (left eye blindness).

Discussion

Hydrocephalus is a common, widespread pathology of the CSF circulation in the pediatric and adult population.[3] Although Hippocrates (466–377 BC) was the first to attempt surgical ventricular access and the first to describe hydrocephalus, Claudius Galen of Pergamon (130–200 AD)

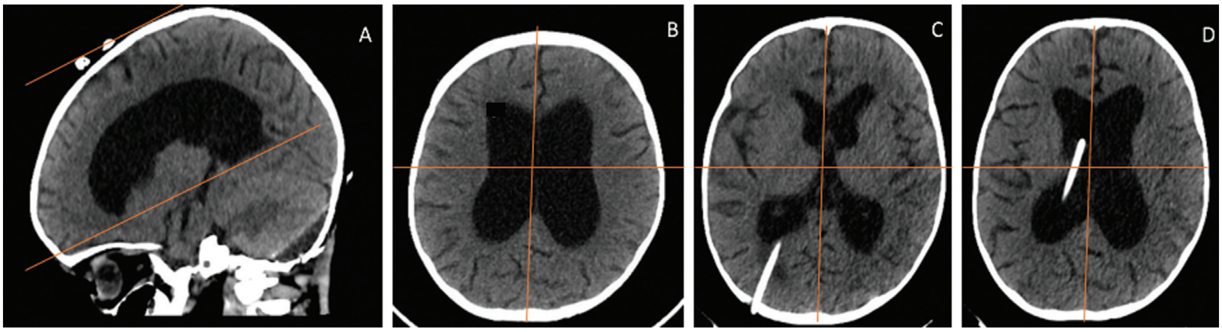

Fig. 4 Sagittal view depicting the superior and inferior limits of catheter insertion point parallel to lateral ventricles; in this case, the patient's head was flexed (**A**). Preoperative axial view for planning the side and point of insertion, depending on the shortest distance between the bony outer table and lateral ventricles (**B**). Postoperative axial views are demonstrating the final location of the ventricular catheter (**C** and **D**).

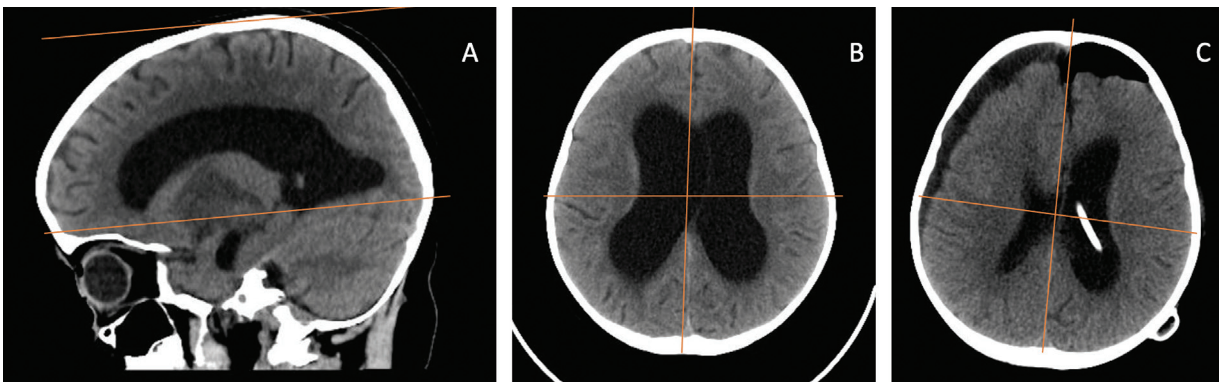

Fig. 5 Sagittal view depicting the superior and inferior limits of catheter insertion point parallel to lateral ventricles (**A**). Preoperative axial view for planning the side and point of insertion, depending on the shortest distance between the bony outer table and lateral ventricles (**B**). Postoperative axial views are showing the final location of the ventricular catheter (**C**).

was the first to give an accurate understanding of the CSF description and ventricular system anatomy.[4–6]

Despite advancement in the field of medicine, and specifically, neurosurgery, hydrocephalus is a significant cause of financial, psychological, and social burden in developed and underdeveloped countries.[3,7] The majority of hydrocephalus etiologies require surgical access to the ventricles, making the ventricular access and catheter insertion indispensable in the neurosurgical practice.[2] Ventricular shunt is a pressure-regulated valve with proximal ventricular and distal catheters; shunt can vary by the distal end location, the burr hole insertion point, and ventricular catheter trajectory. Based on the distal end, the standard type is a VP shunt, where the distal end is embedded inside the peritoneum of the abdominal cavity. Furthermore, the right atrium of the heart can be accessed as a ventriculoatrial shunt, in addition to other sites like pleura or gallbladder.[8] Several approaches and ventricular access points can be used, depending on patients' age group and hydrocephalus etiology.[9–17]

A recent review article described the current different ventricular catheter approaches, based on burr hole location to the external auditory canal.[2] Anterior approaches within the frontal bone include Kocher's, Kaufman's, Paine's, Menovksy's, and Tubbs' points; posterior approaches within the parietooccipital and occipital bones include Keen's, Frazier's, Dandy's, and Sanchez's points.[9–17] Each ventricular access point has various advocates and theoretical justifications; for example, anterior approaches have shorter passage length and avoid choroid plexus that may cause proximal catheter occlusion. In contrast, posterior approaches do not require a second scalp incision and are a desirable location for accessing the ventricles in pediatric population.[18]

In this study, we proposed a complementary method of ventricular catheter insertion in the occipital or parietooccipital area. In contrast to other posterior access points and trajectories, this method has a nonfixed entry point along the axial and sagittal axes. Landmarks include the superior orbital ridge for the skull base level as the inferior limit and the vertex as the superior limit; the burr hole level should be in the middle point between them, or at the junction of the middle and lower third.

On the axial view, our technique's entry point can be planned anywhere between P and R/L points, depending on the shortest route to the ventricles and the most vertex bony curvature. A sticker applied on the opposite end of the insertion site, such as an ECG lead sticker, assists in the intraoperative calculation and accuracy of insertion. The sticker is applied 1 cm above the glabella. We avoid the use of fixed craniometric calculations used in all previously described approaches as it is not feasible in all patients, especially in pediatrics with a different head circumference. The length of ventricular catheter insertion can be approximated by calculating the distance of the outer table of the bone to the foramen of Monro and avoids fixed intervals in previous approaches. The advantage of this approach is the simplicity in deciding the entry point and trajectory of the catheter while bypassing craniometrics calculation. Our approach is individually-based and personalized to any neurosurgeon to tailor their entry point and trajectory of interest.

Conclusion

We propose a complementary method to classic ventricular catheter insertion points. Our technique avoids complex craniometrics calculations and can be tailored to any patient with different head circumference and personalized to any neurosurgeon depending on the shortest ventricle access site between two imaginary lines on the axial image view. This approach can complement classic ventricular insertion techniques to maximize the accuracy and safety of catheter insertion.

Authors' Contributions

TE was responsible for the conceptualization, methodology, writing, and editing. OB contributed to the methodology, editing, and data curation. OA was involved in the conceptualization, editing, supervision, and data curation. Patient families are aware and agree of the publication of this manuscript, and all patient figures are anonymized.

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Conflict of Interest

None declared.

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