A guide to placement of parietooccipital ventricular catheters

Technical note

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Accurate placement of parietooccipital ventricular catheters can be difficult and frustrating. To minimize the morbidity of the procedure and lengthen the duration of shunt function, the catheter tip should lie in the ipsilateral frontal horn. The authors describe a posterior ventricular guide (PVG) for placement of parietooccipital catheters that operates by mechanically coupling the posterior burr hole to the anterior target point. In a series of 38 patients who underwent ventriculoperitoneal shunting with the assistance of the guide, postoperative computerized tomography (CT) scanning revealed that 35 (92.0%) had accurate catheter placement. In comparison, a retrospective review of free-hand posterior catheter placement revealed good catheter position in only 22 of 43 patients (51.1%). The use of the guide added less than 5 minutes to the entire procedure, and there were no complications related to its use. The PVG is a simple and useful tool that aids in the placement of parietooccipital ventricular catheters.

KEY WORDS • hydrocephalus • ventriculoperitoneal shunt • guide • placement

VENTRICULOOPERITONEAL (VP) shunt placement in patients with hydrocephalus is one of the most commonly performed operations in neurological surgery. Despite the relative simplicity of this procedure, the complication rate can be significant. Surgical technique, from proper tissue handling to accurate catheter placement, plays a major role in reducing complications associated with VP shunts. Improper placement of the ventricular catheter may result in neurological injury from the misplaced catheter or early proximal shunt obstruction. Thus, to obtain optimum shunt function and minimize morbidity, proper placement of the proximal catheter is mandatory.

The incidence of misplaced catheters varies and depends on a number of factors, including the experience of the surgeon; the size of the targeted ventricle; the surgical approach (frontal versus parietooccipital); and the use of intraoperative guidance such as fluoroscopy, ultrasound, or endoscopy. Few data are available on this topic, although, in a retrospective series, Albright, et al., 1 found accurate catheter placement in only 55% of frontal shunts and 33% of parietooccipital shunts. Although four cases of ophthalmic injury following ventricular catheter insertion were reported recently 10 and intracerebral hemorrhages secondary to misplacement have appeared in isolated clinical reports, 5, 7 the rate of such complications is not known. Endoscopic placement of ventricular catheters with an accurate placement rate of 90% has recently been reported. 9 The disadvantages of this technique are the cost of the instrumentation, the added operative time, and the time required for the surgeon to become familiar with the technique.

An accurate, rapid, and inexpensive tool to aid in catheter placement has been successfully developed by Ghajar 6 for placement of frontal ventricular catheter. This instrument capitalizes on the anatomical observation that a line passing perpendicular to the skull at the coronal suture will intersect the lateral ventricle. Unfortunately, such an anatomical relationship does not apply in the parietooccipital region.

We report a new device to aid in parietooccipital catheter placement. The posterior ventricular guide (PVG) uses a simple mechanical concept to orient a posterior guide tube toward an anterior target. Catheter placement accuracy using the PVG was assessed and compared to previous results obtained without the guide.
Description of the Ventricular Guide

The PVG is a simple mechanical assembly in which an adjustable catheter guide tube is oriented along a line that intersects a fixed target point. The guide tube and the target point are mechanically coupled so that a catheter passed through the guide tube with a rigid stylet will have the optimum orientation toward the target point.

Lightweight aluminum guides were manufactured in the University of Washington and University of Iowa scientific instrument shops and can be used on all patients regardless of head circumference (Fig. 1A and B). The guides were sterilized by autoclave prior to each use.

Surgical Technique

The patient is positioned and prepped for a standard parietooccipital VP shunt with one exception: the forehead is covered by transparent adhesive drapes to allow visualization of the frontal target site, which is located in the midline 1 cm above the supraorbital rim. A modified Bovie cleaning pad,* with an approximately 5 × 5-mm square cut in the center, is placed on the forehead with the hole directly over the target site. The correct location of the burr hole is imperative for successful use of the PVG; in adults and older children, the burr hole is placed 7 cm above the inion and 3 cm lateral to the midline. In infants, the burr hole is made 3 to 4 cm above the inion and 2 to 3 cm lateral to the midline. A preoperative computerized tomography (CT) scan is used to identify anatomical anomalies and to estimate the depth of catheter placement needed to reach the frontal horn of the lateral ventricle.

Once the burr hole is made and the dura opened, the PVG is positioned with the anterior target indicator resting on the opening in the Bovie pad and the adjustable guide tube positioned several millimeters above the burr hole so that the pial surface is still visible (Fig. 1C and D). A standard 25-cm ventricular catheter over a long straight-wire stylet is passed through the guide tube to the desired depth. The stylet is removed to confirm ventricular entry, the guide tube withdrawn, and the PVG removed from the patient’s head. The remainder of the operation is completed according to standard surgical protocol.

Clinical Studies

Under institutional review board approval, a prospective clinical study of the PVG was initiated at the University of Washington-affiliated hospitals. Over an 18-month period, all patients with hydrocephalus who were on the authors’ (H.R.W., M.S.G.) clinical services underwent parietooccipital VP shunt placement using the PVG, unless there were contraindications to this route.

such as recent occipital surgery. All patients with hydro-
cephalus were included, regardless of ventricular size. The trial was continued at the University of Iowa by one author (M.A.H.) who moved to that institution. The operative records documented the number of attempts made to achieve good catheter placement and any intraoperative difficulties encountered. A postoperative CT scan was obtained prior to discharge to identify the position of the ventricular catheter. A correct placement was classified as one in which the tip of the catheter lay in the anterior horn of the ipsilateral lateral ventricle.

The accuracy of free-hand parietooccipital catheter placement was determined by a retrospective review of all patients undergoing parietooccipital VP shunt placement over a recent 2-year period at both the University of Washington and the University of Iowa. Forty-three patient charts were reviewed, with particular attention paid to operative reports and postoperative studies to document shunt placement. On review, we found that the operative notes often did not take note of the number of pass attempts made, making it difficult to compare to the PVG data. Either anteroposterior and lateral skull radiograms or CT scans were obtained postoperatively in all patients; good placement, as observed on radiogram, consisted of catheter tip placement in the ipsilateral frontal horn. The CT criteria for judging placement were the same for the PVG and free-hand data.

### Clinical Results

#### Patient Population

A total of 38 patients underwent parietooccipital VP shunt placement with the assistance of the PVG. These individuals ranged in age from 7 to 82 years of age, with an average age of 59.6 years. Presumed etiologies of hydrocephalus included subarachnoid hemorrhage, normal-pressure hydrocephalus, trauma, and miscellaneous causes (Table 1).

#### Operative Technique

In 34 of 38 operations (89.5%), the catheter was placed on the first pass; poor flow of cerebrospinal fluid (CSF) in two patients and no flow in two others was noted. Two of these shunts were placed early in the series and the poor CSF flow resulted from incorrect placement of the posterior burr hole; this was corrected by placement of a second burr hole. The catheter was inadvertently deflected on a dural edge within the burr hole in one case; this was easily corrected by retracting the dural leaves with bipolar cautery. The fourth case occurred later in the series in a young patient with small ventricles and elevated intracranial pressure. Following placement of the catheter, a small volume of fluid was released under high pressure, after which spontaneous flow ceased. The catheter was removed and replaced by a second catheter without altering the position of the PVG, on the assumption that the catheter had become obstructed. The flow remained poor through the second catheter, but an intraoperative pneumoencephalogram revealed good catheter position and it was left in place. A postoperative CT scan confirmed the accurate position and the patient made an uneventful recovery.

#### Postoperative Results

Postoperative CT scans demonstrated good catheter placement in 35 of 38 patients (92.0%), with the tip of the catheter being in the ipsilateral frontal horn of the lateral ventricle. In two cases (5.3%), the catheter crossed the midline and ended in the contralateral ventricle. In one case (2.6%), a small hematoma developed along the catheter tract in the parietal lobe, although the catheter was in the correct position (Table 2).

Three patients died (7.9%): one, the first patient of the series, from a myocardial infarction 3 days following shunt placement and two from complications of their underlying diagnosis of subarachnoid hemorrhage. There were no shunt infections or malfunctions during this brief follow-up period.

A total of 43 patients who had undergone free-hand parietooccipital VP shunt placement at both institutions were reviewed. Patient age distribution (mean 53 years) and etiologies of hydrocephalus did not differ significantly from the PVG group (p > 0.05) (Table 1). Accurate operative data were not available for these patients, but all had postoperative radiographic studies to determine catheter position: 37 (86%) had CT scans and six (14%) had anteroposterior and lateral skull radiograms. Twenty-two patients (51.1%) had accurate placement of the ventricular catheter, although 21 (48.9%) did not. In 17 of these latter patients (39.5% of all patients), the catheter crossed the midline to rest in the contralateral anterior horn. In one patient, the catheter traversed the ipsilateral

### Table 1

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>PVG</th>
<th>Free Hand</th>
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<tbody>
<tr>
<td>subarachnoid hemorrhage</td>
<td>14 (36.8%)</td>
<td>11 (25.6%)</td>
</tr>
<tr>
<td>normal pressure hydrocephalus</td>
<td>11 (28.9%)</td>
<td>13 (30.2%)</td>
</tr>
<tr>
<td>traumatic brain injury</td>
<td>6 (15.8%)</td>
<td>5 (11.3%)</td>
</tr>
<tr>
<td>miscellaneous including tumors</td>
<td>7 (18.5%)</td>
<td>14 (32.9%)</td>
</tr>
<tr>
<td>total</td>
<td>38</td>
<td>43</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Position</th>
<th>PVG</th>
<th>Free Hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>correct</td>
<td>35 (92.0%)</td>
<td>22 (51.1%)</td>
</tr>
<tr>
<td>crossed midline</td>
<td>2 (5.3%)</td>
<td>17 (39.5%)</td>
</tr>
<tr>
<td>hematoma</td>
<td>1 (2.6%)</td>
<td>0</td>
</tr>
<tr>
<td>parenchyma</td>
<td>0</td>
<td>4 (9.3%)</td>
</tr>
<tr>
<td>total</td>
<td>38</td>
<td>43</td>
</tr>
</tbody>
</table>

basal ganglia to end in the frontal horn, and in another, the catheter was passed too far, with the tip in the periventricular frontal lobe. A single catheter was also not placed deeply enough and ended at the foramen of Munro (Table 2). None of these patients suffered any immediate clinical consequences from the positions of the catheters; however, long-term follow-up is not available.

The frequency of optimal catheter placement was compared between the PVG group and the free-hand group. By chi-square analysis, the difference in accurate placement in the PVG group (92.0%) versus the free-hand group (51.1%) was statistically significant ($\chi^2 = 14.31$, $p < 0.001$).

**Discussion**

In the placement of a VP shunt, the ventricle may be cannulated by one of two approaches: frontal or parietooccipital. Each approach has its advantages and disadvantages. The frontal approach is technically simpler for two reasons: the landmarks are easier to identify and the target distance is shorter. These reasons also make the posterior approach more hazardous; however, there are other factors that counterbalance these shortcomings. The parietooccipital site, for example, is optimally situated for a continuous subcutaneous path to the abdomen, thus avoiding an additional incision. Furthermore, there is evidence that suggests that the parietooccipital shunt carries less risk of epilepsy than a frontal one: Dan and Wade found an incidence of 6.6% for parietooccipital shunts and 54.5% for frontal shunts, although the number of patients in the frontal group was significantly smaller and others have not found any difference.

With a frontal approach, the nose and the ear provide simultaneous spatial references for the surgeon and both are visible during catheter placement. With the posterior approach, the target in the glabellar region is not visible to the surgeon during catheter placement or, conversely, if the surgeon is situated anteriorly, the burr hole and catheter are hidden. The catheter trajectory must be estimated and is subject to inaccuracy.

The distance separating the tip of a misplaced catheter and its intended target depends both on the error in the trajectory angle and the distance the catheter travels. For a given error angle, the absolute distance by which the catheter tip misses the intended target increases linearly with the increasing length of the catheter pass. For example, a parietooccipital catheter 10 cm in length passed in a straight line with a trajectory error angle of 5° will have a final catheter tip position twice as far from the target as a frontal catheter 5 cm in length with the same angle of error (Fig. 2). Thus, the angular trajectory of a posterior catheter is crucial for proper placement.

The PVG is designed to resolve the difficulty in choosing the correct catheter trajectory. By mechanically coupling a guide to target point indicator, the catheter is oriented in the optimum direction toward the target. This technique was successfully used by a number of surgeons in this trial and resulted in accurate catheter placement while adding less than 5 minutes to the procedure. Postoperative CT scans demonstrated correct catheter placement in 35 of 38 cases (92%), a significantly higher percentage than noted in a retrospective series of free-hand posterior catheter placement, in which only 51.1% of patients had accurate catheter placement ($p < 0.001$).

Although these differences are very significant, there are certain facts to be considered. The first is that accuracy of catheter placement depends on the surgeon’s experience with posterior shunt placement. This variable is not controlled in this study; several surgeons performed operations in each group (PVG versus free-hand) and not all were involved in both groups. Second, the clinical consequences of poor catheter placement are not discussed in this paper. Becker and Nulsen first noted the importance of the frontal horn position for parietooccipital shunts in 1968 and Albright, et al., found a statistically significant difference in duration of shunt function between properly placed frontal and parietooccipital catheter and those that either crossed the midline or ended in parenchyma. The most common free-hand placement error noted in this series occurred when the catheter tip crossed the midline to enter the anterior horn of the contralateral ventricle. The long-term significance of this type of error has not been reported and may not be clinically important. Third, although the PVG is simple to use, meticulous surgical technique is still necessary. The guide’s only function is to provide the correct catheter trajectory. It will not, for example, correct for errors in burr-hole selection. Both the bone and the dural edge may deflect the catheter from its intended course, so care must be taken to ensure that the catheter is free from impingement at the pial surface. The stylet must not be bent, as this will cause the catheter to deviate from the target.

The simplicity of use and the high degree of accuracy are compelling arguments for the PVG. In a free-hand placement, once the entrance and target sites are selected, the surgeon must rely on visual-spatial skills to orient the catheter properly. The PVG eliminates the chance associated with this and provides consistent and accurate catheter placement; furthermore, it does so in an inexpensive and rapid manner, adding less than 5 minutes to the placement.
entire procedure. For these reasons, we believe that it is a valuable asset in parietooccipital shunt procedures and will help minimize the morbidity secondary to this common neurosurgical procedure.

Disclosure

The authors have no financial interest in the instrumentation or methodology described in this report.

References


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