An approach using the occipital parietal point for placement of ventriculoperitoneal catheters in adults.

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Abstract

Introduction: Ventriculoperitoneal shunts (VPS) have been widely used in the management of hydrocephalus. No general consensus on cranial entry points has been established for the adult population. We compare the known conventional posterior and frontal approaches with our proposed occipital parietal point (OPP) analyzing its associated outcomes.

Methods: An IRB approved retrospective chart review was conducted on patients at Arrowhead Regional Medical Center between 1999 and 2016. Patient’s age, reasons for hydrocephalus, cranial entry points, and clinical outcomes (optimal placement, blood loss, OR time, malfunctions or infections) were abstracted. Chi-square analyses were conducted to identify the association between treatment and clinical outcomes.

Results: 93 adults (≥ 18 years old) patients were included in the final analysis, average age was 40.8 ± 15.6 years, with 57.0% had catheters placed utilizing the OPP, and 43.0% using conventional landmarks. OPP had less rates of suboptimal placement (p=0.0469), and was less likely to develop a mechanical malfunction (5.7% vs 12.5%, p=0.2441), though the difference was not statistically significant. External ventricular drains (EVD) prior conversion to an internalized VPS had increased risk for infection (11% versus 8 %, with P=0.650) but due to our power was not statistically significant.

Conclusion: OPP can reduce the rates of catheter malposition, avoiding re-operations and its associated comorbidities. The OPP may not only be as safe as the conventional landmarks, but more optimal in long term outcomes. Utilizing the results to further characterize the natural history of adult VPS, future studies can investigate the pathological causes of hydrocephalus and its correlation with shunt failure and infection rates.
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Introduction:

Ventricular shunting has been widely used in the management of hydrocephalus, especially seen within the pediatric population. This procedure diverts cerebrospinal fluid from the ventricular system and subarachnoid space to an alternative location i.e. peritoneum, pleural, or atrial space. Each year there were 38,200–39,900 admissions, 391,000–433,000 hospital days, and total hospital charges of $1.4–2.0 billion for pediatric hydrocephalus, and while shunts have revolutionized the treatment of increased intracranial pressure, they also have their fair share of complications. In the Shunt Design Trial, only 61% of patients did not have a shunt malfunction at 1 year follow up, and 47% at 2 year follow up. This has led to continual investigation and research in determining ways to reduce the risks of shunt malfunction or infection. A post hoc analysis of data for risk factors for failure within the pediatric population indicated that the etiology of the hydrocephalus, position of the ventricular catheter tip, and local environment of the catheter are most common.

Ventricular catheter approaches have been investigated for optimal outcomes with mixed results. Shunts inserted via the frontal or anterior region functioned significantly longer than parietal inserted shunts, while posterior approach groups ‘survived’ slightly longer without malfunction or becoming infected compared to anteriorly placed shunts. Even to date, a randomized controlled trial of anterior versus posterior entry sites is being analyzed to reduce partial or full shunt replacements and its associated co-morbidities.

While predictors of shunt malfunction have been mostly studied in the pediatric population, there is little literature addressing factors and outcomes with ventricular shunt systems in adult patients with hydrocephalus. Like pediatrics, no consensus regarding optimal intracranial catheter placement has been established. Therefore, this current study explores the pathology, rate of malfunction and infections of ventricular shunting system within the adult population. We also want to evaluate a proposed catheter approach at an occipital parietal point (OPP) by a single surgeon, and compare it to conventional posterior and frontal approaches.

Obstruction of the ventricular catheter is the most common reason for mechanical shunt failure in both pediatrics and adults, and it can be caused by proteinaceous cerebrospinal fluid, debris, and more often obstruction by the ventricular wall or choroid plexus. Therefore, optimal catheter placement can reduce the rate of proximal failure. While frameless stereotactic or ultrasonography guidance of the catheter can reduce the rate of obstruction in adults, we propose an approach using alternative anatomical landmarks with the free-hand technique to achieve similar results.

Traditionally used anterior (Kocher’s), posterior (Frazier’s), and parietal (Keen’s) approaches for ventricular catheters have been utilized for entry and placement of the ventricular catheter. With the frontal approach, a bur hole is placed a Kocher’s point which is found 1 cm anterior to the coronal suture, and 2 to 3 cm off to midline entering through the lateral horn to the foramen of Monro. Frazier’s point is 6 cm superior to the inion and 3 cm off midline, with the catheter approaching from a superior lateral to inferior midline direction. Finally, Keen’s point is 3 cm above and 3 cm behind with the direction of the catheter aiming perpendicular to the cortex and slightly cephalic. Our proposed OPP is one half the distance of a line between Frazier’s and Keen’s point, where when measured on the CT scan is the most
medial access point to the ventricles in a straight line and only 2 cm from the ependymal surface. The optimum length is premeasured on computed tomography or MRI of the brain.

Methods:

After obtaining institutional IRB approval, a retrospective chart review was conducted on patients who were admitted into Arrowhead Regional Medical Center (ARMC) between 1999 and 2016, a level II trauma center and acute care teaching facility located in San Bernardino County, CA. Inclusion criteria included patients 18 years or older, that either had a new ventriculoperitoneal shunt placed or a proximal catheter revision. Patient data such as age, intracranial pathology for hydrocephalus, intracranial catheters placed using the OPP versus conventional landmarks, and associated clinical outcomes (optimal placement, blood loss, OR time, malfunctions or infections) were abstracted from the medical record. Suboptimal placement of ventricular catheters is crossing the septum pellucidum over midline, tip in contact with the ventricular walls or choroid plexus, or intraparenchymal placement. Optimal placement was ipsilateral to the site of entry or towards midline superior to the Foramen of Monro. Chi-square analyses were conducted to identify the association between treatment and clinical outcomes.

Results:

A total of 93 adults (≥ 18 years old) patients were included in the final analysis. The average age was 40.8 ± 15.6 years, with half (57.0%) had catheters placed utilizing the OPP, and the other (43.0%) using conventional landmarks. Among patients who used the OPP, only 15.1% had suboptimal placement, which is significantly less frequently than the conventional landmarks (32.5%, p=0.0469). Additionally, the OPP group was less likely to develop a mechanical malfunction (5.7% vs 12.5%, p=0.2441), though the difference was not statistically significant. No statistically significant difference was detected on infection (9.4% vs 10%, p=0.9272), median OR time (85 vs 85 minutes, p=0.5464), and average blood loss volume (18.3 vs 26.3 ml, p=0.2037) between the OPP and conventional landmarks. In evaluating our cohort, 45 had an external ventricular drains (EVD) prior conversion to an internalized VPS, and they also had increased risk for infection (11% versus 8 %, with P=0.650) but due to our power was not statistically significant.

Discussion:

In adults, poor catheter placement was found to be the strongest predictor of shunt failure in a population of ages 0-91 with median age of 44. Shunt malfunction tends to occur after migration of the catheter tip into the frontal brain substance as the ventricles decrease in size, or migration of the catheter itself towards the body of the ventricle into the choroid plexus. Yamada SM et al. analyzed 52 patients and demonstrated that optimal shunt position to prevent proximal obstruction was to be within the anterior center of the lateral ventricle and above the foramen of Monro. Our study demonstrated that with freehand catheter placement using the OPP and freehand technique, the catheter was more likely to end in optimal positions than the conventional entry points (85% versus 67% respectively, p = 0.0469).

The rate of shunt malfunction was also less compared to conventional entry sites (5.7% versus 12.5%, p = 0.2441), however, not able to provide statistical significance due to our sample size. Shunt malfunction has a detrimental to the patient both clinically and financially, and to our national health care system. Hydrocephalus places the patient at the risk of severe disability, even death if left untreated in a timely manner. Shunting procedures then cost our national health care system more than 1 billion each year, where predominantly the costs arise from complication and revision rates. Therefore, optimal positioning is a crucial step in reducing the associated risks of hydrocephalus as well as having a positive economic impact on healthcare.

Our rates of infection had no difference between the OPP and conventional landmarks, as well as OR time or average blood loss. As the only change in surgical technique is the location of catheter placement, we did not expect a drastic change from available literature in the adult population. Korinek et
al. demonstrated that the male sex and previous external ventricular drains (EVD), revisions, CSF leaks, and longer operation times were risks of long term mechanical dysfunction and infection. Our overall infection rate is 9.6%, consistent with current literature. In evaluating our cohort, 45 had an external ventricular drains (EVD) prior conversion to an internalized VPS, and they also had increased risk for infection (11% versus 8%, with P=0.650) but due to our power was not statistically significant. With infection-related cost per 100 de novo shunts placed was $162,659 in adult patients, additional measures can be explored to relieve that financial burden.

The majority of adult patients who required a VPS were due to trauma (25.8%) causing communicating hydrocephalus, which included traumatic subarachnoid hemorrhages, intraparenchymal subdural, epidural hemorrhages, gunshot wounds, and those who required a decompressive craniectomy for refractory intracranial hypertension. The next common causes of hydrocephalus requiring VPS in our adult population are tumors (17.2%) then followed by intraventricular hemorrhages (8.6%).

Being a retrospective review, a disadvantage we can run into is the selection bias due to the inability to achieve randomization. The OPP is selected and preferred by a single neurosurgeon, but as a teaching institution even with guidance, the operative experience can vary by the lead senior resident physician at the time. VPS placed with other entry points are performed by more than one neurosurgeon which was not controlled due to the retrospective nature. Certain exposures or extent of degenerative pathologies may not have been able to be controlled.

Conclusion:

We demonstrated that utilizing the OPP can reduce the rates of catheter malposition, essentially avoiding future operations and its associated comorbidities reducing personal and financial burdens. The technique can be performed freehand without the need of stereotactic guidance, reducing operating time and additional costs. Also, we found that risks of shunt infection are increased to having an EVD in place prior, consistent with previous literature. Our review was also able to further provide additional data on the natural history of VPS in adults, raising areas that can further be investigated.
References


Figure 1: The OPP demonstrated as the point between Keen’s and Frazier’s known conventional landmarks.