Outcome of Proximal Ventricular Catheter Placement in Ventriculoperitoneal Shunt Operations using the Parietal Approach

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Background: *The VP shunt operation is one of the most common in neurosurgical practice for treatment of hydrocephalus. However, malfunction due to proximal obstruction of the ventricular catheter caused by improper placement of the ventricular catheter tip is still a common occurrence. This retrospective study aimed to provide information on proper placement for problem evaluation and further planning in order to improve surgical outcomes in Rajavithi Hospital.*

Objective: *The present research in Rajavithi Hospital, Bangkok, examined the outcomes of ventricular catheter tip position in patients undergoing VP shunt operations using the parietal approach and parameters related to improper placement.*

Material and Method: *This was a retrospective study of 42 adult patients who underwent VP shunt operations via the parietal route. Only post-operative images (CT or MRI) obtained from Rajavithi Hospital's PACS between November 2012 and September 2014 were included. Baseline characteristics (sex, age, etiologies of hydrocephalus) and associated parameters (burr hole location, ventricular size, angle of catheter to midline, length of catheter) were recorded and analyzed. From post-operative images, the positions of ventricular catheter tips were evaluated and graded on a 3-point scale as: 1) grade 1 - optimal position, free-floating in cerebrospinal fluid in frontal horn; 2) grade 2 - touching choroid plexus or ventricular wall; and 3) grade 3 - tip within or passing through brain parenchyma.*

Results: *From 42 parietal approach operations, grade 1 placement was found in 15 cases (35.7%), grade 2 in 11 (26.2%) and grade 3 in 16 cases (38.1%). Length of ventricular catheter and ventricular size were significant parameters in this study ($p<0.001$). The average length of catheter in grade 3 placements was significantly greater (139.04 mm) and ventricular size was significantly larger (22.59 mm) than in the other two grades.*

Conclusion: *Overlong ventricular catheter and large ventricular size were significant variables in poor placement outcomes in the present study. Pre-operative planning from CT or MRI can be used to determine the optimal length in order to improve the outcomes.*

Keywords: *Hydrocephalus, Ventriculo-peritoneal shunt, Malfunction, Parietal approach*

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Since the introduction of Holter and Pudenz valves, the VP shunt has been the operation of choice for hydrocephalus treatment(1,2,14,17); however, malfunction due to ventricular catheter obstruction is still the most commonly-found problem(3,7,8,13,15-18), and choroid plexus is the material most often guilty of blocking holes in the perforated end of the ventricular catheter(5,6,8). Former studies have emphasized the importance of ventricular tip placement: ideally, it should be free-floating in CSF(11,23) and away from the choroid plexus though the frontal horn of the ipsilateral ventricle anterior to the foramen of Monroe (3,4,8,14). In order to approach the frontal horn, there are three burr hole locations to choose from: frontal (anterior at Kocher's point), temporo-parietal (lateral at Keen's point) or occipital (posterior at Frazier's point), depending on surgeons' preferences(20,21). The lateral (temporo-parietal) approach has its benefits: it requires less skin incision as it takes the shortest path from the peritoneal cavity; it is comfortable and cosmetically pleasing for the patient due to the bulky reservoir on the post-auricular area; and it is easier for the surgeon to achieve successful cannulation of the ventricular catheter into the wider ventricular atrium(11,12,20). However, maintaining the catheter tip to the frontal horn anterior to the foramen of Monroe is more difficult because of its curving path to the target zone(20,21). Placement of the ventricular catheter in the frontal horn, anterior to the choroid plexus, appears to result in

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prolonged shunt function[13]. Albright et al, reporting in an article about the location of the ventricular catheter achieved via the parietal route, graded placement as “good” if the catheter tip was located in the ipsilateral ventricle anterior to the foramen of Monroe, “fair” if it was in the contralateral frontal horn or near the choroid plexus, and “poor” if it was partially located in the parenchyma. Their study results revealed the following outcomes: good = 33%; fair = 55%; and poor = 14%. They concluded that catheters positioned within the ipsilateral frontal horn functioned for a significantly longer period than those in other ventricular locations[15]. In Rajavithi Hospital, prior to the current research, there had been no study of the outcomes of proximal ventricular catheter placement via the parietal approach. This retrospective study of proper placement rates can be useful in problem evaluation and planning in order to improve surgical techniques and outcomes in our hospital.

Material and Method

The present study was approved by the research ethics committee of Rajavithi Hospital. The primary objective was to identify outcomes of ventriculo-peritoneal (VP) shunt operations via the parietal approach in terms of the position of catheter tips. The position of the proximal catheter was classified into 3 levels: grade 1 = optimal; grade 2 = fair; and grade 3 = poor. The second objective was to identify the parameters that had a significant effect on the outcomes. Data were collected from operating room registration book records of operations performed between November 2012 and September 2014, and 103 VP shunt operations were found. Post-operative images (CT or MRI) from the digital data bank of Rajavithi Hospital’s PACS system were reviewed. Only operations for ventriculo-peritoneal shunt via the parietal route with available data were included in this study. Baseline characteristics (sex, age, etiologies of hydrocephalus) and associated parameters: burr hole location (placements above Keen’s point were categorized as “above” and all other positions were classed as “below”); ventricular size; angle of catheter to midline; and length of catheter were recorded and analysed using computerized measuring tools. A three-point grading classification system was used to describe the location of the proximal (perforated part) ventricular catheter: grade 1 = in optimal position, free floating in CSF in frontal horn of lateral ventricle; grade 2 = touching choroid plexus or ventricular wall; and grade 3 = within or passing through the brain parenchyma. Baseline characteristics and associated parameters were statistically analyzed and significant differences were identified.

Statistical analysis

Descriptive results of continuous variables were expressed as mean $\pm$ SD, and median (min-max). Chi-square tests and One Way Anova were used to compare categorical and continuous variables in each grading group. A *p*-value of less than 0.05 was set for statistical significance.

Results

Between November 2012 and September 2014, 103 VP shunt operations were recorded in Rajavithi Hospital, and post-operative images were reviewed of the 65 for which data was available. Of these, 23 were frontal, and 42 used the parietal approach. Baseline characteristics of the 42 VP shunts via the parietal route are shown in Table 1. Ages ranged from 17 to 83 years old (mean = 55.83), 40.5% of patients were male and 59.5% were female. Operations on the right and left side accounted for 76.2% and 23.8% respectively. Causes of hydrocephalus are shown in Table 2, and the main ones were tumor and hemorrhage. Outcomes for proximal ventricular catheter locations in this study were: grade 1 = 35.7%; grade 2 = 26.2%; and grade 3 =

Table 1. Baseline characteristics (n = 42)

Characteristics	Number	Percent
Sex		
Male	17	40.5
Female	25	59.5
Age		
Mean $\pm$ SD (min-max)	55.83$\pm$16.40 (17-83)	
Op Rt.-Lt.		
Right	32	76.2
Left	10	23.8

Table 2. Etiology of hydrocephalus

Etiology	Number
Hemorrhage	17
Tumor	19
Traumatic brain injury	4
Normal pressure hydrocephalus	1
Congenital	1
Total	42

38.1% (Fig. 1). Baseline characteristics and other parameters (location of burr hole subjectively using Keen's point as reference; ventricular size; angle of catheter insertion to midline; and length of catheter) were statistically compared in each of the grading groups (Table 3). Results showed no significant difference in baseline characteristics in each grading group. Two parameters that showed significant differences ($p<0.001$) in this study were ventricular size and length of ventricular catheter. The average lengths of ventricular catheters in grade 3 (mean = 139.04 mm) were significantly greater than those of grades 1 and 2, and ventricular size in grade 3 was significant larger (mean = 22.59 mm) than those of grades 1 and 2. Locations of burr hole were not significantly different but grades 1 and 2 had 60% and 72.7% "above" placements respectively while grade 3 had 62.5% "below" locations ($p = 0.172$). Also, no significant difference was found in the angle of ventricular catheter insertion to midline: mean degree values were grade 1 = 45; grade 2 = 46.7; and grade 3 = 51.94 degrees ($p = 0.177$).

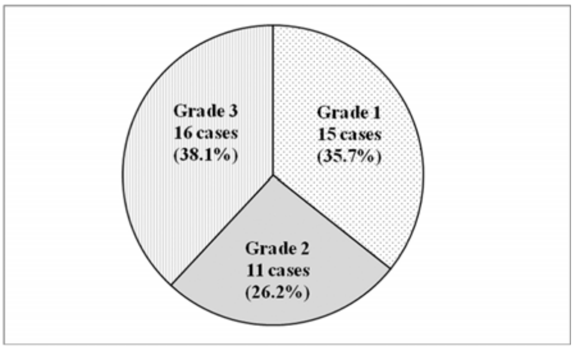

Fig. 1 Outcomes of proximal ventricular catheter location.

Discussion

The present retrospective study revealed a percentage of grade 1 (optimal) locations of proximal ventricular catheter which was comparable to that found in a previous study by Albright (35.7% compared to Albright's 33%), but there were marked differences in the proportion of grade 3 placements (38.1% vs. 14%)[15]. Increased shunt survival time was found to be related to proper placement of the proximal ventricular catheter in the frontal horn anterior to the foramen of Monroe away from the choroid plexus. No final conclusion has yet been drawn with regard to the superiority of the frontal or the parietal approach in terms of longer shunt survival time in a population of children[15,19]. Dickerman[8] studied all ages in a distributed population (1 month to 80 years) and found no significant differences between the two surgical approaches, concluding that the most important variable in shunt malfunction appears to be the final destination of the catheter tip in relation to the choroid plexus. Average length of grade 1 placement was 97.86 mm, comparable to the findings of other studies[20]. The greater prevalence of grade 3 locations in our hospital's outcomes should alert us to a problem which needs to be corrected. Ventricular size and catheter length were two significantly different parameters among the grading groups. Wider

Table 3. Statistic results between grading groups

	Grade 1 (n = 15)	Grade 2 (n = 11)	Grade 3 (n = 16)	*p*-value
Sex				0.607[A]
Male	5 (33.3)	4 (36.4)	8 (50.0)	
Female	10 (66.7)	7 (63.6)	8 (50.0)	
Age (years)	54.27±15.26	60±15.44	54.44±18.48	0.629[B]
Burr hole				0.172[A]
Above	9 (60.0)	8 (72.7)	6 (37.5)	
Below	6 (40.0)	3 (27.3)	10 (62.5)	
Ventricle size (mm)				
1&3, 2&3	18.93±3.86	16.16±3.87	22.59±3.64	<0.001*[B]
Angle (degree)	45.00±13.65	46.64±8.04	51.94±8.54	0.177[B]
Length (mm)				
1&3, 2&3	97.86±10.37	91.34±6.84	139.04±17.97	<0.001*[B]

* Statistical significance at $p<0.05$, values are represented as n (%) and mean ± SD
A = A *p*-value for Chi-square test; B = A *p*-value for One way anova test

ventricular size made it easier to cannulate the catheter into the ventricular atrium[12], but it also allowed more room for a greater length of catheter to be accommodated with good function in the intra-operative and post-operative periods, and when CSF is drained and the ventricle collapses, an excessively long catheter will pass into the brain parenchyma and result in its perforated tip being obstructed[4,13]. To solve this problem and improve surgical outcomes, pre-operative planning should be done to determine the proper location of burr hole, trajectory of catheter insertion and length of ventricular catheter[24,25]. In the present study, the author used measuring tools in the PACS system's software to collect data and found that it would be useful if these parameters were applied in addition to conventional surgical techniques which rely exclusively on anatomical landmarks and surgeon preference. Further studies should be conducted to determine how to utilize pre-operative images of individual patients to identify proper burr hole location and trajectory of catheter insertion in each operation, in a similar way to the use of stereotactic principles in the navigator system. However, although in recent articles the usefulness of navigator systems in effecting significant improvement in final outcomes has been highlighted, this technology involves significant additional costs[9,10,14,22].

Conclusion

Two significant factors that influenced the poor outcomes in the present study were ventricular size and catheter length. Further research should be performed to determine how to use patient data for pre-operative planning and prepare appropriate surgical techniques. Digital data from CT or MRI brain should be utilized and applied in order to gain enhanced surgical outcomes.

What is already known in this topic?

Previous studies have revealed that the placement of the proximal ventricular catheter in the frontal horn of the lateral ventricle can decrease proximal shunt obstruction and prolong shunt survival. Ventriculo-peritoneal shunts that operate via the parietal route are still preferred by neurosurgeons; however, with the freehand insertion technique, misplacement of the ventricular catheter tip from the frontal horn anterior to the foramen of Monroe is still a common occurrence. There is as yet no definitive method for performing the freehand operation to achieve optimal placement without utilising high-technology assistance such as navigator or endoscope.

What this study adds?

The present study aimed to determine the outcomes of proximal ventricular placement using the parietal approach and to analyze the associated parameters relating to surgical techniques that affected significantly different variables between the good and poor outcomes. Our results can be used to obtain further improvement in surgical techniques and final outcomes.

Potential conflicts of interest

None.

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ผลของตำแหน่งการวางปลายสายส่วนเวนตริเคิลของสายระบายน้ำจากโพรงสมองลงช่องท้องที่ผ่าตัดทางพาริเอทัล

อนันต์ อนันทนันดร

ภูมิหลัง: *การใส่สายระบายน้ำโพรงสมองลงช่องท้องเป็นการผ่าตัดที่ทำบ่อยที่สุดแบบหนึ่งของงานศัลยกรรมประสาทในการรักษาภาวะน้ำคั่งในโพรงสมอง อย่างไรก็ตามการเสียการทำงานเนื่องจากมีการอุดตันของปลายสายส่วนต้นของสายในเวนตริเคิลยังเป็นสิ่งที่เกิดขึ้นเสมอ การศึกษาย้อนหลังเกี่ยวกับอัตราการวางสายที่ถูกต้องสามารถให้ข้อมูลเพื่อวิเคราะห์ปัญหาและวางแผนการปรับปรุงให้ได้ผลการผ่าตัดที่ดีขึ้นต่อไป*

วัตถุประสงค์: *เพื่อหาผลของตำแหน่งการวางปลายสายส่วนเวนตริเคิลในผู้ป่วยที่ได้รับการผ่าตัดใส่สาย ระบายน้ำโพรงสมองลงช่องท้องทางพาริเอทัล และปัจจัยที่เกี่ยวข้องในกลุ่มที่วางได้ไม่ถูกต้องในโรงพยาบาลราชวิถี*

วัสดุและวิธีการ: *การศึกษานี้เป็นการศึกษาย้อนหลังในผู้ป่วยผู้ใหญ่ 42 ราย ที่ได้รับการผ่าตัดระบายน้ำโพรงสมองลงช่องท้องทางพาริเอทัลที่มีภาพสแกนสมองหลังผ่าตัด (ซีทีหรือเอ็มอาร์ไอ) ในระบบคอมพิวเตอร์กลางของโรงพยาบาลราชวิถีระหว่างวันที่ 1 พฤศจิกายน พ.ศ. 2555 ถึง 29 กันยายน พ.ศ. 2557 ข้อมูลพื้นฐาน (อายุ, เพศ, สาเหตุของภาวะน้ำคั่งในโพรงสมอง) และปัจจัยที่เกี่ยวข้อง (ตำแหน่งเจาะรูที่กะโหลกศีรษะ, ขนาดของโพรงสมอง, มุมของสายเทียบกับเส้นกึ่งกลาง, ความยาวของสาย) ได้รับการบันทึกและวิเคราะห์จากภาพสแกนสมองหลังผ่าตัด ตำแหน่งของปลายสายส่วนเวนตริเคิลได้รับการประเมินและแบ่งเกรดเป็น 3 ระดับดังนี้ เกรด 1 คือ ตำแหน่งเหมาะสม ปลายสายลอยอยู่อิสระในน้ำโพรงสมองในโพรงสมองส่วนหน้า เกรด 2 คือ ปลายสายสัมผัสคอรอยด์เพลคซัสหรือผนังโพรงสมอง เกรด 3 คือ ปลายสายอยู่ในเนื้อสมองหรือผ่านเนื้อสมองออกไป*

ผลการศึกษา: *จาก 42 รายที่ได้รับการผ่าตัดทางพาริเอทัลพบว่าเป็น เกรด 1 15 ราย (35.7%), เกรด 2 11 ราย (26.2%), และเกรด 3 16 ราย (38.1%) ความยาวของสายส่วนเวนตริเคิลและขนาดของโพรงสมองเป็นปัจจัยที่แตกต่างชัดเจนระหว่างเกรด ($p<0.001$) ความยาวเฉลี่ยของสายยาวกว่าชัดเจนในเกรด 3 (139.04 มม.) และขนาดโพรงสมองใหญ่กว่าชัดเจน (22.59 มม.)*

สรุป: *ความยาวของสายส่วนเวนตริเคิลที่ยาวเกินไปและขนาดโพรงสมองที่ใหญ่กว่าเป็นปัจจัยสำคัญ ในผลของการวางปลายสายส่วนเวนตริเคิลที่ไม่เหมาะสมในการศึกษานี้ การวางแผนก่อนผ่าตัดจากภาพสแกนสมองสามารถประเมินหาความยาวที่เหมาะสม เพื่อนำไปใช้ในการผ่าตัดให้ได้ผลที่ดีขึ้นต่อไป*