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Original Article

Role of EVD Placement in Patients with Hydrocephalus Secondary to Subarachnoid Hemorrhage and Need for Permanent Ventriculoperitoneal Shunt Placement

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ABSTRACT

Background: Subarachnoid hemorrhage (SAH), often caused by aneurysm rupture, is a critical neurosurgical condition frequently leading to hydrocephalus. Management typically involves the use of an external ventricular drain (EVD) to reduce intracranial pressure and drain cerebrospinal fluid (CSF). The transition from EVD to permanent ventriculoperitoneal shunt (VPS) placement is a pivotal decision in patient management, influenced by various factors.

Objective: This study aims to analyze the role of EVD placement in patients with hydrocephalus secondary to spontaneous SAH and the subsequent need for permanent VPS placement.

Methods: Conducted at Jinnah Postgraduate Medical Center, Karachi, over six months, this retrospective study included 30 patients. After securing hospital ethical committee approval, several parameters were recorded: age, gender, Glasgow Coma Scale (GCS) score, aneurysm details (size and location), vasospasm occurrence, EVD placement in ICU, duration of EVD placement, CSF output, clamp trials, and wean failures.

Results: Out of 30 patients, 8 (26.66%) required VPS placement. No significant difference was found in VPS placement regarding age, gender, GCS score, aneurysm treatment and location, vasospasm, and EVD placement in ICU. However, patients requiring VPS had statistically longer EVD duration (p=0.0001), larger aneurysm size, more wean trials, clamp trials, and instances of wean failure (p=0.0001).

Conclusion: The study highlights the complexities in managing hydrocephalus post-SAH, particularly the significant association between the need for VPS installation and factors like EVD duration, aneurysm size, and wean trial outcomes. It underscores the need for future prospective studies with larger sample sizes to better identify patients who would benefit from shunt insertion post-SAH.

Keywords: EVD, Hydrocephalus, SAH, Ventriculoperitoneal Shunt, Wean Trials.

INTRODUCTION

Subarachnoid hemorrhage (SAH), a critical form of cerebrovascular disease, is characterized by a significant mortality rate of 40-60% and an incidence of 8-20 per 10,000 individuals, primarily occurring due to aneurysm rupture (18). A prevalent complication following aneurysmal SAH is hydrocephalus, necessitating meticulous management to ensure optimal patient outcomes. The implantation of an external ventricular drain (EVD) is a critical intervention in this context, employed in 7-65% of SAH patients to aid in cerebrospinal fluid (CSF) drainage, either for alleviating symptomatic hydrocephalus or for facilitating brain relaxation post-aneurysm clipping (1, 2). This study was conducted to explore the role of EVD placement in patients with hydrocephalus secondary to SAH, focusing on its impact on patient outcomes, prognosis, and the subsequent need for permanent ventriculoperitoneal shunt (VPS) placement, which is pivotal in determining long-term management and outcome.

The management of CSF leakage from EVD varies across institutions, reflecting a diversity of approaches based on clinical judgment and institutional protocols. One common method involves keeping the EVD clamped, releasing it only if intracranial pressure exceeds 20 mm Hg. This approach is aimed at directing CSF through normal channels, thereby preventing the formation of clots and occlusive membranes. Alternatively, the EVD is left open and then clamped if no signs of vasospasm are present, the CSF red blood cell (RBC)

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count is below 10,000 cells per cubic millimeter, and there are no indications of hydrocephalus, EVD leakage, or pseudomeningocele (3, 4). Another strategy adopted by several institutions is a progressive weaning technique, inspired by practices in endotracheal and chest tube management. This involves gradually increasing CSF drainage from the EVD over a period before clamping it.

The decision to transition from EVD to permanent VPS varies considerably. Some institutions opt for multiple EVD challenges, while others may place a VPS in response to a single failed EVD clamp trial (5). In some cases, clinical or radiographic criteria might dictate the placement of a VPS without a clamp trial. It is estimated that 8-63% of SAH patients eventually require a permanent VPS. Various factors influencing the necessity for VPS placement have been identified, including patient age, gender, comorbidities, intubation status, aneurysm location, size, treatment method, intraventricular hemorrhage (IVH), vasospasm, and admission CSF parameters like RBC, glucose, and protein levels. Notably, age, female gender, Hunt & Hess, and Fisher scores are significant predictors. The influence of regional and cultural practices on the decision to insert a VPS is also evident, suggesting the presence of additional criteria that may affect this choice (6, 7).

In this context, determining which types of EVD failure necessitate VPS placement and which do not becomes crucial. Employing a gradual weaning technique allows for this distinction. Repeated clamp trials aim to obviate the need for EVD, potentially reducing the rate of VPS placement compared to some reported figures. This study hypothesized that the reasons for the failure of EVD weaning would correlate with the necessity for VPS implantation. Additionally, the investigation sought to identify low-risk causes of EVD weaning failure that might not require VPS installation. The findings of this study are anticipated to provide deeper insights into the management of hydrocephalus in SAH patients, potentially informing clinical decisions and improving patient outcomes.

MATERIAL AND METHODS

This study employed a retrospective approach to investigate the management of hydrocephalus in patients with spontaneous subarachnoid hemorrhage (SAH) at Jinnah Postgraduate Medical Center, Karachi. Conducted between December 2020 and May 2021, it meticulously analyzed patient data, focusing on those who required the implementation of an external ventricular drain (EVD). The sample comprised thirty patients, carefully selected based on specific inclusion and exclusion criteria to ensure the study's integrity and relevance.

Participants included in the study were those diagnosed with spontaneous SAH necessitating EVD implantation. This was critical to ensure a homogeneous sample reflecting the study's objective. Excluded were patients with a primary diagnosis other than SAH, those who had been treated at other facilities for more than 48 hours prior to admission, patients with a history of SAH, cases of traumatic SAH, individuals who did not require EVD during hospitalization, those whose care was discontinued during acute hospitalization, and patients who succumbed during the study period. This selection process was crucial to maintain the study's focus and eliminate confounding variables that could skew results.

The methodology for EVD placement involved implanting the drains before securing the aneurysm to minimize the risk of rebleeding. Post-aneurysm securing, the EVDs were opened and lowered to facilitate CSF drainage. The decision to start weaning off the EVD was contingent on the absence of active vasospasm. In cases without vasospasm, the EVD was incrementally elevated and clamped. Conversely, if patients exhibited clinical symptoms like headache, altered mental state, nausea, or vomiting, or if there were signs of EVD site leakage or radiographic deterioration in hydrocephalus, the EVD was lowered and/or unclamped.

For data analysis, the study utilized SPSS 23, employing both descriptive and inferential statistics. Variables such as age, gender, Glasgow Coma Scale (GCS) score, treated aneurysm characteristics (size and location), presence of vasospasm, EVD placement in ICU, duration of EVD, CSF output, number of clamp trials, and instances of wean failure were meticulously recorded and analyzed. The use of a T-test for table one and a Chi-square test for table two facilitated a comprehensive statistical assessment. Conducted under the approval of the hospital's ethical committee, the study adhered to rigorous ethical standards, ensuring the integrity and reliability of its findings.

RESULTS

The current study encompassed a cohort of 30 patients, all of whom were diagnosed with hydrocephalus secondary to spontaneous subarachnoid hemorrhage and required the implantation of an external ventricular drain (EVD). Of these patients, 8, constituting 26.66% of the sample, necessitated the placement of a permanent ventriculoperitoneal shunt (VPS). Intriguingly, the decision to place a VPS did not significantly correlate with factors such as age, gender, Glasgow Coma Scale (GCS) score, the treatment and location of the aneurysm, presence of vasospasm, or the initial placement of EVD in the intensive care unit.

However, a noteworthy pattern emerged regarding the duration of EVD placement and the extent of wean trials. Patients whose EVD remained in place for a longer period and those who underwent extended wean trials with increased failure rates exhibited a higher likelihood of requiring a permanent VPS. Additionally, a significant relationship was observed between larger aneurysm sizes

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and the necessity for permanent VP shunting. This suggests that the complexity of the aneurysmal condition may play a role in the progression towards permanent shunt dependency.

Regarding the demographics of the patient sample, the ages ranged between 40 to 60 years, providing a middle-aged perspective on the condition. The gender distribution within the study was noteworthy, with 11 male and 19 female patients, as detailed in the table of qualitative results. This skew towards a female majority could offer insights into gender-based predispositions or outcomes in the treatment of hydrocephalus post-SAH. Additionally, the GCS scores of the patients were divided, with 10 patients presenting a score higher than 9 and the remaining 20 falling within the range of 10 to 15, indicating varying degrees of consciousness and neurological impairment among the participants.

The detailed data on other variables, including the specifics of aneurysm characteristics, the frequency and outcomes of EVD clamp trials, and the quantified CSF outputs, are meticulously cataloged in the accompanying table. This comprehensive dataset provides a rich source of information for understanding the nuances and intricacies involved in the management of hydrocephalus in SAH patients, particularly in relation to the necessity and timing of transitioning to a permanent VPS.

Table 1 Results of quantitative variables

Variables	Ventriculoperitoneal shunt placement		p value
	Yes	No	
Age (mean±SD)	49.75±7.74	52.95±7.29	0.304
Aneurysm size (mm) (mean±SD)	7.50±0.53	4.95±0.84	0.0001*
EVD Days	15.38±0.52	12.27±0.46	0.0001*
CSF Output (ml) Before Final Clamp Trial (mean±SD)	189.25±18.48	122.05±22.23	0.0001*
Wean Trial (mean±SD)	5.75±0.46	3.50±0.51	0.0001*
Clamp Trials (mean±SD)	1.88±0.35	1.14±0.36	0.0001*
Wean Failures (mean±SD)	3.50±0.53	0.82±0.39	0.0001*

*Significant ($p<0.05$)

Table 1 in the study presents a detailed comparison of quantitative variables between two groups of patients: those who required ventriculoperitoneal shunt (VPS) placement and those who did not. The variables analyzed include age, aneurysm size, the number of days the external ventricular drain (EVD) was in place, cerebrospinal fluid (CSF) output before the final clamp trial, the number of wean trials, clamp trials, and wean failures. Each variable is presented with mean values and standard deviations.

The age of the patients, although slightly lower in the VPS group (mean 49.75 years) compared to the non-VPS group (mean 52.95 years), did not show a statistically significant difference (p-value = 0.304). However, other variables demonstrated significant differences between the two groups.

Notably, the aneurysm size was significantly larger in the VPS group (mean 7.50 mm) compared to the non-VPS group (mean 4.95 mm), with a p-value of 0.0001, indicating a strong association between larger aneurysm sizes and the need for VPS placement. Similarly, the number of EVD days was higher in the VPS group (mean 15.38 days) than in the non-VPS group (mean 12.27 days), also with a highly significant p-value of 0.0001.

The CSF output before the final clamp trial was considerably greater in the VPS group (mean 189.25 ml) compared to the non-VPS group (mean 122.05 ml), suggesting that higher CSF outputs are associated with the need for VPS placement. This is supported by the very significant p-value of 0.0001.

The mean number of wean trials, clamp trials, and wean failures were also significantly higher in the VPS group compared to the non-VPS group, all with p-values of 0.0001. Specifically, the VPS group had more wean trials (mean 5.75), clamp trials (mean 1.88), and wean failures (mean 3.50) compared to the non-VPS group (mean 3.50 for wean trials, 1.14 for clamp trials, and 0.82 for wean failures).

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Table 2 Results of qualitative variables

Variables		Ventriculoperitoneal shunt placement		Total	P value
		Yes	No		
Gender	Male	3	8	11	0.954
		37.5%	36.4%	36.7%	
	Female	5	14	19	
		62.5%	63.6%	63.3%	
Glasgow Coma Scale	<9	2	8	10	0.559
		25.0%	36.4%	33.3%	
	10-15	6	14	20	
		75.0%	63.6%	66.7%	
Treated Aneurysm,	Yes	7	19	26	0.935
		87.5%	86.4%	86.7%	
	No	1	3	4	
		12.5%	13.6%	13.3%	
Location Aneurysm	Posterior	1	6	7	0.398
		12.5%	27.3%	23.3%	
	Anterior	7	16	23	
		87.5%	72.7%	76.7%	
Vasospasm	Yes	5	11	16	0.544
		62.5%	50.0%	53.3%	
	No	3	11	14	
		37.5%	50.0%	46.7%	
EVD Placed in ICU	Yes	7	17	24	0.536
		87.5%	77.3%	80.0%	
	No	1	5	6	
		12.5%	22.7%	20.0%	

Table 2 in the study presents an analysis of qualitative variables in relation to the necessity of ventriculoperitoneal shunt (VPS) placement in patients with hydrocephalus secondary to spontaneous subarachnoid hemorrhage. The variables assessed include gender, Glasgow Coma Scale (GCS) score, treatment of the aneurysm, location of the aneurysm, presence of vasospasm, and whether the external ventricular drain (EVD) was placed in the intensive care unit (ICU). These variables were compared between the group of patients who required a VPS and those who did not.

The findings showed that gender distribution was nearly even across both groups, with 37.5% males and 62.5% females in the VPS group, and 36.4% males and 63.6% females in the non-VPS group. This suggests that gender did not significantly influence the need for VPS placement (p-value = 0.954).

In terms of GCS scores, 25% of patients in the VPS group had a score of less than 9, while 75% had scores between 10 and 15. This distribution was similar to the non-VPS group (36.4% with scores <9 and 63.6% with scores 10-15), indicating no significant association between GCS scores and VPS placement (p-value = 0.559).

Regarding the treatment of aneurysms, the majority of patients in both groups had their aneurysms treated (87.5% in the VPS group and 86.4% in the non-VPS group), showing no significant difference (p-value = 0.935). Similarly, the location of the aneurysm (posterior or anterior) did not significantly affect the likelihood of VPS placement, with most patients in both groups having anterior aneurysms (87.5% in the VPS group and 72.7% in the non-VPS group, p-value = 0.398).

The presence of vasospasm was observed in 62.5% of the VPS group and 50% of the non-VPS group, again showing no significant difference (p-value = 0.544). Lastly, the placement of EVD in the ICU was common in both groups (87.5% in the VPS group and 77.3% in the non-VPS group), with no significant correlation to VPS necessity (p-value = 0.536).

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Overall, the analysis in Table 2 reveals that factors like gender, GCS score, aneurysm treatment and location, presence of vasospasm, and EVD placement in the ICU did not significantly influence the need for VPS placement in patients with hydrocephalus following spontaneous subarachnoid hemorrhage. This suggests that other factors, possibly quantitative in nature, might be more critical in determining the need for permanent shunting in this patient population.

DISCUSSION

Subarachnoid hemorrhage (SAH), predominantly resulting from aneurysm rupture, is a critical neurosurgical emergency often leading to hydrocephalus. The standard treatment involves the installation of an external ventricular drain (EVD) for temporary relief of intracranial pressure and drainage of cerebrospinal fluid (CSF)(8). This study focused on exploring the dynamics of EVD management, particularly the factors influencing the need for a transition to permanent ventriculoperitoneal shunt (VPS) placement. Our investigation revealed that only 26.66% of patients required VPS implantation, a figure that falls within the broad range of 8-63% reported in prior research. This variability in the need for VPS across studies points towards the complexity of SAH and its management. Notably, our findings align with some previous studies that found no significant correlation between VPS placement and variables such as age, gender, aneurysm size, and location (13, 14). This suggests that the criteria for VPS placement may be more intricate and not solely dependent on these factors. However, it's important to acknowledge the potential influence of small sample sizes and varying EVD management practices across different studies.

Lillemoe et al. (12) identified increased third ventricular size and elevated CSF protein levels as potential risk factors for delayed VPS implantation. Interestingly, in our study, we observed that the type of wean failure was a significant predictor for VPS placement. This finding is crucial as it underscores the importance of understanding the underlying cause of wean failure, which may be transient or indicative of a more severe form of hydrocephalus.

The management of hydrocephalus in SAH patients remains a debated topic. For instance, Kang et al. (3) suggested that rapid EVD weaning and shunt insertion could effectively treat hydrocephalus in patients with severe SAH. On the other hand, Klopfenstein et al. (19) conducted a prospective, randomized trial comparing the immediate versus gradual removal of EVD. Their findings suggested that quick removal of the EVD is at least as safe as gradual removal, with reduced durations of stay in the critical care unit and hospital. This finding challenges the traditional gradual weaning approach and opens up new avenues for EVD management.

The pathophysiology of hydrocephalus post-SAH is multifaceted. While intraventricular hemorrhage is a strong predictor of acute hydrocephalus, the exact mechanisms remain unclear. It is hypothesized that the occlusion of ventricular foramina and increased resistance to CSF flow play a significant role (20). Additionally, the obstruction of arachnoid villi by red blood cells and the hypersecretion of CSF by the choroid plexus epithelium are other proposed contributing factors. These multiple mechanisms imply that the management of hydrocephalus in SAH patients requires a tailored approach, considering the individual patient's pathophysiology.

Our study's strength lies in its focused approach on a specific patient population, offering insights into the complexities of managing hydrocephalus in SAH. However, it is not without limitations. The retrospective nature of the study and the relatively small sample size may limit the generalizability of the findings. Additionally, the lack of standardization in the timing of EVD weaning and the decision-making process for VPS placement after failed clamp trials may have introduced biases. Future research could benefit from a prospective design with larger sample sizes and standardized protocols for EVD management and VPS placement.

The management of hydrocephalus in SAH patients remains a challenging and dynamic field, with several variables influencing the decision-making process. The current study contributes to this body of knowledge by highlighting the importance of understanding the reasons behind EVD wean failure and their impact on the necessity for VPS placement. Moving forward, a more standardized approach in managing these patients, along with further research in this area, will be crucial in optimizing patient outcomes and providing more personalized care.

CONCLUSION

This study from Pakistan, one of the few of its kind in the region, highlights the complexity of managing hydrocephalus in patients with spontaneous subarachnoid hemorrhage (SAH), particularly regarding the role of external ventricular drain (EVD) placement and the subsequent need for a permanent ventriculoperitoneal shunt (VPS). Our findings underscore that prolonged EVD placement, increased duration and number of EVD clamp and wean trials, and higher instances of wean failure are significant predictors of the need for VPS placement. Additionally, larger aneurysm sizes were associated with a higher likelihood of requiring VPS. In contrast, factors such as age, gender, Glasgow Coma Scale score, aneurysm treatment approach and location, vasospasm, and EVD placement in the ICU did not show a significant predictive value in our study. The limited scope of studies from Pakistan on this topic suggests

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a need for more extensive data collection to enhance the understanding and treatment of this condition, ultimately paving the way for future advancements in patient care.

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