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Role of Ommaya Reservoir Placement in Hydrocephalus Management following Aneurysmal Subarachnoid Hemorrhage, an Initial Experience

Papel da colocação do reservatório de Ommaya no tratamento da hidrocefalia após hemorragia subaracnoidea aneurismática, uma experiência inicial

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Abstract

Introduction Weaning from external ventricular drainage (EVD) of cerebrospinal fluid (CSF) in hydrocephalus induced by aneurismal subarachnoid hemorrhage (SAH) had been proposed either through the rapid, gradual or intermittent approaches. There are no uniform guidelines for it. Given this, we planned to study the comparative outcome between EVD drainage with intermittent clamping versus EDV followed by Ommaya reservoir.

Material and Methods The present retrograde observational study was conducted from July 2018 to March 2021 in the department of neurosurgery with 67 patients who developed hydrocephalus following SAH after aneurysm rupture. We divided the patients into two groups. Group 1 had only EVD placed for CSF drainage with intermittent clamping before the placement of the ventriculoperitoneal (VP) shunt, and, in group 2, an Ommaya reservoir was placed after EVD before the shunt.

Result There were 38 patients in group 1 and 29 in group 2. They were age-matched, with a mild male predominance in group 1. Shunt dependency was significantly reduced in group 2 patients ($p = 0.011$), along with reduced length of stay in ICU ($p = 0,001$) and length of stay in Hospital ($p = 0.019$). We found improved Glasgow outcome score in group 2 patients ($p = 0.006$) together with reduced incidence of infarct ($p = 0.0095$).

Conclusion We may infer from the present study that continuous drainage through EVD, initially, in hydrocephalus induced by SAH following aneurysm rupture, increases cerebral perfusion pressure (CPP) and decreases intracranial pressure (ICP) leading to

Keywords

- shunt dependent hydrocephalus
- subarachnoid hemorrhage
- aneurysm rupture
- continuous and intermittent drainage
- external ventricular drainage
- Ommaya

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decreased infarct rate and intermittent drainage through Ommaya following EVD reservoir, decreases shunt dependency, reduces ICU and hospital stay, with improved Glasgow outcome score on follow-up, but these findings need to be validated in a prospective randomized control trial.

Resumo

Introdução O desmame da drenagem ventricular externa (DVE) do líquido cefalorraquidiano (LCR) na hidrocefalia induzida por hemorragia subaracnóidea aneurismática (HSA) foi proposto pelas abordagens rápida, gradual ou intermitente. Não há diretrizes uniformes para isso. Diante disso, planejamos estudar o resultado comparativo entre drenagem DVE com pinçamento intermitente versus DVE seguido de reservatório de Ommaya.

Materiais e métodos O presente estudo observacional retrógrado foi realizado de julho de 2018 a março de 2021 no departamento de neurocirurgia com 67 pacientes que desenvolveram hidrocefalia após HSA consequente de ruptura de aneurisma. Dividimos os pacientes em dois grupos. O grupo 1 teve apenas DVE colocado para drenagem do líquor com pinçamento intermitente antes da colocação da derivação ventrículo-peritoneal (VP) e, no grupo 2, um reservatório de Ommaya foi colocado após a DVE antes da derivação.

Resultado Havia 38 pacientes no grupo 1 e 29 no grupo 2. Eles eram pareados por idade, com leve predominância do sexo masculino no grupo 1. A dependência de shunt foi significativamente reduzida nos pacientes do grupo 2 ($p = 0,011$), juntamente com menor tempo de internação na UTI ($p = 0,001$) e tempo de permanência no Hospital ($p = 0,019$). Encontramos melhora no escore de Glasgow nos pacientes do grupo 2 ($p = 0,006$) juntamente com redução da incidência de infarto ($p = 0,0095$).

Conclusão Podemos inferir do presente estudo que a drenagem contínua por DVE, inicialmente, na hidrocefalia induzida por HSA após ruptura de aneurisma, aumenta a pressão de perfusão cerebral (PPC) e diminui a pressão intracraniana (PIC) levando à diminuição da taxa de infarto e drenagem intermitente por Ommaya após DVE reservatório, diminui a dependência do shunt, reduz a permanência na UTI e no hospital, com melhora do escore de Glasgow no acompanhamento, mas esses achados precisam ser validados em um estudo prospectivo randomizado de controle.

Palavras-chave
- hidrocefalia dependente de derivação
- hemorragia subaracnoide
- ruptura de aneurisma
- drenagem contínua e intermitente
- drenagem ventricular externa
- Ommaya

Introduction

Hydrocephalus develops in between 6 and 60% of cases following subarachnoid hemorrhage (SAH).[1] Most often, hydrocephalus responds to cisternostomy while performing aneurysmal clipping and by putting external ventricular drainage (EVD) during surgery and postoperatively. Similarly, EVD is placed before coiling, when the endovascular procedure is planned or following it if hydrocephalus persists. In between 40 and 50% of these patients, removing EVD leads to ventriculomegaly and clinical deterioration due to which ventriculoperitoneal shunt needs to be placed. Continuous drainage through EVD has the inherent risk of developing infection (between 0 and 45% of the cases), tube blockage, intracranial hemorrhage, etc.[2] There is growing evidence emphasizing intermittent and slow drainage of CSF leading to lesser chances of EVD-related complications. Replacement of EVD by Ommaya reservoir has been found to reduce chances of infection in different studies.[3,4] Some studies have reported reduced shunt dependency in hydrocephalus following SAH when CSF is drained intermittently and gradually when compared with continuous drainage and fast weaning.[5] Few studies suggested a reduction in the rate of complications associated with intermittent EVD drainage and decreased number of ventriculoperitoneal shunts required in it.[6] There are conflicting reports that these findings in other studies are associated with increased risk of vasospasm, no difference in shunt dependency, and outcome following intermittent CSF drainage when compared with continuous CSF drainage. Therefore, we tried to evaluate the efficacy of Ommaya reservoir placement in such cases in reducing shunt dependency as well the length of stay in hospital and the functional outcome on follow-up.

Material and Methods

Ethical clearance for the present study was obtained from the institution. We have adhered to the Institutional and Departmental Ethical Guidelines while working on the present study and during its final submission with institutional ethical clearance (no. IEC/2021/355). Detailed written informed consent was obtained at the time of admission in the hospital from the patients, next of kin, or guardian for the use of their data for teaching and clinical research purposes.

The present study was conducted between July 2018 and March 2021in the department of Neurosurgery at our institute. In this period, 250 cases of ruptured aneurysms were treated, out of which 67 cases were included in the study as they were presenting with hydrocephalus. In the present study, we included the patients who developed hydrocephalus following ruptured aneurysm with intracranial bleeding (subarachnoid, intraventricular, etc.) and required EVD. The primary objective of the present study was to assess the reduction in the requirement of ventriculoperitoneal shunt following Ommaya reservoir placement after failed EVD and the second objective was to assess the reduction in duration of stay in ICU and hospital together with any improvement in Glasgow outcome score on follow-up in this group of patients.

Clinical information was obtained from the medical charts of the patients. The following data were collected: age, gender, Glasgow Coma Scale (GCS) score at the time of admission, Hunt and Hess grade, Fischer score on computed tomography (CT), duration of EVD placement, complications associated with EVD, Ommaya reservoir placement, history of CSF drainage, Glasgow outcome score at follow-up, and comorbidities, including obstructive lung diseases (i.e., asthma and chronic obstructive pulmonary disease), coronary artery diseases, heart failure, stroke, diabetes, cirrhosis, chronic kidney disease, hemodialysis, and metastases.

Radiological findings on NCCT head as Fischer grade of subarachnoid haemorrhage (SAH), Evan's index, periventricular lusency were noted from medical records of the patients. Preoperative aneurysm configuration, postoperative obliteration of aneurysm, vasospasm were noted from DSA findings as observed in records available.

The following laboratory data were collected preoperatively and postoperatively: routine blood investigations, CSF routine microscopy sent at regular intervals and associated CBC findings, CSF culture, and sensitivity report of CSF.

Ommaya reservoir was placed 2.5 cm lateral and 1 cm in front of the coronal suture by making an elliptical incision and placing a burr hole within the scalp. Ommaya reservoir tapping was done with number 16 scalp vein with its tubings and kept under sterile transparent dressings.

EVD Management Protocol

We placed EVD in cases with hydrocephalus following aneurysmal SAH and to open it intermittently to drain from 50 to 100 ml depending on ICP measurement of > 20 cm or lower. We performed continuous drainage through EVD after the aneurysms were secured by either endovascular coiling or microsurgical clipping. Once the patient started improving postoperatively, we gradually weaned off the patient from EVD by intermittently opening the EVD. Meanwhile, we strictly monitored any drop in GCS and rise in blood pressure to look for features of raised ICP. Trial of weaning from EVD was given every 48 hours in patients with Hunt and Hess grades 1 and 2 and 72 hours in grades 3and 4, so that multiple trials of tube clamping can be made to ensure removal of EVD at the appropriate time. During these repeated trials, few patients had hardware complications as frequent blockage, infections, etc, for which it was replaced by Ommaya reservoir. Placement of Ommaya reservoir act as a conduit for intermittent CSF drainage and antibiotics installation, which helped us in decreasing intracranial infection and in performing a gradual and intermittent EVD drainage.

Once the Ommaya reservoir was placed, we used to assess the requirement of tapping CSF through it depending on the GCS status of the patient which was bserved and charted in critical care sheet at regular interval. In patients for whom more frequent drainage was required through the scalp vein set ($>$ 3 or 4 times/day) regularly for 4 or 5 days as we used to wait for CSF sample to become sterile and replace it with VP shunt. Once the patient's GCS improved and became stable, we assessed the need for continuation of Ommaya reservoir by reducing tapping of CSF through it. Initially, it was done 3-4 times at a 24-hour interval, followed by draining CSF through it at 48 hours twice and then 72 hourly twice, if the patient remained stable while this Ommaya reservoir was taken out. It was challenging to measure opening CSF pressure or measure ICP regularly through different monitoring devices and it was not done in all patients included in the study, but we rely more on clinical parameters as repeat measures of GCS, Blood pressure, pulse rate, and respiratory rate, O2 saturation as reflective of increased intracranial pressure.

Ommaya reservoir was preferred as it reduces external hardware-related risks of getting infected, blocked, pullout, etc, and helps better patient mobilization with intermittent draining by the scalp vein set.

Indications for putting an Ommaya reservoir in the patients who were earlier having EVD for hydrocephalus following SAH after aneurysm rupture in the present study were:

1. Patients in whom cisternostomy was perfomed while performing microsurgical clipping required lesser Ommaya reservoir after external ventricular drainage. This requirement was least in patients in whom lamina terminalis and fenestration of Liliquist membrane was done simultaneously ($p = 0.002$).
2. Patients who could not be weaned from EVD drainage and who required some more time to assess for GCS to get stabilized.

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and were compared using independent *t*-tests. Categorical variables were expressed as numbers (percentage) and compared using the chi-squared test or the Fisher exact test, as appropriate. Multiple logistic regression analysis was performed to identify the factors related to Ommaya reservoir placement. Factors with a ***p-value*** < 0.05

in the univariate analysis were entered into the stepwise logistic regression analysis. A two-tailed *p-value* < 0.05 was considered statistically significant. The significance of Ommaya reservoir placement and duration of ICU stay and of hospital stay was analyzed using single variable analysis of variance (ANOVA) test. Shunt dependency following Ommaya reservoir on follow-up was calculated from Kaplan–Miere curve and significance risk ratio for shunt dependency in absence of Ommaya was calculated from COX-Proportional hazard ratio.

Results

Patient in group 1 with EVD only has 39 patients and group 2 who required Ommaya after EVD has 28 patients. Both groups were age-group matched, with a slight male preponderance in group 1. Ommaya reservoir placement was significantly associated with high Fischer grade on CT and infarct on preoperative CT scan. It was not significantly associated with the location of the aneurysm or with the type of procedure (clipping versus coiling). (►**Table 1**)

Different risk factors were analysed which may have been responsible for continuation of Ommaya reservoir after taking out EVD as age, sex, procedure (clip vs. coil, vasospasm, infarction), CSF protein measured from day1-10, CSF findings suggesting CNS infection, Fischer grade, Hunt and Hess grade etc. On stepwise multiple regression analysis we found that Fischer grade on CT ($p = 0.0073$), CSF findings suggestive of infection (0.0071), and CSF protein as measured on 7th day of EVD insertion was significantly responsile for taking out EVD and replacing it by Ommaya reservoir. On comparative analysis, the receiver operator curve (ROC) showed the area under the curve of these factors as 0.932, with a positive predictive value of 0.88. (►**Table 2**)(►**Figure 1**)

Patients in whom cisternostomy was perfomed while performing microsurgical clipping required lesser Ommaya reservoir after external ventricular drainage. This requirement was least in patients in whom lamina terminalis and fenestration of Liliquist membrane was done simultaneously ($p = 0.002$). (►**Table 3**)

Supplementation with Ommaya reservoir placement after removal of EVD was more common in patients in whom no cisternostomy was performed as observed in patients who underwent endovascular coiling. (►**Table 4**)

Shunt dependency was less in patients in whom EVD was removed and replaced by Ommaya (19 of 29, 65.5%) when compared to patients in whom trial of Ommaya reservoir placement was not done after removal of EVD (3 of 38 patients, 7.8%). (►**Table 5**)

There was a significant decrease in the length of ICU stay in patients in whom Ommaya was placed (29.65 ± 7.26

Table 1 Demography and clinical features of patients with hydrocephalus with and without Ommaya

Variables	Group 1 (Hydrocephalus with EVD only) ($n = 38$)	Group 2 (Hydrocephalus with EVD followed by Ommaya) ($n = 29$)	*p-value*
Age (years old)	51.10 ± 10.83	50.63 ± 9.53	0.12
Gender (M/F)	10/19	21/17	
Location of the aneurysm	16	19	0.059
Anterior circulation	10	22	
Posterior circulation			
Hunt and hess grade			
< 3	8	14	0.12
> 3	30	15	
Fischer grade on CT			
1	–	–	0.003
2	5	6	
3	16	12	
4	17	11	
Infarct on CT head	32/38	15/29	0.0095
Procedure			
Microsurgical clipping	12	17	0.059
Coiling	21	17	
Spasmolysis			
Responded	9	17	0.056
Not responded	29	12	

Abbreviations: CT, computed tomography; EVD, external ventricular drainage; F, female; M, male.

Table 2 Risk factors predisposing placement of Ommaya reservoir following external ventricular drainage on multiple logistic regression analysis

Variable	Coefficient	Std. Error	Odds ratio	95%CI	Wald	*p-value*
Infection in EVD	2.82574	1.04901	16.8734	2.1591–131.8677	7.2561	0.0071
Duration of EVD	0.35785	0.13339	1.4303	1.1012–1.8576	7.1976	0.0073
Fischer grade on CT	−1.80728	0.81816	0.1641	0.0330–0.8157	4.8795	0.0272
Procedure (Clipping versus coiling)	1.58530	0.92061	4.8807	0.8032–29.6570	2.9653	0.0851
CSF opening pressure	1.07135	0.89699	2.9193	0.5032–16.9361	1.4266	0.2323
Constant	−5.97053	3.72866			2.5640	0.1093

Abbreviations: CI, confidence interval; CSF, cerebrospinal fluid; EVD, external ventricular drainage.

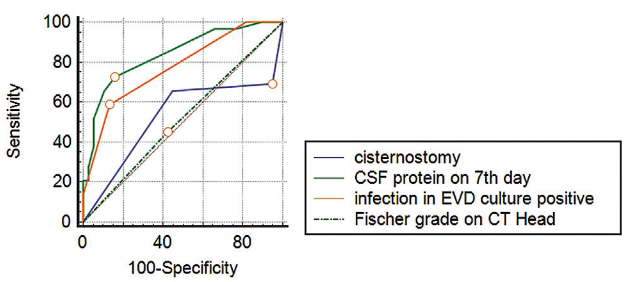

Fig. 1 Reciever operating curve (ROC) suggesting area under curve of 0.9 and predictive value of 0.88 of risk factors predisposing Ommaya placement.

versus 36.13 ± 4.80; $p = 0.001$); similarly, there was a significant decrease in the length of hospital stay (in days) in group 1 (39.63 ± 7.35 versus 44.86 ± 5.61; $p = 0.019$) (►**Figure 2**). One patient in group 1 and 2 patients in group 2 succumbed to death due to cardiac illnesses (►**Table 6**). On follow-up, there was a significant reduction in shunt dependency as observed on Kaplan-Miere survival curve analysis. Cox proportional hazard ratio for shunt dependency on not placing Ommaya reservoir had a coefficient of 1.244 with a 95% confidence interval (CI) (1.6026–7.5107), with a *p-value* of 0.0016. (►**Figure 3**)

Discussion

Patients who develop hydrocephalus following SAH have raised intracranial pressure ICP, leading to decreased perfusion pressure (PF). There may be other factors, such as infarct and edema due to vasospasm, leading to increased ICP and decreased PF. We come across a tricky situation when we put EVD for a prolonged time and it either stops draining due to blockage in the tube or gets infected with the patient developing meningitis and ventriculitis. Intermittent CSF drain through Ommaya reservoir helps us in reducing intracranial pressure and instilling antibiotics through it reduces meningitis, such findings are reported in other studies also.[2,4]

Intermittent drainage of CSF has a certain advantage over continuous drainage through EVD in terms of establishing a pressure gradient across the CSF drainage pathway, which helps in the healthy and early recovery of the natural CSF drainage pathway. There are studies in which the only cisternostomy had been performed without placement of

Table 3 Cisternostomy and Ommaya reservoir placement

Ommaya reservoir placement	Cisternostomy				
	Lamina terminalis opened	Liliquist membrane opened	Both cisterns opened	None	
Present	9 31.0% RT 81.8% CT 13.4% GT	0 0.0% RT 0.0% CT 0.0% GT	1 3.4% RT 5.3% CT 1.5% GT	19 65.5% RT 52.8% CT 28.4% GT	29 (43.3%)
Absent	2 5.3% RT 18.2% CT 3.0% GT	1 2.6% RT 100.0% CT 1.5% GT	18 47.4% RT 94.7% CT 26.9% GT	17 44.7% RT 47.2% CT 25.4% GT	38 (56.7%)
	11 (16.4%)	1 (1.5%)	19 (28.4%)	36 (53.7%)	67
		Chi-squared	19.927		
		DF	3		
		Significance level	$p = 0.0002$		

Abbreviations: RT, row total; CT, column total; GT, grand total, DF, degree of freedom.

Table 4 Ommaya reservoir placement and shunt dependency

Shunt-dependent	Ommaya reservoir placement		
	Present	Absent	
Present	10 34.5% RT 22.2% CT 14.9% GT	19 65.5% RT 86.4% CT 28.4% GT	29 (43.3%)
Absent	35 92.1% RT 77.8% CT 52.2% GT	3 7.9% RT 13.6% CT 4.5% GT	38 (56.7%)
	Chi-squared	24.394	
	DF	1	
	Significance level	$p < 0.0001$	

Abbreviations: RT, row total; CT, column total; GT, grand total, DF, degree of freedom.

Table 5 Ommaya reservoir placement and Glasgow outcome score at follow-up

Ommaya reservoir placement	Glasgow outcome score					
	1	2	3	4	5	
Present	0 0.0% RT 0.0% CT 0.0% GT	0 0.0% RT 0.0% CT 0.0% GT	7 24.1% RT 22.6% CT 10.4% GT	13 44.8% RT 59.1% CT 19.4% GT	9 31.0% RT 90.0% CT 13.4% GT	29 (43.3%)
Absent	1 2.6% RT 100.0% CT 1.5% GT	3 7.9% RT 100.0% CT 4.5% GT	24 63.2% RT 77.4% CT 35.8% GT	9 23.7% RT 40.9% CT 13.4% GT	1 2.6% RT 10.0% CT 1.5% GT	38 (56.7%)
	1 (1.5%)	3 (4.5%)	31 (46.3%)	22 (32.8%)	10 (14.9%)	67
				Chi-squared	19.594	
				DF	4	
				Significance level	$p = 0.0006$	
				Contingency coefficient	0.476	
				Chi-squared	19.594	

5-Resumption of normal life with minor neurological deficits; 4-moderately disabled patient independent in daily life; 3-Severely disabled patient dependent for daily work; 2-Neurovegetative state;1-Death.
Abbreviations: RT, row total; CT, column total; GT, grand total, DF, degree of freedom.

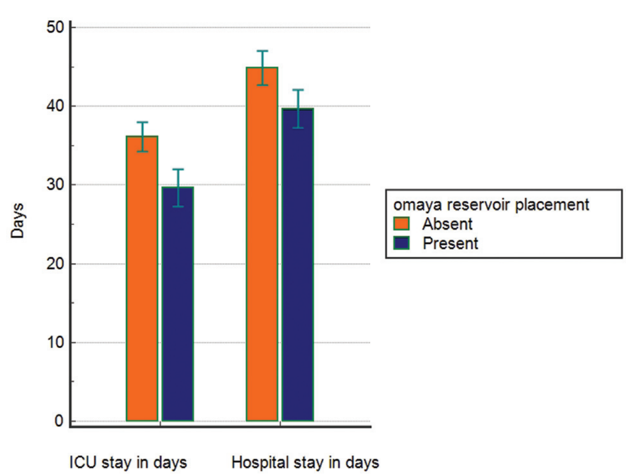

Fig. 2 ICU and hospital stay in patients who required Ommaya reservoir placement.

EVD with good effect, without the requirement of subsequent ventriculoperitoneal shunt.[7,8] In the present study, in which multiple cisterns (lamina terminalis cistern, the membrane of Liliquist, etc) were opened intraoperatively required. In the present study, patients in whom multiple cisterns (both lamina terminalis membrane of liliquist, etc.) were opened to release CSF require lesser number of EVD, Ommaya reservoir placement and were less shunt dependent when compared to patients in whom multiple cisternostomies were not performed. In the study by Komotar et al., in which they performed fenestration of the lamina terminalis, 14% the of patients with acute hydrocephalus following SAH required VP shunt, but in the study by Winkler et al. who had performed fenestration of the lamina terminalis and of the Liliquist membrane, 3.2% of the cases required VP shunt.[9,10] In both studies, EVD was not performed. These findings suggest early recovery of the drainage pathway if continuous CSF drainage is avoided through EVD.

Table 6 Outcome after Ommaya reservoir placement

		Group 2 with Ommaya ($n = 28$)	Group 1 without Ommaya ($n = 39$)	*p-value*
ICU stay		29.65 ± 7.26	36.13 ± 4.80	0.019
Hospital stay		39.63 ± 7.35	44.86 ± 5.61	0.011
Shunt independency		21	1	0.0006
Mortality		1	2	–

Abbreviation: ICU, intensive care unit.

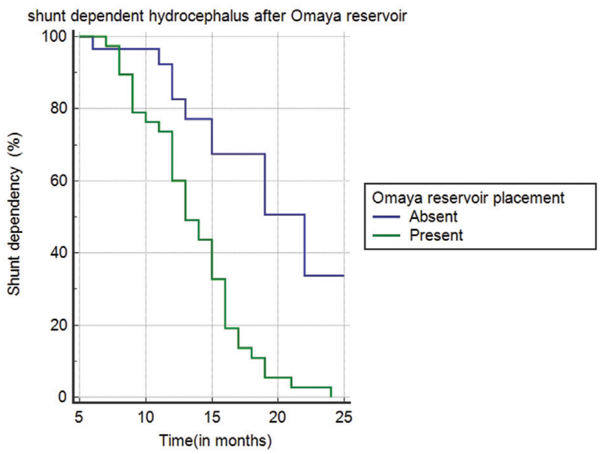

Fig. 3 Kaplan–Miere survival analysis curve revealing shunt dependency following Ommaya reservoir placement on follow-up.

Perhaps, intermittent drainage through the Ommaya pathway leads to the early establishment of the CSF pathway which leads to a reduction in the shunt dependency as has also been observed in our study.

Intermittent clamping reduces shunt dependency, but it requires careful patient monitoring and persistence, as observed in the study by Ascanio et al., in which they made multiple trials of EVD clamping before putting a shunt, which resulted in the decreased number of cases who were shunt dependent when compared with the study of Klopfenstein et al., who emphasized gradual weaning with a single clamp trial and reported a higher number of cases requiring VP shunt at the end.[5,11] Intermittent CSF drainage through the Ommaya reservoir works on the same principle and was also utilized in our cases, which gave us more time to wait for intracranial infections to subside following antibiotics installations and to try intermittently and gradually to observe for the avoidance of further external CSF drainage. It also resulted in the reduced number of shunt-dependent patients on follow-up in our study, when compared with intermittent EVD draining while weaning from continuous CSF drainage.

Increased risk of cerebral vasospasm and delayed ischemic neurological deficits have been reported in the study by Kim et al. and by Amato et al. where continuous drainage of CSF had been done for the treatment of hydrocephalus following SAH.[7,8] Olson et al. reported more complications and a higher incidence of vasospasm in the subgroup of patients with continuous CSF drainage and intermittent monitoring than in groups with intermittent CSF drainage with continuous monitoring.[12] In all three studies, although there was a higher rate of vasospasm in the continuous draining group, the difference reported was not statistically significant compared with the present study, which suggests reduced vasospasm resulting in decreased infarct observed in the group with Ommaya reservoir compared with the group only treated by EVD. The probable reason for this difference in intermittent drainage by the Ommaya group was associated with more chances of washout and drainage of blood degradation products, which are a formidable source of vasospasm, which is also reflected in lesser shunt dependency in this scenario. There are no exact guidelines for either continuous or intermittent drainage of CSF to decrease blood products in cisterns following SAH.[11–16]

Rao et al. had reported decreased ICU stay, hospital stay, and better Glasgow outcome score in the group with intermittent CSF drainage with rapid weaning.[14] Decreased ICU stay, hospital stay, and improved Glasgow outcome score on follow-up had been reported in the present study, similar to the study by Rao et al., but it differs from the study by Klopfenstein et al., who have reported decreased ICU and hospital stay, but an increased rate of shunt-dependent cases on follow-up.[11] Patients in whom EVD was inserted for CSF drainage and given lesser weaning trial by intermittent clamping of it have higher chances of being converted to VP shunt, as observed in the study by Klopfenstein et al.[11] (63% of the patients) when compared to more number of intermittent clamping trial of EVD before converting to shunt, as suggested in study by Rao et al.[14] and Olson et al.

In the studies by Klopfenstein et al. and by Olson et al., the subgroup of cases with rapid CSF drainage by EVD had a higher rate of tube clogging and shunt infection, similar to the present study.[11,13] We found high CSF protein content in the subgroup of patients with high blockage and infection. We preferred the Ommaya reservoir for intermittent drainage of CSF in patients in whom continuous drainage through EVD didn't work. In retrospect, we found better outcomes on the follow-up in these cases in which the Ommaya reservoir was placed.

Although we put Ommaya reservoir as a replacement for EVD, since it was not working, it helped our patients to achieve a better outcome. The main reason behind this may be the increased transcisternal pressure gradient and arachnoid granulations leading to faster recovery of CSF drainage pathway and less shunt dependence. Another proposition is that lower CSF pressure due to continuous drainage leads to reduced CSF secretion and decreased CSF pressure gradient across the drainage pathway, leading to slower recovery and more shunt-dependent patients in these circumstances. The third reason for less VP shunt dependence with Ommaya reservoir was more attempts with intermittent drainage and lesser complications, such as blockage and infection, gave us more time to help the patient for the establishment of the natural CSF drainage pathway. Similar observations were made by Karimy et al. in his study.[17]

Conclusion

Continuous drainage through EVD helped initially in patients with hydrocephalus following SAH in decreasing ICP and increasing perfusion pressure leading to decreased infarct subsequently. Intermittent drainage through Ommaya in the later phase of CSF drainage probably helped in the maintenance of the CSF pressure gradient through the CSF drainage pathway, leading to decreased shunt dependency, and early recovery in ICU with decreased ICU and hospital stay. It appears from our study that patients developing hydrocephalus following SAH may be benefitted in a better way if CSF drainage is done continuously through EVD followed by intermittent CSF drainage by Ommaya reservoir; however, to validate these results, prospective randomized trials would be better.

Contribution of the Authors

Conceptualization, clinical work, data collection, data analysis, manuscript drafting and revision were done by Jha V. C. Data collection and analysis were done by Jha V. C, and Shahnawaz A. Data analysis and manuscript supervision were performed by Jha V. C, MSA and NJ. All authors have read and approved the final version of the manuscript. This manuscript has neither been presented as a whole nor part in any conference or scientific meeting. This article is neither published nor under consideration for publication anywhere else.

Conflict of Interests

The authors have no conflict of interests to declare.

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