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Original Article

Comparison between Ventriculosubgaleal Shunt and Extraventricular Drainage to Treat Acute Hydrocephalus in Adults

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Abstract

Context: Hydrocephalus, due to subarachnoid or intraventricular hemorrhage (IVH), meningitis, or tumor compression, is usually transient and may resolve after treatment. There are several temporary methods of cerebrospinal fluid (CSF) diversion, none of it is superior to the other, and the decision is based on its various etiologies and factors. Ventriculosubgaleal shunt (VSGS) is one of those temporary measures, which is a simple and rapid CSF decompression method without causing electrolyte and nutritional losses. **Aims:** The aim is to study the efficacy of VSGS for temporary CSF diversion, compared to extraventricular drainage (EVD) in adult hydrocephalus patients; to evaluate the outcome in terms of avoiding a permanent shunt, and to look for incidences of their complications. **Settings and Design:** This was a retrospective observational study. **Subjects and Methods:** The data were acquired from case notes of fifty patients with acute hydrocephalus: 26 secondary to IVH, 10 from aneurysm rupture, 8 posttrauma, and 6 from infection. All these patients had undergone CSF diversion in Hospital Queen Elizabeth II, Sabah, Malaysia, between 2013 and 2015. The patients were followed up from the date of treatment until the resolution of hydrocephalus, where parameters such as shunt dependency and complications were documented. **Statistical Analysis Used:** All analyses were carried out using Statistical Packages for the Social Sciences Version 22.0. Chi-squared test or Fisher's exact test is used for univariate analysis of categorical variables. **Results:** A total of 21 (42%) patients underwent EVD insertion and 29 (58%) underwent VSGS insertion. Thirty-seven (74%) patients did not require a permanent shunt; 24 (64.8%) of them were from the VSGS group (P = 0.097). EVD had more intracranial complications (44.1%) compared with VSGS (23.5%), with a statistically significant P = 0.026. **Conclusions:** VSGS is a safe and viable option for adult hydrocephalus patients, with the possibility of continuation of the treatment for such patients in nonneurosurgical centers, as opposed to patients with EVDs. Furthermore, even though this method had no statistical difference in avoiding a permanent ventriculoperitoneal shunt, VSGS has statistically significant less intracranial complications compared with EVD.

Keywords: *Cerebrospinal fluid diversion, extraventricular drainage, hydrocephalus, permanent shunt, ventriculoperitoneal shunt, ventriculosubgaleal shunt*

Introduction

Hydrocephalus is a state of excessive intracranial accumulation of cerebrospinal fluid (CSF) in the ventricular system of the brain as a result of excessive production and circulation or decreased absorption of CSF. The management can be challenging and complex, based on its underlying etiology. Treatment options must be considered, ranging from temporary to permanent. Temporary methods, which are routinely used in the management of acute hydrocephalus, such as extraventricular drainage (EVD), repeated lumbar drainage, Ommaya reservoir insertion for frequent tapping, or ventriculosubgaleal shunt (VSGS). Each method has its pros and cons; the decision on which procedure to choose depends on many factors, including medical, patient, and environmental factors. This is a retrospective observation of acute hydrocephalus in adult patients due to different etiologies, given two different treatments (VSGS and EVD), as their dependency on a permanent shunt was yet to be determined at the time of presentation in Hospital Queen Elizabeth between 2013 and 2015. We determined the outcome in terms of avoiding permanent shunt, number of procedures required, and complications due to each treatment modality.

Subjects and Methods

In this retrospective observational study, the data were acquired from case review

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of patients who underwent temporary CSF diversion using either EVD or VSGS from the period of June 2013 to January 2015 in the Neurosurgical Unit, Hospital Queen Elizabeth, Sabah, where the patients had EVD insertion as the first procedure, and clinically improved in terms of Glasgow Coma Scale (GCS) or computed tomography (CT) brain findings. After EVD insertion, their underlying etiology would be treated while challenging the EVD. As some hydrocephalus patients needed longer periods for the underlying etiologies to resolve, the dependency on a permanent shunt was yet to be determined. For patients who failed weaning off their EVD, they were then subjected for the second operation either re-siting of EVD (control group) or conversion to VSGS (study group), which was decided by the surgeon in charge of the patients.

Inclusion criteria

Adult patients diagnosed with acute hydrocephalus from clinical presentation and confirmed with CT brain findings, who would benefit from temporary CSF diversion and permanent ventriculoperitoneal shunt (VPS) dependency was yet to determined, such as:

1. Spontaneous intracranial hemorrhage (ICH) with intraventricular hemorrhage (IVH)
2. Spontaneous subarachnoid hemorrhage (SAH) with or without IVH secondary to intracerebral aneurysmal rupture from CT angiogram
3. Infective hydrocephalus, suspected clinically with CSF confirmation before surgical intervention
4. Posttraumatic hydrocephalus.

Exclusion criteria

1. Congenital hydrocephalus
2. Hydrocephalus secondary to previous VPS failure or malfunction
3. Infective hydrocephalus due to infection related to the previous VPS
4. Hydrocephalus due to space occupying lesions or tumors
5. Hydrocephalus due to ventriculitis who needed intraventricular antibiotics.

Surgical procedure

The procedures for EVD and VSGS insertion were adopted from the standard procedures suggested by previous literature and practiced by most of the neurosurgeons as described in the literature review for EVD[1] and VSGS.[2,3] The EVD tubing for both EVD and VSGS was the same, using the Surgiwear ventricular kit, containing one ventricular catheter (30 cm long), one guide wire (30 cm long), and one connector, without any valve. Figures 1 and 2 show intraoperative photos: the creation of adequate subgaleal 10 cm × 10 cm pouch and anchoring the VSGS tubing without any valve or connector. Figure 3 shows the normal functional VSGS with bulging of the subgaleal pocket.

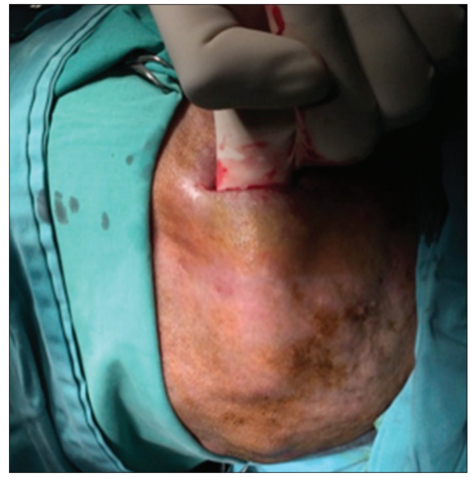

Figure 1: Creation of subgaleal pouch

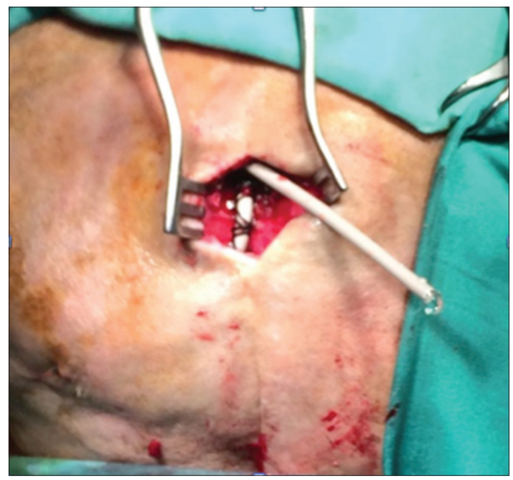

Figure 2: Secured the ventriculosugaleal shunt to the periosteum with suture

Figure 3: Bulging of ventriculosubgaleal pocket posteriorly, avoiding the region of the forehead for cosmesis

The subsequent outcome after each treatment modality within 6 months was observed and documented until the resolution of hydrocephalus or conversion to a permanent

VPS. The outcome in terms of avoiding a permanent shunt, modified Rankin scale (mRS), intracranial complication such as device-related ventriculitis, intracranial bleed, dislodged or blocked tubing, CSF leak, and seizure, as well as extracranial complications such as hospital-, ventilator-, or line-related sepsis, cardiovascular events, and uncontrolled hypertension. The raw data were then translated into SPSS version 22.0 is a statistic software used in this study manufactured by IBM Chi-squared test or Fisher's exact test was used for univariate analysis of categorical variables. The $P < 0.05$ was considered statistically significant.

Results

A total of 50 cases were studied based on data acquired from our retrospective case review of patients with acute hydrocephalus admitted to Hospital Queen Elizabeth, between June 2013 and January 2015. There were 21 cases from the EVD group and 29 cases from the VSGS group. Table 1 shows the demography and medical characteristic for each treatment modality. The patients were distributed according to the etiology of the acute hydrocephalus, GCS, and the status of the surgeon who performed the procedure, all of which had no statistical significant distribution between the two treatment groups.

Table 2 shows the outcome parameters between these two treatment modalities. In the VSGS group, more patients were weaned off ventricular drainage without requiring a permanent VPS (13 out of 21 patients who had EVD and 24 out of 29 patients who had VSGS). However, the comparison did not show any statistical significance at a $P = 0.097$. Outcomes in terms of mRS and number of procedures required until the resolution of the hydrocephalus or conversion to a permanent shunt were not statistically significant for both treatment modalities as well. However, the comparison on the presence of complications between the two treatment modalities showed a statistically significant difference, at a $P = 0.008$.

Further breakdown to compare between intracranial and extracranial complications yielded a significant difference for intracranial complications, where the EVD group had a higher complication rate compared to the VSGS group ($P = 0.022$). Of the patients who underwent EVD insertion, 15 of them developed intracranial complications as opposed to 4 of them who developed extracranial complications. The opposite was observed in the VSGS group, where 8 patients developed intracranial complications, as opposed to 12 patients who had extracranial complications.

Among the intracranial complications, infection (meningitis or ventriculitis) related to the device was observed, where 8 (38.1%) cases were from the EVD group, whereas only 1 (3.4%) came from the VSGS group. The organism detected from the CSF culture was *Acinetobacter* spp. for 7 cases, whereas the other 1 was *Aerococcus* spp. Other complications included blocked EVD in 3 cases (14.3%) and dislodgement in 3 cases (14.3%). One case had deteriorating GCS, which led to death after failure of challenging the EVD.

For the VSGS group, intracranial complications included seizure in 3 cases (10.3%) and leaking from the

Table 1: Summary of demographic, medical characteristic for each treatment modality

	EVD (%)	VSGS (%)	Total	P
Total	21 (42.0)	29 (58)	50 (100.0)	
Gender				
Male	11 (22.0)	20 (40.0)	31 (62.0)	0.233
Female	10 (20.0)	9 (18.0)	19 (30.0)	
Mean age (SD)	46.6 (15.50)	47.4 (16.32)		0.887
Etiology				
Aneurysm	4 (8.0)	6 (12.0)	10 (20.0)	0.938
Infection	2 (4.0)	4 (8.0)	6 (12.0)	
IVH	11 (22.0)	15 (30.0)	26 (52.0)	
Trauma	4 (8.0)	4 (8.0)	8 (16.0)	
GCS on arrival				
Mild (14-15)	5 (10.0)	4 (8.0)	9 (18.0)	0.344
Moderate (9-13)	6 (12.0)	11 (22.0)	17 (34.0)	
Severe (3-8)	10 (10.0)	14 (28.0)	24 (48.0)	
Surgeon status				
Specialist	3 (6.0)	12 (24.0)	15 (30.0)	0.077
Registrar	8 (16.0)	5 (10.0)	13 (26.0)	
Medical officer	10 (20.0)	12 (24.0)	22 (44.0)	

SD – Standard deviation; GCS – Glasgow coma scale; EVD – Extraventricular drainage; VSGS – Ventriculosubgaleal shunt; IVH – Intraventricular hemorrhage

Table 2: Summary of outcome in each treatment modality

	EVD (%)	VSGS (%)	P
Shunt requirement			
No VPS	8 (38.1)	5 (17.2)	0.097
VPS	13 (61.9)	24 (82.8)	
Total	21 (100.0)	29 (100.0)	
Number of procedure			
<4	14 (66.7)	22 (75.9)	0.475
4 or >4	7 (33.3)	7 (24.1)	
Total	21 (100.0)	29 (100.0)	
mRS			
Favorable (0-3)	5 (23.8)	13 (44.8)	0.126
Nonfavorable (4-6)	16 (76.2)	16 (55.2)	
Total	21 (100.0)	29 (100.0)	
Cx			
Nil	2 (9.5)	9 (31.0)	0.008
Intracranial	15 (71.4)	8 (27.6)	
Extracranial	4 (19.1)	12 (41.4)	
Total	21 (100.0)	29 (100.0)	

EVD – Extraventricular drainage; VSGS – Ventriculosubgaleal shunt; VPS – Ventriculoperitoneal shunt; Cx – Complications; mRS – Modified Rankin Scale subgaleal surgical sites in 2 cases (6.9%). One patient had ventriculitis (3.4%), one patient had posterior fossa pseudomeningocoele after posterior fossa decompressive craniectomy and despite VSGS, it only resolved after a permanent shunt was inserted. One patient had failure of VSGS due to shunt tubing kinked by galeal sutures.

Discussion

In this study, the outcome in terms of conversion to permanent VPS was higher in the EVD group compared to the VSGS group; however, this difference did not show any statistical significance. Dependency on a permanent shunt was related directly to the etiology of the hydrocephalus, and not the method of CSF conversion that we picked. The number of procedures needed for the patients in this study was related to the etiology of hydrocephalus and also the complications associated with the EVD or VSGS. However, complications associated with EVDs were higher than VSGS, especially for intracranial complications, of which device-related meningitis was the most significant. Extracranial complications for each treatment modality were almost the same and showed no statistical significance.

Device-related meningitis or ventriculitis was as high as 38.1% in the EVD group, but only 3.4% in the VSGS group. We had a higher rate of EVD-related infection compared to Hospital Kuala Lumpur (32.2%),[4] and 16.6% in University Medical Center Utrecht, Netherlands.[5] Inversely, we had a lower rate of VSGS-related infection as compared to other studies. The rate of infection associated with VSGS is reported to be 66.7% by Willis *et al*.,[6] 8.0% by Köksal and Öktem,[3] 5.9% by Tubbs *et al*.,[7] 0% by Fulmer *et al*.,[8] and Rahman *et al*.[9]

Infection due to EVD is significantly higher than VSGS because EVD exposes the intraventricular environment to the exterior milieu. Device-related meningitis subsequently increases the number of procedures for re-siting of EVD, as well as prolonged hospital stay. It also increases the morbidity and mortality on top of an already ill neurosurgical patient.

The other complication seen during monitoring of the cases with VSGS was CSF leakage from the incision site. The rate of CSF leak has been reported to be 16.6% by Willis *et al*.,[6] 4.7% by Tubbs *et al*.,[7] 5% by Fulmer *et al*.,[8] and 29% by Köksal and Öktem.[3] This study showed that the rate of CSF leakage from the incision site was 6.9%, consistent with the results in other literature. This complication may be reduced by paying a more vigilant attention to the surgical closure technique.[3]

CSF leak was observed in two patients from the EVD group, where the leak was from the EVD catheter exit site rather than from the incision site. CSF leak in EVD or VSGS may indicate a high intracranial pressure (ICP) or is attributed to poor surgical technique in wound closure. Once CSF leak is noted, the patency and functionality of the device or raised ICP need to be ruled out. For EVD, we can easily rule outraised ICP by connecting the EVD to a transducer for the ICP monitoring. However, for VSGS, it is more difficult to determine the functionality of the device based on clinical evaluation alone without a CT of the brain because palpation for the consistency of the subgaleal pocket is highly subjective. This is the reason why our center inserts an EVD as the first procedure for CSF diversion, especially for patients presenting with a low GCS.

Other complications rarely mentioned in literature include the development of ICH following the procedure. There was no ICH observed in our VSGS group but one patient developed ICH in the EVD group. As for the VSGS group, the development of a new intraparenchymal hemorrhage has been noted in two cases (1.1%) by Tubbs *et al*.[7] and 5% by Fulmer *et al*.,[8] whereas it was noted in 1.1% of EVD cases by Daniel Sciubba.[1] The patient who had ICH following EVD in this study was due to overdrainage of the EVD, evidenced by a sudden rise in CSF flow to 200 mls within 4 h as the patient was restless and sat up without clamping or readjusting the height of the EVD. Subsequently, that patient had a drop in consciousness with pupillary changes until the evacuation of clot was performed. In view of this potentially devastating complication, patients with EVDs are all strictly monitored at the neurosurgical unit. Meanwhile, patients with VSGS can be transferred to other departments or hospitals for continuation of care; it can even shorten hospital stay.

At our center, VSGS is usually inserted as the second procedure after an initial CSF diversion with EVD or following craniotomy for the evacuation of clot or clipping of aneurysm. If the patient requires a longer period of CSF diversion of more than 7 days or has failed weaning off the EVD, the second surgery is done, either reinsertion of EVD or conversion from EVD to VSGS based on surgeon preference, as there is no clear guideline to show which method is superior for the patient. After the VSGS is inserted, our patients can be managed at their original district hospitals with the VSGS left in place for a duration of 3 months, enough time for the ventricle to be clear from blood, infection, or postoperative debris.

After 3 months of inserting the VSGS, and persistent hydrocephalus is found from clinical signs, symptoms, and radiological findings, the VSGS is removed and a VPS is inserted, as described by Sklar *et al*.[10] On the occasion that the hydrocephalus shows evidence of clinical progression despite an apparently functioning VSGS, then a permanent VPS system is inserted earlier than 3 months. On the other hand, if the hydrocephalus appears to have arrested, the VSGS is left in place and removed later electively under local anesthesia, or removed in the same setting of cranioplasty.

Table 3: Summary of results in the reported literature with >10 ventriculosubgaleal shunts

References	Causes PHH/all	Mean age (weeks)	Total Cx (%)	Infection Cx (%)	Mean duration of VSGS (days)	Mortality	VPS (%)
Andrea *et al.*	72/102	27.3	15.2	8.3	87.9	4.2	87.5
Fulmer *et al.*	20/32	33/37.2	9.3	0	35.1	25	75
Köksal and Öktem	25	29.32	36	8	44	28	60
Rahman *et al.*	15	29	NA	0	9.16 week	NA	80
Sklar *et al.*	62	29.8	42	10	NA	1.6	90
Tubbs *et al.*	71/185	NA	11.7	5.9	37.4	9	NA
Our report	21/29	47.3 years	27.6	3.4	85.8	6.9	17.2

Cx – Complications; NA – Not available; PHH – Posthemorrhagic hydrocephalus; VSGS – Ventriculosubgaleal shunt;
VPS – Ventriculoperitoneal shunt

In terms of permanent shunt dependency for acute hydrocephalus, our study had 5 out of 29 (17.2%) VSGS patients, excluding the two deceased patients. We compared to previous studies: Sklar *et al*. had 90%,[10] Nagy *et al*. had 87.5%,[11] Rahman *et al*. had 80%,[9] and Fulmer *et al*. had 75%,[8] whereas Köksal and Öktem had 60%.[3] The lower number of shunt dependency from our study may be due to our longer waiting time of up to 3 months for the underlying pathology of hydrocephalus to resolve. Besides, the lower threshold for VPS insertion for neonatal age group is also a contributing factor as the above studies were subjected in neonatal age group only. A summary of the reported literatures for VSGS with their complication percentage together with their outcome for the insertion of permanent VPS is shown in Table 3, which is adopted from Nagy *et al.*[11]

Conclusion

The result showed no statistical different in avoiding a permanent ventriculoperitoneal shunt, however VSGS has less intracranial complication.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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