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Original Article

Factors affecting ventriculoperitoneal shunt survival in adult patients

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Abstract

Background: Ventriculoperitoneal (VP) shunt insertion remains the mainstay of treatment for hydrocephalus despite a high rate of complications. The predictors of shunt malfunction have been studied mostly in pediatric patients. In this study, we report our 11-year experience with VP shunts in adult patients with hydrocephalus. We also assess the various factors affecting shunt survival in a developing country setting.

Methods: A retrospective chart analysis was conducted for all adult patients who had undergone shunt placement between the years 2001 and 2011. Kaplan–Meier curves were used to determine the duration from shunt placement to first malfunction and log-rank (Cox–Mantel) tests were used to determine the factors affecting shunt survival.

Results: A total of 227 patients aged 18–85 years (mean: 45.8 years) were included in the study. The top four etiologies of hydrocephalus included post-cranial surgery (23.3%), brain tumor or cyst (22.9%), normal pressure hydrocephalus (15%), and intracranial hemorrhage (13.7%). The overall incidence of shunt malfunction was 15.4% with the median time to first shunt failure being 120 days. Etiology of hydrocephalus ($P = 0.030$) had a significant association with the development of shunt malfunction. Early shunt failure was associated with age ($P < 0.001$), duration of hospital stay ($P < 0.001$), Glasgow Coma Scale (GCS) score less than 13 ($P = 0.010$), excision of brain tumors ($P = 0.008$), and placement of extra-ventricular drains ($P = 0.033$).

Conclusions: Patients with increased age, prolonged hospital stay, GCS score of less than 13, extra-ventricular drains *in situ*, or excision of brain tumors were more likely to experience early shunt malfunction.

Key Words: Cerebrospinal fluid shunt, hydrocephalus, ventriculoperitoneal shunt

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INTRODUCTION

Ventriculoperitoneal (VP) shunt placement is the mainstay of treatment for hydrocephalus in both adult and pediatric patients.[2,5,28,33,43] In the United States alone, more than 30,000 procedures to relieve hydrocephalus are performed every year.[4,24] Despite this fact, VP shunting remains vulnerable to a number of complications. The

1-year failure rate for VP shunts had been reported at around 40-50% for pediatric patients and 29% for adults until a few decades ago.[5,6,18,40] More recent studies report a relatively lower rate of shunt failure, though it still remains substantial.[15,32,33,38,42]

VP shunt malfunction remains the most frequent reason for shunt revisions.[5,6,26,27,38] Although shunt failure has been studied extensively, most of the studies have addressed pediatric patients, and very little has been published on adult patients.[6,14,20,34,42] Moreover, many of these studies are from developed countries, which theoretically have only limited application to developing countries by virtue of the difference in etiologies.[9,16,41]

Hereby, we report an 11-year experience of managing adult hydrocephalus, including etiologies of disease, patient demographics, shunt survival and failure rate, and causes of shunt malfunction.

MATERIALS AND METHODS

We performed a retrospective chart review using our inpatient database. Files were retrieved using International Classification of Diseases, 9th Revision-Clinical Modification (ICD-9-CM) codes for "hydrocephalus" and "ventriculoperitoneal shunt." Adult patients were defined as those who were 18 years of age or older. Each file was individually reviewed for various details such as patient demographics, presentation, neurological examination, laboratory and radiological investigations, medical and surgical management, hospital stay, follow-up, and further management. Follow-up in neurosurgery clinics was specifically reviewed for periodic shunt assessment, persistent or new onset symptoms, and any neurological deficits in terms of visual symptoms and motor and cognitive deficits. In case of shunt malfunction, cause and delay from first insertion to revision were also studied. Any and all further hospital admissions and surgeries were also studied.

Types of hydrocephalus we identified included normal pressure hydrocephalus (NPH), obstructive hydrocephalus, idiopathic hydrocephalus (etiology unknown), and communicating hydrocephalus, as previously reported by Reddy *et al.*[33] NPH at our center was diagnosed through a standard protocol involving gait and memory assessment pre- and post-diagnostic lumbar drainage. This assessment involved the consultation of a neurologist as well as a physical therapist. Communicating hydrocephalus was the diagnosis reserved for high-pressure hydrocephalus without an obvious obstructive pathology involving the ventricular system, although there might have been impairment in cerebrospinal fluid (CSF) absorption. Etiologies were grouped into different categories, which was slightly modified from Reddy *et al.*[33] and Mori *et al.*,[22] and included NPH, infectious or post-infectious (bacterial meningitis or abscess, and tuberculous meningitis), infarcts, brain tumor/colloid and other types of cysts, subarachnoid hemorrhage (SAH), post-cranial surgery, aneurysm or vascular malformation, and intracranial hemorrhage (other than SAH, but including intraventricular and intracerebral hemorrhages).[22,29,33] Post-cranial surgery hydrocephalus is a unique subset of hydrocephalus that develops in patients following a cranial surgery.[10,21,39] It is believed to result from a combination of iatrogenic damage that occurred during the surgical procedure to the cells of the choroid plexus[11,21] and the alterations occurring postoperatively in the CSF circulation, cerebral blood flow auto-regulation, and cerebral compliance.[39] Other etiologies included shunt malfunction (infection or blockage) presenting to us with known or unknown etiology, idiopathic, Arnold–Chiari or Dandy–Walker malformations, and traumatic brain injury (TBI).

The primary outcome of interest of this retrospective clinical study was shunt survival and revision rate. Causes of shunt failure were also determined. Shunt failure was defined as by Reddy *et al.*[33] and categorized as shunt infection, blockage and migration, CSF ascites, or shunt failure caused by an unknown factor. All these shunt complications led to shunt revision.

Data were recorded on a pre-tested proforma. Statistical procedures included frequency determination, mean and standard deviation, and Pearson's Chi-square test for comparison of proportions. The Student's *t*-test and independent sample *t*-test or the Mann–Whitney U test was used for comparison of means or medians, respectively. For all comparisons, a $P < 0.05$ was considered statistically significant. Kaplan–Meier curves were used to determine duration from shunt placement to first malfunction. The log-rank (Mantel–Cox) test was used to determine the factors affecting shunt survival. Data entry and statistical analysis were performed on Statistical Package for Social Sciences version 19 (IBM SPSS Statistics 19, IBM Corporation, Chicago, Illinois).

RESULTS

Patient demographics

A total of 319 patients underwent VP shunt placement during the 11-year period. The total number of all types of neurosurgical procedures carried out at our center during the same time period was approximately 13,000. These VP shunt procedures were performed by seven different neurosurgeons. Pressure-controlled shunts (Medtronic) were used in all cases at a medium pressure in most cases; these shunts have a distal valve located within the pump and cost about US $240 in Pakistan.

Out of the 319 patients identified initially, 92 were excluded because of the unavailability of medical records [Figure 1]. The mean age of patients

included in our study was 45.8 years, ranging from a minimum of 18 years to a maximum of 85 years. One hundred and fifty-one (66.5%) patients were male, and hypertension (n = 161, 70.9%) and diabetes mellitus (n = 30, 13.2%) were the most common co-morbid conditions [Table 1].

Etiologies and clinical manifestations

The etiologies of hydrocephalus in our patients included post-cranial surgery (n = 53, 23.3%), brain tumor or cyst (n = 52, 22.9%), NPH (n = 34, 15%), hemorrhage (n = 31, 13.7%), tuberculous meningitis (n = 9, 4.0%), bacterial meningitis or brain abscess (n = 2, 0.9%), and others (n = 46, 20.3%). Other etiologies included shunt malfunction (n = 16, 7%), TBI (n = 13, 5.7%), post-meningitis (n = 14, 6.2%), Arnold–Chiari or Dandy–Walker malformation (n = 8, 3.5%), and idiopathic (n = 7, 3.1%), as given in Table 2. Some patients had more than one etiology contributing to the development of hydrocephalus. Furthermore, all the patients who presented with shunt malfunction as etiology had undergone VP shunt placement in the past outside our center.

Of the 31 (13.7%) patients with intracranial hemorrhage as an etiology, 23 (10.1%) had SAH, 6 (2.6%) had intraparenchymal hemorrhage, and 2 (0.9%) had subdural hematoma. Among patients with brain tumors (n = 52, 22.9%), extra-axial tumors (n = 30, 13.2%) were more common than intra-axial tumors (n = 22, 9.7%). Meningioma or oligodendroglioma (n = 12, 5.3%), vestibular schwannoma (n = 10, 4.4%), and hemangioblastoma or hemangioma (n = 7, 3.1%) were the most common. Posterior cranial fossa (n = 16,

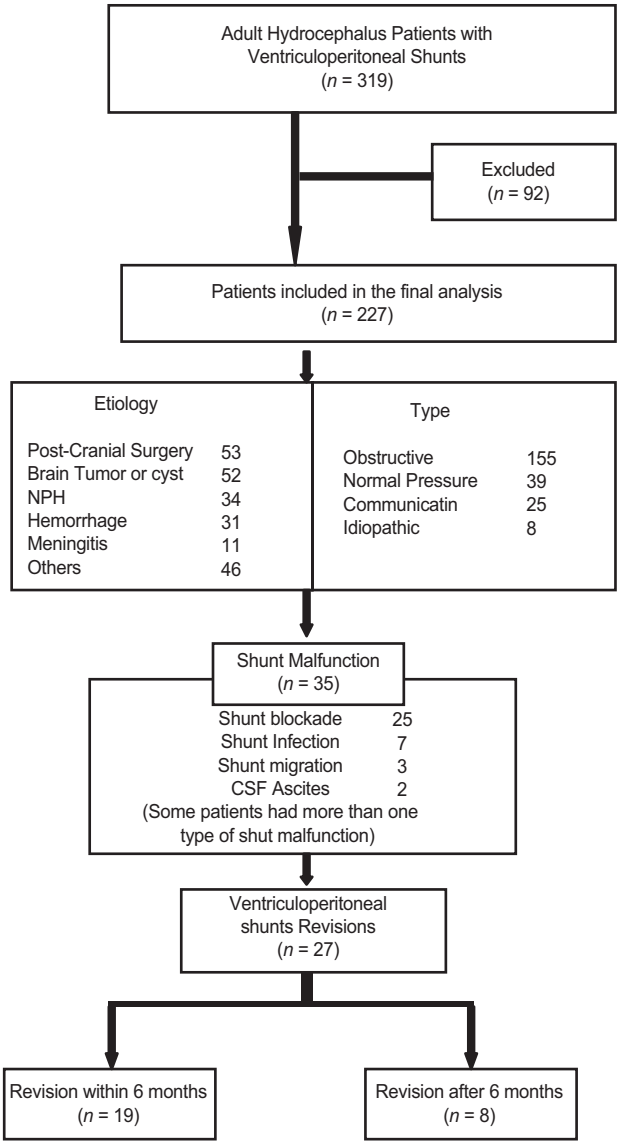

Figure 1: Illustrating the inclusion and exclusion of patient records for analysis in this study and a summary of the various etiologies and types of hydrocephalus with subsequent ventriculoperitoneal shunt procedures. NPH: Normal pressure hydrocephalus

Table 1: Demographics (N=227)

Characteristics	n (%)
Sex	
Male	151 (66.5)
Female	76 (33.5)
Age (>17 years)	
Mean age	45.8±1.1 years
Young (18-40 years)	90 (39.6)
Middle-aged (40-65 years)	89 (39.2)
Elderly (>65 years)	48 (21.1)
Co-morbidities	
Hypertension	161 (70.9)
Diabetes mellitus	30 (13.2)
Ischemic heart disease	7 (3.1)

Table 2: Etiologies of hydrocephalus with malfunction (P<0.05)

Etiology	Patients (N=227)* (%)	Patients with shunt malfunction (n=35) (%)
Post-cranial surgery	53 (23.3)	7 (13.21)
Brain tumor	52 (22.9)	9 (17.31)
Normal pressure hydrocephalus	34 (15.0)	3 (8.82)
Hemorrhage	31 (13.7)	1 (3.23)
Shunt malfunction†	16 (7)	2 (12.50)
Post-meningitis hydrocephalus	14 (6.2)	3 (21.43)
Traumatic brain injury	13 (5.7)	2 (15.38)
Tuberculous meningitis	9 (4.0)	2 (22.22)
Arnold-Chiari/Dandy-Walker malformation	8 (3.5)	4 (50.00)
Idiopathic	7 (3.1)	1 (14.28)
Bacterial meningitis	2 (0.9)	0 (0)
Infarction or stroke	1 (0.4)	1 (100)

*Some patients had more than one etiology of hydrocephalus, †These patients had undergone ventriculoperitoneal shunt placement in the past outside our center and presented to us with shunt malfunction

7.0%), cerebellopontine angle (n = 15, 6.6%) and supra- or parasellar (n = 9, 4.0%) region were the most common sites for tumors. The types of hydrocephalus were obstructive hydrocephalus (n = 155, 68.3%), NPH (n = 39, 17.2%), communicating hydrocephalus (n = 25, 11.0%), and idiopathic (n = 8, 3.5%) [Table 3]. Among patients with brain tumors (n = 52, 22.9%), most (n = 50, 22.0%) had obstructive hydrocephalus, while only two (3.9%) had communicating hydrocephalus secondary to choroid plexus papillomata. The relevant past medical and surgical history of our study subjects is summarized in Table 4.

Symptoms at the time of presentation included headache (n = 101, 44.5%), drowsiness or altered consciousness (n = 91, 40.1%), gait disturbances (n = 89, 39.2%), nausea or vomiting (n = 69, 30.4%), weakness (n = 52, 22.9%), urinary or fecal incontinence (n = 44, 19.4%), decline in memory (n = 26, 11.4%), visual abnormality (n = 26, 11.4%), fever (n = 25, 11.0%), and seizures (n = 22, 9.7%). On presentation, the Glasgow Coma Scale (GCS) score of patients ranged from 3 to 15, with a mean of 12 and a median of 14. Twenty-six (11.4%) patients were comatose (GCS ≤ 8) on presentation, while GCS score was less than 13 in all patients with drowsiness (n = 91, 40.1%). Motor deficits were found in 99 (43.6%) patients. Laboratory investigations in these patients included serum chemistry, blood counts, blood culture, and radiological investigations. Lumbar puncture was performed in 116 (51.1%) patients.

Table 3: Types of hydrocephalus with malfunction (P=0.726)

Type of hydrocephalus (N=227)	n (%)	Patients with shunt malfunction (n=35)
Obstructive hydrocephalus	155 (68.3)	25 (16.13)
Normal pressure hydrocephalus	39 (17.2)	4 (10.26)
Communicating hydrocephalus	25 (11.0)	5 (20.00)
Idiopathic	8 (3.5)	1 (12.50)

Table 4: Past medical and surgical history of study subjects (N=227)

	n	%
Past history		
Mass lesion	47	20.7
Meningitis	25	11.0
Hydrocephalus	24	10.6
Head injury	15	6.6
Subarachnoid hemorrhage	14	6.2
Types of interventions		
Surgery for mass lesion	53	23.3
Ventriculoperitoneal shunt placement	24	10.6
Received antibiotics for meningitis	19	8.4
Anti-tuberculous drugs	17	7.5

Management

Depending on the clinical condition of patients, they were managed in general ward, special care units, or intensive care units. The mean duration of hospital stay was 13.6 ± 1.1 days. One hundred and ninety-five (85.9%) of the patients received antibiotics. Mannitol was administered to 28 (12.3%) patients, while only 9 (4.0%) patients received acetazolamide. Anticonvulsants and steroids were used in 57 (25.1%) and 51 (22.5%) patients, respectively. Nine (4.0%) patients also received anti-tuberculous therapy.

Surgical management of the patients other than VP shunt placement included extra-ventricular drains (n = 43, 18.9%), craniotomy or craniectomy (n = 31, 13.7%), clipping of aneurysm (n = 12, 5.3%), ventriculostomy (n = 5, 2.2%) and other procedures. All the patients included in this study underwent VP shunt placement. Two hundred (88.1%) patients underwent VP shunt placement only once, while 27 (11.9%) patients required revision of the malfunctioned shunt later on. Of these patients, four (1.8%) required revision of the malfunctioned shunt during the same admission. A right-sided shunt was placed in 209 (92.1%) patients, while the remaining 18 (7.9%) patients received a left-sided shunt.

Clinical follow-up

Only 161 (70.9%) patients followed up regularly; rest of the patients (n = 66, 29.1%) were lost to follow-up after the first postoperative clinic visit. The mean duration of follow-up was 321.6 days. Twelve (5.3%) patients died, most of whom (n = 10, 4.4%) died within a month after surgery. The remaining two patients (0.9%) died 2 months and 10 months post-surgery, respectively. Cardiac arrest (n = 3, 1.3%), brain-stem death (n = 2, 0.9%), and pulmonary embolism (n = 1, 0.4%) were the known causes of death in these patients. The exact cause of death in the remaining cases was not known.

Shunt complications

The incidence of overall shunt malfunction was found to be 15.4%, while the incidence of shunt revision was 14.1%. Kaplan–Meier curve showed that shunt failure rates at 6 months, 1 year, and 6 years were 19/227 (8.4%), 25/227 (11.0%), and 35/227 (15.4%), respectively. The most common causes of shunt malfunction were shunt blockade (n = 25, 11.0%), shunt infection (n = 8, 3.5%), shunt migration (n = 2, 0.9%), and CSF ascites (n = 2, 0.9%) [Table 5]. Of the 35 patients who experienced shunt malfunction, two patients suffered both shunt blockage and shunt infection. The development of shunt malfunction was significantly influenced by the principal etiology of the hydrocephalus (P = 0.030). Of 74 patients with brain tumors – some of which were post-excision and the rest were diagnosed during admission – 10 patients had shunt malfunction (P = 0.580). Nine of these patients

Table 5: Complications of ventriculoperitoneal shunt*

Complication type	*n* (%)
Shunt blockage	25 (11)
Shunt infection	7 (3.5)
Shunt migration	3 (1.3)
Shunt CSF ascites	2 (0.9)

CSF: Cerebrospinal fluid, *Two patients experienced both shunt blockage and shunt infection

Table 6: Factors affecting shunt malfunction (*N*=227)

Factors	*P**	Factors	*P**
Demographics		Management	
Sex	0.503	Hospital care unit	0.601
Age	0.298	Duration of hospital stay	0.249
Comorbid conditions	0.229	Antibiotics given	0.470
Past medical and surgical history		Mannitol	0.067
Meningitis	0.193	Diamox	0.802
Hydrocephalus	0.356	Steroids	0.962
Head injury	0.822	Anticonvulsants	0.391
Stroke/SAH	0.997	Anti-tuberculosis drugs	0.283
Mass lesion	0.810	Surgical intervention	0.994
Antibiotics	0.133	**Type of surgical intervention**	**0.001**
Anti-tuberculosis drugs	0.137	Extra-ventricular drain	0.445
VP shunt	0.160	Side of VP shunt placement	0.507
Surgical repair	0.665	**Number of revisions**	**<0.001**
		KPS	0.364

SAH: Subarachnoid hemorrhage, VP: Ventriculoperitoneal, KPS: Karnofsky performance score, *P value for qualitative and quantitative variables based on Pearson Chi-square (χ^2) test and Mann-Whitney U test, respectively

Factors having a statistically significant association with shunt malfunction are shown in bold.

underwent shunt revision. Out of 53 post-cranial surgery patients, only 7 developed shunt malfunction ($P = 0.611$) and all of them had shunt revision. Of 34 patients with NPH, 3 developed shunt malfunction ($P = 0.248$); shunt revision was performed in all of them. Amongst 31 patients with hemorrhage, only 1 patient had shunt malfunction and required shunt revision ($P = 0.043$). Shunt malfunction was not found to have a significant impact on the overall functional outcome of patients ($P = 0.364$) [Table 6]. Among elderly patients, causes of shunt failure included shunt blockage ($n = 2$), shunt migration ($n = 2$), and shunt infection ($n = 1$).

Factors affecting time to first shunt failure (VP shunt survival)

Overall median time from shunt placement to shunt malfunction was 120 days, ranging from 2 to 2095 days [Figure 2]. Kaplan–Meier plot showed that the median time from shunt placement to first shunt failure was significantly different among all individuals in principal etiologies ($P = 0.003$, log-rank test) [Figure 3]. Individuals with intracranial hemorrhage, brain tumor, post-cranial surgery, and NPH showed a shortest shunt survival to first shunt failure. Median time to VP shunt failure did not differ significantly between the different types of hydrocephalus ($P = 0.174$, log-rank test). Patients' gender did not show significant statistical difference in median time from shunt placement to first shunt failure between male and female individuals ($P = 0.671$, log-rank test) or medical co-morbidities ($P = 0.701$, log-rank test). Time to first shunt failure for elderly patients was significantly lower than that for other patients ($P < 0.001$, log-rank test), ranging between 4 and 120 days. Duration of hospital stay was statistically significant for median time to shunt failure ($P < 0.001$, log-rank test). Difference in median time from shunt

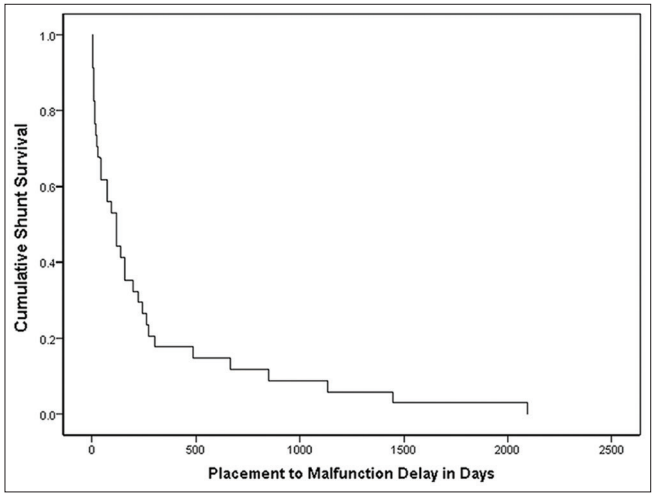

Figure 2: Kaplan–Meier shunt survival analysis for adult hydrocephalus shows overall median time to first shunt failure was 120 days. Shunt survival time ranged from 0 to 2095 days. Out of 35 shunt malfunctions, 30 occurred before 500 days

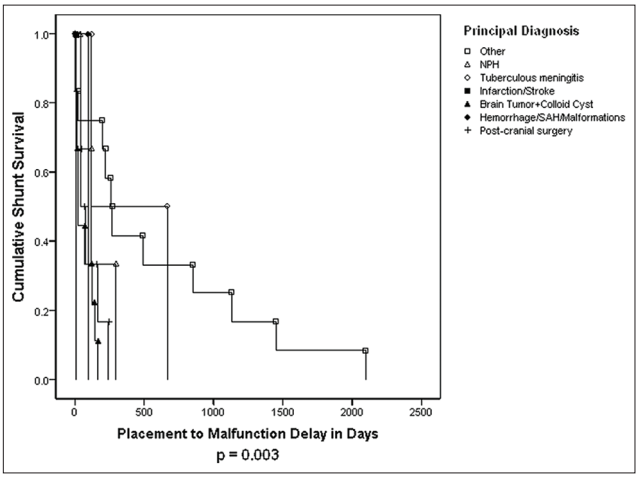

Figure 3: Kaplan–Meier shunt survival analysis for adult hydrocephalus shows that etiologies of hydrocephalus significantly differed in median time to first shunt failure (*P* = 0.003, log-rank test). NPH: Normal pressure hydrocephalus, SAH: Subarachnoid hemorrhage

placement to first shunt failure between the different types of brain tumor ($P = 0.062$, log-rank test) and the different locations of brain tumor ($P = 0.378$, log-rank test) failed to reach statistical significance. Past medical history of the patient did not significantly affect the median time of shunt survival.

Patients who had a GCS score of less than 13 were found to experience early shunt failure ($P = 0.010$, log-rank test) as shown in Figure 4. Similarly, drowsiness or altered consciousness on presentation was found to have a significant effect on shunt survival ($P = 0.010$, log-rank test). This adverse impact of drowsiness or altered consciousness on the medial shunt failure time was independent of the etiology of hydrocephalus. Median shunt survival time was found to be significantly different between patients who underwent different types of surgical interventions other than VP shunt ($P = 0.044$, log-rank test). Similarly, median shunt survival time was also found to be significantly affected by the placement of extra-ventricular drains ($P = 0.033$, log-rank test) before VP shunt [Figure 5]. Side of shunt ($P = 0.882$, log-rank test), hospital care units ($P = 0.171$, log-rank test), and physiotherapy ($P = 0.203$, log-rank test) were not found to have any significant effect on medial shunt survival time.

DISCUSSION

Despite the fact that CSF diversion with VP shunt placement has been the mainstay of management in both pediatric and adult hydrocephalus, VP shunts still have noteworthy complications and failure rate.[8,19] The periodic evaluation of patients who are managed with VP shunt placement for hydrocephalus cannot be overlooked. By studying the patterns of shunt survival extensively, one can attempt to predict the behavior of VP shunt functioning from the time of placement to subsequent follow-up.

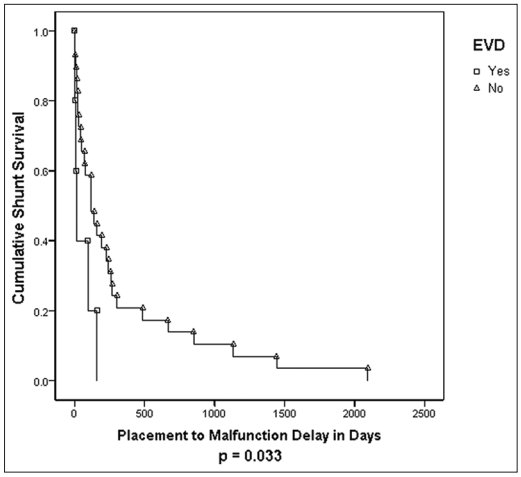

Figure 4: Kaplan–Meier shunt survival analysis for adult hydrocephalus shows that patients with a GCS score of less than 13 were more likely to experience early shunt failure ($P = 0.010$, log-rank test)

Demographics, such as age, gender, and co-morbid conditions, did not upset the shunt function overall, but median time to shunt malfunction was severely affected by extreme of age. This might be accounted for by the fact that elderly patients have fragile and atrophic brain parenchyma. Surgical intervention in such patients was probably associated with a higher risk of iatrogenic trauma inflicted to the nearby tissues while placing the VP shunt. Injury to cells of the choroid plexus within the ventricles could lead to the accumulation of cellular debris within the catheter and clog the tubing of the VP shunt, resulting in shunt blockage.[32] Although this explanation seems plausible theoretically, it cannot be said with certainty that this was the actual reason for early shunt failure in elderly patients in our cohort. Another peculiar observation of our study was a slight predominance of male patients (66.5%) as opposed to female patients (33.5%), which is in line with earlier reports from our region.[13,23,35,36] This might be a consequence of the male-dominated structure of the local society, cultural traditions, and the type of activities that men are more likely to engage into than women.[23]

Among the etiologies of hydrocephalus, hemorrhage was found to have a significantly adverse impact on the functional outcome of patients, which is in line with observation from earlier studies.[3,7,37] VP shunts in patients who have experienced intra-cerebral or intra-parenchymal hemorrhage may become clogged with red blood cells and platelet microthrombi, resulting in shunt blockage.[11] Similarly, some of the etiologies including intracranial hemorrhage, brain tumor, post-cranial surgery, and NPH were found to have the shortest time to first malfunction. Development of hydrocephalus following cranial surgery may be attributed to the damage that occurred to cells

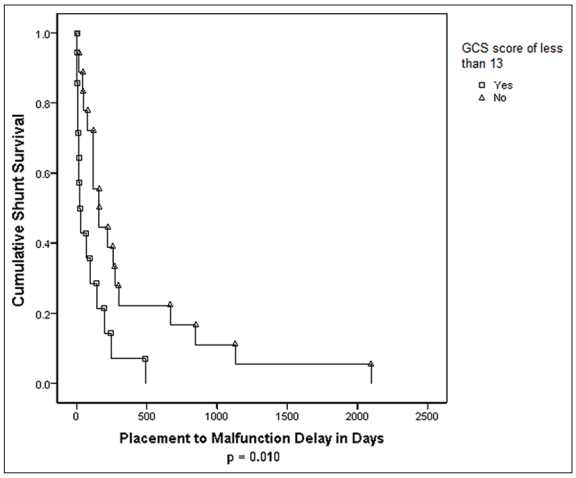

Figure 5: Kaplan–Meier shunt survival analysis for adult hydrocephalus shows that median time to first shunt failure was significantly different among patients who underwent extra-ventricular drain and those who did not ($P = 0.033$, log-rank test). EVD: Extra-ventricular drain

of the choroid plexus and other nearby tissues during the surgical procedure.[11,26,39] Therefore, theoretically speaking, the indication for which cranial surgery was performed, expertise of the operating surgeon, surgical techniques employed, as well as other patient factors may also influence the survival of VP shunts inserted in such patients.[15,20] Likewise, extensive manipulation and injury to tissues occurring during resection of neoplastic disease, as well as alterations in cerebral blood flow and auto-regulation that occur after the procedure result in early shunt failure in patients with brain tumors.[31]

In contrast to the etiology of hydrocephalus, the type of hydrocephalus did not influence overall shunt malfunction and survival. Albeit previous studies have not found any association between clinical features and shunt survival,[30] we observed in our study that patients with drowsiness and low GCS score on examination had prominently reduced median time to first shunt failure. GCS score is an indirect measure of brain functionality and is often used as a marker of severity of TBI.[41] Patients who had a low GCS score on presentation were more likely to have severe abnormalities and pathologies and, therefore, were at increased risk of experiencing shunt failure. However, this association between GCS score and early shunt failure has not been previously reported. Patients who underwent surgical procedures other than VP shunt placement, particularly craniectomy for excision and extra-ventricular drain placement, had a decreased median time to first shunt failure. This may in turn be related to the induction of inflammation and resultant tissue reaction, resulting in precipitation of hydrocephalus.[11,20]

Most of the shunt failures occurred within 6 months post shunt placement, which is compatible with previous reports from developed countries.[5,6,17,20,25,27,30,33,42] Shunt obstruction, infection, migration, and CSF ascites accounted for the most common causes of shunt malfunction. The above observation is also in accordance with the previously reported shunt complications.[1,12,25,30]

The VP shunt failure rate reported earlier ranged from 18% to 29% for adult hydrocephalus.[17,20,30,31,42] The overall VP shunt failure rate (15.4%) that we report is consistent with the shunt failure rate (15.2%) recently recounted by Reddy *et al.*[30] The shunt failure rates at 6 months, i.e. 19/227 (8.37%), and at 500 days, i.e. 26/227 (11.45%), are well below the previously reported failure rates. In another study, Reddy *et al.* reported 32% incidence of shunt revision in adult hydrocephalus patients.[33] The lower shunt failure rate observed in our study was indeed surprising. Meticulous surgical technique and improved asepsis might be considered as factors for this lower rate; however, these factors were not standardized and assessed properly in this retrospective study. Moreover, meticulous surgical technique would also be utilized in other centers, most notably that of Reddy *et al.*[30] A more plausible explanation for this observation could be that shunt failure typically implies a symptomatic shunt failure requiring revision. Patients who might become shunt independent later on would continue to be asymptomatic, even if their VP shunt was not functioning. Such patients would not be separately excluded from this definition, and hence, it might have led to an erroneously low failure rate. The question that arises here is should a patient with a failed shunt, but no hydrocephalus, be categorized as a VP shunt failure? Or should we only consider those patients who would require a revision to have a failed VP shunt? This could be considered a loophole in the definition of shunt failure. In this study, we did not have information for asymptomatic patients with shunt failure. Consequently, we did not consider such patients to have shunt failures. As for the low shunt infection rate in our study, it is interesting to note that some other studies have also documented a markedly low rate recently.[9,14,16,26,29]

This study has certain limitations due to its retrospective design. Results of this study could be affected by technical factors like different surgeons, and their experience and preference of surgical methods. Moreover, only those patients were included in this study whose medical records were complete and retrievable; this might have introduced selection bias. Shunt survival in patients who were excluded due to missing records remains unknown. Similarly, shunt survival analysis was performed only for those who were able to follow-up regularly. A significant proportion of patients who were either excluded due to missing data or failed to follow-up regularly may have skewed the results of our study.

Despite the aforementioned shortcomings, this study contributes substantially to the scientific pool of knowledge. This is the first study from the region to gather and analyze very detailed data of adult patients with hydrocephalus undergoing VP shunt placement. Patients' past medical and surgical history, etiology of hydrocephalus, hospital course, and follow-up in clinics were extensively studied to find the association with shunt survival. Although this study reveals a lower shunt failure rate and a median shunt survival time that concurs with earlier studies, prospective studies focusing on periodic evaluation of shunt and functional status may shed more light on the predictors of shunt survival and long-term functional outcome.

CONCLUSIONS

Our study showed that patients undergoing surgical excision of tumor and patients in whom extra-ventricular drains were placed were more likely to have an early shunt failure. Altered consciousness at presentation (GCS score of less than 13) was a predictor of decreased shunt survival time. Shunt survival was also significantly affected by age and duration of hospital stay.

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