Iraqi JMS

Published by Al-Nahrain College of Medicine
ISSN 1681-6579
Email: Iraqi_jms_alnahrain@yahoo.com
http://www. colmed-nahrain.edu.iq/

Surgical Revision of Ventriculoperitoneal Shunt in Hydrocephalus Patients with Intracranial Tumors

Bassam M Flamerz *MBChB, FICMS*

Dept. of Surgery, Section of Neurosurgery, Al-Kindy College of Medicine, Baghdad University

Abstract

Background Patients with intracranial tumors are predisposed to persistent hydrocephalus, often requiring a permanent CSF diversion procedure with shunts.

Objective This study reviews the long-term experience with ventriculoperitonealshunts for the management of hydrocephalus in patients with intracranial tumors.

Methods Patients with intracranial tumors who underwent ventriculoperitoneal shunt placement for hydrocephalus from January 1999 to January 2009 were included in this study from four neurosurgical centers in Baghdad/Iraq. During the 10-year period, medical charts, operative reports, imaging studies, and clinical follow- up evaluations were reviewed and analyzed retrospectively for all patients. A total of 187 intracranial tumor patients with hydrocephalus were included. The median follow up was 391 days. Malignant tumors were present in 40% of the patients.

Results Overall shunt failure was 27.8%. Single shunt revision occurred in 13% of the patients and 14% had multiple shunt revision. Tumor histology, age and a procedure prior to shunt placement (ventriculostomy/ Ommaya reservoirs) were significantly associated with the shunt revisions. Shunt system replacement and proximal shunt complication were significantly attributed to multiple shunt revisions. The overall shunt revision within 3 months, 6 months, 1 year and 2 years was 17.7%, 18.7%, 19.8% and 24.1%, respectively.

Conclusions The results of the studydemonstrate that VP shunting is an effective procedure for the management of hydrocephalus in patients with intracranial tumors. Age, tumor histology, and a procedure prior to shunt placement (ventriculostomy/Ommaya reservoirs) were significantly associated with the shunt revisions.

Key words Brain neoplasm, Cerebrospinal fluid, Surgery, Shunt

Introduction

Hydrocephalus is a common disorder that results from a disturbance of formation, flow, or absorption of cerebrospinal fluid (CSF), leading to an accumulation of this fluid in the central nervous system (CNS) [1]. It encompasses heterogeneous group of disorders including intracranial tumors, brain hemorrhage, head injury, congenital anomalies, and infections [2,3]. Tumors arising from CNS can block CSF pathways or lead to excessive production of CSF and frequently cause hydrocephalus (Figure 1). Thus, patients with intracranial tumors are at risk of developing hydrocephalus.

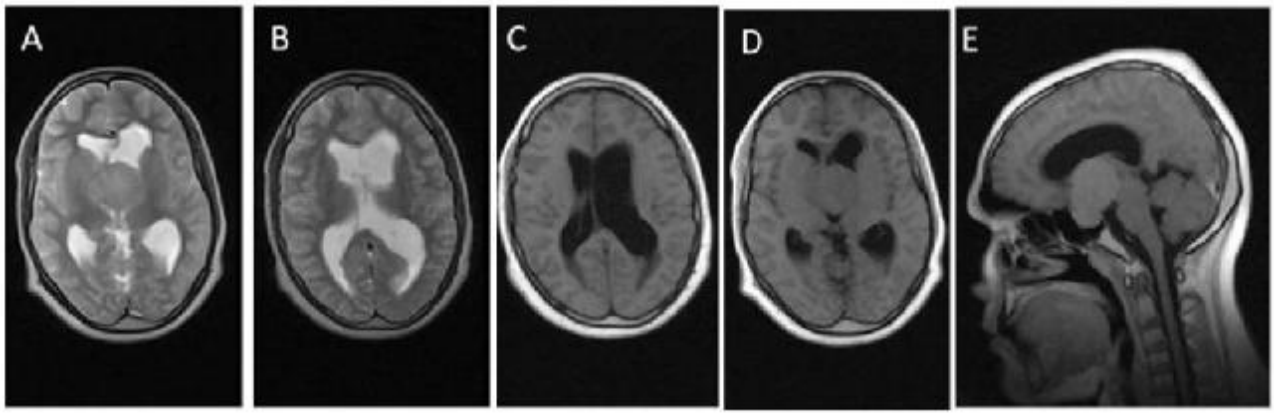

Figure 1. MRI of the brain showing a suprasellar meningioma causing hydrocephalus (A & B T2 axial views, C & D T1 axial views, E T1 sagittal view).

In general, management of hydrocephalus associated with intracranial tumors is a growing concern in neurosurgery. A permanent CSF diversion procedure has been indicated in these patients prior to or after surgical resection of tumor [4]. To date, no consensus exists regarding the management of hydrocephalus in patients with intracranial tumors before, during and after tumor surgery. Some favor [5] preoperative placement of a permanent shunt prior to surgical resection of tumor and others [6] have advocated transitory shunt and steroids to control symptomatic hydrocephalus as a consequence of the subsequent tumor surgery. This would reduce tumor-excision-related morbidity and mortality.

Implantation of a ventriculoperitoneal (VP) shunt is the most widely used treatment for the management of hydrocephalus [7-9]. Although CSF shunting reduces the morbidity and mortality of hydrocephalus, it is associated with potential complications that may require multiple surgical procedures, as well as shunt revisions, during a patient's lifetime [10-13]. Causes for shunt complication and shunt failure include obstruction, infection, mechanical disconnection, and over drainage[10, 11, 12, 13].Thus, the management of hydrocephalus in patients with multiple VP shunt failures is still a challenging problem in neurosurgery.

Earlier studies reveal that an increasing number of previous revisions and shorter time to first revision are associated with the cumulative risk of shunt complications in hydrocephalus patients [12, 14, 15]. The factors that influence the shunt failures or the risk of shunt complications have yet to be fully investigated in hydrocephalus patients with intracranial tumors.

Methods

Patients with intracranial tumors who underwent primary shunt implantation were included in this study between January 1999 and January 2009 in 4 neurosurgical centers in Baghdad/Iraq. The details of the patients' selection for the study are summarized in Figures 2 a and b.

For the 10-year period, medical charts, operative reports, imaging studies, and clinical follow- up evaluations were reviewed retrospectively. Information on each patient, including age, gender, etiology of hydrocephalus, date of shunt placement, date of first and subsequent shunt replacement or revisions, date of last follow-up, and cause of shunt malfunction or failure, were collected from patient's records.

The primary outcome of interest was the

overall shunt revision rate and shunt survival (revision free) in hydrocephalus patients with intracranial tumor. The overall shunt failure was defined as either revision or replacement of an existing VP shunt occurring during the follow-up period.

Statistical Analysis

Multiple logistic regression analysis was used to determine independent risk factors for shunt failure, death, and having multiple revisions (among patients with shunt failure). The Wilcoxon rank-sum test was used to compare groups that are significantly different on shunt failure rate on average number of shunt revisions or failures. The Cox proportional hazards regression model was used to determine independent significant factors for 6-month shunt survival. The Kaplan–Meier method of survival analysis was used to estimate the shunt survival (revision-free) rate and to determine significant factors for shunt failure. The log rank test was used to compare shunt survival rate between categories of identified risk factors for shunt failure; also to compare 2-year patient survival rate between the malignant and benign tumor groups.

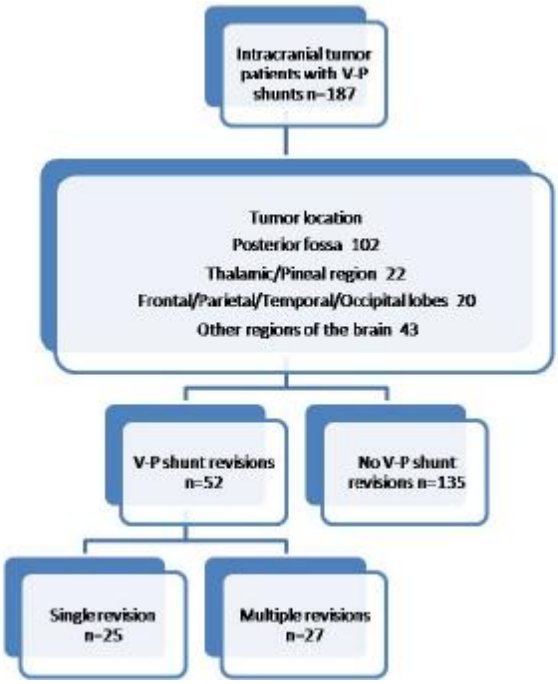

Figure 2a. Flowchart depicting the selection of patients for the study

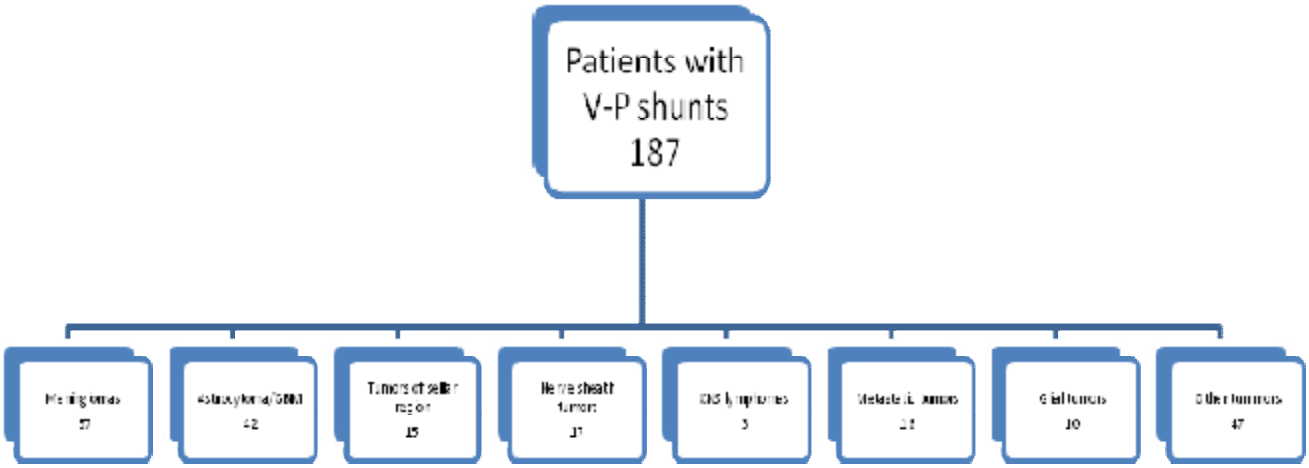

Figure 2b. Flowchart depicting the hydrocephalus patients with intracranial tumors

Results

187 intracranial tumor patients with VP shunt placement were included for the evaluation (Figures 2a, flow chart).

All surgeries were done under general anesthesia and in prone position with proper antisepsis, draping and per-operative and postoperative antibiotic cover and meticulous dressing.

Of the 187 patients, 85 (45%) were male and 102 (55%) were female. Of the 187 patients, 168 (90%) were adults and 19 (10%) were children. The majority of the tumors (54%) were located in the posterior cranial fossa region and tumor size ranged from 0.7 to 10. 7 cm. Benign tumors were present in 112 (60%) patients and 75 (40%) had malignant tumors. There were 131 (70%) patients who had a shunt placement prior to tumor removal and 56 (30%) had a shunt placement after tumor surgery. Of the 187 patients, the majority of the patients (89%) had no prior procedures prior to shunt placement. There were 18 patients who had ventriculostomy and three other patients who had Ommaya reservoirs as a procedure prior to shunt placement.

The site of the burr-hole for shunt placement, depending on the surgeons preference and the site of the tumor, were frontal 33(17.64%), parietal 60 (32.08%), and occipital 94 (50.26%) (Table 1).

Table 1. Demographics of hydrocephalus patients with intracranial tumors

Parameter		No. (%)
Total patients		187 (100%)
Mean age	<18	19 (10.2%)
	>18	168 (89.8%)
Gender	Male	85 (45.4%)
	female	102 (54.6%)
Tumor type	Malignant	75 (40.1%)
	benign	112 (59.9%)
Tumor location	PF region	102 (54%)
	T/P region	22 (12%)
	F/P/T/O lobes	20 (11%)
	Other regions	43 (23%)
Shunt insertion	Before tumor removal	131 (70%)
	After tumor removal	56 (30%)
Procedure prior to VP shunt insertion	Yes	21 (11.2%)
	No	166 (88.8%)
Site of the burr hole for the VP shunt placement	Frontal	33 (17.64%)
	Parietal	60 (32.08%)
	occipital	94 (50.26%)

PF = posterior fossa, T/P = thalamic/pineal, F/P/T/O = frontal/parietal/temporal/occipital.

The median follow up time for all patients was 391days. Of the 187 patients with VP shunt

placement, 52 (28%) experienced one or more shunt failures requiring shunt revision(s). Single shunt revision occurred in 27 (14.4%) patients and multiple shunt revisions occurred in 25 (13.4%) patients after the initial shunt placement (Table 2). Overall, there were 33 (17.7%), 35 (18.7%), 37 (19.8%) and 45 (24.1%) patients experienced shunt failures requiring shunt revisions within 3 months, 6 months, 1 year and 2 years, respectively, after initial shunt placement (Table 2).

Table 2 Shunt revision in hydrocephalus patients with intracranial tumors

Shunt revision	Patients	
	No.	%
Single	25	13.4%
Multiple	27	14.4%
Within 3 months	33	17.7%
Within 6 months	35	18.7%
Within 1 year	37	19.8%
Within 2 year	45	24.1%
Total	52	27.8%

The results in Table 3 list the most common reasons for shunt revisions in hydrocephalus patients with intracranial tumors. A total of 113 shunt revisions occurred in 52 patients, due to various causes such as obstruction, infection, over drainage, mechanical and other shunt complications.

Obstruction caused a total of 45 shunt revisions in 30 (16%) patients. Infection accounted for a total of 16 revisions in 12 (6.4%) patients. Proximal shunt complication caused a total of 43 revisions in 30 (16%) patients. Shunt system replacement accounted for 29 total revisions in 25 (13%) patients.

The findings in Table 4 reveal the risk factors that are independently associated with shunt failure in hydrocephalus patients with intracranial tumors. Among various possible risk factors, tumor histology, procedure prior to shunt placement (ventriculostomy/Ommaya reservoirs), and age were significantly associated with shunt failure.

Table 3. causes of shunt revision among patients and among shunt revisions

Cause	Total patients (n = 187)	Shunt revisions patients (n = 113)
Infection	12 (6.4%)	16 (14.2%)
Obstruction	30 (16.0%)	45 (39.82%)
Overdrainage	3 (1.6%)	4 (3.5%)
Prox. shunt complication	30 (16%)	43 (38.1%)
Dis. shunt complication	13 (7.0%)	16 (14.2%)
Shunt system replacement	25(13.4%)	29 (25.7%)
Valve replacement	16 (8.6%)	17 (15.0%)
Externalization of shunt	13 (7.0%)	14 (12.4%)

Prox. = proximal, Dist. = distal

Table 4. Independent risk factors for shunt failure

Risk factors	OR	95% CI for OR	P value
Benign *vs* malignant	2.56	1.20-5.44	0.015*
Procedure prior to VP shunt (Yes *vs* No)	6.33	2.33-17.24	<0.01**
Age (shunt placement)	0.98	0.97-0.99	0.049

* p = < 0.05, p = < 0.01, OR = odd ratio

The odds for shunt failure among patients with benign tumors were 2.56 times higher than those for patients with malignant tumors; odds for shunt failure among patients who had a procedure prior to their VP shunt placement (ventriculostomy/Ommaya reservoirs) were 6.33 times higher than those for patients with no such prior procedures; for every year increase in age at shunt placement there was a 2% decrease in odds for shunt failure, which indicates that younger patients have a higher risk for shunt failure. Adjusted for the effects of one another on shunt failure, these factors are significantly associated with a patient having

shunt failure or revision. Interestingly, insertion of shunt prior to or after tumor extraction showed no association with shunt failure.

The data in Table 5 show the comparison on average number of shunt failures or revisions between categories of the risk factors for shunt failure. The average number of shunt failures was significantly higher among patients with benign tumors than among those with malignant tumors (0.8 *vs* 0.4, p = 0.02); among pediatric patients than among adults (1.8 *vs* 0.5, p = 0.03); and among patients with a procedure prior to their VP shunt placement (ven-triculostomy/Ommaya reservoirs) than among those with no such prior procedure (1.5 *vs* 0.5, p <0.01).

Table 5. Comparison on average number of shunt revisions among patient groups by factors significantly associated with shunt failure

Group		No.	Shunt failures mean (range)
Malignancy	Benign	112	0.8 (0-7)
	Malignant	75	0.4 (0-5) *
Age group	Pediatric	19	1.8 (0-7)
	Adult	168	0.5 (0-5) *
Procedure prior to VP shunt	Yes	21	1.5 (0-7)
	No	166	0.5 (0-7) **

* = p < 0.05, ** = p < 0.01

Risk factors for multiple shunt failures/revisions were determined among the 52 patients who had a total of 113 shunt revisions. The independent significant factors for multiple revisions are shunt system replacement and proximal shunt complication (Table 6). Adjusted for the effects of other factors, odds for multiple revisions among patients with shunt system replacement(s) were 24.39 times higher than those among patients with no shunt replacement (p < 0.01); odds for multiple revisions among patients with proximal shunt complication were 14.49 times higher than those among patients with no proximal shunt complication (p < 0.05).

Table 6. Independent risk factors for multiple shunt revisions among patients with shunt failure

Risk factors	OR	95% CI for OR	P value
Shunt replacement yes *vs* no	24.39	2.92-200.0	0.003**
Proximal revision yes *vs* no	14.49	1.72-125.0	0.014*

* p = < 0.05, p = < 0.01, OR = odd ratio

Since patients with malignant intracranial tumors are associated with a significantly shorter overall survival rate, we examined the risk factors that are independently associated with 3 and 6 month shunt survival using multivariate analysis. The results indicate that the independent significant factors for 3- and 6-month shunt survival were gender, malignancy and procedures prior to shunt placement such as ventriculostomy or Ommaya reservoirs (Table 7) as determined by multivariate analysis. Male sex, patients with benign tumors and patients with procedure prior to shunt placement (ventriculostomy / Ommaya reservoirs) had significantly lower 3 or 6 month shunt survival rates than female sex, patients with malignant tumors and those with no procedures prior to shunt placement, respectively (Table 7).

Figures 3 through 5 show the 6-months shunt survival rate by gender, tumor status (benign or malignant), and the presence or absence of procedures prior to shunt placement (ventriculostomy/Ommaya reservoirs).

In this study, we observed that the overall shunt revision rate is significantly higher among the patients with benign tumors than those

with malignant tumors. The higher shunt revision rate in patients with benign tumors could simply be due to shorter overall survival rate among the patients with malignant tumor as most of these patients died before they had a chance for their shunts to fail. Therefore, we assessed the mortality rate in patients with malignant tumors and compared to those with benign tumors.

Table 7. Factors significantly associated with 3- and 6-months shunt survival

Factor/Category		3 month survival rate (%)	6month survival rate (%)
All patients (n=187)		82.3	80.7
Gender	Male (n=85)	77.6	74.1
	Female (n=102)	86.3*	86.3*
malignancy	Benign (n=112)	77.6	75.9
	Malignant (n=75)	89.3*	89.3*
Procedure prior to shunt insertion	Yes (n=21)	54.3	52.4
	No (n=166)	86.1**	84.9**

* p = < 0.05, p = < 0.01

The Chi-square analysis indicated that the mortality rates within 3 months, 6 months, 1 year and 2 years of shunt placement were significantly higher among patients with malignant tumors than those with benign tumors (Table 8). These findings clearly indicate that most patients with malignant tumors died before they had a chance for their shunts to fail and thus had significantly lower shunt revision than those with benign tumors. Among various potential risk factors that were analyzed, only the tumor histology is independently associated with mortality of the patients with hydrocephalus. The odds for death among patients with malignant tumors are 2.16 (95% CI 1.19-3.9) times higher than those with benign tumors (p=0.011).

Discussion

The management of hydrocephalus in patients with surgically resectable intracranial tumors remain great challenge and controversial. Some surgeons favor permanent placement of shunts and others recommend external ventricular drains. Although the placement of permanent VP shunts is effective for the management of hydrocephalus, they are associated with myriad potential complications from the shunt itself, including infection, mechanical obstruction, and disconnection. Thus shunt removal, or revision is inevitable in these patients [9,12].

Table 8. Mortality of hydrocephalus patients with intracranial tumors

Time	Malignant tumors (n=75)	Benign tumors (n=112)
3 months	18 (24.0%)	14 (12.5%)*
6 months	20 (26.7%)	15 (13.4%)*
1 year	28 (37.3%)	21 (18.8%)**
2 years	40 (35.3%)	35 (31.2%)**

* p = < 0.05, p = < 0.01

In this study, we retrospectively evaluated the incidence of shunt failures, overall shunt survival and risk factors associated with shunt failures in a cohort of 187 patients with intracranial tumors who underwent VP shunt placement for hydrocephalus in the period between January 1999 and January 2009.

The results from this study show that the overall incidence of shunt revision was 27.8% in hydrocephalus patients with intracranial tumors. The shunt revision rate was similar at 3-months 6 months and 1 year (18, 19 and 20%, respectively) but increased to 24% by 2-years after initial shunt placement. The incidence of VP shunt revision varies considerably among patients with various etiologies of hydrocephalus [12,16-19]. Moreover, pediatric patients experience a high rate (40-50%) of shunts failure compared with adult patients (29%) within the first year of shunt placement [15,20,21]. Although our findings on

the incidence of shunt revision are consistent with these reports, the patient population in this study includes both adults (90%) and children (10%). Furthermore, the etiology in our study is confined to intracranial tumors. However, our results are closely comparable with the study by Hoh et al [16], in which they reported that 26 (30%) of the 87 adult tumor patients with hydrocephalus experienced shunt revisions. In addition, the 6 month revision rate (18.7%) observed in this study is well in agreement with the recent findings reported by Farahmand et al [14] in which they found that 12 (18.5%) of the 65 tumor patients with hydrocephalus experienced shunt revisions within the 6 months of shunt placement.

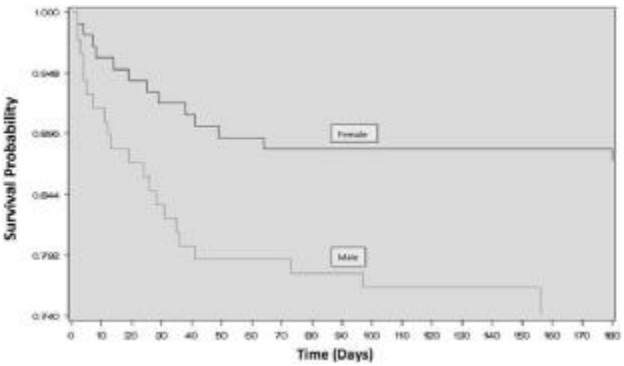

Figure 3. Analysis of shunt survival in hydrocephalus patients with intracranial tumors according to the gender. The Kaplan–Meier plot shows significant differences in 6-month shunt survival between male and female patients (log rank test, p <0.001)

Interestingly, we found that the malignant tumor patients experienced significantly less shunt revisions than benign tumor patients indicating benign tumor patients have a higher risk in developing shunt complications. This could simply be due to the higher death rate in malignant tumor patients. Similar findings have been reported by Hoh et al [16] where the authors found that tumor (non-hemorrhage) patients experienced higher shunt revision than non-tumor (hemorrhage) patients. Moreover, our results revealed that children and patients with a procedure prior to shunt placement (ventriculostomy / Ommaya reservoirs) experienced significantly higher shunt revisions than adults and patients with no procedure prior to shunt placement, respectively.

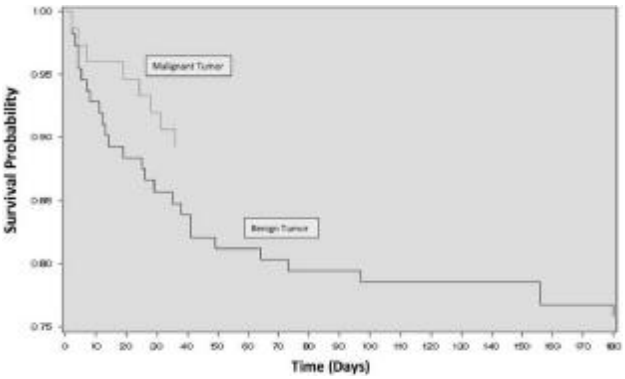

Figure 4. Analysis of shunt survival in hydrocephalus patients with intracranial tumors according to the tumor histology. The Kaplan–Meier plot shows significant differences in 6-month shunt survival between benign and malignant tumor patients (log rank test, p <0.0 01)

Conversely, the results of this study indicate that among various independent risk factors only shunt system replacement and proximal shunt complication are significantly attributed to multiple shunt failures in hydrocephalus patients with intracranial tumors. Previous studies have shown that proximal obstruction contributes to a greater extent to early shunt failure than late failure [22-24]. Currently, it is unclear why shunt system replacement and proximal shunt complication are associated with multiple shunt revisions. Perhaps tumor patients may have tumor growth with resultant obstruction of the shunt by tumor cells or infiltrate, causing proximal shunt malfunction requiring multiple shunt revisions. A thorough analysis of factors affecting shunt system replacement and proximal obstruction is beyond the scope of this study.

It is well known that the risk of death is significantly higher in patients with malignant

tumors than benign tumors. Therefore, we assessed the various risk factors such as gender (male *vs* female), tumor histology (benign or malignant), and a procedure prior to shunt placement (ventriculostomy / Ommaya reservoirs) in relation to 3 and 6 month shunt survival in the patients. Among various risk factors, gender (male), tumor histology (malignant), and a procedure prior to shunt placement (ventriculostomy/Ommaya reservoir) emerged as independent risk factors for 3- and 6-month shunt survival. Similarly, Wu et al [12] observed that the male sex is independently associated with increased risk of shunt complications in patients with hydrocephalus.

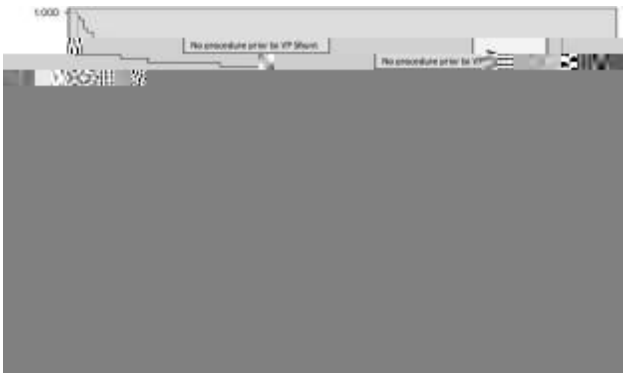

Figure 5. Analysis of shunt survival in hydrocephalus patients with intracranial tumors according to the procedure prior to shunt placement. The Kaplan-Meier plot demonstrates significant differences in 6-month shunt survival between the patients with or without a procedure prior to shunt placement (log rank test, p<0.001)

Overall, the findings of this study demonstrate that VP shunting is an effective neurosurgical procedure for the management of hydrocephalus in patients with intracranial tumors. Several studies are focused on improving shunts by developing material and valve mechanisms [25-27].

Furthermore, endoscopic neurosurgery has been developed as an alternative to avoid invasive surgery or shunt insertion related adverse events. Currently, we are exploring the clinical benefits of endoscopic third ventriculostomy as an alternative treatment option for certain hydrocephalus patients with intracranial tumors.

This study is subject to a number of important limitations. One important shortcoming of this investigation is the retrospective nature of the study that explores the long-term management of hydrocephalus in patients with intra-cranial tumors. Although uniform technique for VP shunt placement was used, the overall treatment was chosen by a number of neurosurgeons. Moreover, the variables included in this study could not be analyzed in a controlled way. Also, many of the variables were dependent on the decisions of individual neurosurgeons involved in shunt placement.

Conclusion

In summary, the results of this study show that the VP shunting is a valuable treatment option for the management of hydrocephalus in patients with intracranial tumors. The overall shunt revision rate observed in this study was comparable to the earlier published reports. Age, benign tumor, and a procedure prior to shunt placement (ventriculostomy/Ommaya reservoirs) were significantly associated with the shunt revisions. In addition, shunt system replacement and proximal shunt complication were significantly attributed to multiple shunt failures.

References

1. Rekate HL. A contemporary definition and classification of hydrocephalus. *Semin Pediatr Neurol* 2009; 16: 9-15.
2. Riva-Cambrin J, Detsky AS, Lamberti-Pasculli M, et al. Predicting postresection hydrocephalus in pediatric patients with posterior fossa tumors. *J Neurosurg Pediatr* 2009; 3: 378-385.
3. Bergsneider M, Miller C, Vespa PM, et al. Surgical management of adult hydrocephalus. *Neurosurgery* 2008; 62(Suppl 2): 643-659.
4. Due-Tonnessen BJ, Helseth E. Management of hydrocephalus in children with posterior fossa tumors: role

of tumor surgery. *Pediatr Neurosurg* 2007; 43: 92-96.
5. Griwan MS, Sharma BS, Mahajan RK, et al. Value of precraniotomy shunts in children with posterior fossa tumors. *Childs Nerv Syst* 1993; 9: 462–465.
6. Van Calenbergh F, Goffin J, Casaer P, et al. Use of a ventriculosubgaleal shunt in the management of hydrocephalus in children with posterior fossa tumors. *Childs Nerv Syst* 1996; 12: 34-37.
7. Piatt JH Jr, Garton HJ. Clinical diagnosis of ventriculoperitoneal shunt failure among children with hydrocephalus. *Pediatr Emerg Care* 2008; 24: 201-210.
8. Bhasin RR, Chen MK, Pincus DW. Salvaging the ''lost peritoneum'' after ventriculoatrial shunt failures. *Childs Nerv Syst* 2007; 23: 483-486.
9. Zhang J, Qu C, Wang Z, et al. Improved ventriculoatrial shunt for cerebrospinal fluid diversion after multiple ventriculoperitoneal shunt failures. *Surg Neurol* 2009; 72(Suppl. 1): S29-S33.
10. Prusseit J, Simon M, von der Brelie C, et al. Epidemiology, prevention and management of ventriculoperitoneal shunt infections in children. *Pediatr Neuro Surg* 2009; 45: 325-336.
11. Simon TD, Hall M, Riva-Cambrin J, et al. Infection rates following initial cerebrospinal fluid shunt placement across pediatric hospitals in the United States. *J Neurosurg Pediatr* 2009; 4: 156-165.
12. Wu Y, Green NL, Wrensch MR, et al. Ventriculoperitoneal shunt complications in California: 1990 to 2000. *Neurosurgery* 2007; 61: 557-562.
13. Stein SC, Guo W. Have we made progress in preventing shunt failure? A critical analysis. *J Neurosurg Pediatr* 2008; 1: 40-47.
14. Farahmand D, Hilmarsson H, Hogfeldt M, et al. Perioperative risk factors for short term shunt revisions in adult hydrocephalus patients. *J Neurol Neurosurg Psychiat* 2009; 80: 1248-1253.
15. Tuli S, Drake J, Lawless J, et al. Risk factors for repeated cerebrospinal shunt failures in pediatric patients with hydrocephalus. *J Neurosurg* 2000; 92: 31-38.
16. Hoh BL, Lang SS, Ortiz MV, et al. Lower incidence of reoperation with longer shunt survival with adult ventriculoperitoneal shunts placed for hemorrhage-related hydrocephalus. *Neurosurgery* 2008; 63: 70-74.
17. Ringel F, Schramm J, Meyer B. Comparison of programmable shunt valves vs standard valves for communicating hydrocephalus of adults: a retrospective analysis of 407 patients. *Surg Neurol* 2005; 63: 36-41.
18. Lund-Johansen M, Svendsen F, Wester K. Shunt failures and complications in adults as related to shunt type, diagnosis, and the experience of the surgeon. *Neurosurgery* 1994; 35: 839-844.
19. Lam CH, Villemure JG. Comparison between ventriculoatrial and ventriculoperitoneal shunting in the adult population. *Br J Neurosurg* 1997; 11: 43-48.
20. Liptak GS, McDonald JV. Ventriculoperitoneal shunts in children: factors affecting shunt survival. *Pediatr Neurosci* 1985; 12: 289-293.
21. Di Rocco C, Marchese E, Velardi F. A survey of the first complication of newly implanted CSF shunts devices for the treatment of nontumoral hydrocephalus. Cooperative survey of the 1991–1992 Education Committee of the ISPN. *Childs Nerv Syst* 1991; 10: 321-327.
22. Winston KR, Lopez JA, Freeman J. CSF shunt failure with stable normal ventricular size. *Pediatr Neurosurg* 2006; 42: 151-155.
23. Piatt JH Jr. Cerebrospinal fluid shunt failure: late is different from early. *Pediatr Neurosurg* 1995; 23: 133-139.
24. Sainte-Rose C, Piatt JH, Renier D, et al. Mechanical complications in shunts. *Pediatr Neurosurg* 1991; 17: 2-9.
25. Aryan HE, Meltzer HS, Park MS, et al. Initial experience with antibiotic-impregnated silicone catheters for shunting of cerebrospinal fluid in children. *Childs Nerv Syst* 2005; 21: 56-61.
26. Pattavilakom A, Xenos C, Bradfield O, et al. Reduction in shunt infection using antibiotic impregnated CSF shunt catheters: an Australian prospective study. *J Clin Neurosci* 2007; 14: 526-531.
27. Kondageski C, Thompson D, Reynolds M, et al. Experience with the Strata valve in the management of shunt over drainage. *J Neurosurg* 2007; 106: 95-102.

E-mail: dr_basam@yahoo.com
Received 19th Sept. 2011: Accepted 9th Feb. 2012