Factors affecting cerebrospinal fluid shunt revision rate in children at King Khalid University Hospital

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ABSTRACT

Ventriculoperitoneal (VP) shunt is a common neurosurgical operation that is associated with a high incidence of complications necessitating revisions. Up to date, there is no data regarding the pattern and incidence of shunt complications and factors affecting shunt revision rate in children in Saudi Arabia. **Methods:** A retrospective review of 133 pediatric patients that underwent VP shunting at King Khalid University Hospital (KKUH) between 1990-1993 was carried. At a follow up of 3 months - 6 years (mean 25 months), 107 revision procedures were performed for the same patients making the total number of shunting operations for these patients 240. **Results**: Fifty-three revisions were due to shunt obstruction and 24 revisions were due to shunt infection. Our overall annual shunt revision rate was 0.39. A significantly higher annual shunt revision rate was encountered in patients aged 6 months or less in general and in premature infants with posthemorrhagic hydrocephalus in particular and in whom the surgery was carried out by the registrar. In addition, premature infants with posthemorrhagic hydrocephalus had a significantly higher incidence of shunt infection than other hydrocephalic patients. However, the shunt revision rate was not significantly affected by the type of shunt, the previous occurrence of a shunt revision and whether the first revision was for an infective or non-infective complication. **Conclusions**: It is recommended that VP shunts for children aged 6 months or less in general and for premature infants with posthemorrhagic hydrocephalus in particular should be carried out by the consultant. Refinement of the surgical technique is essential if shunt complications are to be minimized.

Saudi Medical Journal 1998; Vol. 19 (1) :15-18

Keywords: *Childhood hydrocephalus, ventriculperitoneal shunt, shunt revision, complications, infections.*

The insertion of a ventriculoperitoneal (VP) shunt is technically a relatively simple neurosurgical procedure. It is, however, associated with a high incidence of complications necessitating shunt revisions. With easy access to neurosurgical services, cerebrospinal fluid (CSF) shunt complications are seldom fatal, nevertheless they are a cause of potential morbidity for the patient, a major inconvenience for the family, a burden on the health resources, and at times a nuisance for the surgeon. Shunt complications are usually easy to diagnose particularly when they are bizarre.[1,2] However, at times the shunt malfunction proves to be a diagnostic challenge.[3] Not surprisingly, therefore, neurosurgeons universally are interested in any method that may help in the reduction of the number of shunt revisions either by using alternative procedures to treat the hydrocephalus such as endoscopic third ventriculostomy,[4] or choroid plexus coagulation,[5] or by refining their surgical technique during the shunt placement.[6]

Over the last decade, CSF shunting for childhood hydrocephalus has probably been the most common neurosurgical operation performed in units all over Saudi Arabia. Yet, up to date, there is no published data about the pattern and incidence of shunt complications and the factors affecting the shunt revision rate in children in Saudi Arabia. In this study, the authors attempt to identify the hydrocephalic children with the highest rate of shunt revision based on the experience at King Khalid University Hospital (KKUH) with 240 shunting procedures for 133 patients.

Patients and Methods. This study is based on 133 pediatric patients, 69 males and 64 females with an age range of 2 days to 15 years (median age 9 months) that were treated with a VP shunt at KKUH

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Received December 1996. Accepted for publication in final form April 1997.

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Table 1 - CSF Shunt revision rate in relation to the number of previous revisions

Number of previous revision	No. of patient	Median interval from original shunt (Months)	Annual revision rate afterwards
First	65	3	0.4
Second	28	9	0.33
Third	10	12	0.69
Fourth	2	20	1.07
Fifth	1	40	0.86
Sixth	1	49	0*

*Up to a follow-up of 6 months.

between January 1990 to December 1993. Patients aged more than 15 years at the time of shunting and those who had their original shunt surgery elsewhere or before 1990 and after 1993 were excluded from the study. Codman[R] Accuflow valve (Johnson and Johnson, Raynham MA, USA) was used for the patients who had their surgery during 1990 and 1991 while PS Medical[R] valve (PS Medical, Goleta, CA, USA) was used for the patients who had their surgery during 1992 and 1993. The ventricular catheter was inserted via a right posterior parietal burr hole and the peritoneum was opened via a right subcostal incision. A three-piece shunt system was used for all the patients since we prefer that to the unishunt system. This is because a three-piece shunt system has more flexibility regarding the length of the ventricular catheter with a fixed position for the valve over the burr hole. In addition, we find it easier to do the subcutaneous tunnelling of the peritoneal catheter unattached. All patients received antimicrobial prophylaxis which was started during the operation and continued for 24 hours. Ceftrioxone was the most common drug used. The surgeons were divided into two groups: Consultant and Registrars. Consultants had at least two years of experience after passing a western postgraduate qualification in neurosurgery. When a consultant assisted a registrar, the operation was assigned to the consultant. The procedures were carried out by 3 consultants and 3 registrars.

The patients were followed up to December 1995. The follow-up ranged from 3 months - 6 years (mean 25 months). During the period, 107 shunt revision procedures were carried out for the same patients. Every patient who had a revision was symptomatic. The annual shunt revision rate of a particular group of patients was calculated by dividing their total number of shunt revisions by their total follow-up period in years. The annual shunt revision rate was correlated to the number of previous shunt revisions, the primary cause of hydrocephalus, the age of patient at the initial shunting, the experience of a surgeon, and the type of shunt. In addition, the annual shunt revision rates for the patients before and after their first revision and the rates after a first revision for an infective and a non-ineffective complication were compared. The statistical evaluation was carried out between the different groups of patients with respect to the annual shunt revision rate. The statistical validity of data was analyzed using a chi square test. Differences were deemed significant when $p<0.05$.

Results. The causes of the 107 revisions in the total of 240 shunting procedures were obstruction in 53 (33%) patients, infection in 24 (10%) patients, disconnection in 18 (7.5%) patients, loculated hydrocephalus in 6 (2.5%) patients, chronic subdural hematoma in 3 (1.3%) patients, abdominal pseudocysts in 2 (1%) patients and bowel perforation in 1 (0.4%) patient. The overall annual shunt revision rate in the series was 0.39. Table 1 summarizes the factors affecting the shunt revision primary cause of the childhood hydrocephalus. The annual shunt revision rate of patients aged 6 months or less was 0.65, patient ages more than 6 months to 5 years was 0.25, and patients aged more than 5 years to 15 years was 0.16. Table 3 summarizes the factors affects the shunt revision rate. It is relevant to note that there was no statistically significant difference in the number of operations carried out by the consultants and registrars for patients aged 6 months or less (43% vs 54%) and for premature infants with posthemorrhagic hydrocephalus (20% vs 26%). Of the 24 patients that had a revision for a shunt infection, 21 patients were treated for shunt infection during their first shunt revision. Thirteen of the patients who had a shunt infection were premature infants with posthemorrhagic hydrocephalus ($p<0.0005$).

Discussion. It is possible that a few of the patients that had their original shunting in our hospital were later followed up and treated for a shunt complication elsewhere. These, however, are likely to be a minority since most neurosurgical units are reluctant to take over the management of complications of shunts operated outside their hospital. Shunt

Table 2 - CSF Shunt revision rate in relation to the cause of the childhood hydrocephalus

Cause	No. of patients (%)	Annual revision rate
Congenital polycystic brain	1 (0.8%)	2.25
Post hemorrhagic in premature infants	31 (23%)	0.54
Congenital	27 (20%)	0.48
Spinal dysraphism/encephalocoele	16 (12%)	0.41
Aqueduct stenosis	17 (13%)	0.38
Dandy Walker cyst	7 (5%)	0.37
Post traumatic	3 (2%)	0.24
Post meningitic	8 (6%)	0.18
Space occupying lesion	23 (17%)	0.06

Table 3 - Factors affecting CSF shunt revision rate in children at KKUH.

Feature	No. of Cases	Annual revision rate	Significance
Age:			
- < 6 months	64	0.65	< 0.005
- > 6 months	69	0.19	
Primary cause of hydrocephalus			
- Post hemorrhagic in premature infants	31	0.54	P = 0.05
- Others	102	0.34	
Experience of the surgeon:			
- Consultant	72	0.27	P = 0.01
- Registrar	61	0.49	
Type of shunt:			
- Codman^R	75	0.41	NS
- PS Medical^R	58	0.34	
Effect of the first revision:			
- Overall revision rate	133	0.39	NS
- Revision rate after first revision	65	0.40	
Effect of the cause of the first revision			
- First revision for infection	21	0.41	NS
- First revision not for infection	44	0.39	

complications are common. Sainte-Rose et al[7] calculated an actuarial probability of a shunt failure of 30% in the first year, 55% at 5 years and 81% at 12 years. The percentage of revisions of the original shunting procedures for our patients was 80% which is within the range of 29% - 120% reported in different series in the literature.[7,8] This percentage appears to be directly related to the duration of follow-up of the patients after the study period. In agreement with most reports,[7,9] obstruction which accounted for 50% of all our revisions was the most common complication in this series. It is accepted that obstruction of the ventricular catheter is much more common than that obstruction at the valve or the peritoneal end.[7,9] Hence, there has been some controversy about the ideal location of the ventricular catheter tip. Some authors believe that the placement of the ventricular catheter in the frontal horn is associated with a lower incidence of obstruction.[10] However, others like us,[7,11] believe that there is no optimum site for the ventricular catheter and that the catheter tip location is not the only determining factor since the obstruction can be caused not only by choroid plexus but also by glial tissue, connective tissue, leptomeninges, brain tissue, and ependyma.[12] Valve-related obstruction which has been reported in only 3 to 11% of cases[13] appears uncommon. Yet a recent study[13] showed that up to 81% of implanted shunts failed to meet the manufacturers specified performance data indicating that replacement of the valve may be advisable whenever the shunt is revised.

The shunt infection rate is this series was 10% which is within the range of 5%-10% reported in the literature.[14] The unusually high percentage of multiloculated hydrocephalus related to the shunt infection in our patients has been the subject of a previous publication.[15] In agreement with some reports,[16] but not others,[17] we have found that posthemorrhagic hydrocephalus in premature infants was associated with a significantly higher incidence of shunt infection in particular and shunt revision in general. In our hospital, premature infants are usually treated fairly aggressively irrespective of the degree of their intraventricular hemorrhage, and brain damage.[18] Their shunt infections frequently follow a bacteremia from an extracranial origin and hence, the high incidence of gram negative organism shunt infection in this group of patients.[15] As a result, the shunt revision rate in all hydrocephalic patients aged 6 months or less in this series was significantly higher than the other age groups. Not surprisingly and in agreement with previous experience,[19] the single case of congenital polycystic disease of the brain in this series was associated with the highest shunt revision rate. The fact that shunts performed by registrars resulted in significantly more complications than those performed by the consultants is not surprising.[20,21] With the expected increase in the number of neurosurgical trainees in Saudi Arabia, it is very important that the neurosurgical residents should be assisted by an experienced neurosurgeon for a considerable number of shunt procedures before being allowed to operate independently. Even though the shunting procedures seem relatively simple, it contains many pitfalls than can adversely affect patient outcome. In agreement with a previous report,[20] the shunt revision rate amongst our patients was not significantly affected by the shunt type. We have, however, encountered more disconnections with the Codman^R than with the PS Medical ^{R} shunt. This is because compared to the PS^R shunt, the Codman^R shunt required two extra ties for the connectors and at times the connector appeared faulty in that its groove was not deep enough allowing slippage of the tie. It has been suggested that the risk of an additional shunt revision increases significantly in patients who had already undergone one or more revisions.[8] However, we found no significant difference in the revision rates before and after the first revision and no significant difference in the revision rate following a first revision for an infective or a non infective complication. None of our patients had a shunt revision because of slit ventricles. This is not surprising since it is recognized that in more than 75% of patients the slit ventricles are asymptomatic and only 6% of these cases may require surgical correction.[22]

In conclusion, it appears that the nature and incidence of shunt complications in children in Saudi Arabia are similar to what has been reported in the literature. It is expected that the number of preterm infants with posthemorrhagic hydrocephalus requiring shunting is Saudi Arabia will increase.

This is partly because of the continuing improvement in the neonatal intensive care and partly because of cultural and religious reasons which pressurize clinicians to continue treating these patients aggressively irrespective of their clinical condition. Neurosurgeons should be aware of the increased risk of shunt complications in infants with posthemorrhagic hydrocephalus in particular and those aged 6 months or less in general. It is recommended that the shunting procedure for this group of patients should be carried out by the consultant. Any modifications in the shunt systems to suit these small patients and to reduce the morbidity associated with their shunting are strongly welcome.[23]

Acknowledgment. The authors are grateful to Hilda A. Sumandar for her excellent secretarial assistance.

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