Child's Nervous System (2019) 35:1159–1163
https://doi.org/10.1007/s00381-019-04186-0

ORIGINAL ARTICLE

Prior endoscopic third ventriculostomy does not increase ventriculoperitoneal shunt failure rate

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Received: 11 September 2018 / Accepted: 16 April 2019 / Published online: 9 May 2019

Abstract

Purpose To determine whether prior endoscopic third ventriculostomy (ETV) influences the failure rate of subsequently placed ventriculoperitoneal (VP) shunts.

Methods Our institution's operative database and patient records were reviewed retrospectively to identify all paediatric patients who had undergone a first VP shunt or ETV at our institution between January 2012 and December 2015. Data was analysed using the Microsoft Excel, GraphPad Prism v7 and SPSS statistics. The literature on this topic to date was also reviewed.

Results Eighty-six children were included in the study: 61 patients had a primary VP shunt inserted during the study period and 25 had a VP shunt inserted following failed ETV. There was no significant difference in the underlying aetiology or age of the patients in each group. In the primary VP shunt group, 47.5% (29 patients) required shunt removal at an average of 274 days post-insertion (range 7 days to 3.4 years). The 1-year revision rate was 34.4%. In the shunt post-ETV group, 48% (12 patients) required shunt removal at an average of 207 days post-insertion (range 2 days to 2.7 years). The 1-year revision rate was 36%. The most common reason for revision in both groups was blockage.

Conclusions We found no significant difference in failure rate or pattern between primarily inserted VP shunts and those inserted following an endoscopic third ventriculostomy. On the basis of this study and the small number of previously reported studies, we would advocate a trial of ETV where feasible to allow a chance at shunt independence.

Keywords Hydrocephalus · Endoscopic third ventriculostomy · Ventriculoperitoneal shunt

Introduction

Paediatric hydrocephalus remains a challenging condition for neurosurgeons to manage. Ventriculoperitoneal (VP) shunt placement has been used successfully for many years as a life-saving treatment. Unfortunately, the complication rate of VP shunt insertion remains high. One recent prospective multi-centre study found a failure rate of 33% for a mean follow-up of 400 days [1]. Longer-term longitudinal studies suggest that half of all children will require shunt revision at some point [2]. Multiple revisions and periods of infection have a deleterious effect on the developing nervous system with respect to cognitive impairment, difficulties in school, and quality of life [3]. In addition, these periods of hospitalisation require time out of schooling for children who are often developmentally delayed as a result of the condition underlying their hydrocephalus. Endoscopic procedures are increasingly being used to avoid VP shunt placement and the associated morbidity due to the subsequent complications. Although shunt independence remains the goal clearly, there are some instances in which endoscopic third ventriculostomy (ETV) is unsuccessful and there is a need for subsequent VP shunt placement. The goal of this piece of work was to determine whether shunts placed after ETV were more likely to fail than those inserted primarily.

Methods

Our institution is based in Scotland and serves a population of 2.7 million people; there are on average 275 paediatric cases performed per year. There are a variety of management strategies used by the neurosurgical team to treat paediatric

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hydrocephalus. Within in our institution, there is a range of opinion amongst the surgeons as to how best manage this heterogeneous group of patients. The operative techniques used for both ETV and VP shunt insertion vary between surgeons. In our department, the use of endoscopic third ventriculostomy varies between surgeons. In general, we use the Kulkarni score to counsel parents. The parents are given the likelihood of success of ETV based on the available evidence and they can then make an informed decision whether to try ETV with the hope of avoiding shunt placement or whether to proceed directly to VP shunt insertion with the higher likelihood that only a single operation would be required. We retrospectively reviewed our institutions' operative database to identify all paediatric patients that had undergone either a primary VP shunt insertion or an ETV between January 2012 and December 2015. The median follow-up was 39.7 months (range 15.3–63.1 months). Data was collected from patient records and the national electronic imaging database. The Kulkarni ETV success score [4] was calculated for each patient. Data was analysed using Microsoft Excel, GraphPad Prism v7 and SPSS Statistics. Kaplan–Meier survival curves were constructed for each group and the Mantel–Cox log-rank method was used to compare the two curves.

Results

Primary shunt group

Sixty-one patients underwent primary VP shunt insertion. Twenty-six were female. The average age at insertion was 3.1 years (range 1 day to 16 years). Aetiology of hydrocephalus was tumour in 17 patients, congenital of unknown aetiology in 13, intraventricular haemorrhage in eight patients, cysts in six patients (three posterior fossa and three other intracranial locations), nine neural tube defects (seven thoracolumbar myelomeningoceles and two encephaloceles), Chiari malformation in three, two patients had schizencephaly, two were post-infectious and one patient had idiopathic intracranial hypertension. Fifty-six patients had a parietal ventriculoperitoneal shunt, five a frontal ventriculoperitoneal shunt and in one patient the position of the ventricular catheter not known. Fixed performance valves were used in 39 patients (20 Codman® Hakim® medium low pressure inline valves, 1 Codman® Hakim® low pressure inline valve, 5 Medtronic® delta 1.0 valves, 4 Medtronic® ultra-small medium pressure valves, 2 Medtronic® delta 1.5 valves and 7 Integra OSV II ®); one programmable valve was used (Codman® Hakim® programmable valve); and the type of valve was not known in 21 patients. Fourteen patients had an external ventricular drain placed prior to VP shunt insertion, and two had had a ventriculosubgaleal shunt. The median Kulkarni ETV success score was 60 (range 10–90).

Twenty-nine of the 61 patients (47.5%) required shunt removal in this group at an average of 274 days post-insertion (range 7 days to 3 years). The 1-year revision rate was 34.4%. Reasons for revision were blockage (nine patients), malposition/migration (six patients), infection (five patients), headache in three patients resulting in a change to a programmable valve, overdrainage in two patients (one patient developed a subdural haematoma), disconnection in two patients, one patient was bypassing CSF and the reason for revision was unknown in one patient. Six Codman® Hakim® medium low pressure inline valves required revision, 1 Codman® Hakim® low pressure inline valve, 4 Medtronic® delta 1.0 valves, 2 Medtronic® ultra-small medium pressure valves, 1 Medtronic® delta 1.5 valve and 3 Integra OSV II ® valves. In the remainder of the revised shunts, the primary type of valve used was unknown. Nine patients had died at the time of review, six from progression of intracranial malignancy, two from complications of Meckel–Gruber syndrome and one from sepsis unrelated to shunt insertion. The shunt was revised in one of these children. There were no other complications of ventriculoperitoneal shunt insertion.

Shunt post-ETV group

Thirty-seven patients underwent ETV in the study period; the median ETV success score was 70 (range 30–90). Of these, 25 went on to require VP shunt insertion (67.6%) at an average of 75 days post-ETV (range 2 days to 21 months). Fourteen were female. The average age at shunt insertion was 4.7 years (range 3 days to 15.6 years). The aetiology of hydrocephalus was tumour in ten patients, cysts in five patients four posterior fossa and one quadrigeminal), aqueduct stenosis in five, intraventricular haemorrhage in three, congenital hydrocephalus of unknown aetiology in one and one myelomeningocele. One patient had a re-ETV at the time of ETV failure and one patient had had an ETV many years previously at a different institution. The reasons for ETV failure were leaking from either ETV or other cranial wound in eight patients, increasing head circumference in five patients, clinical and radiological hydrocephalus in four patients, no flow through ETV seen at re-exploration in two patients with CSF infection (one after posterior fossa surgery), one failed EVD challenge after posterior fossa surgery, two patients already had a shunt in situ at the time of ETV and one patient presented with headaches. A parietal ventricular catheter was used in 24 patients and frontal ventricular catheter in one patient. Fixed performance valves were used in 17 patients (12 Codman® Hakim® medium low pressure inline valves, 3 Medtronic® ultra-small medium pressure valves and 2 Integra OSV II ®) and the type of valve was not known in eight patients. Three patients had an external ventricular drain inserted prior to ventriculoperitoneal shunt insertion. One patient developed ventriculitis following endoscopic third ventriculostomy prior to ventriculoperitoneal shunt insertion.

Table 1 Characteristics of patients and types of failure

	Primary shunt	Shunt post-ETV
Median Kulkarni ETV success score	70	70
Median age score	40	40
Median aetiology score	20	20
Median previous shunt score	10	10
Aetiology of hydrocephalus		
Tumour	17 (27.9%)	10 (40%)
Congenital	13 (21.3%)	1 (4%)
Aqueduct stenosis	–	5 (20%)
IVH	8(13.1%)	3 (12%)
Cysts	6 (9.8%)	5 (20%
Neural tube defects	9 (14.8%)	1 (4%)
Chiari malformation	3 (4.9%)	–
Schizencephaly	2 (3.3%)	–
Post-infectious	2 (3.3%)	–
IIH	1 (1.6%)	–
Reasons for shunt failure		
Blockage	9 (31.0%)	7 (58%)
Infection	5 (17.2%)	3 (25%)
Disconnection	2 (6.9%)	1 (8.3%)
Unknown	1 (3.4%)	1 (8.3%)
Malposition/migration	6 (20.7%)	–
Headache	3 (10.3%)	–
Overdrainage	2 (6.9%)	–
Bypassing CSF	1 (3.4%)	–

The median Kulkarni ETV success score was 70 for those patients who went on requiring VP shunt insertion (range 30 to 90). The median ETV success score for those patients who did not require shunt insertion was 80 (range 50–90).

Twelve patients required shunt removal at an average of 207 days post-insertion (range 2 days to 21 months). The 1-year revision rate was 36%. Reasons for revision were blockage (seven patients), infection (three patients), disconnection (one patient) and one was revised for unknown reasons. Four Codman® Hakim® medium low pressure inline valves required revision, and in the remainder of the children in this group, the initial valve type was not known. One child with Dandy–Walker syndrome died in this group; they did not require shunt removal. There was one intraventricular haemorrhage following shunt revision in this group. There were no other complications of either shunt insertion or first revision in this group.

The characteristics of both groups of patients are illustrated in Table 1. The results of both groups are shown in Table 2. Kaplan–Meier survival curves illustrating time to treatment were created for both groups and are shown in Fig. 1. There was no significant difference between the survival curves ($p = 0.92$).

Discussion

Review of the literature on this topic to date identified few studies that commented on failure rates of ventriculoperitoneal shunts after endoscopic third ventriculostomy. In their case series of 23 ETV patients aged less than 6 months, Gallo et al. reported that of the 14 patients who had a shunt inserted after ETV only, two required revision [5]. Warf et al. reviewed their institutional experience with treatment of infant hydrocephalus over a 7-year period [6]. They identified 255 patients who had undergone primary VP shunt insertion, 370 patients that had a VP shunt at the time of abandoned ETV and 275 who had had a shunt inserted after completed but failed ETV. Of the 900 patients included in the study, there were 299 shunt failures; of the remaining 601 patient, the median length of follow-up was 18.8 months. Interestingly, they found that those patients who had a shunt post-ETV had a lower failure rate than primarily inserted VP shunt ($p = 0.008$). The reasons for this are not clear. Subgroup analysis found that this apparent positive effect of prior ETV on subsequent shunt placement was only true for post-infectious hydrocephalus. When this subgroup was

Table 2 Outcomes of primary shunts and shunts inserted post-ETV

		Primary shunt	Shunt post-ETV	
Number of patients	*n*	61	25	
Mean age (years)	Mean	3.12	4.71	Independent unpaired *t* test $t = 1.48$, df (84) $p = 0.1542$
	Standard deviation	4.26	5.50	
Follow-up (months)	Mean	38.8	36.2	Independent unpaired *t* test $t = 0.8405$, df (84) $p = 0.4030$
	Standard deviation	12.9	13.6	
1-year revision rate	*n*	21	9	Fisher's exact test $p = 1.000$
	%	34.4	36.0	
Overall revision rate	*n*	29	12	Fisher's exact test $p = 1.000$
	%	52.5	48.0	
Mean time to failure (days)	Mean	274.0	207.8	Independent unpaired *t* test $t = 0.5748$ df (39) $p = 0.5687$
	Standard deviation	353.0	285.6	

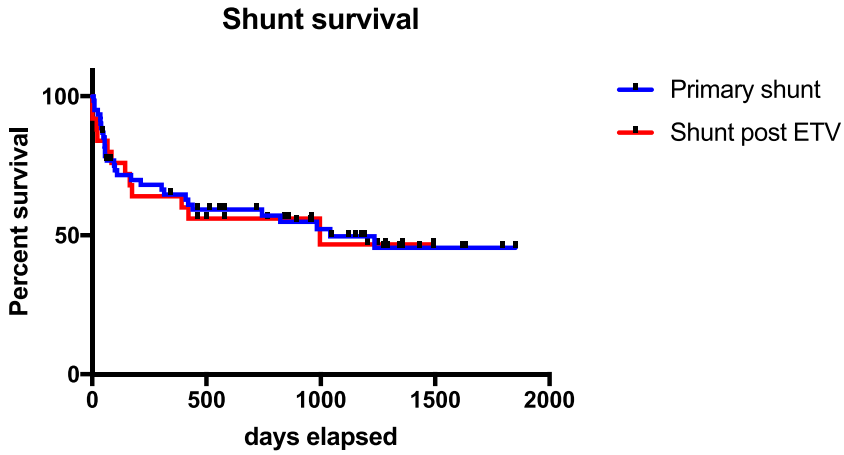

Fig. 1 Kaplan–Meier curve illustrating shunt survival for each group

removed, there was no significant difference between the primary shunt and shunt post-ETV group ($p = 0.92$).

Kulkarni and colleagues performed a post hoc analysis on the prospectively collected data from the International Infant Hydrocephalus Study [7]. They identified 43 infants who had primary shunt inserted and 34 children who had had a shunt post-ETV in infants with aqueductal stenosis. The median follow-up was 800 days. Shunt failure was observed in nine (20.9%) primary shunt patients and ten (29.4%) of shunt post-ETV patients. There was no significant difference in the survival curve between the two groups.

Our study adds to those previously published. We found no significant difference in the failure pattern for shunts inserted after failed endoscopic third ventriculostomy compared with primarily inserted ventriculoperitoneal shunts. The findings of the two comparative cohort studies and our study are summarised in Table 3. There are some differences in baseline characteristics. The mean age of the patients in the primary shunt group in our study was 3.12 years and in the shunt post-ETV group was 4.7 years. This is much older than either of the other two studies. The patients in the study by Warf et al. had a mean age of 9.0 months in the shunt post-ETV group and 9.8 months in the primary shunt group. The patients in the Kulkarni study had a mean age of 3.6 months in the shunt post-ETV group and 2.2 months in the primary shunt group. By design, the Kulkarni study also included only patients with aqueduct stenosis, whereas our study and that of Warf et al. show a diverse range of pathologies.

Table 3 Summary of literature to date on primary shunt versus shunt post-ETV

Study	Number of patients	Shunt Failure rate	Conclusion
Warf et al.	900	33.2% for all patients (median follow-up 28.7 months)	Increased failure rate in primarily shunted patients compared with shunt post-ETV patients
Kulkarni et al.	77	29.4% for shunt post-ETV, 20.9% for primary shunt (median follow-up 800 days)	No significant difference in failure pattern
Current study	86	48% for shunt post-ETV (mean follow-up 36.2 months), 52.5% for primary shunt (mean follow-up 38.8 months)	No significant difference in failure pattern

We found that there continue to be high rates of shunt failure within our paediatric population and that the most common reason for shunt failure remains obstruction (39% of all revisions) as previously described by Kestle et al. [8]. Our 1-year revision rate of 34.4% in the primary shunt and 36% in the shunt post-ETV group is similar to the 38% 1-year revision rate quoted in the same study. We found that endoscopic third ventriculostomy is a safe and well-tolerated procedure with a low complication rate. However, we also found a higher failure rate of endoscopic third ventriculostomy than would have been predicted by the Kulkarni ETV success score. The reasons for this are not clear. It is not always easy to define ETV failure and there is range of opinion within our department. What is clear is that there was a relatively high rate of CSF leak in our study. Some clinicians would interpret this as clear evidence of ETV failure due to an underlying CSF hydrodynamic problem whilst others would interpret this as a problem with wound closure and not necessarily as a direct cause of ETV failure. Patients who had CSF leakage or infection post-ETV were not more likely to develop shunt infection. Ten of shunt post-ETV patients had either CSF leakage or infection post-ETV; of these, four went on to require shunt revision but only one of these was for infection.

Limitations of this study are the small sample size and heterogeneous nature of the underlying aetiology of hydrocephalus in both groups; however, this is an accurate reflection of everyday paediatric neurosurgical practice.

We found that failed endoscopic third ventriculostomy had no effect on subsequent ventriculoperitoneal shunt failure rate in our group of patients. The authors would support a trial of endoscopic third ventriculostomy where feasible to allow children a chance at shunt independence.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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