

Third ventriculostomy vs ventriculoperitoneal shunt in pediatric obstructive hydrocephalus: results from a Swiss series and literature review

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Abstract

Introduction Few series compare endoscopic third ventriculostomies (ETV) and ventriculoperitoneal shunts (VPS). To avoid the complications after a shunt insertion, there is an increased tendency to perform a third ventriculostomy. We reviewed all pediatric patients operated in the French-speaking part of Switzerland for a newly diagnosed obstructive hydrocephalus since 1992 and compared the outcome of patients who benefited from ETV to the outcome of patients who benefited from VPS. There were 24 ETV and 31 VPS.

Discussion At 5 years of follow-up, the failure rate of ETV was 26%, as compared to 42% for the VPS group. This trend is also found in the pediatric series published since 1990 (27 peer-reviewed articles analyzed).

Conclusion In accordance to this trend, although a statistical difference cannot be assessed, we believe that ETV should be the procedure of choice in pediatric obstructive hydrocephalus.

Keywords Pediatric · Hydrocephalus · Ventriculostomy · Ventriculoperitoneal shunt

Introduction

In the last decades, endoscopic third ventriculostomy (ETV) has become the procedure of choice in the treatment of pediatric obstructive hydrocephalus in many centers, replacing ventriculoperitoneal shunts (VPS). Even if the procedures might seem simple, the pathophysiology of hydrocephalus is complex and probably not completely understood; therefore, management of patients with hydrocephalus can be challenging. Since the introduction of the shunt, many new materials have been developed, with each development bringing the hope that the new materials will lead to a better outcome. Some surgeons think that endoscopic third ventriculostomy was the key to success in the cure of hydrocephalus, but does its outcome confirm that thought? Many articles have been published concerning the mortality and morbidity, as well as the outcome, of both approaches. Ventriculo-atrial and VPS have been compared, as well as different types of valves for VPS, but the comparison between third ventriculostomies and cerebrospinal fluid shunts has rarely been addressed.

We studied all pediatric patients diagnosed with obstructive hydrocephalus who were treated in Geneva or Lausanne, Switzerland since 1990. After analyzing the two groups, their outcome and failure rate, we retrieved the last pediatric series published in peer-reviewed literature (on ventriculostomy or VPS from 1990 to June 2006) to compare the two procedures and to see if a difference could be seen in their outcomes. A strict meta-analysis of those series is not possible, as there are, for the moment, no randomized controlled trials.

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Materials and methods

All pediatric patients (0–18 years old) who were diagnosed and treated for the first time for obstructive hydrocephalus, in Lausanne or Geneva, Switzerland, from January 1990 to December 2004 were retrospectively analyzed. There were 24 ETV and 31 VPS performed. Data were analyzed with respect to etiology of hydrocephalus, age, and gender. We compared the operative indications, and in the case of failure, the mean time before revision, the causes of failures, and their risk factors. Failure was defined as the need of a surgical intervention, and included shunt revision, placement of a new shunt, or a new ventriculostomy.

The literature was reviewed using PubMed and Embase, from 1990 to June 2006 with the key words “obstructive hydrocephalus” and “pediatric”, in peer-reviewed journals. Tables of content of the major pediatric neurosurgical journals (Child’s Nervous System, Journal of Neurosurgery: Pediatrics, and Pediatric Neurosurgery) were reviewed as well from 2000 to 2006. All pediatric series that involved more than ten patients and analyzed either third ventriculostomy, shunt procedures, or both were included. Articles describing a technique or only focusing on a special type of complication were not included, unless the general success rate (or failure) and follow-up time were stated. When different articles were written with the same or only slightly different population (for example two studies in the same center overlapping), only one of the articles was included to avoid including the same patients twice. If a series mixed pediatric and adult patients, it was discarded, unless the pediatric population was easily identified. If a series included both obstructive and communicating hydrocephalus, we would consider it only if there was a majority of obstructive patients or if we could separately analyze obstructive patients. In series that included first-time shunts and revisions, we only accounted for the first-time surgery when that was possible. A total of 27 studies were retrieved and included.

Data were analyzed using Student’s *t*-test, Kaplan–Meier, and analysis of variance (Statistica 6.0, StatSoft).

Results

There was a total of 48 patients included. Seven of them had both procedures; therefore, there were 55 new procedures. The mean age of the total population was 4.6 years old (median 8.8 months, 1 day to 17 years). Twenty-four (50%) patients had a failure of their first operation and needed revision. The mean number of revisions was 1.28 (0–15 times). The mean revision-free time was 22 months (median 4.6 months, 1 day–9 years). The follow-up period was 4.4 years (median 39 months).

Third ventriculostomies (ETV)

A total of 24 new ventriculostomies were performed. The patients had a mean age of 6.1 years (median 6 years, 23 days to 17 years old). There were 7 girls and 17 boys. Patients who had had their shunt inserted during the inclusion period and had an ETV after the first shunt failure were also considered in this category (two patients).

There were 11 patients with an aqueductal stenosis, 6 patients with a posterior fossa lesion (four posterior fossa tumors and two cysts), 5 patients with a tectal or tegmental lesion, and 2 patients with another obstructive etiology (membranes in aqueduct after toxoplasmosis, Chiari I).

Eight patients had a failure of their ventriculostomy (33%), leading to a new procedure. In three cases, they underwent a re-ventriculostomy, whereas five patients had a VPS implanted. The mean revision-free time was 19 months (median 1 month, 13 days–9 years). The mean number of revisions was 0.33 times (0–1 times). The follow-up period was 45 months (median 33 months, 14 days–14 years).

Ventriculoperitoneal shunts

A total of 31 new VPS were placed. The patients were 3.5 years old on average (median 5 months, 1 day to 16.5 years old). There were 17 girls and 14 boys. The patients who underwent a VPS after a ventriculostomy failure are included, when the first treatment (ETV) was done during the inclusion’s period (three patients).

There were ten patients with a posterior fossa lesion (five tumoral lesions, three hemorrhagic lesions, two cysts), four patients with a tectal or tegmental lesion, eight patients with an aqueductal stenosis, and nine patients with another obstructive etiology (one Chiari I malformation, one with aqueductal membranes after toxoplasmosis, seven myelomeningoceles).

Sixteen patients had a shunt failure (52%) and 11 underwent a shunt replacement, whereas 5 underwent a ventriculostomy. The mean revision-free time was 24 months (median 7 months, 1 day–8.8 years). The mean number of revisions was 1.6 times (0–15 times). The cause of the first failure was disconnection in two cases, proximal occlusion in five cases, distal occlusion in one case, valve dysfunction in three cases, and infection in two cases (6% of the total procedures and 11% of the patients needing revision). In three cases, we were not able to retrieve the cause of failure from the data. The follow-up period was 57.5 months (median 50 months, 10 days–11.5 years).

Comparison of the two groups

There were slightly more boys in the ventriculostomy group and more girls in the VPS group. The age was not

significantly different between the two procedures, but tended to be younger for the shunted patients ($p=0.09$). The distribution of etiologies is slightly different between the two groups; however, they are all considered as obstructive hydrocephalus (Fig. 1).

The number of revisions per patient was higher for the VPS group ($p=0.06$). There was a slightly longer follow-up period in the VPS group (mean 57 months vs 45 months, $p=0.31$), as this procedure has been performed for a longer time in the two hospitals and only progressively replaced by ETV.

In the ETV group, 8 of 24 patients (33%) needed a revision, whereas 17 of 33 (52%) of the VPS group had a shunt failure. The revision-free time is not significantly different between the two procedures (24 months for VPS and 19 months for ETV, $p=0.75$), but tends to be longer in the VPS group.

The majority of patients in the ETV group underwent only one procedure, although some had a second procedure after closure of the first ventriculostomy. In the VPS group, even if a majority underwent only one procedure, some patients had to undergo more than ten operations.

The number of revisions shows a lower number of revisions in the ETV group per patient; however, there might be a bias, as only three children benefited from a re-intervention consisting of ETV, and all the other ETV failures underwent VPS placement.

The primary cause of failure in the ETV group was closure of the ventriculostomy, although there might have been a bad appreciation of the underlying physiopathology and an associated mal-resorptive hydrocephalus in a few cases. In VPS patients, shunt failure resulted from proximal or distal occlusion, disconnection, valve dysfunction, or infection.

If the percentage of patients free of revisions is considered over time, with definite follow-up period at 6 months, 1, 2, and 5 years after the initial surgery, the

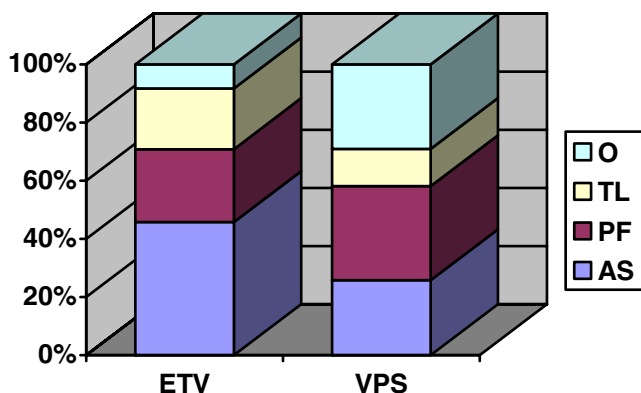


Fig. 1 Etiology of hydrocephalus: There is a majority of cases with aqueductal stenosis in the ETV group, whereas in the VPS group, posterior fossa lesion and other types of lesions are predominant. *PF* posterior fossa lesion, *AS* aqueductal stenosis, *TL* tectal/tegmental lesion, *O* other

dynamic of revisions can be better understood and is shown in Table 1.

There were no statistical differences between the two procedures when analyzing the percentage of patients being revision-free or needing a revision at 6 months, 1, 2, or 5 years (Table 1). The respective failure rates at 2, 5, and 10 years were 26, 26, and 30% for ETV and 34, 42, and 51% for VPS, respectively. Although the majority of patients had a follow-up greater than a year (mean follow-up, 52 months; median, 39 months), a number of patients did not reach 2–5 years, and some others were lost to follow up.

There is a constant decrease in the Kaplan–Meier survival curve (Fig. 2) until 1 year for the VPS patients, then a slowing of that curve. For the ETV patients, there is a rapid decrease at the beginning (first 2 months), then a decrease in the slope, and finally, a constant number. The difference between the two curves is not statistically different. The mean time until first revision is 18 months (median 1.1 months) for ETV, whereas it is 24 months (median 8.8 months) for VPS ($p=0.75$).

There were three unrelated deaths, one in the ETV and two in the VPS group: In all cases, they were at the end-point of tumor progression

Complications There were no major complications in this series, but three children in the ETV group and one in the VPS group developed sub-dural hematomas. In one case of each group, the sub-dural hematoma had to be drained because it had a significant mass effect and led to clinical symptoms. Some patients underwent over- or under-drainage, sometimes handled with an adjustable valve and sometimes needing a surgical intervention, but those patients, as well as the misplaced shunts, have been analyzed in the failures and not in the complications.

Literature

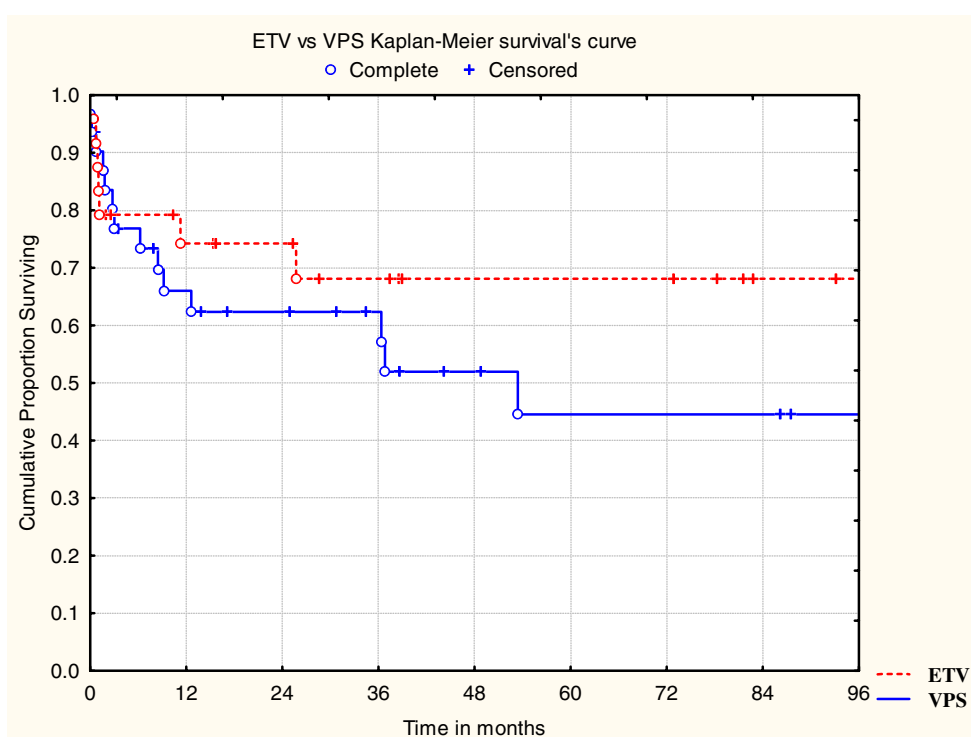
A total of 27 studies were found that included 3,768 VPS patients and 1,624 ETV patients in total. Seventeen series analyzed ETV, seven studies examined shunts alone, and three

Table 1 Percentage of patients who were revision-free

Pediatric	6 months	1 year	2 years	5 years
ETV	70%	65%	52%	30%
VPS	77%	66%	55%	24%
	$p=0.61$	$p=0.87$	$p=0.94$	$p=0.61$

Percentage of patients being revision-free over time for both the ETV and the VPS group. Although there is no significant differences, there is a trend toward less patients needing a revision in the ETV group. At 5 years, there is a sudden drop in both groups due to the fact that some of the patients in the study did not reach this follow-up time (median follow-up time, 39 months).

Fig. 2 Kaplan–Meier survival curve plotted for VPS and ETV. There is a rapid decrease in the first 3 months for ETV, and then a relative plateau, whereas there is a more constant decrease in the VPS group



studies compared the two procedures (Table 2) [2–4, 6, 10, 12, 14, 15, 20–22, 25–30, 32, 33, 35, 36, 39–41, 43–45]. As previously stated, meta-analysis could not be performed. However, a mean failure rate can be obtained when adding all the series and weighting them according to their sample size.

A grouping of all patients from the pediatric series published who had benefited from a ventriculostomy revealed a failure rate of 44%. The same analysis with the children who had benefited from a shunt indicated a mean failure rate of 49% ($p < 0.05$). These numbers are only indications, as there is a large amount of variability in the populations studied in these articles.

In articles reporting ventriculostomies, the failure rate ranges between 8 and 69%, or between 8 and 47% when the series including infants are excluded. When the follow-up of the series is greater than 2 years, the lowest failure rate is 15%. In series of VPS, the failure rate range is 27 to 70%, and 56 to 70% when only analyzing series with a follow-up greater than 2 years. Once again, the failure rate is on the higher side when infants are considered (63%) [33]. It is important to note that most of the third ventriculostomy series do not consider operations that were planned, but abandoned, during the procedure for technical difficulties or complications, as failures. Only a few series mentioned the number of procedures planned but not achieved, and in those series, the ventriculostomy was not possible in 3.4–7% of patients. This contrasts the series on VPS, where all patients are accounted for (a drain in a wrong position would be considered as a failure, as there is a need for a second operation).

Discussion

The management of hydrocephalus is a never-ending problem, and many studies analyzed the treatment options and outcomes [5, 19, 20, 24, 28, 34, 37, 45]. Endoscopic procedures increased in popularity because they provide the opportunity for the patient to be shunt-free. At first, indications for third ventriculostomies were restricted to obstructive hydrocephalus, but some literature suggests that it might also be expanded to some cases of non-obstructive hydrocephalus [7, 16]. However, the hope of being cured should not be confused with being shunt-free. Hydrocephalus might be treated with an ETV; however, the stomy might fail as would a VPS. Progressively, ETV has been replacing VPS as a treatment for obstructive hydrocephalus, with the belief that no shunt is better than the best shunt. In the series reported herein, all cases had an obstructive hydrocephalus, but sometimes, the pathophysiology behind the hydrocephalus might not be understood, and appreciation of the situation might be difficult (some resorption malfunction might be added to the obstructive etiology).

In our series, at 3 years (median follow-up being 3.25 years), the failure rate of ventriculostomy is 26%, whereas it is 38% for VPS ($p = 0.35$); although there are statistical differences, there is a trend toward lower failure rate in the ETV group. In literature, the rate of failure of ETV in the literature is highly variable (8–69%) [4–6, 18, 39]. The rate of failure in ventriculoperitoneal patients is highly variable as well (27–70%) [8, 9, 24, 28, 37]. The success of both procedures might vary depending on the

Table 2 Literature review

Study	Nb ETV	Nb VPS	Mean age ETV	Mean age VPS	Failure rate ETV (%)	Failure rate VPS	FU
Piatt and Carlson [30]		727		ped		73 months (median survival)	
Robinson et al. [33]		158		<1 years		63% 5 years	39.8 months
Vinchon et al. [41]		1564		29.3 months		70%	10.7 years
Tuli et al. [40]		717		1.5 years		56%	11 years
Aryan et al. [2]		11		4.5 years		27%	19 months
Kestle and Walker [25]		201				33%	1 year
Warf [43]		152				46, 00%	1 year
Jones et al. [21]	24		8.4 years		38		
Cinalli et al. [6]	213				28		45 months
Kim et al. [26]	32		5.2 years		19		19 months
Beems and Grotenhuis [4]	66		5 months		47		4 years
Mohanty et al. [28]	72		? (ped)		18		15 months
Wellons et al. [45]	13		10 years		15		31 months
Singh et al. [35]	29		0–2 years		28		1–18 months
Smyth et al. [36]	12		9.2 years		33		20 months
Gorayeb et al. [15]	36		4.7 months		36		47 months
Koch and Wagner [27]	16		3 months		69		29 months, median 25
Baykan et al. [3]	210		2 months–10 years		8.10		3 months
Etus and Ceylan [10]	25		6 months		44		1 year, 8 months
Fritsch et al. [12]	18		4.9 months		61		50 months
Kadrian et al. [22]	22		(6–24 months) 0–78 years		42		5 years
Ray et al. [32]	43				30		24 months
Warf [44]	550		14.5 years		44		14.3 months
Navarro et al. [29]	136				37		3.3 years
Tuli et al. [39]	32	210	8.1 years	3.6 years	44	45%	1 to 11 years
Javadpour et al. [20]	21	26	6 weeks (median)	2 weeks (median)	67	na	18 months
Garton et al. [14]	28	28			46	60%	34.7 months

Twenty-seven studies were found in the literature.

Nb ETV/VPS number of patients included in the study who underwent ETV/VPS. *Mean age ETV/VPS* mean age at which the procedure was done. *Failure rate ETV/VPS* the failure rate in percentage. *FU* the mean follow-up (when not available, the range is given). *na* not available. *ped* pediatric series

age of the patient, with a higher failure rate for infants [4, 8, 15, 27, 33, 42].

The difference in failure rate between ETV and VPS in the first 6 months of follow-up might reveal either technical difficulties in the ETV group (small space in front of basilar artery, arachnoid membranes lower down the clivus,...) or a bad appreciation in the selection of the patient for the operation [13]. Unfortunately, late failures do occur in both groups, as evidenced by reports of sudden deaths in the literature [40, 17]. This implies that long-term follow-up is needed in all patients, and that children who underwent ETV cannot be considered as cured.

Procedure-related complications that are reported in the literature are also different between the two procedures,

with more major complications reported with ETV such as basilar artery perforation and diabetes insipidus [1, 3, 17, 29, 34]. On the other hand, some of the complications are the same for both procedures, including infections that sometimes lead to fatal meningitis. The reported complication rate varies from 6 to 11% [1, 29, 34]. The complications encountered in our series of ventriculostomies are similar to those found in the literature.

It has been questioned whether shunt infections might affect the IQ [23, 31, 38], but to our knowledge, there have been no studies done on cognitive dysfunction after ventriculostomy failure. A rare, but fatal complication in the treatment of hydrocephalus is an acute dysfunction with a rapid increase in intracranial pressure and sudden death,

which might occur many months or years after the procedure, and seems to happen more frequently in ETV [17] than in shunting procedures [19, 40]. One hypothesis is that, in shunted patients, there is a progressive dysfunction of the shunt, with either some drainage around the shunt in obstructive failure or within the fibrotic tunnel in disconnection. A second reason might be the patient's and family perception of the disease: Although they are well aware of any symptoms that might be caused by shunt dysfunction, and react promptly by coming to the attention of a medical care giver, there might be a popular and medical belief that third ventriculostomy is a one-time curative procedure, and therefore, the patients or their families might not react to the first signs of re-obstruction. Therefore, follow-up of patients is necessary in all cases, but the management of the patients might not be exactly the same. For example, ETV might not change the size of the ventricles, and the patency of the stomy has to be assessed (with 2-D cine phase contrast or T2-weighted fast spin echo) [11], whereas in the follow-up of shunts, ventricular size might be assessed, as well as continuity of the shunt [24].

Conclusion

Our personal series does not enable us to state that third ventriculostomy is a better treatment for obstructive hydrocephalus than shunt. However, there is a tendency in long-term follow-up for ventriculostomy to be associated with less revisions and a larger revision-free time. The same trend, with a lower failure rate, is seen in the literature. However, the morbidity associates to the procedure, according to literature, might be higher in ventriculostomies than in VPS. We would, therefore, advise to carefully select the patients in which ETV might be of benefit and to keep it as the treatment of choice in obstructive hydrocephalus of those patients.

Patient awareness is extremely important, as late obstruction might occur with both procedures. The patients and their families should be followed on long-term basis and informed on signs and symptoms that might occur in recurring hydrocephalus.

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