Ventricular reservoirs and ventriculoperitoneal shunts for newborn infants with hydrocephalus: An institutional experience.

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Abstract

Background: Hydrocephalus is a common condition that leads to progressive ventricular dilatation caused by physical or functional obstruction of cerebral spinal fluid flow. The main treatment for hydrocephalus is surgical.

Objectives: The aim of our study is to present our experience on patients for whom a ventricular reservoir and/or ventriculoperitoneal shunt was placed because of progressive hydrocephalus.

Methods: The record of patients who were born between 2013-2018 and diagnosed with progressive hydrocephalus was reviewed retrospectively. Demographical and clinical characteristics, complications and the need for ventriculoperitoneal shunt were documented.

Results: Among the 68 babies, 25 babies were preterm (median birth weight 2650 g; mean gestational age 36 weeks), 43 babies were determined as term (mean birth weight 3195 g; mean gestational age 39 weeks). The etiology of hydrocephalus was spinal dysraphism in 49 (72%) patients, congenital hydrocephalus in 13 (19.1%) patients, intraventricular hemorrhage in 6 (8.9%) patients. Mean placement time of the reservoir was 27.1 (range 4 – 57) days of birth, while the mean age at which a reservoir was converted to a permanent shunt was 49.4 (20 – 92) days. Ventriculoperitoneal shunt was placed to 66 infants (97.1%). Complications related to the reservoir were skin necrosis in one patient. Five infants (7.4%) died; three of five infants had major cardiac malformation and two of five babies who have anomalies of other systems.

Conclusion: In preterm babies with low birth weights and term infants who have intraventricular hemorrhage VP shunt surgery may not be performed. Ventricular temporary reservoir placement is effective procedure for cerebrospinal fluid drainage in cases of progressive hydrocephalus.

Introduction

Hydrocephalus results from the imbalance between production and absorption of cerebrospinal fluid (CSF). Congenital forms of hydrocephalus are particularly complicated, both anatomically and mechanistically. Hydrocephalus is heterogeneous and complex in pathogenesis. Definition of the hydrocephalus is that proposed as part of the International Hydrocephalus Working Group, which Hydrocephalus is an active distension of the ventricular system of the brain resulting from inadequate passage of CSF from its point of production within the cerebral ventricles to its point of absorption into the systemic circulation [1-3].

Hydrocephalus was recently estimated to affect 1.1 in 1000 infants. Since long term increased intracranial pressure and ventricular dilatation affect neuronal development negatively, timely intervention for neonatal progressive hydrocephalus decreases the morbidity and mortality rate. In preterm infants with intraventricular hemorrhage (IVH), drainage of the CSF is recommended when the ventricular diameter is 4 mm above the 97th percentile according to the ventricular index values developed by Levene [4]. In infants in whom an indication for drainage of cerebrospinal fluid is found, different methods are used in different centers with this objective (e.g. serial lumbar punctions (LP), subcutaneous ventricular reservoir, ventricular tap or extraventricular drainage) [5-8].

In our study, retrospective assessment of newborn patients who operated with the diagnosis hydrocephalus in our clinic was performed. The aim of our study is to present our experience on patients for whom a ventricular reservoir and/or ventriculoperitoneal shunt was placed because of progressive hydrocephalus and to highlights the evidence-based recommendations for pediatric hydrocephalus to healthcare professionals who often deal with the same disorders.

Methods

From 2013 to 2018, a total of 68 preterm and term neonates were followed up in Istanbul Hospital of Başkent University Medical Faculty-Turkey and in whom V/P shunt or

subcutaneous ventricular reservoir were examined retrospectively. The study was approved by the institutional review board. We retrospectively reviewed the medical records of these patients to analyze the outcome and complications of reservoir placement and permanent VP shunt. All newborn infants were initially admitted to the neonatal intensive care unit and cranial ultrasonography, magnetic resonance imaging (MRI) or computerized tomography was performed in patients who had congenital hydrocephalus, myelochisis and IVH.

The indication for placement of reservoir was decided according to the increase in ventricular dilatation on cranial ultrasonography (a ventricular diameter 4 mm above the 97th percentile according to the "Levene" criteria) and/or findings of increased intracranial pressure and presence of periventriular edema which is the radiological indication for this.

All patients received initial placement of either a VP shunt or a ventricular reservoir. Our strategy was to perform intermittent reservoir tapping until the preterm infants were of appropriate weight; we then determined the need for permanent shunting on an individual basis.

In patient in whom reservoir was placed, removal of CSF from the reservoir (10-20 mL/kg) according to ventricular index (VI) measurements was performed every day on the initial days. The frequency of removal of CSF was judged by the measurement of head circumference, tension of the anterior fontanel, and ventricle size seen on cranial ultrasonography.

Shunt surgery was performed in patients with progressive hydrocephalus who had a CSF protein of <1.5 g/L, whose body weight reached 2500 g and who had no finding of infection.

Data Analysis

Statistical analysis was carried out using PASW statistical software (v. 18; SPSS Inc, Armonk, NY, USA). Averages of the results and standard deviations were measured using descriptive statistical methods. Normal distribution for the continuous variable was assessed by Shapiro–Wilk's test, and all data were analyzed with nonparametric tests according to the test results. The median values were compared using Mann–Whitney's U test and Kruskal–Wallis test followed by Dunn's test. P values less than 0.05 were regarded as statistically significant.

Results

A total of 68 neonates with a median gestational age of 38 weeks (36-39 weeks) and a median birthweight of 3150 g (2615-3525 g) were included in this study, between 2013 and 2018, 25 of whom were preterm and 43 of whom were term. The mean birth weight and the mean gestational age were significantly lower in the preterm group (p<0.001, p<0.001, Table 1). There was no statistically difference in male gender, delivery mode and birth place between groups (Table 1).

Table 1. Demographic properties of the subjects.

Variables	Preterm (n: 25)	Term (n: 43)	p-value
Birth weight (grams)	2650	3195	<0.001
(Median, 25% - 75%)	(1650-3160)	(2820-3840)	
Gestational age (weeks)	36	39	<0.001
(Median, 25% - 75%)	(32.5-36.5)	(38-40)	
Gender (n, %)			
Male	11 (44%)	23 (53.5%)	0.615
Female	14 (56%)	20 (46.5%)	
Birth place			
In center	0	0	---
External Center	25 (100%)	43 (100%)	
Delivery mode			
C/S	18 (72%)	38 (88.4%)	0.08
NSD	7 (28%)	5 (11.6%)	

The most common causes of progressive hydrocephalus in our patients are shown in Table 2. Spinal dysraphism accompanied to 49 patients from 68 (72%). Additionally, in 23 of the patients (33.8%) Chiari malformation, in 8 of them (11.8%) corpus callosum dysgenesis/agenesis, in one of them (1.5%) Dandy-Walker malformation, and in one of them (1.5%) holoprosencephaly accompanied to hydrocephalus table. No pathology accompanying to hydrocephalus was observed in 25 patients (36.8%).

Table 2. The etiology and shunt characteristics.

Variables	Preterm (n: 25)	Term (n: 43)	p-value
Intraventricular hemorrhage (n, %)	6 (24)	0	
Congenital (n, %)	7 (28)	6 (14)	0.044
Myeloschisis (n, %)	12 (48)	37 (86)	0.001
VP shunt placement age (median, 25%-75%)	9 (6-49)	5 (3-8)	<0.001
Need of shunt revision surgery (n, %)	3 (12)	6 (14)	0.819

Subcutaneous reservoir was placed in eight preterm infants because of congenital hydrocephalus (n=2) and IVH (n=6). The mean time of placement of reservoir was 27.1 (4-57) days, and the mean indwelling weight was found 2071 ± 681 (1230 - 3300) g. The mean age at which a reservoir was converted to a permanent shunt was 49.4 ± 24 (20-92) days. The infants who initially received reservoirs were significantly smaller (median, 30.5 weeks vs 38 weeks) in gestational age and lighter (median, 1295 g vs 3165 g) in birth weight than those who received VP shunts initially (p<0.001, p<0.001, respectively). Among patients in whom reservoir was placed, skin necrosis was found in one patient. Central nervous system infection was not found in any patient.

Sixty-six patients (97.1%) underwent permanent CSF diversion procedures. This group included eight patients with persistent hydrocephalus despite initial reservoir placement and 60 patients who received permanent VP shunts initially. The median age at VP shunt placement was significantly different between term and preterm infants (p<0.001) days (Table 2).

Shunt dysfunction developed in three preterm and six term babies (n=9, 13.2%) and shunt revision operation was performed. The causes of shunt dysfunction were shunt infections (n=6) and mechanic reasons (n=3). The rate of shunt revision surgery was similar between groups (p=0.81) (Table 2).

Five infants (7.4%) died, three of five infants had major cardiac malformation (double outlet right ventricle 1%) and one of them had major gastrointestinal anomaly and the last one with hypotonic infant died because of nosocomial sepsis.

Discussion

Hydrocephalus is related with a disorder in absorption or circulation of the cerebrospinal fluid. Hydrocephalus is divided into congenital and acquired forms. Aquaductal stenosis, Dandy-Walker malformation, Chiari Type 2 malformation and X-linked hydrocephalus may lead to congenital hydrocephalus. Neoplasms, posthemorrhagic hydrocephalus and meningitis may lead to acquired hydrocephalus [3]. The most accompanying pathogen to congenital hydrocephalus is spinal dysraphism (meningocele/meningomyelocele) condition and hydrocephalus is seen in most of the patients with spinal dysraphism [9]. In our study, the most common pathology of hydrocephalus in both term and preterm patients was spinal dysraphism. This is due to the fact that our hospital is a surgical center for spinal dysraphism, and all cases are transferred to us from the external center.

Various treatment modalities have been suggested for hydrocephalus in preterm and term newborn infants. Although some of medical drugs (carbonic anhydrase inhibitors and osmotic diuretics) had been tried to reduce CSF in the treatment of hydrocephalus, the effect of this treatment is temporary, and, these drugs are not recommended as methods to reduce the need for shunt placement [10,11]. According to underlying etiology and pathology, surgical treatments include repeated lumbar punctures [8], serial ventricular taps [8], streptokinase [12], DRIFT (drainage, irrigation, and fibrinolytic therapy) [10], temporarily reservoir placement [7], endoscopic third ventriculostomy [13], ventriculosubgaleal shunts [14] and VP shunt placement [15]. The routine use of serial lumbar puncture is not recommended to reduce the need for shunt placement or to avoid the progression of hydrocephalus in infants [11]. Similarly, intraventricular thrombolytic agents including tissue plasminogen activator, urokinase, or streptokinase are also not recommended as methods to reduce the need for shunt placement [11].

Endoscopic third ventriculostomy and the surgical placement of a VP shunt which is transfer CSF in ventricles to peritoneum are options in the treatment of progressive hydrocephalus [6,15]. There is insufficient evidence to demonstrate an advantage for one shunt hardware design over another in the treatment of pediatric hydrocephalus [16]. Medium pressure ventriculoperitoneal shunt was preferred in our cases. Other methods can be tried to prevent excessive pressure on the brain parenchyma in newborns in whom shunt surgery cannot be performed. Ventricular reservoir is an alternative method which allows CSF drainage before shunt surgery in these patients. For instance, in low birth weight infants who intraventricular hemorrhage, VP shunt surgery may not be performed because of increased CSF protein and low weight of the infant [6,7]. Intermittent CSF drainage prevents the development or progression of hydrocephalus, while also removing blood and protein from CSF. Therefore, efficient CSF drainage is provided with ventricular reservoir before shunt surgery in preterm infants. In our center, serial ventricular reservoir tapping was used until preterm babies could gain weight, and, if hydrocephalus persisted VP shunt was inserted. Although complications of ventricular reservoir including infections (meningitis, ventriculitis), skin necrosis or fistula [6,7], no any serious complication occurred in our patients, except for one patient who skin necrosis. The mean time of placement of subcutaneous ventricular reservoir is varying between 9 and 184 days [7,17] and the rate of requirement for shunt reported as 43-88% in these patients [3,6,17]. In our patient group the mean time of placement of reservoir and the rate of requirement for shunt was same.

Shunt dysfunction is the important complication that owing to mechanic or infective reasons. There is insufficient evidence to recommend either shunt externalization or complete shunt removal as a preferred surgical strategy for the management of CSF shunt infection. Therefore, clinical judgment is required [18]. Overall 48% of infants had their shunts revised in the present series. Revised shunt rates as high as 68% have been reported in the literature, especially in premature infants who had IVH [9,14,19]. In the recent study Aykanat et al. [9] has been reported only 7% shunt dysfunction in term infants who had hydrocephalus. In our study, shunt dysfunction developed in 13.2% of babies and their shunt was revised. Although it changes depending on prognosis etiology, the survival rate of the patients with hydrocephalus is around 90%, but, half of the untreated cases have been reported to die in the first three years [20]. The mortality rate was not high than the literature in our study.

Our study has limitations. Retrospective study design was a limitation. We had no access to long-term follow-up because many of babies were followed up in the hospitals where they were born. Our study was further limited by the heterogeneity of the study patients. Last, some of these patients had been included in a prior publication.

Conclusion

Because of there is insufficient evidence to recommend a specific weight or CSF parameter to direct the timing of shunt placement in premature infants with progressive hydrocephalus [11], clinical judgment is still having more importance. Birth weight and age are critical parameters in choosing a treatment strategy of progressive hydrocephalus. In preterm babies with low birth weights and term infants who have intraventricular hemorrhage VP shunt surgery may not be performed. These infants benefitted from an initial ventricular reservoir placement followed by more permanent VP shunting.

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