DOI: 10.5137/1019-5149.JTN.18677-16.0
Received: 01.08.2016 / Accepted: 30.08.2016
Published Online: 11.10.2016

Turk Neurosurg 28(1):137-141, 2018

Original Investigation

Early Endoscopic Ventricular Irrigation for the Treatment of Neonatal Posthemorrhagic Hydrocephalus: A Feasible Treatment Option or Not? A Multicenter Study

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This study was presented in the 43rd Annual Meeting of ISPN, October 4-8, 2015, İzmir, Turkey

ABSTRACT

AIM: Neonatal intraventricular hemorrhage (IVH) usually results in posthemorrhagic hydrocephalus (PHH). This multicenter study describes the approach of early neuroendoscopic ventricular irrigation for the treatment of IVH/PHH and compares the results with the cases that have been initially treated only with conventional temporary cerebrospinal fluid (CSF) diversion techniques.

MATERIAL and METHODS: The data of 74 neonatal PHH cases, that have been treated at three pediatric neurosurgery centers, were retrospectively analyzed. 23 neonates with PHH underwent early endoscopic ventricular irrigation (Group-A). 29 neonates were initially treated with conventional methods (Group-B). 22 neonates underwent ventriculosubgaleal shunt placement (Group-C). Complications, shunt dependency rates, incidence of multiloculated hydrocephalus and incidence of CSF infection were evaluated and compared retrospectively.

RESULTS: Group-A, Group-B and Group-C cases did not differ significantly regarding gestational age and birth weight. In Group-A, 60.8% of the patients required a later shunt insertion, as compared with 93.1% of the cases in Group-B and 77.2% of the cases in Group-C. Group-A patients were also associated with significantly fewer CSF infections as well as significantly lower incidence for multiloculated hydrocephalus development as compared with Group-B and Group-C.

CONCLUSION: Early removal of intraventricular blood degradation products and residual hematoma via neuroendoscopic ventricular irrigation is feasible and safe for the treatment of PHH in neonates with IVH. Neuroendoscopic technique seems to offer significantly lower shunt rates and fewer complications such as infection and development of multiloculated hydrocephalus in those cases.

KEYWORDS: Neuroendoscopy, Hydrocephalus, Hemorrhage, Intraventricular, Neonate

INTRODUCTION

Intraventricular hemorrhage (IVH) is still the most severe and the most frequent complication of prematurity which occurred 25% to 30% of this group (2,14,15). IVH usually result in posthemorrhagic ventriculomegaly which remains a challenge since this condition may evolve into posthemorrhagic hydrocephalus (PHH) with increased intracranial pressure (ICP) (3,15,18). Murphy et al. reported that approximately half of the preterm survivors with IVH had no ventricular dilatation, quarter of them had non progressive posthemorrhagic ventriculomegaly and the remaining quarter had progressive

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PHH (16). In the literature, the ratio of cases with posthemorrhagic ventriculomegaly that require treatment has been reported in a range of 25% to 50% (5,15). Currently no medications are recommended to treat symptomatic PHH and, on the other hand, there is no solid consensus on the timing and the optimal surgical technique for PHH (1,2,5,18,30).

Today, several initial treatment techniques are preferred for progressive posthemorrhagic ventriculomegaly in neonates who suffered from IVH. These interventions include serial cerebrospinal fluid (CSF) tapping (lumbar puncture or ventricular tap), external ventricular drainage, ventricular access devices, ventriculosubgaleal shunt and endoscopic ventricular irrigation (2,5,20). There is still debate about the most feasible approach for PHH and the results of the studies that compare the effectivity of the forementioned techniques are not concordant. Most of the previous reports recommended multi-center works and larger series for more clear conclusions (1,2,5,15,18). Designed as a multi-center study with larger number of cases, the present work aims to compare the results of those management techniques for the initial treatment of PHH secondary to IVH in neonates. In this study, we describe the approach of early neuroendoscopic ventricular lavage for the treatment of ventriculomegaly/hydrocephalus following IVH in neonates and compare the results with the cases that have been initially treated only with conventional temporary CSF diversion techniques or that have undergone ventriculosubgaleal shunt treatment.

MATERIAL and METHODS

The data of 74 neonatal PHH cases which had undergone surgical treatment at 3 pediatric neurosurgery centers (Kocaeli University, Ankara University and Selcuk University) between January 2000 and February 2016 were collected and retrospectively analyzed. The neonates with congenital hydrocephalus or with myelomeningocele were not included the study. All patients had born preterm with a body weight less than 1500 grams. In all cases, the diagnosis of IVH has been made by transcranial ultrasonography examination. Serial head ultrasounds have been performed in the cases with Grade III–IV IVH to monitor for ventricular enlargement. Those infants with PHH and concordant physical examination findings (increasing daily head circumference measurements, tense anterior fontanel, splaying of cranial sutures, change in neurological status or vital signs) have undergone neurosurgical treatment with either temporary CSF diversion via lumbar punctures, ventricular taps, a ventricular access device, or an external ventricular drain or with a ventriculosubgaleal shunt placement procedure, depending on the surgeon's experience or preference. Routine neurosurgical techniques were used to implant ventricular access device, external ventricular drain and ventriculosubgaleal shunts. A written informed consent has been obtained from each patient's parent. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Neuroendoscopic Ventricular Irrigation Procedure

In patients in whom neuroendoscopic ventricular irrigation procedure has been performed, the ventricle with the larger amount of hematoma was punctured with the endoscopic unit (GAAB Set, Karl Storz, Germany). Once the ventricle was entered, continuous irrigation was started with warmed (37°C) Ringer solution, through the irrigation channel of the endoscopic unit. Simultaneously, a passive outflow was ensured through the unit's second channel to balance the intracranial volume and avoid any significant changes in intracranial pressure. Continuous irrigation allowed orientation along landmarks and identification of the clotted hematoma. The hematoma was usually attached either along the course of the choroid plexus or as a mass along the anterior lateral ventricular wall. The third ventricle was entered to remove possible free-floating hematoma clots by irrigation and to ensure the patency of the aqueduct. Performing an interventricular septostomy, similar irrigation of the hematoma within the contralateral ventricle was performed. Irrigation was stopped once the fluid within the ventricular system was clear to allow a thorough inspection. Generally, 2000–2500 ml of Ringer solution was used for the endoscopic ventricular irrigation procedure. After removal of the endoscope, a ventricular drainage was placed to allow possible later CSF aspiration in all cases. Postoperatively, all patients were transferred to the neonatal intensive care unit. Head circumference was recorded daily, and transcranial ultrasonography was performed at an interval of 48 hours. In cases of continued signs of active hydrocephalus with progressively and abnormally enlarging head circumference, or a combination of progressively enlarging ventricular size at serial ultrasonography examinations and clinical signs, CSF was withdrawn (approximately 10 ml/kg of body weight) via the external ventricular drainage system. When three consecutive CSF withdraws failed to arrest the clinical signs of active hydrocephalus, then external ventricular drain was left open for drainage at a level of 10 cm H_2O above the external acoustic meatus. Prophylactic antibiotics were administered. The decision to implant a permanent ventriculoperitoneal shunt was made if continuous CSF drainage via the external ventricular drain failed to arrest the clinical signs of active hydrocephalus. Ventriculoperitoneal shunt surgery was planned in cases having a minimum weight of 1500 g, once the CSF protein concentration was less than 2 g/L with sterile CSF culture results.

Case Groups and Statistical Analysis

In the study design, the cases were divided into 3 groups according to treatment techniques:

Group A consisted of the cases that have been treated with early endoscopic ventricular irrigation for removal of intraventricular blood remnants.

Group B consisted of the cases that have been initially treated with conventional techniques such as temporary CSF diversion via lumbar punctures, ventricular taps, a ventricular access device, or an external ventricular drain.

Group C consisted of the cases that have undergone ventriculosubgaleal shunt treatment.

Complications, permanent CSF shunt dependency rates, incidence of multiloculated hydrocephalus and incidence of CSF infection were evaluated retrospectively.

Statistical analysis was performed using SPSS v23 software (SPSS Inc., Chicago, IL, USA). One-way ANOVA and the Pearson chi-square tests were used to analyze statistical significance among the case groups. A p value of ≤ 0.05 was considered statistically significant.

RESULTS

Data of 74 neonatal PHH cases were retrospectively analyzed in the study. Regarding gestational age and birth weight, statistical analysis did not reveal any significant difference among Group A, Group B and Group C.

In Group A, no immediate complications were observed after the initial endoscopic procedure. There were no cases of recurrent hemorrhage, hygroma formation, CSF leakage after the endoscopic procedure.

The number of cases which developed multiloculated hydrocephalus was 2 among 23 cases in Group A (8.6%), 10 among 29 cases in Group B (34.4%) and 9 among 22 cases in Group C (40.9%). Statistical analysis revealed that the difference was significant (p=0.037). Among 23 infants in Group A 14 cases (60.8%) required a later shunt insertion, as compared with 27 (93.1%) of the 29 infants in Group B and 17 (77.2%) of the 22 infants in Group C. When compared statistically, the difference was found to be significant (p=0.019). The number of cases that experienced CSF infection during the initial treatment process was 1 among 23 cases in Group A (4.3%), 8 among 29 cases in Group B (27.5%) and 8 among 22 cases in Group C (36.6%). When analyzed statistically, the results were found to be significantly different (p=0.029).

All these results indicate that Group A cases were associated with significantly fewer CSF infections as well as significantly lower incidence for multiloculated hydrocephalus development and significantly lower incidence of permanent shunt requirement as compared with Group B and Group C. The results are summarized in Table I.

DISCUSSION

IVH is the main cause of posthemorrhagic ventriculomegaly and PHH for preterm neonates and may require permanent CSF shunting (2,3,12). According to current reports, approximately 15% of preterm infants who suffer IVH may require permanent CSF diversion (2,18). In premature infants, IVH develops mostly due to germinal matrix hemorrhage (2,3,18). Preterm infants are quiet vulnerable to cerebrovascular injury however the pathophysiology of germinal matrix hemorrhage and acquired posthemorrhagic infarction mechanism has not been described clearly (8,18). Clinical pattern of IVH in preterms may be catastrophic, saltatory or silent (18,24). Because of its feasibility, cranial ultrasonography is considered to be the first choice of imaging technique for the diagnosis and follow-up of neonates with IVH and PHH. Computerized cranial tomography may support decision making of treatment approaches in patients suspected of serious intracranial hemorrhage. Magnetic resonance imaging is another imaging technique for the infants with IVH or/and PHH which is more informative than cranial ultrasonography or cranial tomography, and may be preferred if the patient is stable enough for transport (2,18).

Since previous studies demonstrated that the agents like acetazolamide and furosemide did not decrease the need for permanent shunt insertion or the likelihood of mortality and neurological morbidity, pharmacotherapy is not recommended for the management of PHH (13,18). Robinson advised daily removal of 10 ml CSF via lumbar punctures for the stabilization of head circumference (18). Zaben et al. reported that, in United Kingdom (UK) lumbar or ventricular taps are used in 10%-30% of the cases with neonatal PHH (30). Whitelaw and Aquilina showed that serial lumbar tapping for IVH/PHH cases resulted in a rate of 16.2% complete remission while 30% of cases required permanent shunting (26). Studies on efficacy of intraventricular injection of streptokinase in these patients did not show better results compared to standard treatment techniques in terms of decreasing mortality or rates of shunt dependence (27,29).

External ventricular drainage is another safe technique which is commonly used for the initial treatment of PPH. Zaban et al. reported that 15% of the neurosurgeons in UK preferred this technique if other temporary strategies failed for the management of IVH/PPH (30). In various series, external ventricular drainage related infection rates were reported

Table I: Summary of Cases with Complications (Multiloculated Hydrocephalus Development and CSF Infection during Treatment) and that became Permanent Shunt Dependent, according to Preferred Treatment Techniques (Early Endoscopic Ventricular Irrigation, Ventriculosubgaleal Shunt and Conventional Temporary CSF Diversion Methods).

	Group A Early Endoscopic Ventricular Irrigation (n=23)	**Group B Conventional Treatment (n=29)**	**Group C Ventriculosubgaleal Shunt (n=22)**
Number of cases that developed multiloculated hydrocephalus	2 (8.6%)	10 (34.4%)	9 (40.9%)
Number of cases with shunt dependency	14 (60.8%)	27 (93.1%)	17 (77.2%)
Number of cases that experienced CSF infection during treatment	1 (4.3%)	8 (27.5%)	8 (36.6%)

ranging from 0% to 50% (7,17,23). Moreover permanent shunt placement following external ventricular drainage treatment is still very common (6,15,23).

Ventricular access devices also named ventricular reservoirs may be used as an alternative technique for the initial treatment of IVH/PHH in neonates. Especially in United States and UK this technique is preferred commonly (26,30). Shooman et al. explained that ventricular access device is less traumatic than serial lumbar punctures and ventricular tapping and causes fewer problems than external ventricular drainage or subgaleal shunts (21). Regarding the initial treatment with ventricular access device technique, different series reported infection rates ranging between 6% and 10% (6,10,22). In cases where ventricular access device placement was preferred as the initial treatment for PHH, device revision rates were reported as high as 20%, and permanent CSF shunt requirement rates was reported up to 88% (4,6,10,22).

Ventriculosubgaleal shunt is another technique for the management of IVH/PHH. Ventriculosubgaleal shunt technique seems to be more physiological and safe, compared to external ventricular drainage and ventricular access device techniques. The major advantage of this temporary treatment option is the possibility to obtain continuous CSF drainage. Zaben et al. reported that, in UK, ventriculosubgaleal shunt technique is preferred in 15% of IVH/PHH cases (30). The infection rates vary in a wide spectrum and reported from 0% to 94% in the literature (9,11,28). In the series of Wellons et al., 86% of the neonates treated with ventriculosubgaleal shunt technique required permanent shunting (25). In the same series, 69% of the neonates treated with ventricular access device were reported to require a permanent CSF shunting procedure.

Another important issue during IVH/PPH management is the development of multiloculated hydrocephalus. Multiloculated hydrocephalus development is associated not only with IVH but also with CSF infection and ventriculitis (19). In their series, Christian et al. reported that 11 of the 67 PHH cases developed multiloculated hydrocephalus in the follow-up period and 5 of those cases had a CSF infection prior to development of multiloculated hydrocephalus (5). However, regarding multiloculated hydrocephalus development, they did not comment on any relationship with the preferred treatment technique for PHH cases. In our multicenter study, the incidence of multiloculated hydrocephalus development was analyzed among preferred treatment techniques, as well as the incidence of CSF infection and shunt dependency rates. According to our data, multiloculated hydrocephalus development was shown to be significantly less in cases that have undergone endoscopic ventricular irrigation as compared to other preferred treatment techniques.

In a recent study, Schulz et al. retrospectively compared the complications and shunt dependency rates of 19 neonates who have been treated with neuroendoscopic ventricular lavage for their PHH, with 10 neonatal PHH cases that have been treated with other conventional temporary CSF diversion methods (20). According to their results, endoscopic ventricular lavage was associated with fewer numbers of overall necessary procedures, significantly fewer infections, or multiloculated hydrocephalus development. Our data seem to support their results. In our study, we additionally evaluated and compared the shunt dependency rates and complications of ventriculosubgaleal shunt treatment with neuroendoscopic ventricular irrigation treatment as well as the other conventional temporary CSF diversion methods.

CONCLUSION

To our knowledge, this is the first multicenter based retrospective study that compares the results of neurosurgical techniques used for the all initial treatment of neonatal PHH secondary to IVH. Our results demonstrate that neuroendoscopic ventricular irrigation, as an initial treatment for neonatal PHH, is feasible and safe as compared with other treatment techniques. When compared with the results of the techniques such as serial lumbar punctures or ventricular taps, external ventricular drain, ventricular access device or ventriculosubgaleal shunt placement, early neuroendoscopic ventricular irrigation treatment seems to offer significantly lower permanent shunt rates and fewer complications such as CSF infection and development of multiloculated hydrocephalus in neonatal PHH cases.

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