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Original Investigation

The Association between the Timing of Shunt Placement and Shunt Infection in Hydrocephalus Associated with Myelomeningocele

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ABSTRACT

AIM: To determine whether the timing of shunt placement affects shunt infection rate in hydrocephalus associated with myelomeningocele (MMC).

MATERIAL and METHODS: The cases of 67 consecutive patients who underwent MMC repair and ventriculoperitoneal (VP) shunt placement between 2010 and 2017 were analyzed, retrospectively. Shunt infection rates were compared for three different approaches: simultaneous shunting (MMC repair and shunting in the same session; n=22), early shunting (shunting in the first week after MMC repair; n=21), and delayed shunting (shunting in the second week after MMC repair; n=24).

RESULTS: Three patients in the simultaneous shunting group (13.6%) and two patients in the early shunting group (9.5%) developed shunt infection, whereas no such infections occurred in the delayed shunting group ($p>0.05$).

CONCLUSION: While the shunt infection rates for the simultaneous, early and delayed shunting groups were not significant, it is of interest that no shunt infections occurred in the delayed shunting group. Investigation with a larger number of patients is warranted to assess whether delayed shunting might reduce the risk of shunt infection.

KEYWORDS: Antibiotics, Hydrocephalus, Myelomeningocele, Shunt infection, Timing

INTRODUCTION

The reported incidence of hydrocephalus in patients with myelomeningocele (MMC) ranges from 65% to 93% (9,15,19); however, prominent hydrocephalus is seen in 5% to 25% of children born with MMC (1,12). This has generated ongoing controversy regarding whether MMC repair and ventriculoperitoneal (VP) shunting should be performed simultaneously or whether the shunt should be placed during a later session. Because these children are highly susceptible to shunt infections, it is of paramount importance to determine the ideal time for shunt placement.

Various studies have been published regarding shunt complications as they relate to the timing of shunt insertion in patients who have hydrocephalus associated with MMC. Some authors have supported delayed shunting in a separate session after MMC repair because of potential higher infection risk and possible shunt failure with the simultaneous approach (1,13,16). These authors also emphasized that shunt insertion might not be needed in patients with mild and non-progressive hydrocephalus, and that unnecessary shunting could be avoided. In contrast, others have published in favor of simultaneous MMC repair and shunting in the same session (12,19,23,25). They assert that this approach facilitates more rapid recovery of the MMC wound, avoids further brain damage that can occur with delayed shunting, and carries lower risk of cerebrospinal fluid (CSF) leakage.

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Studies in the current literature have evaluated two approaches: 1) shunting simultaneous with MMC repair, and 2) delayed shunting in a separate session. No investigation to date has evaluated whether different periods of delay affect shunt infection rates. In this study, we compared shunt infection rates for three different approaches: shunting simultaneous with MMC repair, early shunting after MMC repair, and delayed shunting after MMC repair. We sought to evaluate whether delayed shunting decreases shunt infections and, if so, what extent of delay significantly reduces these infections. The ultimate goal was to determine the optimal timing for shunt placement in patients who have hydrocephalus associated with MMC.

MATERIAL and METHODS

Patients

We retrospectively analyzed the cases of 67 consecutive newborns with MMC and hydrocephalus who underwent MMC repair and shunt placement between 2010 and 2017. To obtain a homogenous group, certain patients were excluded: those shunted more than 2 weeks after birth, those born with MMC but without hydrocephalus, those with documented wound infection and meningitis in the preoperative period,and those whose MMCs were repaired more than 24 hours after birth (i.e., usually patients referred from other hospitals). The purpose of these exclusions was to be able to determine the pure effect of timing on the infection rate.

Approaches and Treatments

Because early repair of MMC is known to be associated with lower infection rate (1,9), for the last 10 years at our center almost all newborns with MMC have undergone MMC repair within 24 hours after birth. For this study, we established three groups based on the approach used: 1) the "simultaneous shunting" group (n=22) had a VP shunt placed during the same session as MMC repair; 2) the "early shunting" (n=21) group had the shunt placedin the first week after MMC repair; 3) the "delayed shunting" group (n=24) had the shunt placed in the second week after MMC repair.

The decision to place a shunt simultaneously with MMC repair as opposed to during a separate operation was based primarily on the surgeon's preference and the newborn's medical condition (i.e., any concerns regarding low body weight, back wound recovery, and prominence of hydrocephalus). The simultaneous shunting group consisted mainly of patients with MMC and overt hydrocephalus. The early shunting group consisted mainly of patients who had MMC and hydrocephalus that was mild at birth but progressed to non-tolerable level in the first week. The delayed shunting group consisted mainly of two categories of patients: 1) those who had MMC and hydrocephalus that was mild at birth but progressed to non-tolerable level in the second week, and 2) patients whose clinical status was similar to those in the simultaneous and early groups but who were unsuitable for shunting in the first week. Babies in the latter subgroup were managed in the newborn critical care unit until optimal conditions for shunting were reached. All patients who had overt hydrocephalus but lacked optimal conditions for shunting were managed with consecutive ventricular taps until shunt placement.

All patients (with or without CSF leakage) were started on prophylactic antibiotic treatment with ceftriaxone 100 mg/kg/day immediately after birth (or admission in the case of referrals). Each was prepared for surgery as soon as possible. For every MMC repair and/or shunting procedure, ceftriaxone 50 mg/kg was administered 30 minutes prior to the skin incision and ceftriaxone 100 mg/kg/day was continued for at least 3 days postoperatively. Since 90% of shunt infections occur within 3 months of the initial shunting procedure (18), we analyzed only shunt infections that were recorded within this period.

Statistical Analysis

Data were analyzed using Number Cruncher Statistical System (NCSS) 2007 statistical software (NCSS LLC, Kaysville, Utah, USA). The Mann-Whitney U test was used to compare differences between two independent groups with abnormally distributed variables. Fisher's exact test and the Fisher Freeman Haltontest were used to analyze qualitative data. A p value <0.05 was considered significant.

RESULTS

A total of 67 newborns (girl=31, boy=36) were analyzed. Locations of the MMCs were categorized as cervical, thoracic, or lumbosacral (Table I). Three patients in the simultaneous shunting group (13.6%) and two in the early shunting group (9.5%) developed VP shunt infections, whereas none occurred in the delayed shunting group ($p>0.05$) (Table II). In other words, five (11.6%) of 43 total patients in the simultaneous and early shunting groups developed shunt infections, whereas no shunt infections occurred in the delayed shunting group.

DISCUSSION

Since only 5% to 25% of children with MMC present with overt hydrocephalus, the need to perform VP shunting in the same session as MMC repair is questionable (1,12). According to the literature, there is continued controversy regarding the timing of shunt insertion for these patients. In particular, there is no clear guideline about whether to perform shunting simultaneously with MMC repair or in a separate operation.

Reported rates of VP shunt infection in the pediatric age group range from 2% to 39% (16). In cases where hydrocephalus is associated with MMC, however, this rate ranges from 10% to 25% regardless of the approach used. Concurrent shunting in the same session with MMC repair may increase the risk of shunt infection or shunt failure (21,22). Bell et al. reported 6% shunt infection rate in pediatric patients who underwent simultaneous procedures, whereas they observed no infection when shunts were inserted in a separate session (2). It has been postulated that shunt placement allows the CSF to reach the ventricles from the lumbar region by reversing the direction of CSF flow, which is a known risk factor for infection (4,10).

Some authors recommend that VP shunting be delayed at least 3 to 7 days after MMC repair in this patient group

Table I: Patient Demographics

Patient Group	Gender	Myelomeningocele Location			No. of Infections
		Cervical	Thoracic	Lumbosacral	
Simultaneous Shunting	M (*n*=12)	1	2	9	1
	F (*n*=10)	-	1	9	2
Early Shunting	M (*n*=12)	-	1	11	1
	F (*n*=9)	1	-	8	1
Delayed Shunting	M (*n*=12)	1	1	10	-
	F (*n*=12)	-	1	11	-

Simultaneous shunting: *MMC repair and shunting in the same session,* ***Early shunting:*** *shunting in the first week after MMC repair,* ***Delayed shunting:*** *shunting in the second week after MMC repair,* ***F:*** *Female,* ***M:*** *Male.*

Table II: Shunt Infection Ratesfor the Three Different Approaches

		Patient Group			Test Result
		Simultaneous Shunting n (%)	Early Shunting n (%)	Delayed Shunting n (%)	p
Infection	**No**	19 (86.4)	19 (90.5)	24 (100.00)	χ^2=3.354
	Yes	3 (13.6)	2 (9.5)	0 (0.0)	*0.178

Fisher Freeman Halton Test.

Simultaneous shunting: *MMC repair and shunting in the same session,* ***Early shunting:*** *shunting in the first week after MMC repair,* ***Delayed shunting:*** *shunting in the second week after MMC repair.*

(2,16). As emphasized by Caldarelli et al., MMC repair with simultaneous shunt insertion might decrease the risk of CSF leakage (4), yet the risk of shunt infection remains. These authors reported a 23.1% rate of infection in patients who were treated with the concurrent approach, and they deemed this method undesirable despite the reduced risk of CSF leakage. In our study, three shunt infections occurred in the simultaneous shunting group (13.6%) and two occurred in the early shunting group (9.5%). None of the patients in the 2-week-delay shunting group developed infection.

Nearly 9% of the 170 pediatric patients with hydrocephalus and MMC investigated by Caldarelli et al. (4), and 13% of 166 in the series by Arslan et al. (1), required no shunt placement. These authors preferred close follow-up rather than shunting for asymptomatic patients with mild and stable hydrocephalus. Notably, Chakraborty et al. stated that it would be possible to avoid unnecessary shunting by accepting moderate ventriculomegaly and mild progression after MMC repair (6). Our study included only patients who had required a VP shunt within the first 2 weeks after birth; as such, we have no data regarding patients who did not need shunt placement after MMC repair.

While some authors support delayed shunting because of its advantages (e.g., lower infection rate), others have expressed opposing views. Tuli et al. investigated repeated shunt failures in pediatric patients with hydrocephalus and reported no significant difference between shunt infection rates for the groups who underwent simultaneous procedures versus delayed procedures (21). Still, many authors have recommended simultaneous MMC repair and shunt placement (2,5,9,12,19), and these reports cite several advantages: more rapid recovery of MMC, one operation instead of two, avoidance of further brain damage, lower risk of CSF leakage, and shorter hospitalization time. Series reported by Parent and McMillan (17), and Machado and De Oliveira (12) involved 69 and 24 patients, respectively, and both reports concluded that the simultaneous approach carries no higher risk of infection than delayed shunting. Miller et al. noted a higher rate of CSF leakage and longer hospitalization time for children who underwent MMC repair and shunting in separate sessions (15). In their comparative analysis of 127 children with MMC, Radmanesh et al. concluded that delayed shunting is not associated with lower risk of complications compared to concurrent procedures (19). It is noteworthy that, to date, no comparative study in the literature has evaluated the association between delay time and shunt infection rate. For this reason, we grouped our patients in three categories based on different timings of VP shunt placement relative to MMC repair. We sought to determine whether delayed shunting reduces the likelihood of shunt infection, and if so then what extent of delay significantly decreases the shunt infection rate.

Regarding pediatric patients with MMC and hydrocephalus, rates of shunt infection for those who have undergone

simultaneous procedures have been reported as 25.8% by Gamache (10), 23.1% by Caldarelli et al. (4), 12% by McLone et al. (14), 7.5% by Ersahin et al. (8), and 5.2% by Brau et al. (3). Oktem and colleagues found that 19.3% of these patients who underwent simultaneous procedures developed meningitis, whereas only 9.5% of those who had shunt placement in a separate session did so (16). Caldarelli et al. observed a shunt infection rate of 23% with simultaneous procedures, as opposed to 7% with delayed shunting (4). As noted, in our study the shunt infection rate was 13.6% in the simultaneous shunting group and 9.5% in the early shunting group, whereas no shunt infections occurred in the delayed shunting group. Considering our findings in context of the literature, it is not clear whether delayed shunting actually lowers the risk of shunt infection.

Margaron et al. reported that patients shunted for hydrocephalus prior to, simultaneously with, or within the first 4 days after MMC repair had a five fold higher infection rate than those shunted 5-10 days after MMC repair (13). They concluded that one week of postoperative antibiotics after MMC repair might have helped lower the risk of shunt infection in their delayed group. Although debate continues regarding early or delayed shunting in cases of hydrocephalus associated with MMC, there is more or less consensus that early repair of MMC is more reliable. Brau et al. reported no difference between early and late MMC repair regarding risk of ventriculitis before or after 48 hours of life (3); however, the recent literature clearly states that any delay in repair will increase the risk of infection. Most researchers suggest that MMC repair in the first 24 to 48 hours of life decreases risk of infection. Oktem et al. (16), and Arslan et al. (1) found lower rates of infection for patients who underwent early MMC repair, and both these author groups stated that MMC repair after 48 hours is associated with significantly more mortality and morbidity. Delayed MMC repair has also been reported to lead to shunt failure due to increased CSF proteins, which can occlude a VP shunt even without infection (14,24). Furthermore, Tarcan et al. reported that MMC repair within 24 hours of delivery provides significantly greater mean bladder capacity and the best chance for favorable lower urinary tract function (20). Given that late MMC repair is known to increase risk for shunt infection, and considering that this could confound findings for time of MMC repair or time of shunting relative to shunt infection rate, we studied only patients who underwent MMC repair within the first 24 hours after birth.

Factors such as poorly developed immune system, poorer skin condition, and high skin bacterial density have been implicated as risk factors for infection in infants with hydrocephalus and MMC (21). In addition, younger age at time of first shunt placement is known to be associated with higher risk for repeated shunt failure (7,11,22). Moreover, MMC patients are at higher overall risk for shunt infection (4). Consequently, there are five main possible reasons for the association between delayed shunting and lower shunt infection rate: 1) the immune system is relatively poorly developed at birth, 2) infants are less prone to infections after MMC repair and complete wound closure, 3) antibiotic prophylaxis after MMC repair and prior to shunting might reduce bacterial colonization and, thus, the likelihood of shunt infection, 4) early shunting diverts the flow of infected CSF from the lumbar region to the ventricles, and 5) shorter duration of operation is known to be associated with lower infection rate in shunt surgery.

While our sample size was limited, the study finding of no infection in the delayed shunting group is noteworthy. Differences among the groups were not statistically significant due to the low number of cases in each group. Further studies with larger sample size need to be conducted to verify our results. Specifically, prospective controlled trials would help clarify whether delay time actually reduces shunt infections in this patient group.

■ CONCLUSIONS

No statistically significant differences were found among the shunt infection rates for patients with hydrocephalus associated MMC who underwent VP shunting simultaneous with MMC repair, or at early (first week) and delayed (second week) times post-repair. It is of particular interest that no shunt infections occurred in the delayed shunting group. Investigating the possible beneficial effect of this delay further with a larger number of patients is warranted.

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