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Surgical Treatment of Myelomeningocele Carried Out at 'Time Zero' Immediately after Birth

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Key Words
Myelomeningocele · Neurosurgery · Hydrocephalus · Shunt · Pediatric

Abstract
Background/Aims: To present a protocol of immediate surgical repair of myelomeningocele (MMC) after birth ('time zero') and compare this surgical outcome with the surgery performed after the newborn's admission to the nursery before the operation. ***Methods:*** Data from the medical files of 31 patients with MMC that underwent surgery after birth and after admission at the nursery (group I) were compared with a group of 23 patients with MMC admitted and prospectively followed, who underwent surgery immediately after birth – 'at time zero' (group II). ***Results:*** The preoperative rupture of the MMC occurred more frequently in group I (67 vs. 39%, $p < 0.05$). The need for ventriculoperitoneal shunt was 84% in group I and 65% in group II and 4 of them were performed during the same anesthetic time as the immediate MMC repair, with no statistically significant difference. Group I had a higher incidence of small dehiscences when compared to group II (29 vs. 13%, $p < 0.05$); however, there was no statistically significant difference regarding infections. After 1 year of follow-up, 61% of group I showed neurodevelopmental delay, whereas only 35% of group II showed it. ***Conclusions:*** The surgical intervention carried out immediately after the birth showed benefits regarding a lower incidence of preoperative rupture of the MMC, postoperative dehiscences and lower incidence of neurodevelopmental delay 1 year after birth.

Introduction

Myelomeningocele (MMC) is the most common open spinal dysraphism eligible for surgical repair. Several considerations have been made regarding the best time for surgical repair, aiming at the lowest number of complications, especially surgical wound dehiscences, CSF fistulae and infections (meningitis and ventriculitis), as well as the best possible neurological evolution [1–5].

Several studies have reported the outcome of intrauterine surgery, with the decrease in Chiari II malformations as the main benefit, as well as the consequent lower need for ventriculoperitoneal shunts (VPS) for the treatment of hydrocephalus [6–9].

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The present study aims to present a protocol of surgical repair carried out immediately after birth, which is called 'time zero', and compare the surgical outcome with that observed when the surgery is performed at up to the third day of life.

Patients and Methods

We compared the data from the medical files of a group of 31 sequential patients with MMC, who were submitted to surgery from January 1999 to June 2000 after birth and after being admitted to the nursery (group I), with data from a group of 23 patients with MMC who were admitted and prospectively followed from June 2004 to December 2006, who underwent surgery immediately after birth – 'at time zero' (group II).

In both groups, the pregnant women were followed during the prenatal period by the fetal medicine and obstetrics teams during consecutive visits. All fetuses were assessed through sequential ultrasonographic evaluations to determine MMC topography and dimensions and to investigate the presence and evolution of hydrocephalus. All fetuses were submitted to an echocardiography.

In group I, the neurosurgery team was informed about the patient with MMC after the birth, when the infant was admitted to the nursery. The preoperative assessment, in addition to the physical and neurological examination, consisted of CBC and sodium, potassium, urea, creatinine and glycemia measurements. The MMC was protected with sterile, wet and occlusive dressings. If the defect was larger than 25 cm^2, the plastic surgery team would participate in the surgery to employ graft rotation techniques to cover the defect, when necessary. The VPS procedure was never employed simultaneously with the MMC repair; if necessary, consecutive transfontanelle relief punctures were performed and the VPS was carried out after the MMC repair, in the absence of meningitis or ventriculitis.

The 'time zero' protocol is presented in table 1. In group II, the parents were referred, during the pregnancy, for an appointment with the neurosurgery team in order to receive information on the procedure at birth and prognosis. A suitable caesarean section date was chosen by the fetal medicine and obstetrics teams when the fetus was full term and a surgical room was prepared next to the delivery room for the immediate repair of the MMC by the neurosurgery and plastic surgery teams, as soon as the newborn was evaluated and discharged by the neonatal pediatric team. The only exclusion criteria employed for the immediate repair of the MMC at birth was the presence of congenital heart malformation, evaluated by the fetal echocardiogram performed during gestation. If the area of the MMC was larger than 25 cm^2, the plastic surgery team participated in the surgery to employ graft rotation techniques to cover the defect, when necessary. The VPS was performed subsequently, although during the same anesthetic time of the immediate MMC repair, when the cephalic perimeter had a percentile >97.5% and if there was a bulging bregmatic fontanelle.

All patients were followed for 12 months. The epidemiological data, surgical outcomes and postoperative complications were statistically analyzed by Student's t test, Fisher's exact test and Wilcoxon's test. $p < 0.05$ was considered statistically significant.

Table 1. 'Time zero' protocol design

Time zero
(1) Prenatal visit USG (topography and MMC size) USG (ventricular progression) Fetal echocardiography
(2) Caesarean section appointment Obstetrics Neurosurgery Plastic surgery Nursery
(3) MMC surgery – 'next room' VPS if P >97.5 and bulging BF

USG = Ultrasonography; P = percentile of cephalic perimeter; BF = bregmatic fontanel.

Table 2. Epidemiological data

	After birth group I	Immediately after birth group II
Number of patients	31	23
Male	18	11
Female	12	12
Mean birth weight, g	2,998	2,944
Mean maternal age, years	23.6	23.2
Antenatal diagnosis	31 (100%)	23 (100%)
Mean gestational age	37 weeks and 5 days	38 weeks
Associated anomalies	10 club feet 1 single kidney	6 club feet
Hydrocephalus	22 (71%)	15 (65%)

Results

The epidemiological data are shown in table 2 and the surgical data are shown in table 3. The mean time between birth and the surgical procedure was 3.9 days for group I and 90 min for group II. The preoperative rupture of the MMC occurred more frequently in group I than in group II (67 vs. 39%, $p < 0.05$). The need for VPS was 84% in group I and 65% in group II and 4 of the 15 VPS procedures in group II were performed during the same anesthetic time as the immediate MMC repair, although there was no statistically significant difference. Group I

Table 3. Surgical data

	Immediately after birth	After birth
Defect dimension, cm^2		
Minimum	2.25	8
Maximum	80	72
Mean	16.86	36.72
Defect location		
Lumbar	8	3
Sacral	3	7
Thoracolumbar	4	6
Lumbosacral	7	15
Thoracic	1	0
Mean time of surgery after birth	1 h 30 min	3.9 days*
Preoperative rupture present	9 (39%)	21 (67%)*
Surgical procedure		
Direct closure	20	13
Single rhomboid flap	1	3
Double rhomboid flap	2	10
Latissimus dorsi flap	0	5

* $p < 0.05$.

Table 4. Need for VPS, complications, 1-year follow-up

	Immediately after birth	After birth
Number of patients	23	31
Need for ventriculoperitoneal shunt	15 (65.2%)	26 (84%)
Immediately	4 (17.4%)	
Second time	11 (47.8%)	
Complications		
Minor dehiscences with no need for reoperation	3 (13%)	9 (29%)*
Major dehiscences with need for reoperation	1	2
Surgical infection (meningitis and ventriculitis)	2	2
CSF leak	3	3
Neurodevelopment (1-year follow-up)	8 delayed (35%)	19 delayed (61%)*
	15 normal (65%)	12 normal (39%)

* $p < 0.05$.

had a higher incidence of small dehiscences when compared to group II (29 vs. 13%, $p < 0.05$). The number of patients with postoperative infections (ventriculitis and meningitis) was similar in both groups (table 4) and none of the VPS procedures performed simultaneously with the MMC repair presented any complications. There was no alteration regarding the motor strength of the lower limbs between the pre- and postoperative neurological examinations in either group. However, after 1 year of follow-up, 61% of group I showed neurodevelopmental delay and 35% of group II showed neurodevelopmental delay ($p < 0.05$).

Discussion

The debate about the best time to perform the MMC surgical repair reappeared alongside pathological observations, experimental models and initial experiences of intrauterine surgeries [2, 21–25]. Since 1997, the number of experimental studies has been increasing and there is a growing body of clinical experience in fetal surgery in the United States [2, 6, 26].

At least 80% of patients with spina bifida will be submitted to a VPS in order to prevent the intellectual impairment that often accompanies ventriculomegalies [27–30]. Previous studies have shown that fetal surgery for MMC reduces the need for VPS by around 50%, before the first year of life [6].

In 2003, Tulipan et al. [9] published data that showed a significant decrease in the general rates (85.7% control vs. 54.8% study group) of VPS, when they compared fetal surgery with the traditional treatment, even after considering the degree of the lesion. They also observed that intrauterine surgery performed at the gestational age $\leq$25 weeks significantly decreased the need for VPS [9].

Almost all cases that underwent intrauterine surgery showed improvement in the herniation of the intracranial structures of the posterior fossa associated with Arnold-Chiari malformation, probably due to the normalization of the CSF flow [5, 7]. The positive results were demonstrated when the Vanderbilt University group assessed lower-limb function after fetal repair of MMC in 2 controlled, non-randomized studies [5, 31].

Regarding the urological aspect, fewer urinary tract infections and vesicoureteral reflux episodes were observed in patients who had undergone intrauterine surgery. However, this beneficial effect could be ascribed to the exceptional medical care given to the study children by their families [32]. On the other hand, Tarcan et al. [33], in a retrospective study on the best moment to in-

stitute conventional treatment, observed a better prognosis for urinary symptoms in patients who had undergone surgical repair within 72 h after birth and suggested that closing the lesion in the first 24 h increased the chance of attaining better urinary tract function [33].

The need for a controlled and randomized study culminated in the creation of the MOMS (Management of Myelomeningocele Study) trial [30, 34]. Started in 2003 and currently ongoing, the study aims to compare the safety and efficacy of intrauterine MMC repair with the conventional postnatal repair. The 3 centers with the largest experience in fetal surgery, Children's Hospital of Philadelphia, University of California, San Francisco and Vanderbilt University, have carried out the study, whereas the other institutions in the USA have agreed not to perform the intrauterine procedure.

Much is known about the potential risks and benefits of the intrauterine surgery for MMC repair, thanks to more than 270 cases that have undergone surgery in several centers worldwide and have been published in nonrandomized, observational controlled studies [3]. At this time, with the help of the MOMS trial outcome, it is advisable to compare the therapies and short- and long-term outcomes, in order to identify the ideal candidates and the institutions which have the potential to perform such procedure.

In this context, but without using the intrauterine approach, we propose the 'time zero' treatment for patients with MMC.

Attempts to do so have included the history of institutional controls, nonrandomized contemporary controls, controls from other institutions and historical databases, which are all far from being ideal. A further complication was the evidence that the management of newborns with MMC was changing and, therefore, it was not possible to compare data from different centers. However, the attained benefits in our study were: a lower incidence of preoperative MMC rupture (39 vs. 67%, $p < 0.05$), postoperative dehiscences (13 vs. 29%, $p < 0.05$), possibility of simultaneous treatment of hydrocephalus with no signs of infection and lower incidence of neurodevelopmental delay (35 vs. 61%, $p < 0.05$).

The newborns from the 'time zero' group did not need the usual preoperative 6-hour fasting period. The nursery multidisciplinary team received a patient that had undergone surgery and who needed specific care; however, there was no concern regarding the rupture of the MMC, contamination or hydroelectrolytic complications due to loss of CSF. The parents had been instructed and did not have to go through the anxiety of waiting for the MMC repair surgery after the birth.

The surgical repair of the MMC and, in the specific cases of hydrocephalus with macrocephaly (cephalic perimeter percentile >97.5) and bulging bregmatic fontanelle, the immediate and subsequent VPS implantation with a low-pressure valve model for newborns allowed a shorter exposure time of the open myelodysplasia and the CSF to the external environment. The patient was always repositioned, submitted once again to aseptic procedures and all surgical material was renewed before the VPS procedure. There were no infectious complications (meningitis and ventriculitis) among these patients, which suggests this order should be followed (MMC first, then VPS, during the same surgical procedure) as the best conduct [35, 36].

Miller et al. [37] demonstrated benefits with the association of MMC repair and VPS in the same procedure. They compared 21 infants who had undergone simultaneous MMC repair and shunting, with 48 who had undergone sequential, but not simultaneous, procedures. They demonstrated a decrease in hospital stay duration (22 vs. 13 days, $p = 0.05$) and back wound morbidity (8 vs. 0, $p = 0.05$) in those patients with evidence of hydrocephalus at birth, with no remarkable increase in shunt-related complications. Machado and Santos de Oliveira [38] compared 11 infants who had undergone simultaneous MMC repair and shunting with 17 who had undergone sequential procedures. They also demonstrated that the simultaneous insertion of the shunt and MMC correction did not pose an additional risk to the child and had some advantages, such as promoting healing without CSF leakage and protecting the brain from the effects of progressive ventricular dilation.

A larger sample size might have demonstrated a statistical association between the lower incidence of preoperative MMC rupture in the 'time zero' group with fewer infectious complications; similarly, a lower incidence of small dehiscences might be related to the preoperative fasting period, which the newborns submitted to surgery after the birth had to undergo.

At any rate, the outcome of the present study leads us to believe that the most advisable conduct is to initiate treatment immediately after birth. It is an organized multidisciplinary procedure, as well as humanized treatment of the fetus and concern for the parents. Additionally, it makes it easier to care for newborns at the nursery, regarding the management of the MMC, as well as their nutritional care and hydroelectrolytic balance. At the same time, in medical centers where the 'time zero' pro-

tocol cannot be carried out, we observe that, apparently, the surgical results are not worse if the surgery is performed up to the third day of life, at least regarding the infectious complications. However, the authors maintain that the prenatal appointment with a neurosurgeon represents one of the most important points in the humanization of the medical care, adherence to treatment and emotional support to the families of patients with MMC.

Conclusions

The surgical intervention carried out immediately after the birth showed benefits regarding a lower incidence of preoperative rupture of the MMC, postoperative dehiscences, and lower incidence of neurodevelopmental delay, assessed 1 year after birth, as well as making it easier to care for the newborn at the nursery and providing a higher level of security to the parents during the birth.

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