

# Pseudomeningocele after in utero repair of myelomeningocele as an early sign of hypertensive hydrocephalus – a case report and review of the literature

Daniel Dante Cardeal<sup>1</sup>, Ingrid Schwach Werneck Britto<sup>1</sup>, Sandra Rejane Silva Herbst<sup>1</sup>, Milton Hikaru Toita<sup>2</sup>, Gabriela Duarte Bordini<sup>1</sup>, José Carlos Esteves Veiga<sup>2</sup>, Rodrigo Ruano<sup>3</sup>

<sup>1</sup> Division of Maternal-Fetal Medicine, Faculty of Medical Sciences of Santa Casa of Sao Paulo, Brazil

<sup>2</sup> Department of Surgery, Division of Neurosurgery, Santa Casa Medical School, Sao Paulo, Brazil

<sup>3</sup> Division of Maternal-Fetal Medicine, Fetal Center, Department of Obstetrics, Gynecology and Reproductive Sciences, McGovern Medical School at the University of Texas Health Science Center Houston (UTHealth), USA

To whom correspondence should be addressed: Daniel Dante Cardeal, MD

e-mail:  
dcardeal@yahoo.com.br

Available at:  
<http://www.archpedneurosurg.com.br/>

**Background:** Myelomeningocele (MMC) is the most common congenital defect of the spine. The Management of Myelomeningocele study (MOMS trial) demonstrated that the prenatal repair decreased shunt implant, reversal of hindbrain herniation and better neurologic function compared to postnatal repair. Several ultrasound findings can predict the risk of postnatal hydrocephalus after intrauterine MMC repair. This report shows a prenatal pseudomeningocele after intrauterine correction of MMC as an early sign of hydrocephalus.

**Method:** A 34-year-old female G2P1 with a prenatal diagnosis of MMC with anatomical level L4 and ventricular enlargement was submitted to open surgery intrauterine repair. Follow up ultrasound showed regression of the lemon sign, partial regression of hindbrain herniation and a progressive increase in the wound with local bulging characterizing a pseudomeningocele. In the postnatal period, after correction of the pseudomeningocele, the neonate showed signs of hypertensive hydrocephalus. After ventriculoperitoneal shunt, the patient was discharged.

**Conclusion:** Presence of pseudomeningocele prenatally after in utero repair of MMC may represent an early sign of hypertensive hydrocephalus.

**Keywords:** Myelomeningocele, Hydrocephalus, Ventriculoperitoneal Shunt, Arnold-Chiari Malformation, Prenatal Diagnosis, Fetal Surgery

## INTRODUCTION

Myelomeningocele (MMC) is the most common congenital defect of the spine and spinal cord[1]. MMC is characterized by sensorimotor deficits, hydrocephalus, neurogenic bladder, and cognitive impairment[2–5]. Currently, the benefits of treating MMC in utero are well established especially regarding the prevention of

hydrocephalus[6]. The regression of Chiari malformation (CM) type II after in utero repair of MMC may be associated with changes in the dynamics of cerebrospinal fluid (CSF) flow and improvement in brainstem function[7,8]. Studies have evaluated the cephalic and intracranial parameters after in utero repair of MMC to determine the prognosis of hydrocephalus after birth[9]. However, the dynamics of CSF flow involves the entire neuraxis; and changes in the spinal



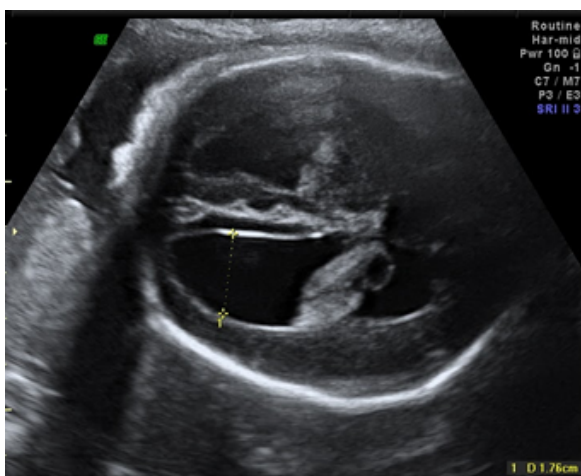
## Pseudomeningocele after in utero repair of myelomeningocele as an early sign of hypertensive hydrocephalus – a case report and review of the literature

cord canal prenatally may impact the risk of progression to hydrocephalus[10]. In this article, we present a case report of a child who underwent in utero repair of MMC, who developed bulging of the repair site (pseudomeningocele) prenatally despite the partial regression of CM type II. We discuss the possible pathophysiology of hydrocephalus and the value of pseudomeningocele as a prognostic factor in this setting.

### CASE REPORT

A 34-year-old female, gesta 2 para 1, with a 5-year-old healthy child, was referred to our Fetal Center because of congenital spinal defect and ventriculomegaly in the fetus. The fetus had a prenatal diagnosis of MMC with anatomical level L4 and ventricular enlargement (posterior horn 14 and 15 mm) and met the eligibility criteria for intrauterine MMC correction[11]. The MMC surgery was performed at 24 weeks of gestation. The surgical technique used in the procedure was open surgery by mini-hysterotomy (4 centimeter). After fetal exposure, the neurosurgery team performed MMC closure under microscope visualization using the conventional 3-layer technique (dura mater, muscle fascia, and skin); no relief incisions were needed. The total procedure time was 4 hours, and there were no additional complications.

Follow up ultrasound examinations were performed every 2 weeks after in utero repair. Progressively, the ultrasound examination showed regression of the lemon sign and partial regression of CM type II (confirmed on prenatal MRI at 30 weeks of gestation), but progression of ventricular enlargement, especially after 28 weeks of gestation. (Figure 1).

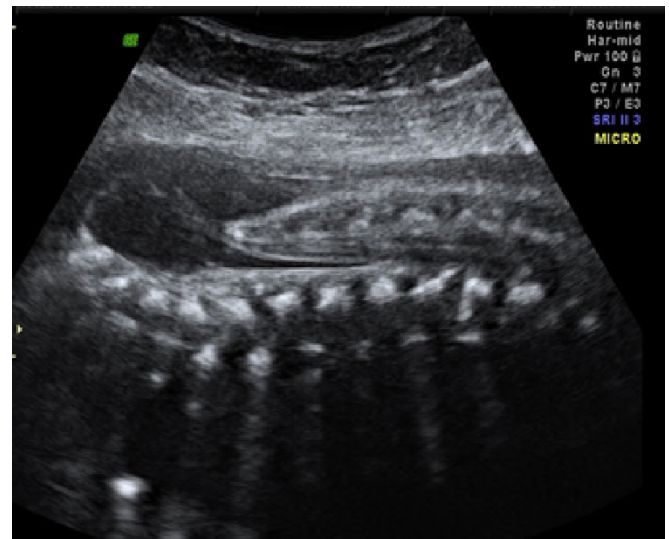


**Figure 1** - Fetal measurement of the posterior ventricle 4 weeks after the surgery

Table 1 presents the ultrasound findings before and after in utero repair of MMC for this patient. Unexpectedly, ultrasound examination showed a progressive increase in the wound with local bulging and signs of externally thick tissue, suggesting integrity and concomitant expansion of the skin. This ultrasound finding was initially identified at 28 weeks of gestation (Figure 2).

**Table 1** - Fetal measurement of the posterior ventricle before and after fetal surgery on the ultrasound.

	Preop	Week 2	Week 4	Week 6	Week 8	Week 10
Posterior horn (mm)	14/15	14/16	17/18	17/18	17/18	19/19

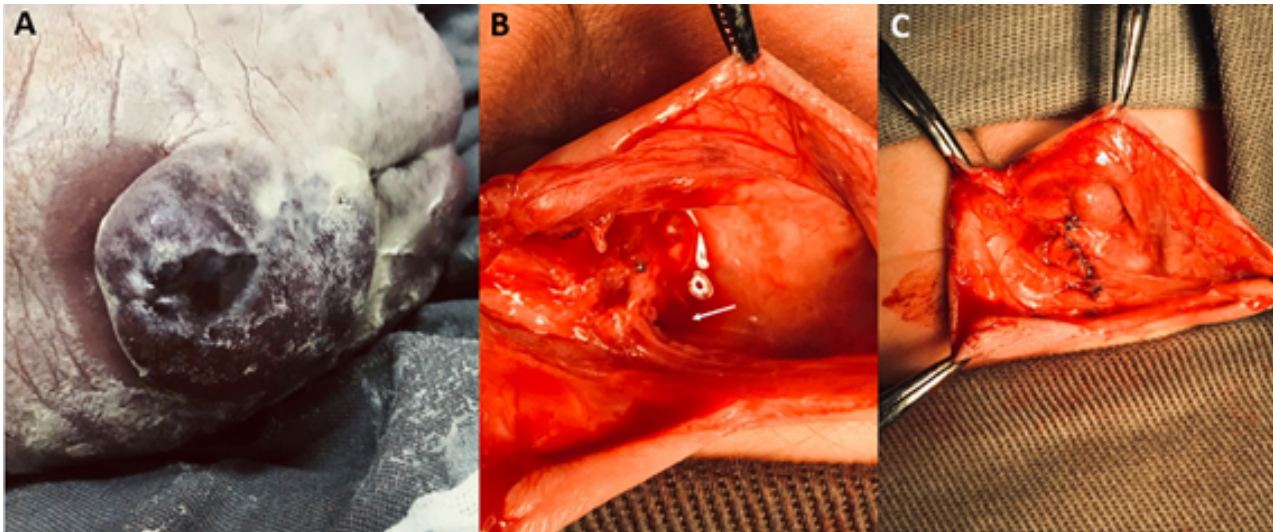


**Figure 2** - Prenatal ultrasound image showing a local bulging on the surgical site repair 4 weeks after surgery

A 2.995 grams, male newborn was delivered by cesarean section at 37 weeks of gestation, with APGAR 9/10/10 and head circumference 34.5 cm). The newborn was transferred to neonatal intensive care unit, without needing respiratory support. Physical examination confirmed a large local bulging with distended skin and slight scarification at the bottom of the bulging sac, but without signs of CSF leakage. The newborn was referred for surgical correction of the lesion. Intra-operatively, we observed a distension of the skin with CSF content and, after reopening the skin, a small opening in the muscle fascia without exposure of the placode or dura mater (Figure 3).

The muscle fascia was resutured and the skin was closed using layered anatomic closure. The patient remained under

## Pseudomeningocele after in utero repair of myelomeningocele as an early sign of hypertensive hydrocephalus – a case report and review of the literature



**Figure 3** - (A) Photo of the surgical site repair of a newborn who underwent intrauterine MMC correction showing distension and bulging of the skin without signs of a CSF leakage. (B) Intraoperative photo - the arrow shows an opening in the muscle fascia. (C) Photo showing muscle fascia suture with CSF fistula occlusion.

clinical observation without evidence of fontanelle bulging and/or worsening of ventricular enlargement. After 10 days, there was a CSF leakage through the incision of the surgical site repair associated with worsening of the ventricular enlargement. The clinical picture of hypertensive hydrocephalus was clear, VPS was indicated and the CSF leakage regressed after the procedure.

### DISCUSSION

The pathophysiology of hydrocephalus in MMC remains unclear and still merits further studies. One of the most accepted theories for the development of hydrocephalus in these children is based on the unified McLone theory[12]. According to this theory, a continuous fetal CSF leakage during pregnancy induces the formation of a small and overcrowded posterior fossa with consequent obliteration of the outflow of the fourth ventricle, causing CM type II and aqueductal changes with consequent ventricular dilation. However, other theories have been proposed, such as venous hypertension of the posterior fossa structures caused by bone structural changes during mesenchymal development[13]. According to this theory the main factor causing CSF flow disturbance would not be obstructive leading to a communicating hydrocephalus. Changes in the tectum of mesencephalon (beaking of the tectum) could also contribute to the genesis of ventricular enlargement due to aqueduct stenosis, which would explain the obstructive nature of hydrocephalus in these patients[14]. Contrast studies have shown the obstruction and possible stenosis at

the level of the aqueduct of Sylvius. However, one-third of the studied patients have permeable aqueduct[15]. These theories reinforce the peculiar nature of hydrocephalus in MMC combining communicating and obstructive components on its genesis.

The MOMs trial showed clearly benefits of in utero repair MMC by demonstrating significant reduction of the frequency of postnatal hydrocephalus in newborns who underwent prenatal repair compared to those who underwent postnatal repair [11]. However, this randomized controlled trial showed that 40% of the newborns who underwent prenatal repair still required ventriculoperitoneal shunt (VPS). Indications for VPS are a combination of increased head circumference, bulging of the fontanelle, increased ventricular index or a cephalic percentile above 97.5[11]. Other isolated indications include symptoms of CM type II, syringomyelia and bulging or CSF leakage in the surgical site repair. In a review of the MOMs trial cases, the non-regression of CM type II was shown to be the worst prognostic factor for hydrocephalus. In addition, ventricular enlargement > 15 mm was associated with a 79% need for VPS in the postnatal period[16]. The analysis of postoperative prenatal ultrasonography after MMC treatment could predict the postnatal prognosis of hydrocephalus and provide information on which subgroups of patients would have a higher risk of VPS after birth.

Studies have already shown the importance of CSF flow during the embryonic phase for adequate cortical formation and structuring of cerebral ventricles[17]. Morais et al. showed that ventricular enlargement is present in up to 94%

## Pseudomeningocele after in utero repair of myelomeningocele as an early sign of hypertensive hydrocephalus – a case report and review of the literature

of the MMC patients in a magnetic resonance study of MMC postnatal related brain abnormalities[18]. This shows that most indications of VPS during the postnatal period are related to the presence of intracranial hypertension and ventricular enlargement. However, in a discussion about the failure of endoscopic treatment of hydrocephalus in patients with MMC, Marlin[19] emphasizes the importance of the communicating role in hydrocephalus. The theory is that although there is blockage in the outflow of the fourth ventricle in the subarachnoid spaces by Luscha and Magendie foramen obstruction, there is still permeability and CSF flow through the obex and central canal of the spinal cord, which explains the presence of syringomyelia in these patients.

In a meta-analysis conducted by Kabagambe et al.[6] the indications for VPS in children who have undergone MMC correction during the prenatal period ranged from 32% to 45%. In patients who underwent fetoscopy MMC fetal surgery, Graf et al.[20] described a need for wound re-suture due to CSF leakage in up to 35% after birth. Pedreira et al.[21] described syringomyelia in 30% of operated patients. Belfort et al.[22] described a case of an extremely premature (26 weeks) newborn who underwent in utero MMC treatment by fetoscopy with pseudomeningocele with CSF leakage requiring VPS in the postnatal period. However, there was no report of the appearance of pseudomeningocele on prenatal ultrasound. The lack of detail in the description of VPS indications and the high rate of complications of the surgical site repair of the MMC in most of the studies in the literature indicate that some cases described as technical closure failures could instead be a consequence of hypertensive hydrocephalus, especially if there is a combination of pseudomeningocele with ventriculomegaly[23].

In our patient, a progressive bulging of the surgical MMC site was observed prenatally after the fetal surgery, despite the partial regression of CM type II. Initially, the bulging of the surgical site repair observed on prenatal ultrasound was considered as a technical failure of MMC closure, but the possibility of disturbance of the CSF flow was not ruled out. Tamburrini et al.[24] reported that most neurosurgeons consider CSF leakage and surgical site repair bulging as signs of hypertensive hydrocephalus. However, the simultaneous treatment of the site repair and the performance of VPS could be associated with a higher rate of infectious complications[25]. For this reason and the absence of bulging of the fontanelle, it was decided to initially treat the site repair and monitor the enlargement of the ventricle.

The restructuring of the outlet of the fourth ventricle was not the only cause of hydrocephalus in our patient; and the changes in the subarachnoid space were responsible for communicating hydrocephalus. This hypothesis is reinforced

by the fact that the CSF leakage occurred ten days after the correction of the pseudomeningocele. The bulging of the surgical MMC site repair in cases of fetal MMC correction is considered an absolute indication of VPS in the postnatal period, according to the MOMs trial criteria. However, the appearance of pseudomeningocele in the postoperative prenatal period has not yet been described, which indicates that some cases reported in other studies may have been described as CSF leakage or suture dehiscence. The pseudomeningocele combined with ventricular enlargement in this case was an early sign of hydrocephalus decompensation, and immediate treatment with VPS should be considered.

In conclusion, the presence of pseudomeningocele associated with progressive prenatal ventriculomegaly after in utero MMC repair may represent an early sign of hypertensive hydrocephalus present even before birth. Correction of pseudomeningocele alone may not be effective and treatment of hydrocephalus should be performed.

### DISCLOSURES

### DISCLOSURES

#### *Ethical approval*

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the local Ethics Committee

#### *Consent to participate*

The patient gave consent to use his information and images for research proposes.

#### *Consent for publication*

The patient gave consent to use his information and images for publication.

#### *Conflict of interest*

The authors declare no conflicts of interest with respect to the content, authorship, and/or publication of this article.

#### *Funding*

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors

## Pseudomeningocele after in utero repair of myelomeningocele as an early sign of hypertensive hydrocephalus – a case report and review of the literature

### REFERENCES

1. Au KS, Ashley-Koch A, Northrup H. Epidemiologic and genetic aspects of spina bifida and other neural tube defects. *Dev Disabil Res Rev.* 2010;16(1):6–15.
2. Stein Sherman C, Schut L. Hydrocephalus in myelomeningocele. *Childs Brain.* 1979;5:413–9.
3. Van Gool JD, Dik P, De Jong TPVM. Bladder-sphincter dysfunction in myelomeningocele. *Eur J Pediatr.* 2001;160(7):414–20.
4. Flanagan A, Gorzkowski M, Altiok H, Hassani S, Ahn KW. Activity level, functional health, and quality of life of children with myelomeningocele as perceived by parents. *Clin Orthop Relat Res.* 2011;469(5):1230–5.
5. Burro F, Cama A, Lertora V, Veneselli E, Rossetti S, Pezzuti L. Intellectual efficiency in children and adolescents with spina bifida myelomeningocele and shunted hydrocephalus. *Dev Neuropsychol [Internet].* 2018;43(3):198–206. Available from: <https://doi.org/10.1080/87565641.2018.1439035>
6. Kabagambe SK, Jensen GW, Chen YJ, Vanover MA, Farmer DL. Fetal Surgery for Myelomeningocele: A Systematic Review and Meta-Analysis of Outcomes in Fetoscopic versus Open Repair. *Fetal Diagn Ther.* 2018;43(3):161–74.
7. Danzer E, Finkel RS, Rintoul NE, Bebbington MW, Schwartz ES, Zarnow DM, et al. Reversal of hindbrain herniation after maternal-fetal surgery for myelomeningocele subsequently impacts on brain stem function. *Neuropediatrics.* 2008;39(6):359–62.
8. Ruano R, Daniels DJ, Ahn ES, Ibirogba ER, Lu VM, Snyder KA, et al. In Utero Restoration of Hindbrain Herniation in Fetal Myelomeningocele as Part of Prenatal Regenerative Therapy Program at Mayo Clinic. *Mayo Clin Proc.* 2020;95(4):738–46.
9. Danzer E, Johnson MP, Bebbington M, Simon EM, Wilson RD, Bilaniuk LT, et al. Fetal head biometry assessed by fetal magnetic resonance imaging following in utero myelomeningocele repair. *Fetal Diagn Ther.* 2006;22(1):1–6.
10. Marlin A, Hochwaldt G, Hoff JR. Myelomeningocele : a Progressive Intra-uterine Disease. 1970;12–5.
11. Adzick NS, Thom EA, Spong CY, Brock JW, Burrows PK, Johnson MP, et al. A randomized trial of prenatal versus postnatal repair of myelomeningocele. *N Engl J Med.* 2011;364(11):993–1004.
12. McLone DG, Knepper PA. The Cause of Chiari II Malformation: A Unified Theory. *Pediatr Neurosci.* 1989;15:1–12.
13. Oi S, Di Rocco C. Proposal of “evolution theory in cerebrospinal fluid dynamics” and minor pathway hydrocephalus in developing immature brain. *Child’s Nerv Syst.* 2006;22(7):662–9.
14. Tortori-Donati P, Rossi A, Cama A. Spinal dysraphism: A review of neuroradiological features with embryological correlations and proposal for a new classification. *Neuroradiology.* 2000;42(7):471–91.
15. Yamada H, Nakamura S, Tanaka Y, Tajima M, Kageyama N. Ventriculography and Cisternography with Wather-Soluble Contrast Media in Infants with Myelomeningocele. *Radiology.* 1982;143:75–83.
16. Heuer GG, Moldenhauer JS, Scott Adzick N. Prenatal surgery for myelomeningocele: review of the literature and future directions. *Child’s Nerv Syst.* 2017;33(7):1149–55.
17. Desmond ME, Jacobson AG. Embryonic brain enlargement requires cerebrospinal fluid pressure. *Dev Biol.* 1977;57(1):188–98.
18. Morais BA, Solla DJF, Yamaki VN, Ferracioli SF, Alves CAPF, Cardeal DD, et al. Brain abnormalities in myelomeningocele patients. *Child’s Nerv Syst.* 2020;36(7):1507–13.
19. Marlin AE. Management of hydrocephalus in the patient with myelomeningocele: an argument against third ventriculostomy. *Neurosurg Focus.* 2004;16(2):1–3.
20. Graf K, Kohl T, Neubauer BA, Dey F, Faas D, Wanis FA, et al. Percutaneous minimally invasive fetoscopic surgery for spina bifida aperta. Part III: Neurosurgical intervention in the first postnatal year. *Ultrasound Obstet Gynecol.* 2016;47(2):158–61.
21. Pedreira DAL, Zanon N, Nishikuni K, Moreira De Sá RA, Acacio GL, Chmait RH, et al. Endoscopic surgery for the antenatal treatment of myelomeningocele: The CECAM trial. *Am J Obstet Gynecol [Internet].* 2016;214(1):111.e1-111.e11. Available from: <http://dx.doi.org/10.1016/j.ajog.2015.09.065>
22. Belfort MA, Whitehead WE, Shamshirsaz AA, Bateni ZH, Olutoye OO, Olutoye OA, et al. Fetoscopic open neural tube defect repair: Development and refinement of a two-port, carbon dioxide insufflation technique. *Obstet Gynecol.* 2017;129(4):734–43.
23. Lu VM, Snyder KA, Ibirogba ER, Ruano R, Daniels DJ, Ahn ES. Progressive hydrocephalus despite early complete reversal of hindbrain herniation after prenatal open myelomeningocele repair. *Neurosurg Focus.* 2019;47(4):10–5.
24. Tamburrini G, Frassanito P, Iakovaki K, Pignotti F, Rendeli C, Murolo D, et al. Myelomeningocele: The management of the associated hydrocephalus. *Child’s Nerv Syst.* 2013;29(9):1569–79.
25. Tuli S, Drake J, Lamberti-Pasculli M. Long-term outcome of hydrocephalus management in myelomeningoceles. *Child’s Nerv Syst.* 2003;19(5–6):286–91.