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Case Report

Can Closed-Incision Negative Pressure Wound Therapy Improve Wound Healing in Myelomeningocele Repair?

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Abstract

Background: Myelomeningocele (MMC) is a common subset of spina bifida occurring globally in one of 1000 births. In most cases it is diagnosed prenatally. Many neurological deficits and comorbidities are described, the most important being hydrocephalus and Arnold Chiari Syndrome II. Early surgical closure is mandatory to avoid further complications, especially infection and sepsis. However, the postoperative course following soft tissue reconstruction remains vulnerable to wound dehiscence, cerebrospinal fluid leakage, and surgical site infection, particularly in the neonatal lumbosacral region.

Case report: A male neonate born at 38+5 weeks presented with an L3 myeloschisis and a 5 × 3 cm exposed neural placode. Late prenatal diagnosis at 33 weeks precluded fetal intervention. On the day of birth, combined neurosurgical and plastic surgical repair was undertaken: watertight multi-layered dural closure reinforced with fibrin sealant, followed by bilateral paraspinal muscle advancement (Ramirez technique). A Prevena ciNPWT system was applied to the closed incision at −50 mmHg continuous pressure for six days. A ventriculoperitoneal shunt was placed intraoperatively for congenital obstructive hydrocephalus.

Results: Primary wound healing was achieved without surgical site infection, wound dehiscence, or cerebrospinal fluid leakage. No cutaneous adverse events, including epidermal blistering, were observed throughout the treatment period. At three-month follow-up, the incision site demonstrated complete epithelialization with resolving localized erythema. Notably, the patient exhibited unanticipated neurological recovery, with active bilateral pedal movement and sporadic hip flexion documented by postoperative day nine, despite an initial presentation of lower extremity plegia.

Conclusions: To our knowledge, this represents the first prophylactic application of low-pressure ciNPWT following Ramirez muscle transposition for neonatal myeloschisis. This adjunctive strategy may reduce wound complications and optimize healing in a population where standard postoperative protocols remain undefined.

Keywords: Myelomeningocele; Spina bifida; Ramirez bilateral muscle advancement; closed-incision negative pressure wound therapy; ciNPWT

Abbreviations: MMC: Myelomeningocele; ciNPWT: Closed-Incision Negative Pressure Wound Therapy; NPWT: Negative Pressure Wound Therapy; CSF: Cerebrospinal Fluid; VP: Ventriculoperitoneal; APGAR: Apgar Score; BMI: Body Mass Index; MRI: Magnetic Resonance Imaging; VEGF: Vascular Endothelial Growth Factor; TGF-β: Transforming Growth Factor-Beta; TNF-α: Tumor Necrosis Factor-Alpha; FDA: Food and Drug Administration

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Introduction

The spina bifida spectrum encompasses defects (dysraphias) in the posterior midline that can affect the skin as well as the spinal column and its contents. Myelomeningocele is a specific type of spina bifida in which nerve roots, the meninges, and the medulla protrude [1]. The incidence of this congenital defect varies among countries. It has been estimated that there are 0.5–0.8 cases per 1,000 births in the United States and most of Europe, while in some parts of Asia the incidence is 20 times greater [2]. Low or delayed folic acid intake is a recognized risk factor for spina bifida [3]. Other maternal and environmental factors related to neural tube defects range from alcohol or substance abuse to extreme body temperature variations [2]. Early treatment has been advocated as the best course of action to achieve positive results and to reduce the disability rate [4], with prenatal treatment of this condition showing even better results [5]. When repairing spina bifida, skin approximation must be achieved in addition to neural tube and meningeal closure. Diverse techniques have been attempted to achieve this, from skin grafts to flaps of varied designs [6]. Ideally, the skin closure must be tension-free, enduring, sensate, and have adequate blood flow. The specific location of the defect and its size inform the decision regarding the treatment method [7], since smaller defects can be treated with simpler techniques. For larger defects, muscle transposition techniques are often required. The Ramirez technique is a well-established method for primary closure of large myelomeningocele defects that involves bilateral medial advancement of the latissimus dorsi and gluteus maximus muscles [8]. However, the postoperative course remains vulnerable to dehiscence, infection, and marginal necrosis, particularly given the poor tissue quality of the neonatal lumbosacral region [8,9]. Closed-incision negative pressure wound therapy (ciNPWT) has shown efficacy in reducing surgical site complications in other settings [10-12], yet its prophylactic use in neonatal myelomeningocele repair has not been described. We present the first reported case of low-pressure ciNPWT applied immediately following Ramirez muscle transposition for primary myeloschisis closure in a neonate.

Patient Presentation

The patient is a male infant born at 38 weeks and 5 days of gestation via planned Cesarean section due to a prenatal diagnosis of myeloschisis. APGAR scores were 5, 8, and 10 at 1, 5, and 10 minutes, respectively, birth weight 3kg. The primary concern was the diagnosis of an open neural tube defect (myeloschisis) starting at L3 with associated central nervous system anomalies, including Chiari II malformation and congenital obstructive hydrocephalus. The 34 year old mother, a G2P1 with a BMI of 38.8 and gestational diabetes, reported protocol compliant folic acid intake. Due to insufficient prenatal screening, a late diagnosis of fetal spina bifida and Chiari II malformation was confirmed via fetal MRI at 33 weeks gestation. A spinal defect (myelocele and tethered cord extending from L3 to the sacral/coccygeal region) and associated ventriculomegaly were identified, mandating immediate planning of the definitive repair upon birth. Physical examination at birth confirmed the diagnosis of an open myeloschisis, presenting as a 5 cm lumbosacral defect with an exposed neural placode (Figure 1). Initial neurological assessment revealed observable movement of the upper extremities but no discernible movement of the lower extremities.

Figure 1: Preoperative presentation of lumbosacral myeloschisis. A 5 × 3 cm midline lumbosacral defect with exposed neural tissue and absence of epithelial coverage. The surrounding skin demonstrates violaceous discoloration, consistent with compromised soft tissue.

Materials and Methods

A combined neurosurgical and plastic reconstruction was performed on the day of birth under a single general anesthesia. Following the reconstruction of the neural tube and its associated structures, the neurosurgical team achieved a multi-layered, watertight closure of both the arachnoid and dura mater. The repair was further reinforced with a fibrin sealant patch (TachoSil) to provide a secondary hemostatic barrier and ensure a secure seal. The procedure was subsequently continued by the plastic surgery team. The 5 x 3 cm defect was addressed under loupe magnification according to the Ramirez technique, a well-established method for primary closure of large myelomeningocele defects that involves bilateral medial advancement of the latissimus dorsi and gluteus maximus muscles [8]. The undersurface of the latissimus dorsi was identified bilaterally along with the gluteus maximus and the posterior superior iliac spine. To facilitate proximal mobilization, the trapezius was additionally incised paravertebrally and released from the spine. The latissimus dorsi was then scored along its medial aspect and mobilized from lateral to medial bilaterally. Inferiorly, the gluteus maximus was released from the posterior superior iliac spine and sacrum and advanced medially. All muscle units were approximated in the midline with 3-0 Vicryl sutures, achieving complete defect coverage (Figure 2). The skin edges were conservatively débrided of livid, compromised tissue and closed with 5-0 Vicryl Rapid simple interrupted sutures (Figure 3).

A Prevena closed incision negative pressure wound therapy (ciNPWT) system was then applied to the suture line at a continuous negative pressure of -50 mmHg (Figure 4). This lower pressure setting was intentionally chosen to minimize the risk of both epidermal injury in neonatal skin and Cerebrospinal Fluid (CSF) leakage through the dural repair, while maintaining adequate wound stabilization. The neurosurgery team finalized the intervention by placing a Ventriculoperitoneal (VP) shunt to address the hydrocephalus linked to Chiari II malformation.

Upon transfer from the operating room, the patient was hemodynamically stable on minimal catecholamine support and was well-ventilated bilaterally, with the lumbar wound sealed under the ciNPWT system. While standard utilization protocols advocate for dressing changes in 48 to 72 hour intervals [13], the team strategically extended this duration. Sustained absence of inflammatory parameters and a stable unremarkable local wound appearance clinically justified this deviation. During the six-day treatment period, the ciNPWT system maintained optimal adherence without evidence of dehiscence or CSF leakage. This structural integrity persisted despite the challenges of VP-shunt malposition and the resulting pronounced fluctuations in intracranial pressure. Rigorous serial neurosonographic examinations synchronized with confirmatory magnetic resonance imaging guided ongoing management.

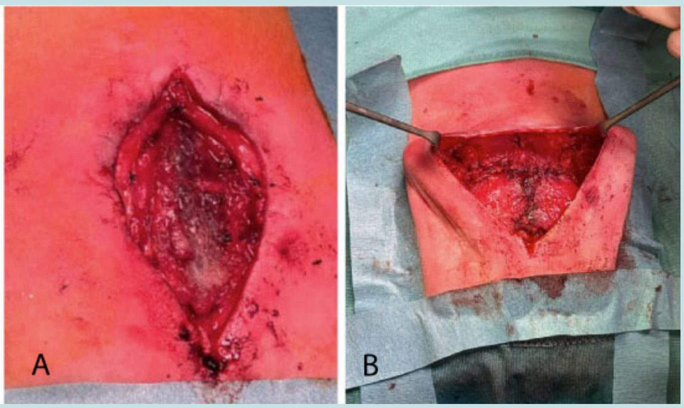

Figure 2: Intraoperative findings and reconstrucion.
(A) Intraoperative view following exposure of the lumbosacral defect, demonstrating the neural placode and surrounding soft tissue after initial preparation.
(B) After dural closure, bilateral paraspinal muscle advancement (according to Ramirez technique) is performed, with approximation of well-vascularized tissue over the midline defect.

Figure 3: Midline closure of the lumbosacral defect after dural repair and bilateral paraspinal muscle advancement demonstrating complete soft tissue coverage with well-approximated wound edges and no visible residual defect.

Figure 4: Postoperative application of closed-incision negative pressure wound therapy (ciNPWT).
A ciNPWT system (Prevena) applied over the closed lumbosacral incision, with an occlusive dressing and suction interface in place, providing continuous negative pressure therapy to support wound healing and reduce postoperative complications.

Figure 5: Wound status at postoperative day 6.
(A) Lateral view demonstrating intact midline incision with complete soft tissue adherence under a sealed ciNPWT system (Prevena) prior to removal. No evidence of wound dehiscence, cerebrospinal fluid leakage, or device-related complications is observed.
(B) Early postoperative wound status following removal of ciNPWT at postoperative day 6.
Lateral view of the lumbosacral incision demonstrating intact midline closure with sutures in situ. The wound edges are well approximated without evidence of dehiscence or cerebrospinal fluid leakage. Mild surrounding erythema and localized swelling are present, consistent with early postoperative changes.

Results

The patient remained free of local cutaneous complications at every stage, avoiding the epidermal blistering frequently associated with negative pressure wound therapy in adult populations [10]. Upon system removal on the sixth postoperative day, the incision appeared dry and uninflamed (Figure 5). Subsequent management included conservative dry dressing changes performed every other day. Alongside favorable local wound healing, the patient demonstrated unexpected functional gains by the ninth postoperative day. Clinical examination revealed active bilateral pedal movement and sporadic gross motor hip flexion of the right lower extremity, despite the initial preoperative assessment of lower extremity plegia. At a five-month follow-up, clinical examination demonstrated a small, superficial fistula at the lumbar incision site, which showed spontaneous resolution without the need for surgical revision (Figure 6). The surrounding soft tissue appeared stable, with no evidence of wound dehiscence or infection. A separate healing impairment in the parieto-occipital region occurred during the subsequent clinical course; however, this was anatomically remote from the lumbar defect and unrelated to the primary reconstruction.

Figure 6: Late postoperative follow-up at 5 months.
Follow-up image demonstrating a small superficial fistula in the lumbosacral region, without signs of active infection or wound dehiscence. The lesion resolved spontaneously without the need for surgical revision.

Discussion

While bilateral muscle advancement is the established surgical gold standard for reconstructing massive, open myelomeningocele defects in neonates, the postoperative course is frequently jeopardized by complications such as wound dehiscence, CSF leaks, infections, and marginal necrosis [8]. The inherently poor tissue integrity of the lumbosacral region further intensifies this danger, often necessitating advanced adjunctive strategies to reinforce the repair [8,9]. To our knowledge, this is the first documented case demonstrating the prophylactic application of low-pressure ciNPWT immediately following a complex muscle advancement for a neonatal myeloschisis. By employing Prevena™ Incision Management System (Solventum, St. Paul, MN) to effectively seal the entire repair site, our goal was to establish a stable, controlled environment that protected the fragile suture line during its most vulnerable healing phase [10,11]. The successful primary closure of this extensive lumbosacral defect highlights the clinical synergy between the bilateral muscle advancement and low-pressure ciNPWT. Currently, there is an emerging consensus within the pediatric surgical community recognizing the efficacy of NPWT in the management of complex neonatal wounds, including extensive spinal defects [14-17]. However, the rarity of these cases and the ethical complexities of studying such a vulnerable population mean that prospective clinical trials are unlikely in the near future. This challenge is further reinforced by the fact that standardized adult wound assessment scales frequently fail to adequately represent the distinct physiological characteristics of neonatal skin. For instance, decreased epidermal-to-dermal cohesion makes neonates highly prone to severe epidermal stripping from standard adhesive dressings [14]. While standardized protocols for neonatal NPWT remain limited, our clinical rationale was guided by the American Academy of Pediatrics. Their framework supports the off-label use of devices when it serves the patient's best interest and when traditional methods are deemed inferior [18]. We therefore relied on established NPWT mechanisms, alongside general postoperative guidelines for myeloschisis closures. These recommendations emphasize minimizing adverse effects by actively reducing contamination and fluid accumulation, while maintaining an optimal moist wound environment [14,19]. This approach is supported by a growing body of literature demonstrating that the application of NPWT to closed incisions significantly lowers the incidence of surgical site infections and seromas [11,12,20]. This is especially vital given the high risk of fecal contamination in the neonatal lumbosacral area. By minimizing dressing change frequency and shielding the early repair from external contaminants, we maintained the integrity of the healing tissue and a stable, moist microenvironment essential for tissue maturation [17,19]. Additionally, this approach eliminated the repetitive tissue trauma inherent to the mechanical peeling of traditional dressings [11,14-16]. The resulting reduction in dressing-associated bedside procedures lowered the burden on the clinical team. Our observations align with the view that NPWT serves as a reliable addition or even alternative to traditional methods, such as saline-soaked gauze [16,21]. Importantly, the decreased frequency of dressing changes did not jeopardize the rigorous safety monitoring protocols required of the nursing and physician teams. While the patient experienced significant fluctuations in intracranial pressure secondary to VP-shunt malposition, the mechanical integrity of the vacuum dressing remained stable. Consequently, the predefined criteria for therapy cessation, such as audible leaks or evidence of CSF egress, were never met, allowing for uninterrupted wound stabilization. This continuous macroscopic stabilization proved essential, as the benefits of the vacuum extend far beyond acting as a static physical shield. At the microscopic level, the sustained application of subatmospheric pressure triggers cellular effects critical for the survival of mobilized tissues, such as those utilized in the Ramirez technique. The application of subatmospheric pressure causes tissue microdeformations and microstrains that stretch the cellular cytoskeleton, driving cell proliferation and accelerating recovery [11,22]. At a molecular level, this mechanical stress up regulates Vascular Endothelial Growth Factor (VEGF) for angiogenesis, and transforming growth factor-beta (TGF-β) to drive granulation, while downregulating pro-inflammatory cytokines like tumor necrosis factor-alpha (TNF-α) [23]. In the context of this massive lumbosacral reconstruction, we hypothesize that this mechanically-driven shift toward a vascularized and anti-inflammatory profile may have contributed to lowering the risk of marginal flap necrosis and supported the definitive engraftment of the advanced muscle flaps. The safe application of NPWT in myeloschisis reconstruction requires the definitive exclusion of a Cerebrospinal Fluid (CSF) leak. Therefore, a robust, watertight primary dural repair is a mandatory prerequisite for its use [24-26]. In accordance with this principle, therapy must be discontinued immediately if a new dural breach is suspected. The application of subatmospheric pressure to an open CSF tract could potentially induce massive fluid shifts, trigger severe intracranial hemorrhage and rapid neurological deterioration [16,25,26]. Beyond localized tissue repair, early NPWT application offers a critical systemic advantage. Due to a high surface-area-to-volume ratio, neonates are exceptionally vulnerable to extracellular fluid shifts [15]. While conventional dressings obscure fluid loss through absorption, the NPWT collection canister captures and quantifies extracellular drainage, allowing for accurate fluid replacement and the maintenance of hemodynamic stability [15]. Balancing these systemic benefits with local tissue safety remains challenging. High-level evidence, such as recent Cochrane analyses, warns of an increased risk of local skin blistering with NPWT, yet these conclusions are derived exclusively from adult cohorts [10]. Consequently, practitioners are forced to rely heavily on Level IV and V evidence (primarily retrospective case series and expert opinion) to guide critical technical decisions [15,16,26,27], which informed our selection of the conservative pediatric consensus pressure of -50mmHg [14]. When the dural repair is successfully covered by closed native tissues (such as muscle and fascia), as was achieved in our prophylactic application, the patient's own tissue acts as a safe, natural barrier separating the dural sac from the vacuum device [26]. However, the inherent complexity of myeloschisis repairs dictates that severe postoperative complications, such as wound dehiscence or flap necrosis with subsequent dural exposure, can still occur. In salvage scenarios where native tissue coverage is lost to necrosis, multidisciplinary strategies are required to safely maintain vacuum therapy. Recent reports describe that once an autologous flap fails, practitioners are forced to interpose artificial physical barriers, such as dermal regeneration templates or nonadherent contact layers, directly over the exposed neural elements to buffer the subatmospheric pressure, often in conjunction with active internal cerebrospinal fluid diversion [15,28]. Although conventional surgical principles caution against the application of NPWT near exposed neural elements, recent biophysical and clinical evidence challenges this concept. Experimental models utilizing high-fidelity tissue pressure microsensors demonstrate that NPWT actually generates localized hyperbaric pressure within the underlying tissue bed [29]. This creates a mechanical tamponade effect that physically compresses the tissue and has been reported to halt active cerebrospinal fluid leakage without inducing neurologic injury [30]. Importantly, in the present case, the definitively closed muscle flap provided a robust native tissue barrier, making direct contact between the vacuum and neural elements unnecessary. Drawing on these principles, our strategy aimed to harness the mechanical stabilization provided by this tamponade effect. By actively compressing the native tissue barrier against the primary neurosurgical repair, this approach provides a synergistic layer of protection, proactively mitigating the inherent risk of dehiscence. The multidisciplinary management of this patient was ultimately dictated by the underlying pathophysiology. As noted by Morais et al. [31], patients with myelomeningocele consistently exhibit a broad spectrum of intracranial anomalies, most prevalently hydrocephalus (94.5%) and Chiari malformation type II (89.1%) [31]. The resulting intracranial hypertension creates a persistent gradient that forces CSF through the spinal repair, perpetuating the risk of leakage and preventing flap adhesion. Consequently, the insertion of a VP shunt served a dual purpose: treating the primary neurological condition and protecting the spinal repair from internal hydrostatic pressure. Externally, combining a watertight Ramirez closure with early ciNPWT acted as both a cohesive stabilizing element and a sterile mechanical shield. By optimizing microvascular perfusion and mitigating tissue edema, subatmospheric pressure stabilized the flap without disrupting the underlying dural repair. At three months, the site demonstrated optimal maturation without dehiscence. While ciNPWT did not directly precipitate neurological improvement, it served as a critical stabilizing shield. By maintaining a sealed, low-tension environment, the therapy preserved the structural integrity of the neurosurgical repair and secured the physiological window necessary for intrinsic recovery. Integrating prophylactic ciNPWT at the time of reconstruction offers a reproducible strategy to protect high-tension muscle transpositions, effectively bridging the gap between surgical closure and definitive tissue incorporation in high-risk neonates.

Limitations

This study has several limitations. As a single-center case report, the findings cannot be generalized, and the absence of a control group precludes any causal inference regarding the efficacy of ciNPWT. The observed neurological improvement is likely attributable to the successful neural tube repair and VP shunt placement rather than to the wound management strategy itself. Furthermore, the extended dressing duration and low-pressure setting were based on clinical judgment rather than standardized protocols, limiting reproducibility. Finally, the current evidence base for neonatal NPWT relies predominantly on Level IV and V evidence [15,16,26,27], and the FDA has not endorsed specific safety parameters for this demographic [32].

Conclusion

This case demonstrates that the application of low-pressure (-50 mmHg) ciNPWT immediately following primary myeloschisis repair appears safe, provided that bilateral muscle advancement serves as a foundational barrier isolating the vacuum system from the dural closure. Despite the inherently high risks of infection and CSF leakage, the ciNPWT established a stable environment for healing. The late prenatal diagnosis at 33 weeks precluded fetal surgery, underscoring the importance of optimizing postnatal wound stabilization. Although based on a single case, the successful outcome aligns with the growing body of evidence supporting off-label ciNPWT use in pediatric patients [14–17]. Reporting such outcomes remains vital for the development of standardized neonatal guidelines.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Ethical Approval

The study was performed in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from the patient's legal guardian for publication of this case and accompanying images. The patient is not identifiable from the images provided.

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