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Predictors of Postoperative Complications Following Postnatal Meningomyelocele Repair: A Retrospective Cohort Study from Northeast India

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Abstract

Background

Postnatal repair of meningomyelocele (MMC) continues to be the primary treatment approach in many low- and middle-income settings. Postoperative complications have a substantial impact on both early and long-term outcomes and contribute significantly to morbidity and mortality. This study evaluated the pattern, incidence, and determinants of postoperative complications following postnatal MMC repair.

Methods

This retrospective observational study analyzed patients (aged 0–18 years) who underwent postnatal MMC repair between January 2016 and December 2025. Consecutive eligible patients were included. Data on demographics, lesion morphology, surgical timing, and associated anomalies were extracted. Complications were classified into wound-related, cerebrospinal fluid (CSF)-related, neurological, infective, and systemic categories. Statistical analysis was performed to identify factors associated with adverse outcomes.

Results

A total of 104 patients were included. Postoperative complications were frequent, with wound-related complications in 34 (32.7%), CSF leak in 18 (17.3%), and meningitis in 12 (11.5%). Among initially non-shunted patients, 7/43 (16.3%) required ventriculoperitoneal shunt placement. Multivariate analysis identified ruptured sac (adjusted OR 3.8, 95% CI 1.6–8.9; p = 0.01) and defect size > 5 cm (adjusted OR 4.2, 95% CI 1.9–9.4; p = 0.02) as independent predictors of postoperative complications.

Conclusion

Postnatal MMC repair is associated with a high burden of wound and CSF-related complications. The presence of a ruptured sac and large defect size was associated with increased risk and serves as a critical indicator of postoperative complications. Enhancing meticulous closure techniques and optimizing perioperative protocols are vital to improving surgical outcomes in resource-constrained environments.

Introduction

Meningomyelocele (MMC), the most severe form of spina bifida aperta, results from incomplete closure of the neural tube during the third to fourth week of gestation [1–3]. It is characterized by herniation of neural elements through a vertebral defect and is frequently associated with hydrocephalus, Chiari II malformation, neurogenic bladder, and orthopaedic deformities. Despite advances in antenatal

screening and folic acid supplementation, MMC remains an important public health concern in developing countries.

The primary goals of postnatal MMC repair are protection of exposed neural tissue, prevention of infection, achievement of watertight dural closure, and provision of durable soft tissue coverage [4–6]. Early operative intervention has long been recommended to reduce the risk of meningitis and progressive neurological injury. However, even with timely surgery, postoperative complications remain common and substantially influence early morbidity, mortality, length of hospital stay, and long-term functional outcomes [6–8].

The Management of Myelomeningocele Study (MOMS) demonstrated the benefits of prenatal repair in reducing shunt dependency and improving motor outcomes [9], but its applicability is limited by strict selection criteria, resource requirements, and potential maternal risks. Consequently, postnatal repair continues to be the predominant treatment modality in most centres worldwide [7, 10]. In this context, a detailed understanding of postoperative complications following postnatal MMC repair is essential for improving outcomes, refining surgical techniques, and counselling caregivers.

While several studies have described overall outcomes after MMC repair, focused analyses of postoperative complications and their predictors are limited, particularly in resource-constrained settings [7, 10]. The present study aims to systematically evaluate postoperative complications following postnatal MMC repair and identify factors influencing their occurrence.

Materials and Methods

Study Design and Setting

This retrospective observational study was conducted at a tertiary care centre over a 10-year period from January 2016 to December 2025. This study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Sampling Technique

A consecutive non-probability sampling method was used. All eligible patients undergoing postnatal MMC repair during the study period were screened.

Inclusion Criteria

- Patients aged 0–18 years
- Diagnosed with meningomyelocele
- Underwent definitive postnatal surgical repair
- Available perioperative records and postoperative follow-up documentation

Exclusion Criteria

- Lipomyelomeningocele
- Associated encephalocele or other major dysraphism syndromes
- Death before definitive surgery
- Incomplete clinical records

Preoperative Evaluation

All patients underwent a detailed clinical evaluation at admission, including assessment of neurological status, anatomical level of the lesion, defect size, sac integrity (intact or ruptured), and the presence of associated congenital anomalies.

Cranial computed tomography (CT) was performed to assess ventricular size and identify associated intracranial abnormalities. Magnetic resonance imaging (MRI) of the spine was obtained in all patients to define lesion characteristics and neural involvement.

Surgical Management and Postoperative Care

All patients underwent definitive postnatal meningomyelocele repair under general anaesthesia following a standardized institutional protocol. Patients were positioned prone with appropriate padding of pressure points. Prophylactic intravenous antibiotics were administered at induction and continued postoperatively according to institutional policy.

Following sterile preparation and draping, a transverse incision was made over the dome of the swelling. The dysplastic neural placode was carefully dissected free from the surrounding tissue, preserving viable neural elements whenever possible. The neural placode was reconstructed by gentle tubularization where feasible, and a meticulous watertight dural closure was performed using continuous 4 – 0 Prolene sutures. In cases where primary dural approximation was not possible because of a large defect or attenuated dura, adjacent dural mobilization was undertaken to achieve a tension-free closure.

Paraspinal fascia was mobilized and closed in layers to provide additional soft-tissue reinforcement over the dural repair. Skin closure was performed without excessive tension using primary approximation whenever feasible. In patients with large defects or limited skin availability, local skin flap mobilization was used to achieve adequate soft-tissue coverage and minimize wound tension. Closed-suction drains were not used routinely.

Patients with established symptomatic hydrocephalus or progressive ventricular enlargement underwent ventriculoperitoneal shunt placement either before or after meningomyelocele repair, depending on the severity of hydrocephalus, associated clinical findings, and the treating surgeon's judgment.

Postoperatively, patients were closely monitored for wound integrity, cerebrospinal fluid (CSF) leak, signs of infection, and changes in neurological status. Serial head circumference measurements and cranial imaging were performed to monitor for the development or progression of hydrocephalus.

Outcome Measures

The primary outcome of interest was the occurrence of postoperative complications following meningomyelocele repair, encompassing wound-related complications, cerebrospinal fluid (CSF) leak, surgical site infection, meningitis, hydrocephalus requiring cerebrospinal fluid diversion, neurological deterioration, and mortality.

Statistical Analysis

Data were analysed using standard statistical software. Continuous variables were expressed as mean ± standard deviation, and categorical variables were presented as frequencies and percentages. Associations between categorical variables were assessed using Pearson chi-square test or Fisher's exact test, as appropriate. Variables significant on univariate analysis were entered into multivariate logistic regression. Potential confounders identified a priori included age at surgery, lesion level, hydrocephalus status, sac rupture at presentation, defect size, and timing of repair. These variables were considered during model construction to adjust for confounding and identify independent predictors of postoperative complications. Statistical significance was defined as a p-value < 0.05.

Ethics Statement

This retrospective observational study was approved by the Institutional Ethics Committee. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and institutional guidelines for human research. Patient confidentiality and privacy were maintained throughout the study.

Results

Patient Demographics and Lesion Characteristics

A total of 104 patients underwent postnatal MMC repair during the study period. The mean age at surgery was 12.0 ± 4.6 months, with a male predominance (58 males, 46 females). Lumbosacral lesions were the most common [69 (66.3%)], followed by thoracolumbar [25 (24.0%)] and cervical/thoracic lesions [10 (9.6%)].

A ruptured sac at presentation was observed in 24 (23.1%) of patients. Preoperative hydrocephalus was present in 61 (58.6%) patients, while 43 (41.3%) were initially non-shunted (Table 1).

Table 1
Demographic and Lesion Characteristics (n = 104)

Variable	Number (%)
Total patients	104
Male : Female	58 : 46
Mean age at surgery (months)	12.0 ± 4.6
Anatomical Level of Lesion	
• Lumbosacral lesion	69 (66.3%)
• Thoracolumbar lesion	25 (24.0%)
• Cervical/Thoracic lesion	10 (9.6%)
Ruptured sac at presentation	24 (23.1%)
Preoperative hydrocephalus	61 (58.6%)
Initially non-shunted patients	43 (41.3%)

Postoperative Complications

Postoperative complications were common following postnatal meningomyelocele repair. Representative clinical images of these complications are shown in Figs. 1 (A-C).

(A) Wound dehiscence demonstrating separation of the surgical incision with exposure of underlying tissue
(B) Wound necrosis showing devitalized tissue and breakdown of the surgical closure
(C) Cerebrospinal fluid leak from the operative site

Wound-related complications constituted the most frequent adverse events, occurring in 34 (32.69%) patients. Among these, wound dehiscence was observed in 20 (19.2%), while wound necrosis occurred in 14 (13.5%) patients.

Cerebrospinal fluid (CSF) leak was noted in 18 (17.3%) patients, and meningitis developed in 12 (11.5%). Among patients who were not shunted preoperatively, 7 (16.3%) required ventriculoperitoneal shunt placement following repair due to progressive hydrocephalus. Neurological deterioration occurred in 6 (5.8%), and the overall mortality rate was 4.8% (Table 2).

Table 2
Postoperative Complications Following Postnatal MMC Repair

Complication	Number (%)
Wound-related complications	34 (32.7%)
• Wound necrosis	14 (13.5%)
• Wound dehiscence	20 (19.2%)
CSF leak	18 (17.3%)
Surgical site infection	15 (14.4%)
Meningitis	12 (11.5%)
Progressive hydrocephalus requiring VP shunt*	7 (16.3%)
Neurological deterioration	6 (5.8%)
Mortality	5 (4.8%)
*Percentage calculated among initially non-shunted patients (n = 43)	

Risk Factor Analysis

Univariate analysis demonstrated that preoperative sac rupture and larger defect size (> 5 cm) were significantly associated with postoperative complications. Patients presenting with a ruptured sac had a higher complication rate than those with intact sacs ($\chi^2 = 9.78$, $p = 0.002$). Similarly, defects larger than 5 cm were associated with a significantly increased risk of postoperative morbidity compared with smaller defects ($\chi^2 = 7.10$, $p = 0.008$).

On multivariate logistic regression, both preoperative sac rupture (adjusted OR 3.8, 95% CI 1.6–8.9; $p = 0.01$) and defect size > 5 cm (adjusted OR 4.2, 95% CI 1.9–9.4; $p = 0.02$) remained independent predictors of postoperative complications. The overall model was significant (likelihood ratio $\chi^2 = 18.42$, $df = 2$; $p < 0.001$) and demonstrated satisfactory calibration (Hosmer–Lemeshow $\chi^2 = 5.21$, $p = 0.74$).

Discussion

Postoperative complications following postnatal meningomyelocele (MMC) repair continue to represent a significant challenge in neurosurgical practice. In the present study, postoperative complications were frequent, with wound-related and cerebrospinal fluid (CSF)–related complications accounting for the majority of adverse events. These findings highlight the inherent complexity of MMC repair, particularly in patients presenting beyond the neonatal period.

Wound-Related and CSF-Related Complications

Wound-related complications constituted the most common postoperative morbidity in this series, affecting nearly one-third of patients. Importantly, wound complications were further subclassified into wound dehiscence and wound necrosis, allowing more granular analysis. Multivariate analysis identified preoperative sac rupture and larger defect size (> 5 cm) as independent predictors of postoperative complications, underscoring the critical role of local tissue integrity and defect characteristics in determining surgical outcomes.

Ruptured sacs are frequently associated with contamination, friable tissue planes, and impaired wound healing, predisposing to both wound dehiscence and necrosis. Similarly, larger defects pose reconstructive challenges and increase tension across the closure, thereby elevating the risk of wound failure. The observed rates of wound complications in this study are comparable to those reported in previous series, which range from 20% to 40% following postnatal MMC repair [6, 8, 11–13].

CSF leak was another common complication and often coexisted with wound-related problems. Although hydrocephalus and raised intracranial pressure are known contributors to CSF leakage, the present analysis specifically identified defect size and sac rupture as the principal predictors of postoperative morbidity. These findings emphasize the importance of meticulous perioperative planning and close postoperative surveillance in high-risk patients.

Infective Complications

Infective complications, including surgical site infection and meningitis, were observed in a notable proportion of patients. The exposed neural elements inherent to MMC, coupled with CSF leakage and compromised wound integrity, create a favourable environment for infection [8, 12, 14]. While the present study was not designed to assess causality, the coexistence of wound complications and infection highlights the interrelated nature of these adverse events. Early recognition, prompt treatment, and strict adherence to perioperative infection-control protocols remain essential to reducing infective morbidity.

Hydrocephalus and CSF Diversion

Hydrocephalus was common in this cohort, with over half of the patients demonstrating preoperative ventricular enlargement. Among patients who were initially non-shunted, 16% required ventriculoperitoneal shunt placement postoperatively due to progressive hydrocephalus. This finding aligns with existing literature and reflects the strong association between MMC, Chiari II malformation, and altered CSF dynamics[3, 9, 15–17]. Although prenatal repair has been shown to reduce shunt dependency, postnatal repair continues to be associated with a substantial need for CSF diversion, particularly in patients presenting later in infancy.

Neurological Outcomes

Postoperative neurological deterioration was uncommon in this series, suggesting that preservation of preoperative neurological status is achievable in the majority of patients undergoing postnatal repair [6, 18]. Potential mechanisms for neurological worsening include infection, ischemic insult, or secondary

effects of hydrocephalus. However, the retrospective nature of this study and limited neurological follow-up preclude definitive conclusions regarding long-term neurological outcomes.

Timing of Repair

The mean age at surgery in this cohort was 12.0 ± 4.6 months, considerably later than the neonatal window of 24–72 hours after birth recommended by most current guidelines for postnatal MMC closure [4, 6]. This delay likely reflects realities common to resource-constrained settings, including delayed recognition of the defect at birth in peripheral facilities, geographic and logistic barriers to timely referral, limited neurosurgical capacity, and delayed presentation of caregivers to tertiary care [7, 10, 13].

Delayed repair carries meaningful clinical implications. Prolonged exposure of the neural placode increases the risk of desiccation, local wound colonization, and ascending infection, and may compound the wound-healing difficulties described above, particularly in patients who also present with a ruptured sac. It is plausible that the high rates of wound-related and infective complications observed in this study are attributable, at least in part, to delayed timing of intervention rather than to intraoperative technique alone. At the same time, timing and lesion characteristics are likely interrelated rather than fully independent: some infants survived to present beyond the neonatal period precisely because their sac remained intact and infection was averted, while those with early rupture were more likely to present, and be operated on, sooner.

These observations position timing of repair as an important, potentially modifiable system-level factor in resource-limited environments. Strategies to shorten the interval between birth and surgery, such as earlier antenatal or postnatal diagnosis, expedited referral pathways from peripheral centres, and expansion of neurosurgical capacity, may meaningfully reduce postoperative morbidity independent of surgical technique. Although timing of repair was considered a priori as a potential confounder in this analysis, larger prospective studies are needed to evaluate it explicitly as an independent predictor variable, rather than as a background characteristic, in order to clarify its contribution to postoperative outcomes.

Limitations

The present study is limited by its retrospective, single-centre design, which is subject to selection bias and variability in documentation. The moderate sample size may have limited statistical power and restricts the generalizability of the findings to other settings.

The analysis focused primarily on early postoperative outcomes; therefore, long-term neurological, urological, orthopedic, and functional outcomes could not be systematically evaluated. In addition, potential unmeasured confounders, including nutritional status, socioeconomic factors, and perioperative care variations, were not assessed.

Despite these limitations, the study provides clinically relevant evidence that may assist perioperative risk stratification and optimization of surgical outcomes following postnatal myelomeningocele repair.

Conclusion

Postnatal repair of meningomyelocele is associated with a substantial burden of early postoperative complications, with wound-related morbidity and CSF-related events being the most frequent. Preoperative sac rupture and larger defect size were identified as significant predictors of postoperative complications, particularly wound necrosis, wound dehiscence, and CSF leak. Hydrocephalus remains a common associated condition, with a significant proportion of initially non-shunted patients requiring subsequent CSF diversion. Meticulous surgical technique, early identification of high-risk patients, and vigilant postoperative care are essential to minimize complications and improve early outcomes following postnatal meningomyelocele repair.

Declarations

Funding

No funding was received for conducting this study.

Competing interests

The authors have no competing interests to declare that are relevant to the content of this article.

Ethics approval

This study was approved by the Institutional Ethics Committee of Gauhati Medical College and Hospital. The study was conducted in accordance with the ethical standards of the institutional research committee and with the principles of the Declaration of Helsinki.

Consent to participate

The requirement for informed consent was waived by the Institutional Ethics Committee due to the retrospective nature of the study.

Consent for publication

Written informed consent for publication of clinical details and accompanying images was obtained from the parents or legal guardians of the patients included in this study.

Author Contribution

R.K.B.- conceived and designed the study, supervised the research, interpreted the data, critically reviewed the manuscript for important intellectual content, and approved the final version.S.A.R.- contributed to study design, data collection, data analysis and interpretation, literature review, drafting of the manuscript, preparation of tables and figures, and revision of the manuscript.N.D.- assisted in study

supervision, data curation, literature review, manuscript editing, and approved the final version.A.K.B.- assisted in study supervision, statistical analysis, interpretation of findings, critical revision of the manuscript, and approved the final version.P.N.- contributed to data acquisition, interpretation of results, critical review of the manuscript for intellectual content, and approved the final version.All authors read and approved the final manuscript.

Data Availability

The datasets generated and/or analyzed during the current study are not publicly available because they contain patient-identifiable information and institutional restrictions apply. De-identified data may be made available by the corresponding author upon reasonable request.

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Figures

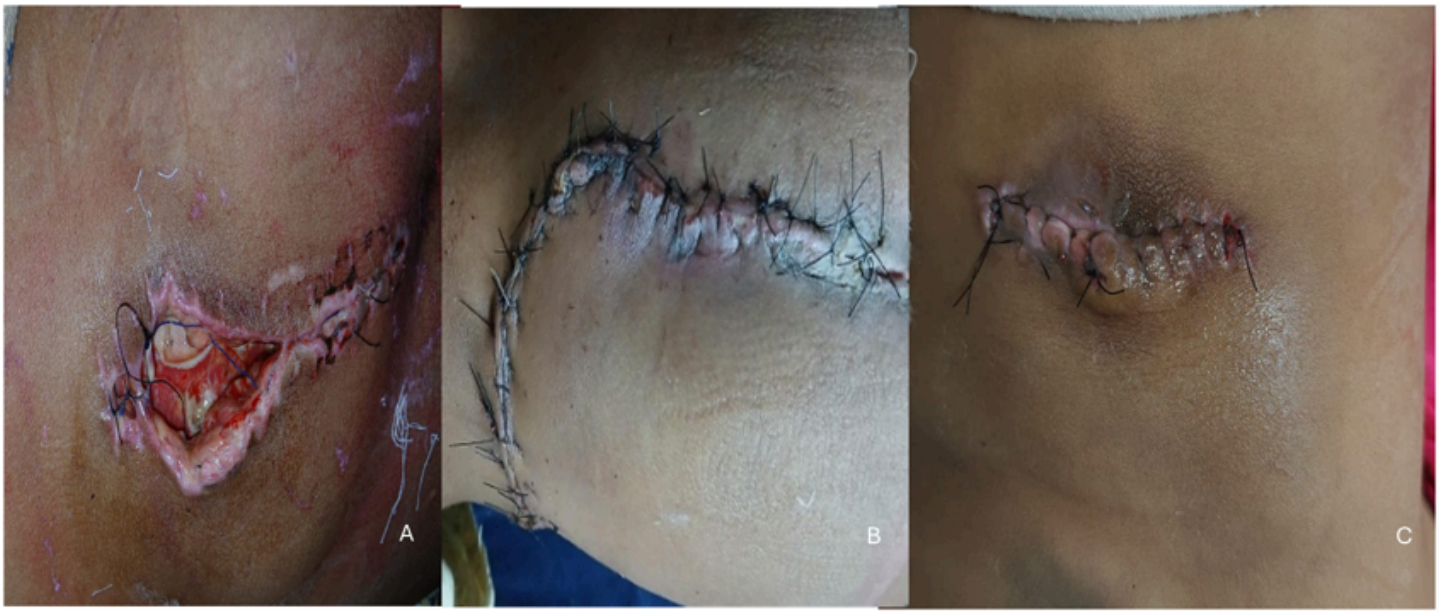


Figure 1

Postoperative wound complications following meningomyelocele repair

(A) Wound dehiscence demonstrating separation of the surgical incision with exposure of underlying tissue
(B) Wound necrosis showing devitalized tissue and breakdown of the surgical closure
(C) Cerebrospinal fluid leak from the operative site