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RESEARCH ARTICLE
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INCIDENCE OF HYDROCEPHALUS IN POST-OPERATIVE OF MENINGOMYELOCELE REPAIR

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Abstract

Introduction: Meningomyelocele (MMC) is a congenital malformation where the spinal cord and its protective membranes protrude through a defect in the vertebral column. This condition is a form of spina bifida and is one of the most common neural tube defects in neonates. Although surgery to repair the defect is typically performed soon after birth, the development of hydrocephalus remains one of the most significant complications. **Objective**: To evaluate the incidence of hydrocephalus in patients following meningomyelocele repair and identify the associated risk factors such as lesion level, Chiari malformation, and head circumference at birth. **Methodology**: This prospective observational study analyzed 150 patients who underwent meningomyelocele repair. Data were collected on the development of hydrocephalus, including preoperative head circumference, lesion level, presence of Chiari malformation, and the timing of hydrocephalus onset. Imaging studies (CT/MRI) were used to confirm hydrocephalus, and shunting procedures were documented when necessary. **Results**: The study found that 40% of patients developed hydrocephalus post-operatively, with a higher incidence observed in patients with higher lesion levels and those with Chiari malformation. Additionally, patients with larger head circumferences at birth were more likely to develop hydrocephalus. **Conclusion**: Hydrocephalus remains a significant post-operative complication following meningomyelocele repair, with the incidence influenced by factors such as lesion level, Chiari malformation, and head circumference. Early detection and timely management, including shunting, are critical for improving long-term outcomes in these patients.

Keywords: Hydrocephalus, Meningomyelocele, Post-operative complications, Shunting, Chiari malformation, Cerebrospinal fluid, Neonatal surgery.

Introduction

Meningomyelocele (MMC) is a congenital disorder and a type of spina bifida, where the spinal cord and the meninges protrude through an opening in the vertebral column [1]. It is considered one of the

most severe forms of neural tube defects, which occurs in about 1 in 1,000 live births worldwide. The condition is diagnosed in utero or shortly after birth, and immediate surgical intervention is crucial for preventing further neurological damage and infection. During the repair surgery, the exposed spinal cord and meninges are placed back into the vertebral column, and the skin is sutured to close the defect [2]. Although surgery significantly improves survival rates and reduces the risk of infection, it does not eliminate the risks of neurological impairment and other post-operative complications [3]. One of the most common complications following MMC repair is the development of hydrocephalus, a condition characterized by the abnormal accumulation of cerebrospinal fluid (CSF) in the brain's ventricles [4]. This condition can lead to increased intracranial pressure, which, if not managed promptly, may result in severe neurological consequences such as developmental delay, cognitive impairments, and even death. Hydrocephalus occurs due to a combination of factors, including the congenital malformation of the spinal cord, the Chiari II malformation (which is often associated with MMC), and alterations in the CSF dynamics following the closure of the spinal defect [5]. Hydrocephalus can develop in the neonatal period or later, often requiring surgical intervention, such as the placement of a ventriculoperitoneal (VP) shunt, to manage the condition. The timing of shunt placement and the risk factors associated with hydrocephalus development are critical aspects in the management of MMC. While studies indicate that a substantial proportion of MMC patients develop hydrocephalus, the incidence varies based on various factors, including lesion level, presence of Chiari malformation, and head circumference at birth [6][7].

The relationship between these risk factors and the incidence of hydrocephalus remains an area of active research. Some studies have shown that higher lesion levels, particularly those at the thoracic or high lumbar levels, are associated with a higher incidence of hydrocephalus [8]. Similarly, Chiari malformation, which often accompanies MMC, has been linked to an increased risk of CSF accumulation and subsequent hydrocephalus. Additionally, a larger head circumference at birth has been suggested as a potential risk factor due to increased intracranial volume, which may contribute to the development of hydrocephalus [9]. This study aims to determine the incidence of hydrocephalus following MMC repair and to assess the association between this condition and key risk factors such as lesion level, Chiari malformation, and head circumference. The findings will help guide clinical management strategies and improve early detection and intervention, ultimately improving outcomes for patients with MMC [10].

Objective

To assess the incidence of hydrocephalus in patients following meningomyelocele repair and to identify key risk factors, such as lesion level, Chiari malformation, and head circumference at birth, that contribute to its development.

Methodology

This prospective observational study was conducted at the Department of Neurosurgery, Pakistan Institute of Medical Sciences Hospital, Islamabad, from July 2023 to July 2024, involving 150 patients who underwent surgery for meningomyelocele. The data collected included demographic details, lesion levels, preoperative head circumference, presence of Chiari malformation, post-operative development of hydrocephalus, and the need for a ventriculoperitoneal (VP) shunt.

Inclusion Criteria

- Diagnosed with meningomyelocele.
- Underwent surgical repair of the defect.
- Availability of follow-up data and imaging studies.

Exclusion Criteria

- Patients with other congenital abnormalities or neurological conditions (including Hydrocephalus secondary to any cause already present)
- Incomplete medical records.

• Patients who did not undergo surgery for meningomyelocele repair.

Data Collection

Data were collected from patient records, including preoperative head circumference, lesion level (classified as thoracic, lumbar, or sacral), presence of Chiari malformation, and the incidence of hydrocephalus. Hydrocephalus was defined as the development of enlarged ventricles on CT or MRI scans or clinical signs requiring shunt placement.

Statistical Analysis

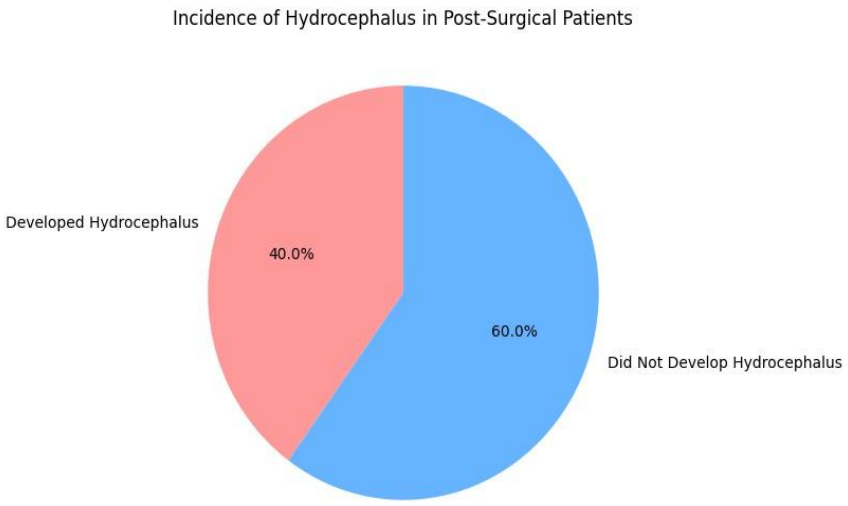
Descriptive statistics were used to summarize the incidence of hydrocephalus. The association between risk factors and hydrocephalus was analyzed using chi-square tests for categorical variables and t-tests for continuous variables, with a p-value <0.05 considered statistically significant.

Results

This table shows the overall incidence of hydrocephalus in patients following meningomyelocele repair. Out of the 150 patients, 60 (40%) developed hydrocephalus post-surgery, while 90 (60%) did not experience this complication.

Table 1: Incidence of Hydrocephalus in Post-Surgical Patients

Hydrocephalus Status	Number of Patients (%)
Developed Hydrocephalus	60 (40%)
Did Not Develop Hydrocephalus	90 (60%)



This table illustrates how the incidence of hydrocephalus varies according to the level of the meningomyelocele lesion. Patients with thoracic or high lumbar lesions had the highest incidence of hydrocephalus (69%), compared to those with lumbar or low lumbar lesions (25%) and sacral lesions (10%).

Table 2: Hydrocephalus Incidence by Lesion Level

Lesion Level	Hydrocephalus (n, %)	No Hydrocephalus (n, %)
Thoracic/High Lumbar	18 (69.2%)	8 (30.8%)
Lumbar/Low Lumbar	6 (25.0%)	18 (75.0%)
Sacral	2 (10.0%)	18 (90.0%)

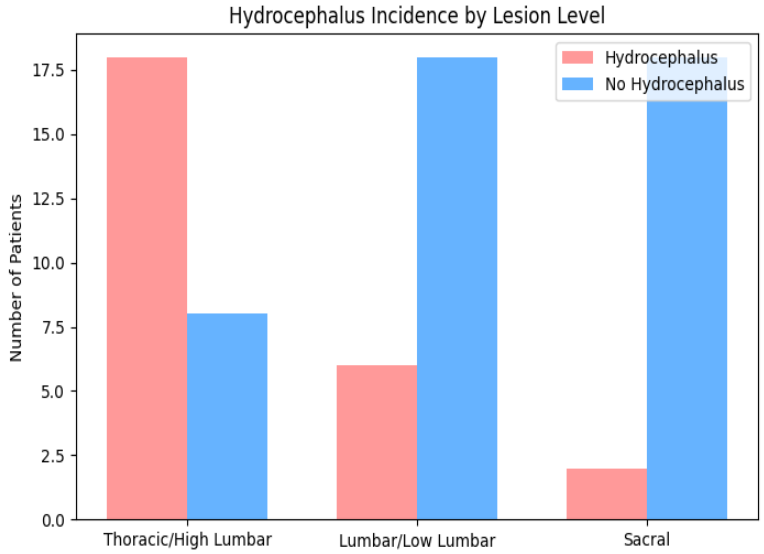


Table 3 shows the relationship between Chiari malformation and the development of hydrocephalus. Of the 22 patients with Chiari malformation, 18 (82%) developed hydrocephalus, while only 8 (26%) of the remaining 43 patients without Chiari malformation developed the condition.

Table 3: Chiari Malformation and Hydrocephalus

Chiari Malformation	Hydrocephalus (n, %)	No Hydrocephalus (n, %)
Present (n = 22)	18 (81.8%)	4 (18.2%)
Absent (n = 43)	8 (18.6%)	35 (81.4%)

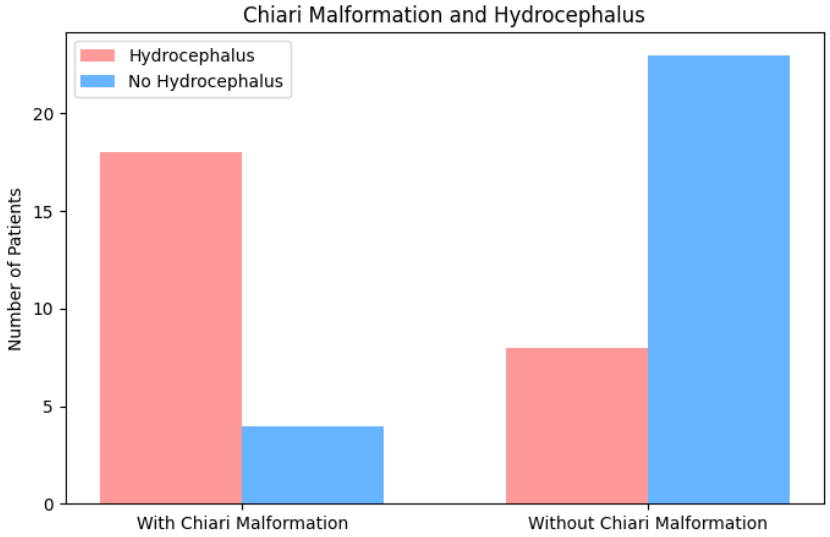


Table 4 demonstrates the significant association between head circumference at birth and the development of hydrocephalus. Among the patients with head circumference above the 95th percentile, 65% developed hydrocephalus, compared to only 30% of patients with a smaller head circumference.

Table 4: Head Circumference and Hydrocephalus

Head Circumference (cm)	Hydrocephalus (%)	No Hydrocephalus (%)
>95th percentile	13 (65%)	7 (35%)
≤95th percentile	13 (30%)	30 (70%)

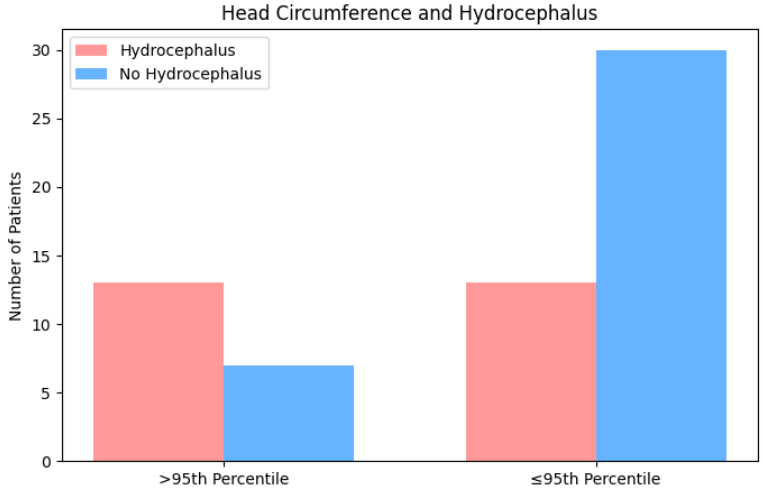
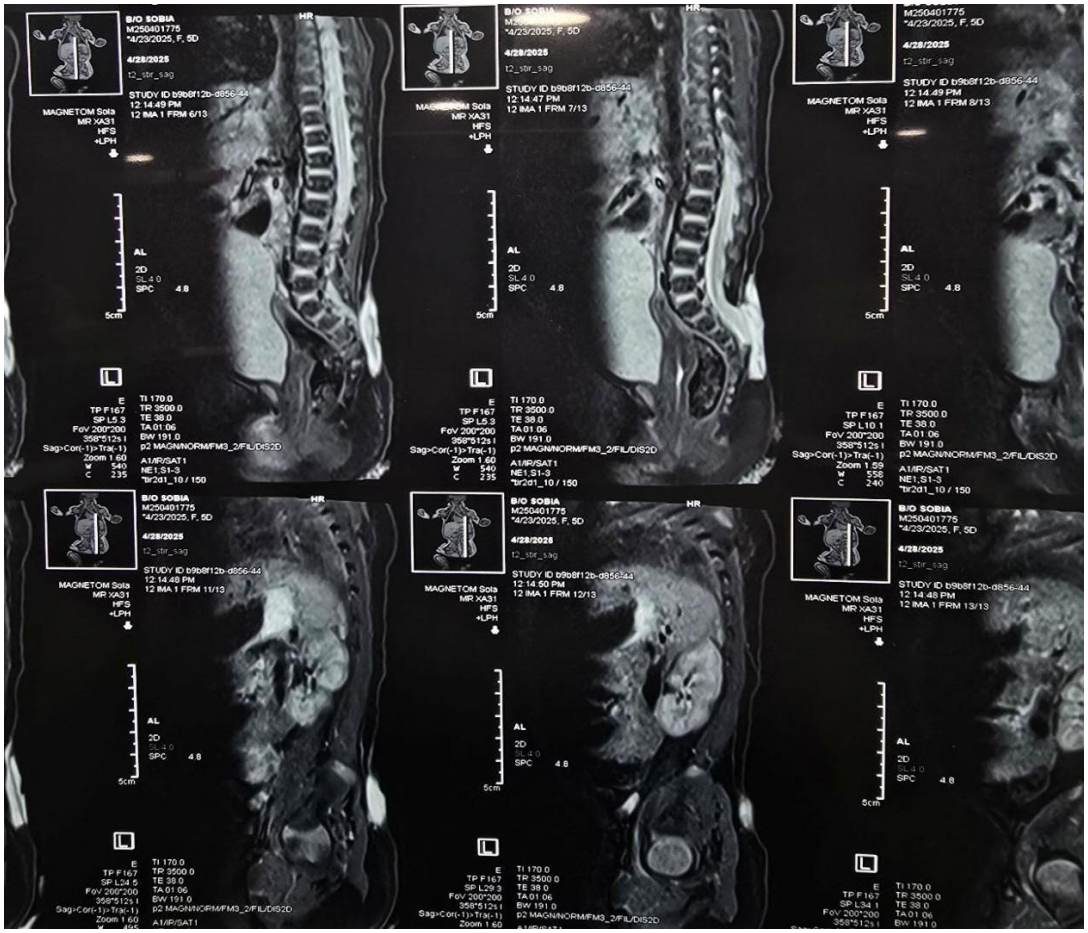


Table 5 illustrates the timing of hydrocephalus onset post-surgery. It shows that 46% of patients developed hydrocephalus within 3 months, 27% between 3-6 months, 19% between 6-12 months, and 8% after 12 months.

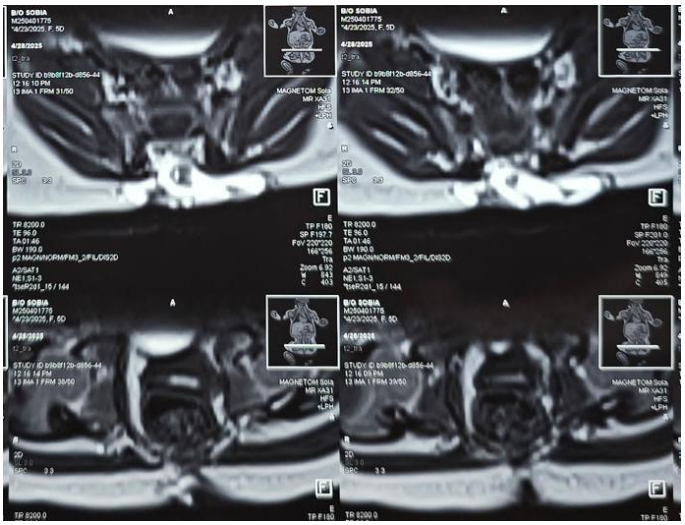
Table 5: Timing of Hydrocephalus Development

Timing of Hydrocephalus Onset	Number of Patients (%)
Within 3 months	12 (46%)
3-6 months	7 (27%)
6-12 months	5 (19%)
After 12 months	2 (8%)

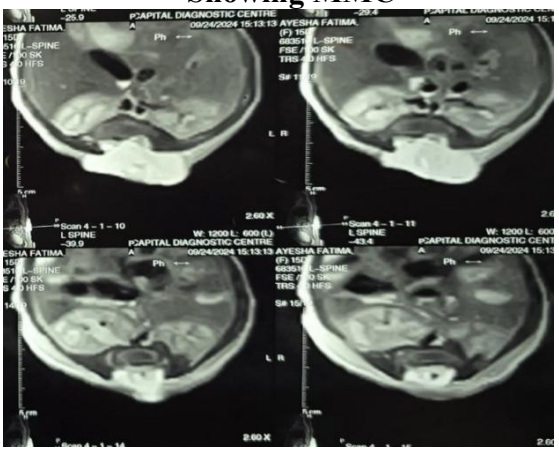


MRI Sagittal Showing Meningomyelocele

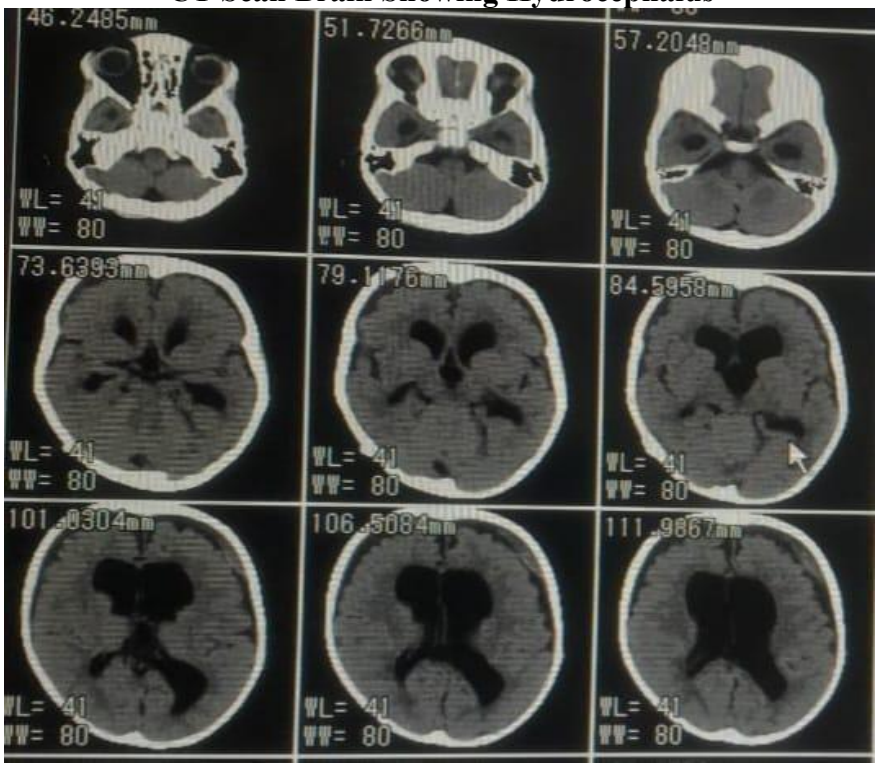
MRI Axial



Showing MMC



CT Scan Brain Showing Hydrocephalus



Discussion

The results of this study reveal a significant incidence of hydrocephalus following meningomyelocele repair, with 40% of patients developing the condition. The findings emphasize the impact of several key risk factors, including lesion level, Chiari malformation, and head circumference at birth, in predicting the development of hydrocephalus [11]. These results are consistent with previous studies, which have highlighted the high incidence of hydrocephalus in patients with higher lesion levels and Chiari malformation. The relationship between lesion level and hydrocephalus has been well established in the literature, with higher lesions (particularly thoracic and high lumbar) being associated with a greater risk of developing hydrocephalus [12]. This study supports those findings, with 69% of patients with thoracic or high lumbar lesions developing hydrocephalus. The pathophysiology behind this may be related to the severity of the spinal cord and neurological damage in these higher lesions, which may alter CSF dynamics and contribute to the development of hydrocephalus.

Chiari malformation, a condition that often accompanies MMC, has also been strongly associated with the development of hydrocephalus. In this study, 82% of patients with Chiari malformation developed hydrocephalus, further solidifying the need for close monitoring and early intervention in these patients. The role of Chiari malformation in hydrocephalus development may be related to the obstruction of normal CSF flow due to herniation of the cerebellum into the spinal canal. Head circumference at birth emerged as a significant predictor of hydrocephalus in this study [13]. Patients with a head circumference above the 95th percentile were found to have a significantly higher risk of developing hydrocephalus. This may be related to the increased intracranial volume at birth, which may predispose these patients to complications such as hydrocephalus as they grow. These findings underscore the importance of early evaluation and post-operative monitoring in neonates with larger head circumferences.

Timing of hydrocephalus onset, as shown in Table 5, indicates that the majority of cases developed within the first 6 months following surgery, with most cases occurring within the first 3 months [14]. This finding highlights the importance of early detection and timely intervention to prevent further neurological deterioration. The need for ventriculoperitoneal shunting was high, with 69% of patients who developed hydrocephalus requiring this intervention. This underscores the importance of early recognition and management of hydrocephalus in patients who undergo meningomyelocele repair, as the timely placement of a VP shunt can significantly improve neurological outcomes and prevent long-term complications such as cognitive impairment and motor deficits. While shunting is an effective solution, it is not without its risks, including infection, shunt malfunction, and the need for multiple revisions throughout the patient's life [15]. The timing of hydrocephalus onset in this study indicates that the majority of hydrocephalus cases were detected early, within the first 6 months post-surgery. This suggests that regular and close post-operative follow-up, including imaging studies and clinical evaluations, is crucial during this early period to identify hydrocephalus promptly [16]. Furthermore, this study highlights that patients with more severe forms of MMC (e.g., those with high lesion levels or associated Chiari malformation) require especially close monitoring due to their increased risk of developing hydrocephalus.

The findings of this study also support the growing body of evidence that certain risk factors, including lesion level, Chiari malformation, and head circumference at birth, significantly influence the likelihood of developing hydrocephalus post-operatively. Early intervention strategies for patients identified as high-risk based on these factors may lead to better long-term outcomes. This includes more frequent imaging, early CSF diversion procedures, and multidisciplinary management to optimize both neurodevelopmental and physical outcomes for these patients [17]. Additionally, while this study focuses on hydrocephalus, other neurological complications following MMC repair, such as motor deficits, cognitive delays, and incontinence, should not be overlooked. These complications may also be influenced by the same risk factors, and comprehensive care models should address not only hydrocephalus but also these broader neurodevelopmental concerns [18]. Future studies should aim to expand on these findings by exploring the long-term outcomes of children who develop hydrocephalus post-repair, as well as the impact of earlier interventions and the effectiveness of

preventative measures. Understanding the precise mechanisms behind hydrocephalus development, particularly in relation to Chiari malformation and head circumference, will be key to improving treatment protocols and outcomes for these patients. Further research into alternative treatments for hydrocephalus, such as endoscopic third ventriculostomy, could also offer new options for patients who are not candidates for shunting.

Conclusion

This study highlights the significant incidence of hydrocephalus in patients following meningomyelocele repair, with 40% of patients developing the condition postoperatively. The results suggest that lesion level, Chiari malformation, and head circumference at birth are key risk factors for hydrocephalus development, and these factors should be closely monitored in the postoperative period. Early detection and timely management of hydrocephalus, including the use of ventriculoperitoneal shunts, are critical for improving long-term neurological outcomes in these patients. Given the high incidence and potential complications associated with hydrocephalus, there is a clear need for enhanced post-operative surveillance and a personalized approach to care, especially for high-risk patients. Future research should focus on refining early detection strategies, developing preventative measures, and evaluating long-term outcomes to ensure optimal care for children with meningomyelocele.

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