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PRENATAL AND POSTNATAL ULTRASONOGRAPHIC EVALUATION OF MYELOMENINGOCELE TO PREDICT POST-SURGICAL OUTCOMES

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Article Info

Abstract

Background:

Myelomeningocele (MMC) is a severe neural tube defect associated with significant morbidity, including motor deficits and hydrocephalus. Early diagnosis and surgical intervention are crucial to improving outcomes.

Objective:

To evaluate the prenatal and postnatal ultrasonographic features of myelomeningocele to predict post-surgical outcomes.

Methods:

A prospective observational study was conducted on 20 pregnant women in their third trimester with fetal MMC confirmed between T1 and S1 levels. Prenatal and postnatal ultrasound evaluations were performed to assess lesion characteristics, associated anomalies (e.g., Chiari II malformation, ventriculomegaly), and surgical outcomes. Statistical analysis included descriptive measures and independent t-tests.

Results:

Forty percent of neonates underwent surgery within 24 hours, while 85% experienced at least one post-surgical complication. VP shunts were required in 40% of cases, and 40% of neonates remained wheelchair dependent. A statistically significant association was found between family history and larger lesion circumference ($p = 0.000$). Only 25% of patients achieved independent ambulation, and 70% required NICU admission.

Conclusion:

Ultrasonography is a valuable diagnostic and prognostic tool for MMC, aiding early detection and guiding surgical planning. Timely intervention and multidisciplinary follow-up remain essential to improving neonatal outcomes, particularly in low-resource settings.

Keywords:

Myelomeningocele, prenatal ultrasound, postnatal ultrasound, ventriculomegaly, Chiari II malformation, surgical outcome, neonates.

Introduction

Myelomeningocele (MMC) as the severe form of spina bifida is a thousandfold challenge in the category of congenital anomalies particularly in resource-scarce parts of the world such as Pakistan (1). It is marked by pushing forward of the spinal cord and meninges through a hole in the vertebral column because of the imperfect closure of the posterior neural tube at the early embryonal stage which is usually at the 4th week of the gestation period. MMC incidence and clinical burden are not proportional to the world of developing countries, although these are markedly increased in most parts of the globe (2). In Pakistan, the prevalence has been estimated at 12-14 per 1000 live births, much higher than the world prevalence indicating both the inability to effectively diagnose the condition and the social and cultural obstacles to antenatal services (3).

MMC is the most multifaceted and disabling type of neural tube defects (NTDs) and constitutes most of the cases of spina bifida. It significantly limits the ability to perform everyday activities of people affected with it, as well as, causes an enormous emotional, financial, and logistic burden on families and the healthcare system (4). Although there are multiple etiologies to the MMC including genetic predisposition and environmental factors (e.g. maternal diabetes, folate deficiency, obesity, and teratogen exposures (e.g. valproic acid and isotretinoin): pathogenesis of the MMC is still not fully understood. To reduce lifelong disabilities and sequelae, such as the neurodevelopmental delay, orthopedic deformity, urological dysfunction, and social disability, the current studies further emphasize the need to detect and treat acutely to limit later morbidities (5).

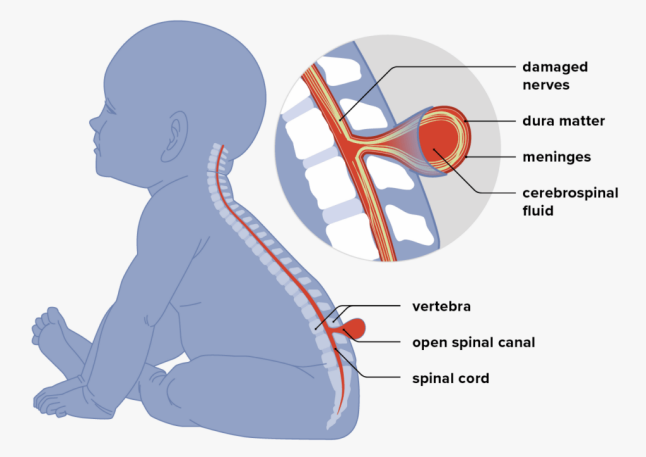

Figure 1.1: Diagram showing myelomeningocele, with a sac protruding from a baby's back.

Sonographic assessment in postnatal life is mandatory to afterbirth assessments of prenatal results and complications, and surgical strategies. The size, contents of the lesion (such as the presence of spinal cord or CSF), and skin coverage are studied with the assistance of ultrasound within the first 24 hours. In real-time imaging it is possible to evaluate CSF flow, leakage or soft tissue edema or infection (6). Also, cranial ultrasound examination is conducted via the anterior fontanelle to check the size of the ventricle and be able to perceive the development of hydrocephalus. Other ultrasound is used after surgery that helps in detecting complications of shunts like obstruction, infection, or migration (7).

In neonatal intensive care units (NICUs), ultrasound (Figure 2) offers a benefit in the ability to perform serial tests without interfering with using the unit clinically due to portability and the safety of the method (8). Such complications are often delayed and can be discovered by the means of longitudinal follow-up utilizing sonography to identify problems with fluid collections, tethered cords and spinal curvature, including scoliosis (9).

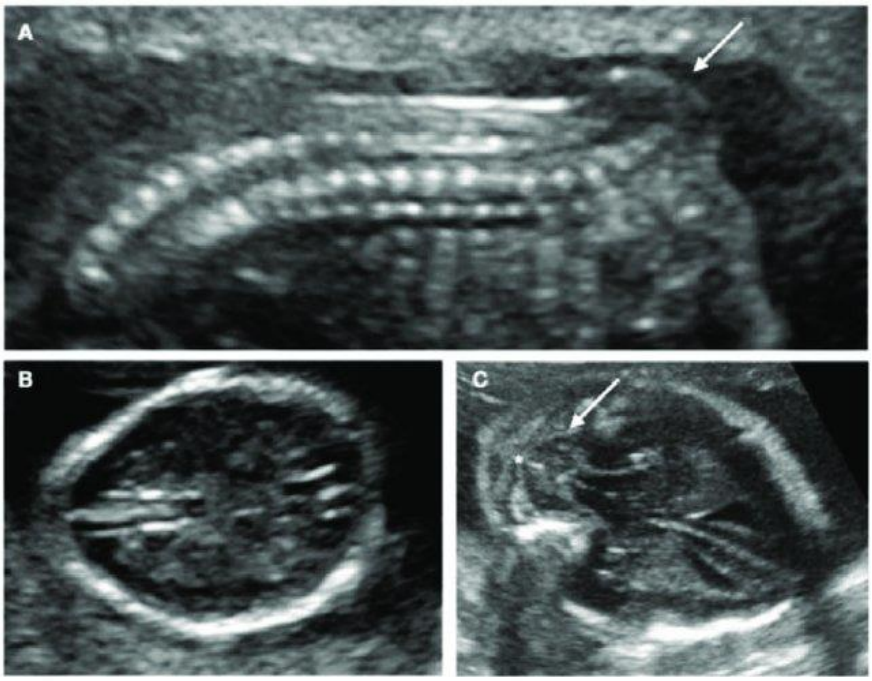

Figure 2. Ultrasound image: A. Myelomeningocele; B. Lemon sign; C. Banana sign; * -Chiari II malformation. Notes: A: myelomeningocele is the most common type of open spinal dysraphism. B: lemon shape head, C: banana-like cerebellum and * -obliteration of the cisterna magna (Chiari II malformation).

Methodology

This study has been carried out as a prospective observational study to analyze the success of prenatal and postnatal ultrasonographic outcomes in the way of predicting surgical results in myelomeningocele (MMC) diagnosed patients. The interest of the study was to study the relationship correlations between sonographic features and postoperative outcomes, and the study aimed at providing clinical decision-making that pivotally applies in counseling during the prenatal process and during the postnatal process. The study was performed at the District Headquarter Chiniot, which is the tertiary care institute that possesses all modern diagnostic imaging tools and special team that deals with congenital neurological disorders.

A total of 20 patients were enrolled in the study. This sample size was calculated using a 95% confidence interval and a 5% margin of error, based on the reported prevalence of myelomeningocele in the local population (approximately 1.3%). A non-probability, consecutive sampling technique was employed.

The study was completed over a period of four months, following the approval from the Institutional Review Board (IRB) of Superior University, Lahore. This duration included patient recruitment, imaging evaluations, postnatal follow-ups, data analysis, and thesis documentation.

Participants included in this prospective observational study were selected based on specific eligibility conditions to ensure consistency and relevance to the research objectives. The study enrolled patients with singleton pregnancies who were in their third trimester of gestation. A confirmed diagnosis of myelomeningocele with the lesion located between the thoracic vertebra T1 and sacral vertebra S1 was mandatory for inclusion. Additionally, only those fetuses exhibiting associated hindbrain herniation, specifically Chiari II malformation, and having a normal fetal karyotype confirmed through prenatal genetic screening were considered eligible for participation.

The study obtained Ethical approval by the Ethics Review Committee of Superior University, Lahore. All of the participants or their guardians signed informed consent representing agreement with the evaluation explaining the purpose, procedures, and benefits of the study.

The data collection process for this study involved both prenatal and postnatal ultrasonographic evaluations, conducted systematically to assess the diagnostic features and outcomes associated with myelomeningocele (MMC). Prenatal assessments were carried out using a G.E Healthcare ultrasound system with a high-resolution convex probe. Transabdominal scans were performed in longitudinal, transverse, and oblique planes to evaluate critical parameters such as the location of the lesion (between T1 and S1), presence of lemon and banana signs, ventriculomegaly, and Chiari II malformation. Additional fetal anomalies and biometric measurements were also documented. Maternal demographic details and prenatal risk factors were recorded to support a comprehensive analysis. Following birth, postnatal ultrasound examinations were performed within 24 to 48 hours and before surgical intervention. Neonates were imaged in prone or lateral decubitus positions to optimize visualization of the lesion characteristics, including size, shape, content, and skin covering. Further assessments included evaluation of spinal cord tethering, ventricular size, hydrocephalus progression, and confirmation of Chiari II malformation. Postoperative scans were also obtained to monitor surgical site healing and to detect any complications such as cerebrospinal fluid (CSF) leakage, infection, or fluid collection.

The data collected during both prenatal and postnatal phases were systematically entered and analyzed using SPSS Version 21.0. Descriptive statistics, including means, standard deviations, and frequencies, were utilized to summarize demographic and clinical characteristics of the study population. To examine the association between sonographic findings and post-surgical outcomes, the Chi-square test was employed. Additionally, a one-way Analysis of Variance (ANOVA) based on a Completely Randomized Design (CRD) was applied to compare differences among groups categorized by lesion severity and other outcome variables. A p-value of less than 0.05 was considered statistically significant, allowing for reliable interpretation of the relationships between ultrasound features and surgical results.

Results:

The study included 20 pregnant women whose fetuses were diagnosed with myelomeningocele (MMC) during the third trimester. The mean maternal age was 30.1 ± 6.93 years, ranging from 20 to 40 years, indicating a broad reproductive age distribution. The gestational age at diagnosis ranged between 24 and 36 weeks, with a mean of 30.65 ± 3.66 weeks. Parity varied from 0 (primigravida) to 4 previous births, with an average of 2.2 ± 1.73, showing that both first-time and multiparous mothers were included.

Table 1. Demographic Characteristics of Participants (n = 20)

Variable	Mean ± SD	Minimum	Maximum
Maternal Age (years)	30.1 ± 6.93	20	40
Gestational Age (weeks)	30.65 ± 3.66	24	36
Parity (no. of children)	2.2 ± 1.73	0	4

Participants were categorized into four maternal age groups: 20–25, 26–30, 31–35, and 36–40 years. The age groups 20–25 and 31–35 each represented 30% of the sample. A further 25% were in the 36–40 age range, while only 15% were between 26 and 30 years. This distribution reveals that a majority of the

participants (75%) were under 35 years of age, which is consistent with peak reproductive age, but a notable proportion (25%) were of advanced maternal age.

Table 2. Maternal Age Group Distribution (n = 20)

Age Group (Years)	Frequency (n)	Percentage (%)
20–25	6	30.0
26–30	3	15.0
31–35	6	30.0
36–40	5	25.0

The timing of surgery is critical in MMC management. In this study, 40% of neonates underwent surgical repair within 24 hours of birth, which is ideal for preventing complications. However, 25% had surgery between 24 and 48 hours, and 35% were delayed beyond 48 hours. Delays could result from factors such as resource constraints, transportation barriers, or neonatal instability. These delays are clinically significant as they increase the risk of infection, cerebrospinal fluid (CSF) leakage, and adverse neurological outcomes.

Table 3. Timing of Surgical Intervention (n = 20)

Timing of Surgery	Frequency (n)	Percentage (%)
Within 24 hours	8	40.0
24–48 hours	5	25.0
After 48 hours	7	35.0

Surgical interventions varied depending on lesion severity and associated complications. VP shunt placement, required to manage hydrocephalus, was the most common procedure, performed in 40% of patients. Primary closure of the spinal defect was done in 25% of cases, likely those with less severe lesions. The remaining 35% underwent other types of surgeries, such as reconstruction or tethered cord release. This distribution reflects the complexity and variability of MMC presentations.

Table 4. Types of Surgical Procedures (n = 20)

Surgical Procedure	Frequency (n)	Percentage (%)
Ventriculoperitoneal (VP) Shunt	8	40.0
Primary Closure	5	25.0
Other	7	35.0

Post-surgical complications were prevalent, with 85% of patients experiencing at least one complication. CSF leakage, hydrocephalus, and motor deficits were each reported in 17.65% of cases. Some patients presented with multiple complications, such as infection with motor deficits or CSF leakage. Wound dehiscence and infection were other common findings. The frequency and overlap of complications highlight the need for timely intervention, rigorous surgical technique, and close postoperative monitoring.

Table 5. Post-Surgical Complications (n = 17)

Complication(s)	Frequency (n)	Percentage (%)
CSF leakage	3	17.65
Hydrocephalus	3	17.65
Hydrocephalus + Motor deficits	1	5.88
Infection	1	5.88
Infection + CSF leakage	2	11.76
Infection + Motor deficits	1	5.88
Motor deficits	3	17.65
Motor deficits + Infection	1	5.88
Wound dehiscence	1	5.88
Wound dehiscence + Motor deficit	1	5.88

Half of the neonates received follow-up imaging after surgery. Long-term interventions, such as orthopedic or urological care, were required in 55% of cases. Maternal risk factors (e.g., folic acid deficiency, diabetes) were identified in 40% of pregnancies. NICU admission was required for 70% of the neonates, indicating the high acuity and clinical complexity of MMC cases post-delivery.

Table 6. Maternal and Postnatal Clinical Summary (n = 20)

Variable	Category	Frequency (n)	Percentage (%)
Follow-up Imaging	Yes	10	50.0
	No	10	50.0
Long-Term Intervention	Yes	11	55.0
	No	9	45.0
Maternal Risk Factors	Yes	8	40.0
	No	12	60.0
NICU Admission	Yes	14	70.0
	No	6	30.0

The post-surgical functional outcomes revealed that 25% of the patients achieved independent ambulation, while 35% required assistance, and 40% were wheelchair-dependent. These outcomes are consistent with lesion levels, surgical timing, and presence of complications. Patients with higher lesions and post-op complications like hydrocephalus or infection were more likely to have limited mobility.

Table 7. Functional Outcomes Post-Surgery (n = 20)

Outcome	Frequency (n)	Percentage (%)
Independent Ambulation	5	25.0
Assisted Ambulation	7	35.0
Wheelchair-Dependent	8	40.0

An independent t-test showed that fetuses with a family history of MMC had significantly larger lesion circumferences (mean = 1291.9 mm) compared to those without such history (mean = 690.3 mm), with a p-value of 0.000. This suggests a potential genetic component not only in MMC occurrence but also in lesion severity.

Table 8. Lesion Circumference by Family History of MMC (n = 20)

Group	Mean (mm)	Std. Dev.	95% Confidence Interval
No Family History	690.3	157.91	[577.34, 803.26]
Yes Family History	1291.9	177.37	[1165.02, 1418.79]
Mean Difference	-601.6	–	[-759.38, -443.82]
p-value	0.000		Statistically significant

Discussion

The findings of this study emphasize the significant diagnostic and prognostic value of both prenatal and postnatal ultrasonography in evaluating fetuses with myelomeningocele (MMC). In a cohort of 20 neonates, several critical clinical patterns were observed that directly influenced post-surgical outcomes. These findings reinforce the utility of ultrasonography in clinical decision-making and also highlight gaps in early intervention and postnatal care, particularly in low-resource settings such as Pakistan.

The demographic profile of participants showed that the majority of mothers were between 20 and 35 years old, consistent with peak reproductive age. However, a noteworthy proportion (25%) were of advanced maternal age (≥36 years), which is an established risk factor for congenital anomalies including MMC. The mean gestational age at diagnosis was approximately 30 weeks, suggesting that late-pregnancy diagnosis remains a limitation in many clinical settings, possibly due to delayed antenatal care or limited access to anomaly scans in the second trimester. This is concerning, as timely prenatal diagnosis is crucial for counseling and perinatal planning.

The data revealed that only 40% of the neonates underwent surgery within 24 hours of birth. While this aligns with international guidelines advocating early intervention to reduce infection risk and preserve neurological function, the fact that 35% of surgeries were delayed beyond 48 hours raises concern. Delayed surgery was frequently associated with complications such as CSF leakage, wound dehiscence, and infection. These outcomes mirror the findings of Paslaru et al. (2021), who highlighted the correlation between early postnatal intervention and improved prognosis. The delays in surgical management likely reflect systemic barriers such as limited neonatal surgical infrastructure, transportation delays, or delayed referrals (10).

The high rate (40%) of VP shunt placement in this cohort indicates a significant prevalence of hydrocephalus among MMC patients, a well-established sequela of Chiari II malformation and altered CSF dynamics. Primary closure was feasible in only 25% of patients, suggesting that most cases presented with complex lesions requiring additional or staged interventions. Post-surgical complications were widespread, affecting 85% of cases—most commonly CSF leakage, hydrocephalus requiring shunting, motor deficits, and infections. These findings are consistent with those of Beuriat et al. (2017), who identified hydrocephalus and motor impairment as leading post-surgical concerns in MMC patients. Moreover, infections—observed either alone or in combination—pose a major threat to neurological integrity and are often linked with poor surgical site care or delayed closure (11).

Functional outcomes varied considerably. A concerning 40% of patients remained wheelchair-dependent, while 35% achieved assisted ambulation, and only 25% were able to ambulate independently. These outcomes strongly reflect lesion level and timing of intervention, as well as the presence or absence of post-surgical complications. Studies such as those by Buskmiller et al. (2021) and Chao et al. (2024) emphasize that lesion level (thoracic vs. sacral) and timely surgical repair are the most reliable predictors of motor function. Our findings reinforce this notion and further suggest that early rehabilitation services are crucial to optimize functional recovery (12, 13).

The statistically significant difference in lesion size between fetuses with and without a family history of MMC ($p < 0.001$) points toward a potential hereditary influence not just in the incidence of MMC, but also in its anatomical severity. This insight is consistent with existing literature indicating that family history is a recognized risk factor for neural tube defects. The larger lesion sizes in familial cases may reflect more aggressive embryological defects or genetic susceptibility. Clinically, this supports the recommendation that pregnancies with known MMC family history should undergo targeted anomaly scans and possibly more detailed fetal neuroimaging.

Additionally, the ability of prenatal ultrasonography to detect classical signs such as the lemon sign, banana sign, and ventriculomegaly underscores its pivotal role in diagnosis. These markers have been validated in prior studies (e.g., Barnes et al., 2022) as reliable predictors of MMC and associated complications. Postnatally, ultrasonography remains essential for assessing lesion extent, hydrocephalus progression, and guiding decisions around VP shunting and NICU care.

One of the most concerning observations was that only 50% of patients received follow-up imaging post-surgery, and 55% required long-term orthopedic or urological interventions. These figures reflect a significant gap in continuity of care and resource allocation. The high NICU admission rate (70%) reflects the medical complexity of MMC neonates and the need for well-equipped neonatal units. However, without consistent follow-up, the benefits of surgical intervention may be undermined by unrecognized complications or delayed rehabilitative care.

These systemic issues highlight the need for better care pathways, especially in low-resource settings. Structured postnatal follow-up, early referral to multidisciplinary teams, and parental education are essential to optimize long-term outcomes. Public health efforts must also target maternal health education, folic acid supplementation, and early antenatal screening to reduce MMC prevalence and severity.

Conclusion

Ultrasonography is a reliable, accessible tool for the prenatal and postnatal evaluation of myelomeningocele, offering critical insights into lesion severity and surgical outcomes, while emphasizing the need for early intervention and multidisciplinary care to improve neonatal prognosis.

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