European Journal of Clinical Pharmacy
Print ISSN: 2385-409X **Online ISSN**: 3105-0409
Website: https://farmclin.com/

Original Research Article

Postoperative Cerebrospinal Fluid Leakage after Surgical Repair of Myelomeningocele and Tethered Cord Syndrome in Pediatric Patients

Article History:

Name of Author:
Mian Iftikhar ul Haq[1], Atif Aman[2], Dipak Chaulagain[3], Khadija Ahmad[4], Hammad Aslam[5], Shahid Mehmood[6], Aziz ur Rehman[7]

Affiliation: *[1]Assistant Professor, Neurosurgery Unit, MTI-Hayatabad Medical Complex, Peshawar, Pakistan*
[2]Senior Registrar Neurosurgery, Neurosurgery Department, MTI-Hayatabad Medical Complex, Peshawar, Pakistan
[3]MD, MS, PhD, Associate Professor, Jalal-Abad International University, Manas, Kyrgyzstan
Uzhhorod National University, Uzhhorod, Ukraine
[4]Assistant Professor Pediatrics Surgery, Rai Medical College, Sargodha, Pakistan
[5]Assistant Professor Paeds Surgery, Jinnah Hospital Lahore/ Allama Iqbal Medical College, Lahore, Pakistan
[6]Assistant Professor, Department of Neurosurgery, Sahara Medical College, Sughra Shafi Medical Complex, Narowal, Pakistan
[7]Medical Officer, Department of Neurosurgery, Khyber Teaching Hospital/ Khyber Medical College, Peshawar, Pakistan

Corresponding Author:
Aziz ur Rehman,

Received: 07-09-2025
Revised: 22-11-2025
Accepted: 08-12-2025
Published: 30-12-2025

Abstract: ***Background:*** Cerebrospinal fluid (CSF) leakage is a significant postoperative complication following surgical repair of myelomeningocele and tethered cord syndrome in pediatric patients. Objective: To evaluate the incidence, risk factors, and clinical consequences of postoperative CSF leakage in children undergoing surgical repair of myelomeningocele and tethered cord syndrome. ***Methods:*** A retrospective observational study was conducted at Hayatabad Medical Complex, Peshawar from June 2024 to June 2025 on 75 pediatric patients treated at a tertiary care neurosurgical center. Data were collected on demographic variables, surgical characteristics, dural closure techniques, postoperative wound status, and complications. The primary outcome was the presence of CSF leakage within 30 days of surgery. ***Results:*** CSF leakage occurred in 12 of 75 patients (16%), with a higher incidence following myelomeningocele repair (22.2%) compared to tethered cord surgery (6.7%). Larger defect size, revision surgery, and the need for duraplasty were significantly associated with increased leakage rates. Patients with CSF leakage experienced higher rates of wound infection (33.3% vs. 4.8%) and longer hospital stays (11.2 ± 3.4 days vs. 6.7 ± 2.8 days). ***Conclusion:*** It is concluded that postoperative CSF leakage remains a clinically important complication in pediatric patients undergoing myelomeningocele and tethered cord repair.

Keywords: Cerebrospinal fluid leakage, myelomeningocele, tethered cord syndrome, pediatric neurosurgery, postoperative complications

INTRODUCTION

Myelomeningocele and tethered cord syndrome represent two of the most prevalent congenital abnormalities that affect the spinal cord in paediatric patients. In such cases, early surgical intervention is often necessary to prevent progressive neurological decline, preserve motor function, and reduce long-term morbidity [1]. Although surgical repair remains the standard of care, postoperative complications continue to present significant clinical challenges. One of the most concerning complications that may arise is cerebrospinal fluid (CSF) leakage, which can occur despite meticulous surgical closure techniques [2]. CSF leakage has been demonstrated to both delays wound healing and increase the risk of infection, pseudomeningocele formation, and, in severe cases, meningitis [3]. These factors can adversely affect neurological outcomes. Post-operative complications resulting from cerebrospinal fluid leakage, following repair of myelomeningocele or tethered cord surgery, pose several risks that can significantly affect patient recovery [4]. The failure to achieve a watertight seal during dural closure, or the disruption of the dural closure itself, can result in the escape of cerebrospinal fluid (CSF) into the subcutaneous tissues or through the incision site. This leakage can lead to wound dehiscence, pseudomeningocele formation, and potential bacterial contamination [5]. The risk of meningitis is of particular concern in neonates and infants, who possess an underdeveloped immune system and are thus more susceptible to severe infections [6]. Furthermore, persistent cerebrospinal fluid (CSF) leakage may necessitate prolonged hospitalisation, further interventions, or repeat surgery, all of which increase the physical, emotional, and financial burden for families and healthcare systems. The incidence of postoperative cerebrospinal fluid (CSF) leakage varies across studies, reflecting differences in patient populations, surgical experience, closure techniques, and institutional practices [7].

In the context of myelomeningocele repair, it is frequently observed that leakage rates are elevated in comparison to other surgical interventions [8]. This phenomenon can be attributed to the inherent anatomical challenges associated with the procedure, including the presence of substantial defect size, thin or underdeveloped dura, and the complexity of achieving multi-layered closure in newborns [9]. Some infants present with large lumbosacral defects for which primary closure may be insufficient, requiring plastic surgical techniques to reinforce soft tissue coverage [10]. In the context of tethered cord release, the potential risk factors for leakage encompass a range of surgical interventions, including revision surgery, extensive adhesiolysis, dural scarring, and the necessity for expansion duraplasty [11]. Despite meticulous technique, postoperative cerebrospinal fluid leakage may still occur due to increased lumbar cisternal pressure, positioning, or subtle gaps in the dural suture line. Recent advancements in surgical materials, including dural sealants, grafts, and reinforced sutures, have contributed to a reduction in leakage rates [12]. Nevertheless, the optimal technique remains a matter of ongoing debate. The utilisation of dural substitutes or sealants is a practice advocated by certain surgeons, while others emphasise that careful multilayer closure alone is sufficient when performed correctly [13]. It is challenging to ascertain the most efficacious methods due to variability in surgeon preference and institutional resources. Furthermore, postoperative care protocols, encompassing patient positioning, wound care, and early detection strategies, exhibit significant variation across medical centres, potentially exerting considerable influence on leak rates [14].

Objective

To evaluate the incidence, risk factors, and clinical consequences of postoperative CSF leakage in children undergoing surgical repair of myelomeningocele and tethered cord syndrome.

METHODOLOGY

This retrospective observational study was conducted at Hayatabad Medical Complex, Peshawar from June 2024 to June 2025. A total of 75 pediatric patients were included. Children ranging from the neonatal period to 14 years of age were eligible if complete medical, operative, and postoperative follow-up records were available. Patients were excluded if they had incomplete documentation, underwent previous spinal surgery at another institution, or had concurrent conditions potentially affecting postoperative wound outcomes.

Data Collection

Clinical data were extracted from hospital charts, operative reports, and postoperative follow-up records. The demographic information encompassed age, sex, diagnosis, anatomical lesion level, defect size, and associated congenital anomalies. A comprehensive review of the surgical details was conducted, encompassing the type of procedure, the

duration of surgery, the dural repair technique employed, the utilisation of grafts or sealants, and the method of soft-tissue closure. Postoperative factors, including wound status, repositioning requirements, duration of hospitalisation, and complications, were meticulously documented. All surgical procedures were carried out by paediatric neurosurgeons in accordance with standardised techniques. The surgical procedure for the repair of myelomeningocele necessitated the identification of the neural placode, its subsequent reconstruction, the implementation of a watertight dural closure, and the execution of a multilayered soft-tissue closure. The surgical intervention encompassed a meticulous approach, entailing laminectomy or laminotomy, microsurgical detethering, and meticulous dural repair. Duraplasty using autologous or synthetic grafts was applied when necessary. Adjunctive dural sealants were utilised at the surgeon's discretion to reinforce closure. The primary outcome was postoperative cerebrospinal fluid (CSF) leakage, defined as visible CSF drainage from the incision, persistent clear wound moisture suspected to be CSF, or radiologically confirmed pseudomeningocele within 30 days of surgery. Secondary outcomes encompassed wound dehiscence, infection, requirement for reoperation, and postoperative length of stay.

Statistical Analysis

Data were entered into a structured database and analyzed using SPSS v26.0. Descriptive statistics were applied, with categorical variables expressed as frequencies and percentages, and continuous variables summarized as means and standard deviations. Associations between CSF leakage and potential risk factors were explored using appropriate statistical tests based on variable type and distribution. A p-value < 0.05 was considered statistically significant.

RESULTS

Data were collected from 75 patients, mean age differed between groups, with myelomeningocele patients being younger (3.2 ± 3.1 years) compared with tethered cord patients (5.5 ± 4.2 years), giving an overall mean age of 4.1 ± 3.8 years. Male sex distribution was similar across groups: 26 males (57.8%) in the myelomeningocele group and 15 males (50.0%) in the tethered cord group, totaling 41 males (54.7%). Most myelomeningocele defects were located at the lumbosacral level (34 patients, 75.6%), whereas only 11 tethered cord patients (36.7%) had lumbosacral involvement. Thoracolumbar lesions were more common in tethered cord patients (13 patients, 43.3%) than in myelomeningocele cases (9 patients, 20.0%). Cervical or upper thoracic defects were observed in 2 myelomeningocele patients (4.4%) and 6 tethered cord patients (20.0%), totaling 8 patients (10.7%). Revision surgery rates were identical in both groups at 13.3% (6 in myelomeningocele and 4 in tethered cord).

Table 1. Baseline Characteristics of Pediatric Patients (N = 75)

Variable	Myelomeningocele (n = 45)	Tethered Cord (n = 30)	Total (N = 75)
Mean age (years ± SD)	3.2 ± 3.1	5.5 ± 4.2	4.1 ± 3.8
Male sex, n (%)	26 (57.8%)	15 (50.0%)	41 (54.7%)
Lumbosacral level, n (%)	34 (75.6%)	11 (36.7%)	45 (60.0%)
Thoracolumbar level, n (%)	9 (20.0%)	13 (43.3%)	22 (29.3%)
Cervical/upper thoracic, n (%)	2 (4.4%)	6 (20.0%)	8 (10.7%)
Revision surgery, n (%)	6 (13.3%)	4 (13.3%)	10 (13.3%)
Defect size > 4 cm, n (%)	27 (60.0%)	4 (13.3%)	31 (41.3%)

A total of 12 out of 75 patients (16.0%) developed CSF leakage. The incidence was notably higher among patients with myelomeningocele, where 10 out of 45 patients (22.2%) experienced leakage, compared to only 2 out of 30 tethered cord patients (6.7%). The average time to detection was slightly longer in the myelomeningocele group (4.1 ± 1.8 days) compared with the tethered cord group (3.5 ± 1.2 days), resulting in an overall mean detection time of 3.9 ± 1.6 days. Two patients (2.7%) developed pseudomeningocele, both from the myelomeningocele group (2 patients, 4.4%).

Table 2. Frequency of Postoperative CSF Leakage

Variable	Myelomeningocele (n = 45)	Tethered Cord (n = 30)	Total (N = 75)
CSF leakage present, n (%)	10 (22.2%)	2 (6.7%)	12 (16.0%)
Time to leakage detection (days ± SD)	4.1 ± 1.8	3.5 ± 1.2	3.9 ± 1.6

Pseudomeningocele, n (%)	2 (4.4%)	0 (0%)	2 (2.7%)
Visible wound drainage, n (%)	8 (17.8%)	2 (6.7%)	10 (13.3%)

Large defects (>4 cm) were present in 9 of 12 leakage cases (75.0%), but only in 22 of 63 non-leakage cases (34.9%). Revision surgery was strongly associated with leakage: 5 of 12 leakage patients (41.7%) had undergone revision compared with only 5 of 63 (7.9%) in the non-leakage group. Duraplasty was performed in 7 leakage patients (58.3%) versus 18 non-leakage patients (28.6%). The use of dural sealant was similar between groups: 6 leakage patients (50.0%) and 31 non-leakage patients (49.2%). Soft-tissue flap closure was used in 8 leakage cases (66.7%) compared with 21 non-leakage cases (33.3%). Mean operative time was longer in patients who developed leakage (142 ± 28 minutes) compared with those who did not (118 ± 24 minutes).

Table 3. Surgical Factors Associated with CSF Leakage

Surgical Factor	Leakage (n = 12)	No Leakage (n = 63)
Large defect (>4 cm), n (%)	9 (75.0%)	22 (34.9%)
Revision surgery, n (%)	5 (41.7%)	5 (7.9%)
Duraplasty performed, n (%)	7 (58.3%)	18 (28.6%)
Use of dural sealant, n (%)	6 (50.0%)	31 (49.2%)
Soft-tissue flap closure, n (%)	8 (66.7%)	21 (33.3%)
Mean operative time (minutes ± SD)	142 ± 28	118 ± 24

Wound infection occurred in 4 of the 12 patients with leakage (33.3%), compared with 3 of the 63 patients without leakage (4.8%). Meningitis developed in 1 leakage patient (8.3%) and in none of the non-leakage patients. Wound dehiscence was observed in 3 leakage patients (25.0%) and 2 non-leakage patients (3.2%). Reoperation was required in 3 leakage patients (25.0%) compared with only 1 non-leakage patient (1.6%). The mean hospital stay was longer for leakage cases, averaging 11.2 ± 3.4 days, compared with 6.7 ± 2.8 days in patients without leakage.

Table 4. Postoperative Complications

Complication	Leakage Group (n = 12)	No Leakage Group (n = 63)
Wound infection, n (%)	4 (33.3%)	3 (4.8%)
Meningitis, n (%)	1 (8.3%)	0 (0%)
Wound dehiscence, n (%)	3 (25.0%)	2 (3.2%)
Reoperation required, n (%)	3 (25.0%)	1 (1.6%)
Mean length of stay (days ± SD)	11.2 ± 3.4	6.7 ± 2.8

The mean age was slightly lower in the leakage group (2.8 ± 2.4 years) than in the non-leakage group (4.5 ± 4.0 years), though this difference was not statistically significant ($p = 0.11$). Large defects (>4 cm) were significantly associated with leakage (9 of 12 patients, 75.0%) compared with the non-leakage group (22 of 63 patients, 34.9%), with $p = 0.01$. Revision surgery showed a powerful association (41.7% in leakage vs. 7.9% in non-leakage, $p = 0.001$). Duraplasty was also more common in leakage patients (58.3% vs. 28.6%, $p = 0.04$). Wound infection was significantly higher among leakage patients (33.3% vs. 4.8%, $p = 0.006$). Length of hospital stay differed significantly, with leakage patients staying 11.2 ± 3.4 days compared with 6.7 ± 2.8 days in the non-leakage group ($p = 0.001$).

Table 5. Comparison of Patients with and Without CSF Leakage

Variable	Leakage (n = 12)	No Leakage (n = 63)	p-value
Mean age (years ± SD)	2.8 ± 2.4	4.5 ± 4.0	0.11
Large defect (>4 cm), n (%)	9 (75.0%)	22 (34.9%)	0.01
Revision surgery, n (%)	5 (41.7%)	5 (7.9%)	0.001
Duraplasty performed, n (%)	7 (58.3%)	18 (28.6%)	0.04
Wound infection, n (%)	4 (33.3%)	3 (4.8%)	0.006
Length of stay (days ± SD)	11.2 ± 3.4	6.7 ± 2.8	0.001

DISCUSSION

This study evaluated postoperative cerebrospinal fluid (CSF) leakage following surgical repair of myelomeningocele and tethered cord syndrome in a cohort of 75 pediatric patients. The overall leakage rate of 16% is consistent with previously reported ranges for paediatric spinal dysraphism surgery, reflecting the inherent challenges of achieving durable dural closure in this population. As anticipated, the incidence of cerebrospinal fluid leakage was found to

be considerably higher in cases of myelomeningocele repair compared to tethered cord release. This observation underscores the intricate anatomical and technical intricacies associated with addressing open spinal defects in neonatal and infant populations. It was demonstrated that an increase in the magnitude of the defect was a significant predictor of postoperative leakage. Among patients who exhibited leakage, 75% had defects measuring more than 4 cm, compared to 34.9% in the non-leakage group. This finding is consistent with the understanding that larger defects require more extensive tissue handling and often lack adequate native dura for closure, increasing the reliance on duraplasty, graft augmentation, or soft-tissue flaps. The elevated leakage rate observed in this particular subgroup underscores the necessity for meticulous planning, the implementation of multiple layers of closure, and a high degree of surgical expertise in the management of extensive spinal dysraphism defects [15].

Furthermore, it was observed that revision surgery was another factor significantly associated with CSF leakage, with 41.7% of leakage cases occurring in patients undergoing reoperation. This figure stands in stark contrast to the 7.9% rate observed in primary surgeries. Revision cases generally involve scarring of the dura, adhesions, and altered anatomy, all of which serve to increase the difficulty of achieving a watertight seal. These findings underscore the necessity for refined intraoperative strategies in revision cases, such as meticulous dural mobilisation, graft reinforcement, or the judicious use of adjunctive sealants when indicated [16]. Furthermore, Duraplasty was observed to be more prevalent among patients who exhibited leakage, suggesting a tendency among surgeons to utilise grafts in more intricate cases. Although duraplasty does not inherently result in leakage, it frequently serves as an indicator of the severity of the underlying defect. Postoperative complications were found to be significantly higher in the leakage group, with increased rates of wound infection, meningitis, and wound dehiscence [17]. The presence of cerebrospinal fluid (CSF) at the wound site has been demonstrated to compromise tissue healing, facilitate bacterial entry, and increase the risk of infectious complications. These findings emphasise the clinical significance of early detection and management of leakage to prevent progression to more severe morbidity. Furthermore, the observation that leakage patients exhibited a significantly longer hospital stay is indicative of the augmented burden on healthcare resources and families [18]. Despite the complications associated with cerebrospinal fluid (CSF) leakage, neurological outcomes remained stable, and most cases resolved with conservative or surgical management. This suggests that with prompt identification and appropriate intervention, long-term neurological harm can often be avoided [19]. Nevertheless, the elevated incidence of infection and the necessity for subsequent surgical procedures underscore the significance of implementing preventative measures [20]. It is imperative to acknowledge the limitations of this study when interpreting the findings. Firstly, the retrospective design of the study is contingent on the accuracy and completeness of existing medical records, which may introduce bias due to documentation. It is important to note that important intraoperative details such as subtle dural defects, suture tension, or surgeon-specific techniques may not have been consistently recorded. Secondly, the study was conducted at a single tertiary care centre, which may limit the generalisability of the results to other institutions with differing surgical expertise, patient populations, or postoperative care protocols. A further limitation is the heterogeneity of the age range of the included patients, which spans from neonates to adolescents. This is due to the fact that tissue characteristics, healing capacity, and anatomical challenges vary significantly with age.

CONCLUSION

It is concluded that postoperative cerebrospinal fluid (CSF) leakage remains a significant complication following surgical repair of myelomeningocele and tethered cord syndrome in pediatric patients. The overall leakage rate of 16% observed in this study highlights the ongoing challenges of achieving durable and watertight dural closure, particularly in cases involving large defects, revision surgeries, or complex anatomical variations. Factors such as extensive defect size, duraplasty, and reoperation were found to be strongly associated with higher leakage rates, emphasizing the need for heightened surgical attention and preventive strategies in these high-risk situations.

REFERENCES

1. Saker E, Henry BM, Tomaszewski KA, et al. The filum terminale internum and externum: A comprehensive review. J Clin Neurosci. 2017;40:6-13.
2. Geyik M, Alptekin M, Erkutlu I, et al. Tethered cord syndrome in children: a single- center experience with 162 patients. Childs Nerv Syst. 2015;31:1559-63.
3. O'Neill BR, Gallegos D, Herron A, et al. Use of magnetic resonance imaging to detect occult spinal dysraphism in infants. J Neurosurg Pediatr. 2017;19:217-26.
4. Khoshhal KI, ABOS MWR, Elgamal EA, Salih MAM Tethered cord syndrome: a study of 35 patients. J Taibah University Med Sci. 2012;7(1):23–8.
5. Sofuoglu OE, Abdallah A, Emel E, Ofluoglu AE, Gunes M, Guler B, et al. Management of tethered cord syndrome in adults: experience of 23 cases Turk Neurosurg. 2017;27(2):226-36.
6. Slot EMH, van Doormaal TPC, van Baarsen

KM, Krayenbühl N, Regli L, Germans MR, Hoving EW. Cerebrospinal fluid leakage after intradural spinal surgery in children. Childs Nerv Syst. 2023 Apr;39(4):1013-1019. doi: 10.1007/s00381-022-05797-w. Epub 2023 Feb 15. PMID: 36790491; PMCID: PMC10160141.
7. Van Lieshout C, Slot EMH, Kinaci A, et al. Cerebrospinal fluid leakage costs after craniotomy and health economic assessment of incidence reduction from a hospital perspective in the Netherlands. BMJ Open. 2021;11(12):e052553. doi:10.1136/bmjopen-2021-052553.
8. Slot EMH, van Baarsen KM, Hoving EW, Zuithoff NPA, van Doormaal TPC. Cerebrospinal fluid leakage after cranial surgery in the pediatric population: a systematic review and meta-analysis. Childs Nerv Syst. 2021;37(5):1439–1447. doi:10.1007/s00381-021-05036-8.
9. Tu A, Tamburrini G, Steinbok P. Management of postoperative pseudomeningoceles: an international survey study. Childs Nerv Syst. 2014;30(11):1791–1801. doi:10.1007/s00381-014-2501-9.
10. Balasubramaniam C, Rao SM, Subramaniam K. Management of CSF leak following spinal surgery. Childs Nerv Syst. 2014;30(9):1543–1547. doi:10.1007/s00381-014-2496-2.
11. Chern JJ, Tubbs RS, Patel AJ, et al. Preventing cerebrospinal fluid leak following transection of a tight filum terminale: clinical article. J Neurosurg Pediatr. 2011;8(1):35–38. doi:10.3171/2011.4.PEDS10502.
12. Goodwin CR, Recinos PF, Zhou X, Yang JX, Jallo GI. Evaluation of complication rates of pediatric spinal procedures in which a polyethylene glycol sealant was used. J Neurosurg Pediatr. 2014;13(3):315–318. doi:10.3171/2013.12.PEDS13456.
13. Kaufman BA, Matthews AE, Zwienenberg-Lee M, Lew SM. Spinal dural closure with nonpenetrating titanium clips in pediatric neurosurgery: clinical article. J Neurosurg Pediatr. 2010;6(4):359–363. doi:10.3171/2010.7.PEDS09545.
14. Liu V, Gillis C, Cochrane D, Singhal A, Steinbok P. CSF complications following intradural spinal surgeries in children. Childs Nerv Syst. 2014;30(2):299–305. doi:10.1007/s00381-013-2276-4.
15. Ogiwara H, Joko M, Takado M, et al. Duration of the horizontal decubitus position for prevention of cerebrospinal fluid leakage following transection of a tight filum terminale. J Neurosurg Pediatr. 2015;15(5):461–464. doi:10.3171/2014.9.PEDS14289.
16. Udayakumaran S, Rathod CT. Tailored strategies to manage cerebrospinal fluid leaks or pseudomeningocele after surgery for tethered cord syndrome. World Neurosurg. 2018;114:e1049–e1056. doi:10.1016/j.wneu.2018.03.144.
17. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The STROBE statement: guidelines for reporting observational studies. PLoS Med. 2007;4(10):e296. doi:10.1371/journal.pmed.0040296.
18. Slot EMH, van Doormaal TPC, van Baarsen KM, Krayenbühl N, Regli L, Germans MR, Hoving EW. Incisional CSF leakage after intradural cranial surgery in children: incidence, risk factors, and complications. J Neurosurg Pediatr. 2023; (forthcoming). doi: Not available.
19. Mehta VA, Bettegowda C, Ahmadi SA, et al. Spinal cord tethering following myelomeningocele repair: clinical article. J Neurosurg Pediatr. 2010;6(5):498–505. doi:10.3171/2010.8.PEDS09491.
20. Ostling LR, Bierbrauer KS, Kuntz C 4th. Outcome, reoperation, and complications in 99 consecutive children operated for tight or fatty filum. World Neurosurg. 2012;77(1):187–191. doi:10.1016/j.wneu.2011.05.017.

