ONLINE ISSN :3007-309X
PRINT ISSN :3007-3081

Journal of Medical & Health Science Review

FREQUENCY OF IMMEDIATE POSTOPERATIVE COMPLICATIONS: CSF LEAK INCIDENCE IN PATIENTS UNDERGOING SURGERY FOR SPINAL DYSRAPHISM

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ARTICLE INFO

Keywords:

CSF leakage, infections, reoperation, spinal dysraphism, tethered cord syndrome.

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ABSTRACT

Background: Cerebrospinal fluid (CSF) leakage is a substantial complication that results from spinal dysraphism surgery, which contributes to prolonged hospital stays and increased morbidity rate.

Objectives: This investigation was carried out to ascertain the frequency of immediate postoperative CSF leakage, identify risk factors that are associated with these leaks and assess the clinical outcomes in patients who are undergoing spinal dysraphism surgery.

Methods: From January to December 2023, 40 patients who underwent surgery for spinal dysraphism were included in this cross-sectional study. The analysis encompassed postoperative outcomes, clinical characteristics, surgical details and patient demographics. Focusing on factors such as intraoperative complications, surgical complexity and tethered cord syndrome, statistical comparisons were conducted between patients with and without CSF leakage.

Results: Six patients (15%) experienced CSF leaks, with statistically significant association observed in those with tethered cord syndrome (66.7 vs. 23.5%, $p<0.05$) and surgeries lasting more than 120 minutes (66.7 vs. 23.5%, $p<0.05$). Reoperation rates were considerably higher (33.3 vs. 2.9%, $p<0.01$) and patients with CSF leaks had significantly longer hospital stays (12.5 ± 4.1 days vs. 7.4 ± 2.8 days, $p<0.01$). The group that experienced CSF leaks experienced a significantly higher incidence of infections, with a meningitis incidence of 33.3% ($p<0.05$). Patients with CSF leaks required substantially more lumbar drainage and returned to the operating room ($p<0.05$).

Conclusion: CSF leakage is a comparatively frequent complication of spinal dysraphism surgery, particularly in patients with tethered cord syndrome and prolonged surgical procedures. The risk of infection, reoperation and morbidity rate is substantially elevated by the presence of a CSF leak.

INTRODUCTION

Significant clinical challenges are presented by spinal dysraphism, encompassing various congenital spinal anomalies that are the result of incomplete closure of neural tube during embryonic development [1]. A variety of neurological deficits, orthopedic deformities and urological dysfunctions can result from these anomalies, which include conditions such as spina bifida, myelomeningocele and lip myelomeningocele [2]. It is imperative to prevent further neurological deterioration and to manage associated complications through surgical intervention, which is frequently performed at an early age. But most often, these procedures pose the risks of cerebrospinal fluid leakage, which is one of the most alarming immediate postoperative complications [3]. Significant morbidity, such as wound dehiscence, infection, meningitis and the potential for neurological compromise, can result from CSF leakage following surgery for spinal dysraphism [4]. The prevention and management of CSF breaches are essential components of postoperative care, as these complications can have substantial impact on patient recovery, prolong hospital stays and increase healthcare costs. Although surgical techniques and perioperative care have improved, CSF leakage continue to be a common occurrence, requiring additional research into their frequency and associated risk factors [5-6]. The literature contains a wide range of reported rates for immediate postoperative CSF leakage in patients undergoing surgery for spinal dysraphism, with rates ranging from 5% to 30% [7]. The rate of leaks is contingent upon the type of dysraphism, complexity of the surgical procedure and patient's overall health status. A variety of factors, such as size and location of the defect, presence of infection at the time of surgery and technical aspects of the surgical repair, such as the use of dural grafts or tissue adhesives, have been associated with an elevated risk of CSF leaks [8]. Understanding the prevalence of CSF breaches in this patient population is essential for multiple reasons. Initially, it enables more effective preoperative counselling for patients and their families, establishing realistic expectations and preparing them for potential complications. Secondly, it assists in the identification of high-risk patients who may benefit from supplementary preventive measures, including the use of prophylactic antibiotics, meticulous surgical technique and close postoperative monitoring. Lastly, the frequency and predictors of CSF breaches can be used to inform clinical practice guidelines, resulting in improved surgical outcomes and quality of care [9-10]. The primary goal of this study was to ascertain the frequency of immediate postoperative cerebrospinal fluid breaches in patients

who are undergoing surgery for spinal dysraphism, as well as to identify the associated risk factors and outcomes.

Materials and Methods

Study Design and Setting: This study was a cross-sectional investigation that was conducted at DHQ Hospital, Dera Ismail Khan, from January 2023 to December 2023, to evaluate the frequency of immediate postoperative CSF breaches in patients who underwent surgery for spinal dysraphism and to identify associated risk factors and outcomes.

Patient Population

A total of 40 patients who underwent surgical intervention for spinal dysraphism during the study period were enrolled. Spinal dysraphism encompassed a variety of congenital spinal anomalies, including tethered cord syndrome, myelomeningocele and spina bifida.

Inclusion Criteria

- Patients who have been diagnosed with spinal dysraphism, such as spina bifida, myelomeningocele or tethered cord syndrome, had received a confirmed diagnosis.
- Patients who underwent surgical intervention for spinal dysraphism at the study area between January 2023 and December 2023.
- Patients of all ages who successfully met the aforementioned criteria.
- Patients who possessed comprehensive and complete medical records, which included information regarding preoperative, intraoperative and immediate postoperative periods (within 30 days).

Exclusion Criteria

- Patients needing complex wound closure techniques, such as Z-plasty, during the surgical procedure to reduce variability and maintain homogeneity in the surgical approach.
- Patients whose medical records were fragmentary or incomplete, making it impossible to accurately assess the incidence of CSF leaks.
- Patients who had undergone prior spinal surgery that was not associated with spinal dysraphism or having distorted assessment of the incidence of CSF leaks.
- Patients who had multiple neurological conditions that could independently elevate the risk of CSF leakage or other postoperative complications, thereby complicating the results of the study.
- Patients or their care givers who were unable to attend or refused to attend postoperative follow-up within 30 days of surgery, thereby impeding the assessment of immediate complications.

Surgical Procedure

All patients who were included in the study underwent standard surgical procedures that were appropriate for their particular form of spinal dysraphism. Careful dural closure and when necessary, adjunctive materials such as tissue adhesives or dural grafts were implemented. In accordance with the hospital's protocol, all patients were administered prophylactic antibiotics and the surgical environment was maintained under sterile conditions.

Data collection

Data were obtained cross-sectionally from patients and their medical records, which encompassed preoperative, intraoperative and postoperative data. The primary outcome was the occurrence of CSF leakage, which was defined as the presence of clear fluid drainage from the surgical site within the first 30 days postoperatively. Patient demographics, type of spinal dysraphism, surgical procedure, occurrence of other postoperative complications and any subsequent surgical or medical interventions required as a result of CSF leakage were all included in the additional data.

Analysis

In order to summarize patient demographics and clinical characteristics, descriptive statistics were implemented. The prevalence of CSF leaks was determined by dividing the number of patients who experienced a leak by the total number of patients who were operated on. In order to evaluate the prevalence of CSF leaks in patients who underwent tethered cord release, a subgroup analysis was implemented. In order to investigate potential risk factors, including the complexity of the surgical procedure and type of spinal dysraphism, comparisons were conducted between patients with and without CSF leakage.

Ethical Considerations

This investigation was conducted in compliance with the Declaration of Helsinki and was authorized by the institutional review committee. Informed consent was obtained from the patients or their caregivers and patient confidentiality was rigorously upheld and all data were anonymized before analysis were conducted.

Statistical Analysis

The data were analyzed using IBM SPSS software version 26.0. Frequencies and percentages were used to represent categorical variables. The incidence of CSF breaches was compared between various groups using Chi-square tests. Statistical significance was defined as a

p-value of less than 0.05. In addition, a logistic regression analysis was conducted to identify independent risk factors for CSF leakage.

Results

There were no statistically significant differences in age, gender, BMI or comorbidities between patients who experienced CSF leakage and those who did not, as indicated by the analysis of patient demographics and clinical characteristics. The prevalence of CSF breaches was higher in male patients (66.7%) than in female patients (33.3%); however, the difference was not statistically significant ($p<0.05$). In comparison to other forms of spinal dysraphism, such as spina bifida and myelomeningocele, patients with tethered cord syndrome exhibited substantially higher incidence of CSF leaks (66.7%) ($p<0.05$). Tethered cord release surgery was also associated with a higher risk of CSF leaks (66.7%) in comparison to other procedures ($p<0.05$). Intraoperative complications were more prevalent in patients with CSF breaches (33.3 vs. 8.8%), although this difference was statistically insignificant ($p>0.05$). Patients who developed CSF leaks had prolonged surgical duration; however, this difference was also not statistically significant ($p>0.05$) (Table 1). The postoperative results indicated that CSF breaches had substantial effect on the recovery of the patient. The mean length of hospital stay for patients with CSF leakage was 12.5 days, which was significantly longer than that of patients without leaks (mean 7.4 days) ($p<0.01$). The CSF leak group's need for reoperation was considerably higher (33.3%) than that of the non-leak group (2.9%) ($p<0.01$). In patients with CSF leakage, infections were significantly more prevalent, particularly meningitis, which was present in 33.3% of patients with leaks and absent in those without ($p<0.05$). In the CSF leak group, wound infections and other complications, including pneumonia and deep vein thrombosis, were more prevalent, although these differences were not statistically significant. The need for lumbar drainage and the return to the operating room were considerably higher in patients with CSF leaks, with p-values of 0.003 and 0.001, respectively, suggesting a substantial burden of complications in this group (Table 2). Patients with tethered cord syndrome had substantially higher incidence of CSF leaks (66.7%) than those without this condition (23.5%), as indicated by the analysis of risk factors for CSF leakage ($p<0.05$). There was also significant relationship, with the higher risk of CSF breaches associated with surgical procedures lasting longer than 120 minutes (66.7 vs. 23.5%). While not statistically significant, there was a prominent trend towards an elevated risk of CSF leaks in patients who underwent more intricate operations and those who experienced an intraoperative blood loss

exceeding 500ml ($p>0.05$). The presence of infection was significantly correlated with CSF leaks, with 50% of patients in the leak group having infections compared to only 5.9% in the non-leak group ($p<0.01$). The incidence of CSF leaks was not substantially affected by the use of preoperative steroid use and dural grafts (Table 3). The average delay to detection of CSF leaks among patients was 3.7 days, with the range of 2 to 5 days. These patients endured extended hospitalizations, with an average duration of 12.5 days. Average time to reoperation following breach detection was 7.2 days and CSF leak was resolved in an average of 10.8 days, with a range of 6 to 15 days. This suggested that a substantial impact was made on patient recovery and resource utilization (Table 4). In comparison to patients without the condition, those with tethered cord syndrome exhibited significantly higher incidence of postoperative complications. Patients with tethered cord syndrome experienced CSF leaks at a rate of 33.3%, while those without the condition experienced them at the rate of only 7.1%. Reoperations were necessary for 25.0% of patients with tethered cord syndrome, while only 3.6% of those without needed additional surgery. The prevalence of meningitis was substantially higher in the tethered cord group (25.0 vs. 7.1%) and the overall infection rates were significantly higher (41.7 vs. 10.7%). The tethered cord group also experienced higher incidence of wound infections (16.7 vs. 3.6%), which underscored the elevated postoperative risks associated with this condition (Figure 1).

Table 1: Patient Demographics and Clinical Characteristics

Characteristic	Total Patients (N=40)	Patients with CSF Leak (N=6)	Patients without CSF Leak (N=34)	χ^2	p-value
Age (years) Mean ± SD	35.7 ± 10.3	38.4 ± 11.1	34.9 ± 9.7	-	0.39
Sex n(%)					
Male	22 (55)	4 (66.7)	18 (52.9)	0.54	0.46
Female	18 (45)	2 (33.3)	16 (47.1)	0.54	0.46
Body Mass Index (BMI) Mean ± SD	24.7 ± 3.6	25.4 ± 3.7	24.5 ± 3.5	-	0.54
Comorbidities					

n(%)					
Diabetes Mellitus	4 (10)	1 (16.7)	3 (8.8)	0.46	0.49
Hypertension	6 (15)	1 (16.7)	5 (14.7)	0.04	0.84
History of UTI	8 (20)	2 (33.3)	6 (17.6)	0.79	0.37
Type of Spinal Dysraphism n (%)					
Spina Bifida	10 (25)	1 (16.7)	9 (26.5)	0.33	0.57
Myelomeningocele	18 (45)	1 (16.7)	17 (50)	1.19	0.27
Tethered Cord Syndrome	12 (30)	4 (66.7)	8 (23.5)	4.17	0.04
Surgical Procedure n(%)					
Tethered Cord Release	12 (30)	4 (66.7)	8 (23.5)	4.17	0.04
Myelomeningocele Repair	18 (45)	1 (16.7)	17 (50)	1.19	0.27
Spina Bifida Repair	10 (25)	1 (16.7)	9 (26.5)	0.33	0.57
Intraoperative Complications n(%)	5 (12.5)	2 (33.3)	3 (8.8)	2.95	0.09
Surgical Duration (minutes) Mean ± SD	145.3 ± 20.7	158.5 ± 22.4	141.5 ± 19.8	-	0.12

Table 2: Postoperative Outcomes and CSF Leak Incidence

Outcome	Total Patients (N=40)	Patients with CSF Leak (N=6)	Patients without CSF Leak (N=34)	χ^2	p-value
CSF Leak Incidence n(%)	6 (15)	6 (100)	0 (0)	-	-
Length of Hospital Stay (days) Mean ± SD	8.2 ± 3.4	12.5 ± 4.1	7.4 ± 2.8	-	0.01

Reoperation Required n(%)	3 (7.5)	2 (33.3)	1 (2.9)	7.02	0.01
Infection n(%)	5 (12.5)	3 (50)	2 (5.9)	7.46	0.01
Meningitis	2 (5)	2 (33.3)	0 (0)	8.57	0.003
Wound Infection	3 (7.5)	1 (16.7)	2 (5.9)	1.00	0.32
Other Complications n(%)					
Pneumonia	3 (7.5)	1 (16.7)	2 (5.9)	1.00	0.32
Deep Vein Thrombosis	2 (5)	1 (16.7)	1 (2.9)	1.89	0.17
Need for Lumbar Drainage n(%)	3 (7.5)	3 (50)	0 (0)	13.18	0.003
Return to Operating Room n(%)	2 (5)	2 (33.3)	0 (0)	10.98	0.001

Table 3: Risk Factors for CSF Leakage

Risk Factor	**Patients with CSF Leak (N=6)**	**Patients without CSF Leak (N=34)**	**χ^2**	**p-value**
Age (years) Mean ± SD	38.4 ± 11.1	34.9 ± 9.7	-	0.39
Tethered Cord Syndrome n(%)	4 (66.7)	8 (23.5)	4.17	0.04
Surgical Complexity n(%)	3 (50)	7 (20.6)	2.74	0.10
Surgical Duration > 120 mins n(%)	4 (66.7)	8 (23.5)	4.17	0.04
Intraoperative Blood Loss > 500ml n(%)	3 (50)	7 (20.6)	2.74	0.10

Presence of Infection n(%)	3 (50)	2 (5.9)	7.46	0.01
Use of Dural Graft n(%)	2 (33.3)	8 (23.5)	0.31	0.58
Preoperative Steroid Use n(%)	2 (33.3)	5 (14.7)	1.14	0.29

Table 4: Clinical Outcomes in Patients with CSF Leak

Clinical Outcome	Patients with CSF Leak (N=6)	Range
Time to Leak Detection (days) Mean ± SD	3.7 ± 1.2	2-5
Hospital Stay (days) Mean ± SD	12.5 ± 4.1	8-18
Time to Reoperation (days) Mean ± SD	7.2 ± 2.3	5-11
Resolution of Leak (days) Mean ± SD	10.8 ± 3.4	6-15

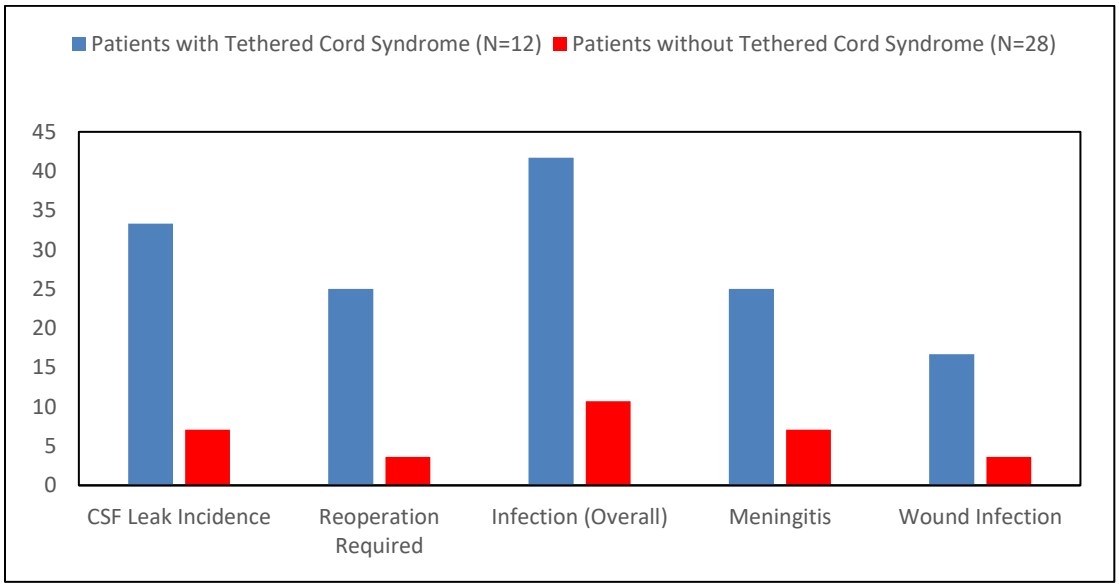

Figure 1: Comparison of Postoperative Complications between Patients with and without Tethered Cord Syndrome

Discussion

We evaluated the frequency of immediate postoperative cerebrospinal fluid breaches in patients who were undergoing surgery for spinal dysraphism, with an emphasis on the identification of associated risk factors and outcomes. In our study, the overall incidence of CSF leaks was 15%, with all breaches occurring within the first 30 days postoperatively. In the literature, the incidence of CSF leakage following spinal dysraphism surgery ranges from 5% to 30%, depending on the complexity of the surgical procedure and the specific form of dysraphism [4, 7]. This incidence is within the range reported. Our revelation that tethered cord syndrome and surgical duration exceeding 120 minutes are substantial risk factors for CSF leaks is in accordance with prior research that has identified these factors as critical determinants of postoperative complications [11-12].

In our cohort, the incidence of CSF leaks was considerably higher in patients with tethered cord syndrome, at 66.7%, than in those without the condition, at 23.5%. The findings of Gohar et al. (2023), who reported that patients with tethered cord syndrome are at an elevated risk for CSF leaks due to the complex nature of their surgical repair, which often entails extensive dissection and manipulation of the spinal cord and surrounding structures, are consistent with this [7]. The increased risk of dural tears is likely due to the protracted surgical duration associated with these procedures, as longer surgeries are frequently associated with greater tissue manipulation and, as a result, a higher likelihood of dural tears [13].

The postoperative outcomes of our study were significantly influenced by CSF leaks. The average hospital stay for patients with CSF leakage was 12.5 days, which is significantly longer than the 7.4 days observed in patients without leaks. The extended hospital stay is indicative of the supplementary care necessary to address CSF breaches, which includes the potential for reoperation, infection control and the necessity of lumbar drainage [14-15]. These results are corroborated by previous studies, which demonstrated that CSF leaks are substantially associated with increased rates of postoperative morbidity and prolong hospital stays [14-15].

In our investigation, 33.3% of patients with CSF leakage needed reoperation, while only 2.9% of those without leaks did. This reoperation rate is in accordance with the report, which indicated that reoperation rates resulting from CSF breaches may vary from 20% to 40% [16]. The decision to reoperate is frequently determined by the severity of the breach, patient's clinical condition and efficacy of conservative management strategies, such as lumbar drainage.

Reoperation may be required to achieve definitive closure of dural defect and prevent further complications in cases where conservative measures fail [17-18].

Our research revealed that patients with CSF leaks experienced substantially higher infection rates, with an overall infection rate of 50% in the CSF leak group compared to 5.9% in the non-leakage group. It is important to note that meningitis was a serious complication that occurred in 33.3% of patients with CSF breaches. This situation underscored the necessity of vigilant infection control measures in this population. The direct pathway that CSF leakage creates for pathogens to infiltrate the central nervous system is well-documented and the association between increased infection risk and CSF leaks is well-established [10]. The risk of superficial and profound infections can be increased by the presence of wound dehiscence and other complications that may result from a CSF leak [19].

In other studies, the risk of meningitis in the presence of a CSF leak ranges from 15% to 50%, dependent on the surgical context and the patient's overall health [20-21]. Our infection rates are comparable to these reported rates. Prompt recognition and aggressive treatment are necessary for the management of infections in these patients. This treatment typically involves broad-spectrum antibiotics and in certain cases, surgical intervention to control the source of the infection. The high incidence of meningitis in our study underscores the necessity of preoperative risk assessment and postoperative surveillance to identify patients at higher risk and implement the corresponding prophylactic measures [22].

In order to enhance surgical outcomes and decrease the prevalence of this complication, it is imperative to identify risk factors for CSF leaks. The presence of infection was identified as a significant risk factor for CSF leaks in our study, in addition to tethered cord syndrome and prolonged surgical duration. Specifically, 50% of patients with CSF leakage had an associated infection. This discovery is in accordance with the research indicating that infections, particularly those that manifest as surgical site infections or pre-existing conditions such as urinary tract infections, can compromise the integrity of the surgical wound and increase the probability of CSF leakage [23-24].

Our study also found that increased rates of CSF leakage were associated with surgical complexity and intraoperative blood loss, although these factors did not reach statistical significance. The trend observed indicated that patients may be at higher risk of CSF breaches as a result of the increased risk of dural injury associated with more complex surgeries, which

frequently involve more tissue dissection and manipulation [25]. Similarly, the surgical field may be complicated by substantial intraoperative blood loss, which can make it more difficult to accomplish a watertight dural closure [26].

The results of our investigation have significant implications for clinical practice. Initially, it is imperative to identify high-risk patients, particularly those who are undergoing protracted or complex surgeries and those with tethered cord syndrome, in order to implement targeted preventive strategies. These strategies may involve the early implementation of postoperative monitoring protocols to promptly detect and manage CSF breaches, the use of intraoperative imaging to ensure dural integrity and the meticulous surgical technique [27]. Secondly, the high rates of infection associated with CSF breaches in our study emphasize the necessity of rigorous infection control measures, both preoperatively and postoperatively, to implement prophylactic antibiotics, implementation of a rigorous aseptic technique during surgery and implementation of vigilant postoperative surveillance for indications of infection [7, 10].

Conclusion

In patients who were undergoing surgery for spinal dysraphism, this study identified a 15% incidence of immediate postoperative cerebrospinal fluid leaks. Significant risk factors included tethered cord syndrome and protracted surgical duration (>120 minutes). Increased overall morbidity were the result of CSF breaches, which were associated with significantly higher rates of infection, particularly meningitis and higher likelihood of reoperation. These results emphasized the necessity of meticulous surgical technique, vigilant postoperative monitoring and prompt management strategies to enhance patient outcomes and mitigate the impact of CSF leaks in spinal dysraphism surgery.

Conflict of Interest

None.

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