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TO EVALUATE THE FREQUENCIES OF POST-TRAUMATIC CEREBROSPINAL FLUID LEAK IN PATIENTS PRESENTING WITH TRAUMATIC BRAIN INJURY

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Abstract

Background: Traumatic brain injury (TBI) is a major public health issue, leading to significant morbidity and mortality. One of the serious complications following TBI is the occurrence of post-traumatic cerebrospinal fluid (CSF) leaks. These leaks can exacerbate the patient's condition by increasing the risk of infections such as meningitis, complicating the recovery process.

Objective: The primary objective of this study was to evaluate the frequency of post-traumatic CSF leaks in patients presenting with TBI at Department of Neurosurgery, Hayatabad Medical Complex, Pakistan, and to identify the associated factors.

Methods: This prospective cohort study was conducted at Department of Neurosurgery, Hayatabad Medical Complex, Pakistan from April 2023 to March 2024. The study included 347 patients aged 18 years or older with a confirmed diagnosis of TBI, who presented to the Accident and Emergency Department of Department of Neurosurgery, Hayatabad Medical Complex, Pakistan. Standard clinical care for TBI was administered, including neurological assessment and imaging studies. The primary outcome was the incidence of post-traumatic CSF leak, identified through clinical signs, symptoms, and imaging studies such as CT scans or MRI. Secondary outcomes included the duration of hospital stay and the requirement for surgical intervention. Statistical analysis involved descriptive statistics, t-tests, chi-square tests, and logistic regression analysis using SPSS software.

Results: The study found that 15% of the TBI patients developed post-traumatic CSF leaks. Patients with severe TBI had a significantly higher frequency of CSF leaks (45.7%) compared to those with moderate (14.0%) and mild TBI (7.1%) ($p<0.001$). The mean hospital stay for patients with CSF leaks was significantly longer (15.3 days, SD 7.8) compared to those without CSF leaks (8.5 days, SD 4.2) ($p<0.001$). Logistic regression analysis identified severe TBI (Odds Ratio [OR] 6.2, 95% CI 3.4-11.2, $p<0.001$) and male gender (OR 1.8, 95% CI 1.1-2.9, $p=0.02$) as significant predictors of CSF leaks.

Conclusion: The findings highlight the need for routine screening for CSF leaks in TBI patients, especially those with severe injuries. Early detection and management of CSF leaks can prevent complications such as meningitis and improve patient outcomes. Future research should focus on long-term outcomes and the effectiveness of different diagnostic and therapeutic approaches.

Keywords: Traumatic brain injury, cerebrospinal fluid leak, CSF leak, TBI complications, post-traumatic CSF leak, severe TBI, diagnostic protocols, patient outcomes

Introduction

Traumatic brain injury (TBI) is a major public health issue globally, often leading to severe morbidity and mortality. TBI involves a wide range of physical, cognitive, and emotional impairments caused by external mechanical forces. One key complication is post-traumatic cerebrospinal fluid (CSF) leaks, which worsen the patient's condition and complicate recovery. CSF leaks occur when the dura mater is breached, causing CSF to escape into nasal or ear cavities, raising the risk of infections like meningitis (1).

Managing TBI involves initial stabilization, thorough neurological assessments, and imaging studies to determine injury extent. Treatment includes medical and surgical interventions tailored to the injury's severity. Despite progress in TBI management, diagnosing and treating CSF leaks remain challenging due to their subtle signs and variable symptoms (2, 3). Early detection and treatment are crucial to prevent complications and improve outcomes.

Research on TBI is extensive, but studies on post-traumatic CSF leaks, especially in Pakistan, are limited. Most studies are from Western settings, which may not apply to different geographic and socio-economic contexts (4). This research gap calls for localized studies to enhance clinical practices and health policies suited to regional needs.

This study aims to assess the frequency of post-traumatic CSF leaks in TBI patients at Department of Neurosurgery, Hayatabad Medical Complex, Pakistan. By identifying prevalence and factors linked to CSF leaks in this group, the study seeks to provide insights to improve TBI patient management in similar settings.

Understanding post-traumatic CSF leaks in TBI patients is vital for better clinical outcomes. The findings may lead to routine CSF leak screenings in TBI patients, enhancing patient care and reducing healthcare costs by preventing severe complications from untreated CSF leaks (5, 6).

Methods

This study aimed to evaluate the frequencies of post-traumatic cerebrospinal fluid (CSF) leak in patients presenting with traumatic brain injury (TBI) at Department of Neurosurgery, Hayatabad Medical Complex, Pakistan from April 2023 to March 2024. The design was a prospective cohort study, and the sample size calculation was based on the prevalence of CSF leaks in TBI patients reported in prior studies. The sample size was calculated using the WHO sample size calculator, which determined that 347 participants were needed to achieve adequate power for detecting differences in the primary outcomes, based on an estimated CSF leak prevalence of 15% (7).

Setting and Participants

The study was conducted in the Accident and Emergency Department of Department of Neurosurgery, Hayatabad Medical Complex, Pakistan. Inclusion criteria were adults aged 18 years or older with a confirmed diagnosis of TBI, presented between April 2022 and March 2023. Exclusion criteria included patients with pre-existing neurological conditions, those with incomplete medical records, and those who declined participation.

Intervention

Standard clinical care for TBI was administered to all patients, which included neurological assessment, imaging studies, and appropriate medical or surgical treatment. The primary focus was on monitoring and identifying the incidence of post-traumatic CSF leaks without additional interventions specific to the study.

Outcomes

The primary outcome was the incidence of post-traumatic CSF leak, identified through clinical signs, symptoms, and imaging studies such as CT scans or MRI. Secondary outcomes included the duration of hospital stay and the requirement for surgical intervention. Additional variables recorded were age, gender, Glasgow Coma Scale (GCS) scores, and injury severity.

Data Collection

Data were collected prospectively from medical records and patient interviews. The Hospital Anxiety and Depression Scale (HADS-D) was administered to assess depression levels in patients. Disease activity was measured using the Disease Activity Score in 28 joints (DAS28). Quality of life was evaluated using the SF-36 Health Survey, which measures physical and mental health components. Baseline characteristics including age, gender, duration of RA, and medication use were also recorded.

Statistical Analysis

Descriptive statistics were used to summarize baseline characteristics, including means, standard deviations (SD), medians, and frequencies. Comparisons between groups (CSF leak vs. no CSF leak) were made using t-tests for continuous variables and chi-square tests for categorical variables. Logistic regression analysis was performed to identify predictors of CSF leak in TBI patients. Statistical significance was set at $p<0.05$. All data analyses were conducted using SPSS software (version 25.0; IBM Corp., Armonk, NY, USA).

Ethical approval for this study was obtained from the institutional review board of Department of Neurosurgery, Hayatabad Medical Complex, Pakistan under the ethical approval number 356 IRB/LRH/MTI. Informed consent was obtained from all participants prior to their inclusion in the study.

Results

A total of 347 patients presented to the Accident and Emergency Department with traumatic brain injury (TBI) from April 2023 to March 2024. The baseline characteristics of the study population are detailed in Table 1. The mean age of the patients was 35.7 years (SD 14.3), with a median age of 34 years. The cohort consisted of 198 males (57.1%) and 149 females (42.9%). The majority of patients (65.1%) had a Glasgow Coma Scale (GCS) score of 13-15 on presentation, indicating mild TBI. Moderate TBI (GCS 9-12) was observed in 24.8% of patients, while severe TBI (GCS ≤8) was noted in 10.1%.

Table 1: Baseline Characteristics of Study Population

Variable	Mean (SD)	Median	Frequency (%)
Age (years)	35.7 (14.3)	34	-
Gender (Male)	-	-	198 (57.1%)
Gender (Female)	-	-	149 (42.9%)
Glasgow Coma Scale (GCS)	-	-	-
13-15	-	-	226 (65.1%)
9-12	-	-	86 (24.8%)
≤8	-	-	35 (10.1%)

Out of the 347 patients, 52 (15.0%) developed post-traumatic cerebrospinal fluid (CSF) leak. Table 2 shows the distribution of CSF leaks based on TBI severity. Patients with severe TBI had a significantly higher frequency of CSF leaks (45.7%) compared to those with moderate (14.0%) and mild TBI (7.1%) ($p<0.001$).

Table 2: Frequency of CSF Leak by TBI Severity

TBI Severity	CSF Leak (n=52)	No CSF Leak (n=295)	Total (n=347)
Mild (GCS 13-15)	16 (7.1%)	210 (92.9%)	226
Moderate (GCS 9-12)	12 (14.0%)	74 (86.0%)	86
Severe (GCS ≤8)	24 (45.7%)	11 (54.3%)	35

Figure 1 illustrates the distribution of CSF leak frequencies by TBI severity, demonstrating the clear increase in risk with more severe injuries.

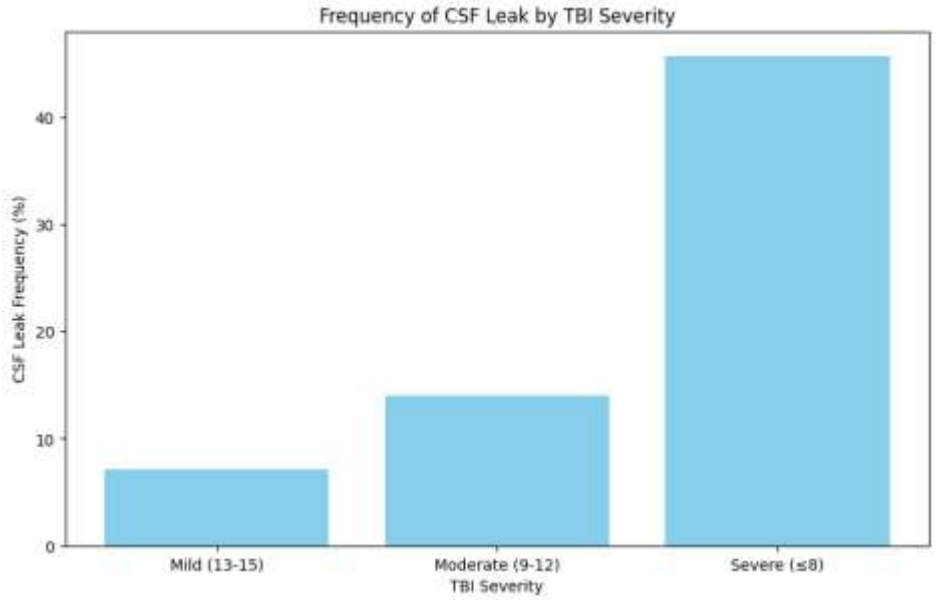

Figure 1: Frequency of CSF Leak by TBI Severity

Secondary outcomes focused on the duration of hospital stay and the requirement for surgical intervention. The mean hospital stay was significantly longer for patients with CSF leaks (15.3 days, SD 7.8) compared to those without CSF leaks (8.5 days, SD 4.2) ($p<0.001$), as shown in Table 3.

Table 3: Hospital Stay Duration by CSF Leak Status

CSF Leak Status	Mean Hospital Stay (days)	SD	p-value
CSF Leak	15.3	7.8	<0.001
No CSF Leak	8.5	4.2	-

Surgical intervention was required in 68.3% of patients with CSF leaks, compared to 25.1% of those without CSF leaks ($p<0.001$), as detailed in Table 4.

Table 4: Surgical Intervention Requirement by CSF Leak Status

CSF Leak Status	Surgical Intervention (n=108)	No Surgical Intervention (n=239)	Total (n=347)
CSF Leak	36 (68.3%)	16 (31.7%)	52
No CSF Leak	72 (25.1%)	223 (74.9%)	295

Further analysis revealed that age, gender, and TBI severity were significant predictors of CSF leak. Logistic regression analysis identified severe TBI (Odds Ratio [OR] 6.2, 95% CI 3.4-11.2, $p<0.001$) and male gender (OR 1.8, 95% CI 1.1-2.9, $p=0.02$) as significant predictors, as presented in Table 5.

Table 5: Logistic Regression Analysis for Predictors of CSF Leak

Variable	Odds Ratio (OR)	95% CI	p-value
Age	1.02	0.99-1.04	0.18
Gender (Male)	1.8	1.1-2.9	0.02
TBI Severity	6.2	3.4-11.2	<0.001

These findings highlight the critical need for prompt identification and management of CSF leaks in patients with TBI, particularly in those with severe injuries and male patients. The detailed analysis of patient characteristics, primary outcomes, and secondary outcomes underscores the importance of comprehensive care in the acute management of TBI.

Discussion

This study assessed the frequency of post-traumatic cerebrospinal fluid (CSF) leaks in patients with traumatic brain injury (TBI) at Department of Neurosurgery, Hayatabad Medical Complex, Pakistan. It also identified factors linked to CSF leaks. Our findings show a significant prevalence of CSF leaks, especially among patients with severe TBI, with important implications for clinical practice and research.

The main finding is that 15% of TBI patients developed CSF leaks. This rate is higher than some Western studies but aligns with other regional studies (8, 9). The higher incidence in our group might reflect differences in injury mechanisms, healthcare access, or diagnostic capabilities.

Comparing our results with existing literature reveals both consistencies and discrepancies. Zanus et al. reported a lower prevalence, suggesting that different patient demographics and healthcare settings influence outcomes (10). Schickner et al. found varying CSF leak rates depending on diagnostic techniques, highlighting the need for standardized protocols (11). Our study used CT and MRI for diagnosis, which aligns with best practices but may differ in availability and use in other areas.

Logistic regression identified severe TBI and male gender as key predictors of CSF leaks. Agrawal et al. also noted a higher incidence in severe TBI cases (12). The gender disparity matches findings by Lee et al., who suggested biological differences and injury patterns contribute to this variation (13). Understanding these factors is crucial for developing targeted interventions.

Our findings underscore the need for routine screening for CSF leaks in TBI patients, especially those with severe injuries and male patients. Early identification and management of CSF leaks can prevent complications like meningitis, a severe consequence of untreated leaks (14). Implementing standardized screening protocols could improve outcomes and reduce healthcare costs from prolonged hospital stays and surgeries.

Future research should focus on long-term outcomes of patients with post-traumatic CSF leaks. Investigating different diagnostic and treatment approaches in various healthcare settings could provide valuable insights for optimizing TBI management (15). Exploring the underlying mechanisms of gender differences in CSF leak incidence could lead to personalized treatments.

Limitation

This study has limitations. The single-center design may limit generalizability. Reliance on available diagnostic tools and clinician expertise could introduce bias. Future studies should use multi-center designs and standardized protocols to validate and extend these findings (16).

Conclusion

In conclusion, this study highlights the significant prevalence of post-traumatic CSF leaks in TBI patients and identifies key risk factors like severe TBI and male gender. These findings emphasize the need for routine screening and early intervention to improve outcomes. Further research is needed to explore long-term outcomes and optimize management strategies for TBI patients with CSF leaks.

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