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Original research article

POST-TRAUMATIC CSF LEAK IN PATIENTS PRESENTING WITH PNEUMOCEPHALUS

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Abstract: *Post-traumatic cerebrospinal fluid (CSF) leak is a serious complication associated with skull base fractures and pneumocephalus, often resulting from traumatic brain injuries. Understanding the frequency and timely management of these leaks is crucial to preventing further complications and improving patient outcomes.* ***Objective:*** *The objective of this study was to determine the frequency of post-traumatic CSF leak in patients with skull base fractures presenting with pneumocephalus.* ***Methods****: After ethical approval from the institutional review board, this prospective cross-sectional study was conducted at the Emergency Department of Shaheed Mohtarma Benazir Bhutto Trauma Centre (SMBBTC), Karachi, from December 2022 to December 2023. Seventy-three patients with skull base fractures were recruited. Each patient underwent comprehensive evaluation, including medical history, clinical examination, and radiological assessment using CT and MRI scans to confirm brain injury. A follow-up CT scan was performed 24 hours post-admission to assess for pneumocephalus and other intracranial injuries. Subsequent CT scans were conducted at 3 and 5 days for stable patients with moderate to severe head trauma. Data were analyzed using descriptive statistics.* ***Results****: Among the 73 patients, the majority were males (75%) and aged 16-30 years (27%). Ear bleeding was observed in 30% of patients, nose bleeding in 56%, and raccoon eyes in 42%. CSF leakage was detected in 10 patients (14%), with 60% of these cases presenting as rhinorrhea. Road traffic accidents accounted for 70% of the cases. Pneumocephalus was detected in 71% of patients within the first 24 hours. Air over the convexity was observed in 55% of patients on CT scans. CSF leak occurred within 24 hours in 50% of the patients and resolved in 40% within two weeks. Repeat CT scans showed improvement of pneumocephalus in 68% of patients.* *Conclusion: Timely detection of pneumocephalus and prompt surgical intervention can effectively reduce adverse health effects and prevent potential complications in patients with skull base fractures.*

Keywords: Brain Injuries, Cerebrospinal Fluid Leak, Pneumocephalus, Skull Fractures, Traumatic Brain Injuries

Introduction

Pneumocephalus (PNC) is a medical condition characterised by the abnormal presence of gas in the cerebral cavity, specifically in the subdural, epidural, intraventricular, subarachnoid, or intraparenchymal compartments. (1). Head injury is the primary factor leading to PNC, with trauma being responsible for 74% of all instances. Other causes include intracranial neoplasms, paranasal sinus surgery, infections, neurosurgery, and diagnostic or neurosurgical treatments such as pneumoencephalography or lumbar puncture. (2). Chiari was the initial individual to document the existence of PNC in 1884 (3). The aetiology of pneumocephalus primarily relies on two factors: a decrease in intracranial pressure and the existence of a dural defect. The cause can be either a ball-valve mechanism that permits air to enter but not depart or a leaking cerebrospinal fluid (CSF), which generates negative pressure and allows air to enter. (4). Post-traumatic cerebrospinal fluid (CSF) leaks occur in around 1% to 3% of all cases of closed traumatic brain injuries (TBI) in adults. Furthermore, head injuries account for 80% to 90% of all cases of CSF leaks in adult patients. (3). The potential for meningitis resulting from the traumatic cerebrospinal fluid (CSF) leak can lead to significant illness and possibly death, depending on the source and location of the leak. With the exception of cases involving spontaneous illnesses, traumatic cerebrospinal fluid (CSF) leaks can have potentially harmful consequences, including the development of bacterial meningitis if not cleared on their own (5). The conventional approach entails administering antibiotics intravenously to treat the infection, along with repairing any suspected dural defects in cases of definite injury. Early identification of cerebrospinal fluid (CSF) leakage is crucial as it directly impacts the patient's prognosis. The choice between observation or surgical intervention is primarily determined by the cause, location, and timing of the leak. (6).

The current guideline recommends a conservative approach for the treatment of posttraumatic cerebrospinal fluid (CSF) leakage for a duration of 10 to 14 days. If the leak does not show improvement with conservative methods within two weeks, it is crucial to take invasive action (7, 8). The standard diagnostic procedures used to identify skull fractures and potential dural tears involve conducting a high-resolution CT scan with coronal and sagittal cuts. Prone posture MRI with T2 weighted images is strongly preferred. Additional procedures such as radionuclide cisternography, metrizamide contrast test, and intrathecal fluorescein dye test can be used to verify the presence of cerebrospinal fluid (CSF) leaks (9). The beta transferrin present in the leaking fluid, along with its glucose levels, can be used to distinguish CSF rhinorrhoea from other potential causes. Complications arising from posttraumatic cerebrospinal fluid (CSF) leaks encompass acute fulminant meningitis, which carries a significantly elevated mortality rate, as well as recurrent pneumocephalus, which may lead to the development of tension pneumocephalus (10). In their study, Bell et al. comprehensively analysed post-traumatic

cerebrospinal fluid (CSF) leaks and their treatment. They found that these leaks occur in 4.6% of patients who had experienced head trauma (11). Junaid M et al did a separate investigation which found that 5.2% of patients experienced a cerebrospinal fluid (CSF) leak. Upon examining the nature of the CSF leak outlet, we found that 2.1% of patients experienced Otorrhea, whereas 3.1% experienced Rhinorrhea (12). The objective of the study was to determine the frequency of post-traumatic CSF leaks in patients with base of skull fractures presenting with pneumocephalus.

Methodology

After the ethical approval from the institutional review board, this prospective cross-sectional study was carried out at the Emergency Department of Shaheed Mohtarma Benazir Bhutto Trauma Centre (SMBBTC), December 2022 to December 2023. Through non-probability convenient sampling, 73 Patients aged between 2-60 years, both gender, presenting with head trauma and having base of skull fracture and pneumocephalus diagnosed on the basis of CT scan were included in the present study. Patients with head injury with open skull fractures, with previous intracranial surgeries, with spontaneous pneumocephalus, and with history of CSF leak were excluded from the study. The study's objectives and advantages were elucidated to the guardian/relative, and their informed consent was gained. Each patient underwent a comprehensive evaluation, including a thorough medical history, clinical examination, and radiological assessment using CT and MRI scans to confirm the presence of brain injury. A follow-up CT scan was conducted in 24 hours to assess for minor pneumocephalus, subdural hematoma (SDH), haemorrhage (SAH), epidural hematoma (EDH), traumatic subarachnoid or contusions. CT scans was repeated at 3 and 5 days after the initial 24-hour CT scan for stable patients with moderate to severe head damage. An urgent follow-up CT scan was performed in cases of a sudden decrease in Glasgow Coma Scale (GCS) score by 2 or more points, pupillary asymmetry, new focal neurological deficits, prolonged vomiting, or seizures. A CSF leak was detected during an examination when there is a sudden flow of fluid through the nostrils or ear while the head is in a lower position. This is known as the Reservoir Sign. To confirm the presence of a CSF leak, a sample of the fluid was collected on a gauze and subjected to the Halo Test. The data were analysed utilising the statistical software SPSS version 21. The mean ± standard deviation was computed for quantitative variables such as age and starting GCS. Categorical characteristics such as gender, location of trauma, kind of trauma, severity of trauma, and CSF leaks were analysed to determine their frequency and percentage. The study stratified cerebrospinal fluid leaks according on age and type of injury, in order to identify any potential effect modifiers. A post-stratification chi-square test was conducted, with a significance level of $P < 0.05$. The findings were displayed in the form of charts and graphs.

Results

Table 1 shows the clinical and demographic characteristics of the study participants. Out of 73 recruited patients, most were 16-30 years old (27%), and most were male (75%). In 30% of the patients ear bleeding was observed, 56% have nose bleeding, and 42% have racoon eyes. Out of 73 patients, 10 (14%) have leakage of CSF; among them, 60% have Rhinorrhea. 70% of the patients recruited are from road traffic accidents (RTA). Pneumocephalus was detected in 71% of the patients in first 24 hours. 55% of the patients have air over convexity detected by CT scans. 10% of the patients have CSF leak within 24hours of presentation. In 50% of the patients CSF leakage was resolved within 2 weeks. Pneumocephalus was improved in 68% of the patients on repeat CT scan. Table 2 shows the age wise stratification of the symptoms in the recruited patients. Table 3 shows the type of injury wise stratification of CSF leakage. Figure 1 shows the frequency of CSF leak in the recruited patients.

Table I: Clinical and demographic parameters of the study participants

Parameters	**N (%)**
Age (years)	
1-5	5 (7%)
6-15	16 (22%)
16-30	20 (27%)
31-45	18 (25%)
46-60	14 (19%)
Gender	
Male	55 (75%)
Female	18 (25%)
Ear bleed	22 (30%)
Nasal bleed	41 (56%)
Racoon eyes	31 (42%)
Battle sign	11 (15%)
Fits	6 (8%)
Presence of CSF leak	10 (14%)
Type of CSF leak	
Rhinorrhea	6 (60%)
Otorrhea	4 (40%)
Mode of Injury	
RTA	51 (70%)
Assault	2 (3%)
Fall	15 (21%)
Hit by heavy object	5 (7%)
Associated CT findings	
EDH	18 (25%)
SDH	15 (21%)
contusions	16 (22%)
SAH	28 (28%)
Linear skull fracture	40 (55%)
Depressed skull fracture	2 (3%)
none	6 (8%)
Time of detection	
During first 24 hours	52 (71%)
Between 48-72 hours	18 (25%)
Between 4-20 days	3 (4%)
CT Findings	
Mount Fuji Sign	14 (19%)
Air in ventricles	8 (11%)
Air in cisterns	16 (22%)
Air over convexity	40 (55%)
CSF Leak Test	

Reservoir sign	73 (100%)
Halo sign	72 (99%)
Onset of CSF leak	
Early (within 48 hr of presentation)	8 (10%)
Delayed (within seven days of presentation)	2 (2%)
no leak	63 (88%)
The total duration of CSF leak	
Resolved in 1 week	5 (50%)
Resolved in 2 weeks	4 (40%)
Unresolved after two weeks	1 (10%)
Density within sinus on CT scan	
Hyperdense	24 (33%)
Mixed density	22 (30%)
Hypodense	14 (19%)
Normal pneumatisation	10 (14%)
Isodense	3 (4%)
Site of skull base fracture	
ACF	22 (30%)
MCF	25 (34%)
ACF+MCF	20 (27%)
Unidentified	6 (8%)
Involved sinus	
Ethmoid	4 (5%)
Sphenoid	10 (14%)
Petrous	7 (9%)
Mastoid	4 (5%)
Frontal+ethmoid	14 (19%)
Frontal+ethmoid+sphenoid	27 (37%)
Petrous+mastoid	2 (3%)
Frontal	5 (7%)
Pneumocephalus on repeat CT	
Improved	50 (68%)
Static	20 (27%)
Increased	3 (4%)
Management	
Strict bed rest and AZM	20 (27%)
Surgical	5 (7%)
None	48 (66%)
GCS at the time of arrival	
14-15	47 (64%)
9-13	20 (27%)
5-8	3 (4%)
<5	3 (4%)
GCS post management	
Improved	41 (56%)
Static	27 (37%)
Deranged	5 (7%)
GCS at discharged	
Improved	44 (60%)
Static	25 (34%)
Deranged	4 (5%)
Other cranial fractures	
Frontal	28 (38%)
Parietal	14 (19%)
Temporal	23 (32%)
Occipital	4 (5%)
Nasal	12 (16%)
None	5 (7%)
Time of discharge	
24-48 hours	20 (27%)
48-72 hours	12 (16%)
3-7 days	18 (25%)
7-14 days	9 (12%)
14-20 days	8 (11%)
After 20 days	6 (8%)
Outcome after 20 days	
Kept admitted	3 (4%)
Discharged home	68 (93%)
Deceased	2 (3%)

Table II: Stratification of presenting symptoms acc. to age groups

Age groups	**Ear Bleed**		**P value**
	Yes	No	
1-5	4 (80%)	1 (20%)	0.04
6-15	5 (31%)	11 (69%)	
16-30	6 (30%)	14 (70%)	
31-45	2 (11%)	16 (89%)	
46-60	5 (36%)	9 (64%)	
Nose Bleed			
1-5	4 (80%)	1 (20%)	0.19
6-15	9 (56%)	7 (44%)	
16-30	7 (35%)	13 (65%)	
31-45	13 (72%)	5 (28%)	
46-60	8 (57%)	6 (43%)	
Racoon eyes			
1-5	2 (40%)	3 (60%)	0.33
6-15	5 (31%)	11 (69%)	
16-30	7 (35%)	13 (65%)	
31-45	11 (61%)	7 (39%)	
46-60	6 (43%)	8 (57%)	
Battle signs			
1-5	0	5 (100%)	0.158
6-15	0	16 (100%)	
16-30	4 (20%)	16 (80%)	

31-45	3 (17%)	15 (83%)	
46-60	4 (29%)	10 (71%)	
Fits			
1-5	0	5 (100%)	0.56
6-15	0	16 (100%)	
16-30	2 (10%)	18 (90%)	
31-45	2 (11%)	16 (89%)	
46-60	2(14%)	12 (86%)	
CSF Leak			
1-5	1 (25%)	4 (76%)	0.549
6-15	2 (13%)	13 (87%)	
16-30	0 (0%)	20 (100%)	
31-45	4 (22%)	14 (78%)	
46-60	3 (16%)	15 (84%)	

Table III: Stratification CSF leak acc. to injury type

Injury type	**CSF Leak**		**P value**
	Yes	**No**	
RTA	7 (14%)	44 (86%)	0.0351
Assault	0	2 (100%)	
Fall	2 (13%)	13 (87%)	
Hit by a heavy object	1 (25%)	4 (75%)	

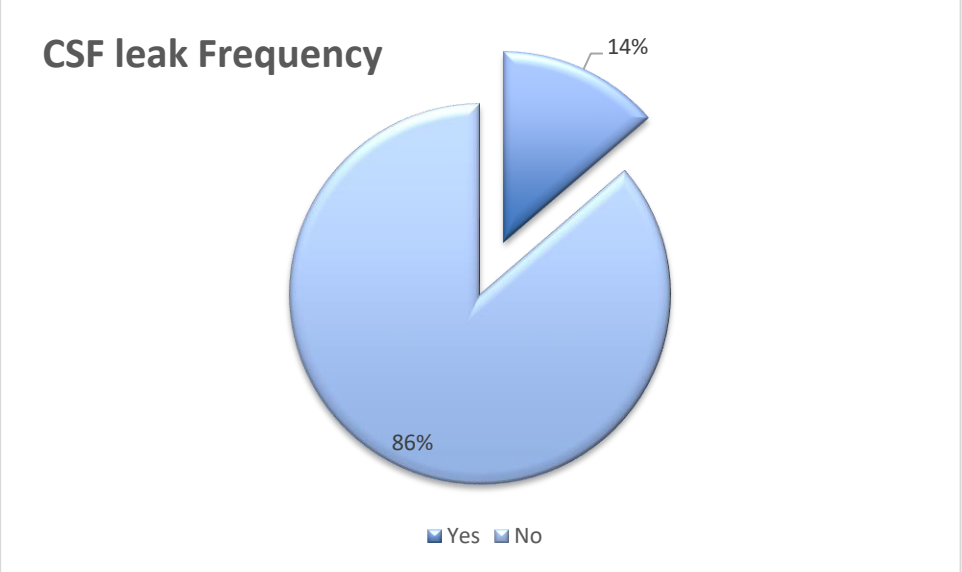

Figure 1: Frequency of post traumatic CSF leak

Discussion

PNC is linked to various causative variables, including surgical interventions, head trauma, infection, and neoplasms. Posterior nasal cerebrospinal fluid (CSF) leaks are commonly observed following head trauma, especially when accompanied by fractures in the base of the skull and loss of CSF. (13). Spontaneous, nontraumatic pneumocephalus is rare, mostly caused by sneezing, nasal blowing, and the Valsalva manoeuvre. Environmental factors, such as those experienced while flying, mountain climbs, and scuba diving, can also contribute to this condition. The primary manifestation of pneumocephalus typically manifests as a headache, accompanied by other symptoms such as cerebrospinal fluid (CSF) rhinorrhea (as observed in our study), meningeal signs, papilledema, hemiparesis, and cranial nerve palsies. Nevertheless, the manifestation of pneumocephalus is frequently ambiguous. (4).

Pneumocephalus typically occurs due to a cranial or facial fracture that allows air to enter the cerebral cavity. Two suggested mechanisms aim to explain the occurrence of Pneumocephalus. (14). The first mechanism involves CSF leakage in the presence of a discontinuity in the skull and destruction of the leptomeninges. Further progression of relative negative intracranial pressure (ICP) leads to a significant "vacuum effect, " resulting in more air buildup within the cranial cavity. (15). This air is often dispersed inside the subarachnoid space. The second process relies on a "unidirectional valve" at the location of the leptomeningeal rupture. In this scenario, the pressure inside

the middle ear is higher than the ICP, causing air to be pushed from the paranasal sinuses into the cranial cavity. When the intracranial pressure (ICP) becomes higher than the pressure in the air collection, a "one-way valve" shuts, preventing the trapped air from escaping 19 and 20. In this process, the atypical air is often dispersed within the extradural space (16).

Among the 73 patients recruited in the present study, the majority (27%) were in the age category of 16-30 years, and most (75%) were male. Ear bleeding was reported in 30% of the patients, nose bleeding in 56%, and raccoon eyes in 42%. Among the 73 patients, 10 (14%) exhibit cerebrospinal fluid (CSF) leaking, with 60% of those experiencing Rhinorrhea. The majority, precisely 70%, of the patients enrolled in the study are individuals involved in road traffic accidents (RTA). Pneumocephalus was observed in 71% of the patients within 24 hours. CT scans indicated air over convexity in 55% of the patients. 50% of the patients experience cerebrospinal fluid (CSF) leakage within 24 hours after their initial presentation. Within two weeks, CSF leaking was cured in 40% of the patients. 68% of the patients showed improvement in pneumocephalus on repeat CT scans. In a separate investigation carried out by Hameedullah et al., it was documented that post-traumatic cerebrospinal fluid (CSF) leaks occur in 1% to 3% of all cases of closed traumatic brain injuries (TBI) in adults. Furthermore, head injuries account for 80% to 90% of all instances of CSF leaks in adult patients. (17).

Conclusion

Posttraumatic pneumocephalus is an uncommon condition that is typically linked to severe injuries to the cranial base and face. It can occur as a result of both blunt and penetrating injuries. Prompt identification and a high level of clinical suspicion are crucial, as timely treatment leads to improvement in most cases. Computed tomography (CT) is considered the most reliable and accurate diagnosing of this illness.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate.

It is approved by the department concerned. IRBEC/23/SMBBTC-1002),

Consent for publication

Approved

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Conflict of interest

The authors declared an absence of conflict of interest.

Authors Contribution

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