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Original Research Article

A Cross-Sectional Autopsy Study of Pyogenic Meningitis in Cases of Fatal Head Trauma

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Abstract:

Background: Traumatic brain injury (TBI) and meningitis are serious complications with high mortality rates. Little is known about the specific factors influencing mortality in patients with both conditions.

Objectives: To study autopsy findings, survival time, isolate and study microscopic finding of meningitis in fatal head trauma cases.

Methods: This cross-sectional autopsy study included 118 deceased patients with TBI and meningitis who underwent medico-legal autopsies between January 2021 and August 2022. Data were collected on socio-demographic characteristics, type of injury, skull fracture type, CSF findings, organisms isolated from CSF culture, and survival time.

Results: Male gender, young age (20-39 years), Hindu religion, road traffic accidents as the injury cause, linear skull fractures, bloody or turbid CSF appearance, increased cell count and protein, and decreased glucose in CSF analysis were independent predictors of mortality. Streptococcus pneumoniae and Hemophilus influenza were the most commonly isolated organisms. Median survival time was short, at only 5 days.

Conclusion: This study highlights the alarmingly high mortality rate and its association with specific socio-demographic and clinical factors in patients with TBI and meningitis. Early diagnosis, comprehensive intervention, and targeted approaches based on risk factors are crucial to improve survival and outcomes in these vulnerable patients.

Introduction

Any damage to the brain, skull, or scalp caused by accidents, falls, or violence are put under the umbrella of Head injuries. They can lead to traumatic brain injury (TBI), a serious condition. On top of that it affects millions of people every year and is a leading cause of death and disability. Classified by the type of force that caused it, TBI could be of these types: blunt, penetrating, or blast. The most severe cases usually result from Road traffic accidents (RTA) or falls. [1]

TBI is common in children, young adults, and the elderly. It is more prevalent in males than females. Elderly people have the highest risk of dying from TBI, even though they account for only 10% of the cases.[2] To rule out intracranial injury in head trauma patients careful evaluation and often is needed. Skull X-rays are only useful for detecting foreign objects or wounds. Head trauma is a major public health concern and often involves other organ injuries.

According to the Monro-Kellie hypothesis, the total volume inside the skull (made up of brain tissue, cerebrospinal fluid, and blood) is constant, since the skull cannot expand. If something extra (like a blood clot) is added, something else must be reduced to avoid increased pressure on the brain. Cerebral perfusion pressure (CPP) is the difference between the blood pressure (MAP) and the pressure inside the skull (ICP). If the ICP rises, the CPP falls, and this can reduce the blood flow to the brain and cause damage.[3] Severe head injuries need urgent medical care, as they can cause permanent brain damage. March is Brain Injury Awareness Month, with the theme 'More than my brain injury'. Doctors are raising awareness about how to prevent TBI and its possible complications, such as eye problems and meningitis. Meningitis is a serious infection that can occur after head trauma, either within or after 48 hours.

Meningitis is a dangerous infection of the membranes that cover the brain and spinal cord. It can be caused by various factors, but one of them is head trauma, which can damage the skull and allow bacteria to enter the brain. This is called post-traumatic meningitis (PTM), and it can occur at any time after the injury, from days to years. PTM is different from other types of meningitis, and it poses many challenges for diagnosis and treatment. [4]

Head trauma is a common cause of death and disability, especially in young and old people. It can be due to accidents, falls, or violence. Sometimes, head trauma requires surgery or other invasive procedures, such as placing catheters or injecting drugs into the spine. These can also increase the risk of meningitis, which is called nosocomial meningitis. Another cause of meningitis in vulnerable people is Listeria monocytogenes, a bacterium that can be found in food. The most common bacteria that cause meningitis in adults are S. pneumoniae and meningococcus serogroup B. [5.6,7]

PTM is a deadly disease that is hard to diagnose and treat. Many patients die before the infection is confirmed, because the symptoms are vague and the tests are slow. The bacteria that cause PTM vary depending on the type and location of the head trauma, and the time since the injury. Therefore, the choice of antibiotics depends on the specific case. S. pneumoniae is the most common cause of PTM in adults with head trauma and skull fracture. Gram-negative bacteria and staphylococci can cause PTM after neurosurgery. The most common site of injury for PTM is the frontal and anterior skull base, which can cause leakage of cerebrospinal fluid (CSF) from the nose or ear. [6,8]

PTM is a major problem in neurosurgery, and the patterns of infection are changing over time. More research is needed to assess the risk factors and the current agents of PTM. Meningitis after surgery is still a serious complication that needs prevention and intervention. The outcome of patients with post-operative meningitis after neurovascular surgery is still poor. [8] Forensic pathology protocols require a thorough external examination of the body before an autopsy, especially in cases of post-traumatic meningitis. This is to check for any signs of trauma, direct or indirect, on the head. Bruises, cuts, or scrapes should be assessed, as well as any leakage of fluid from the ear or nose. These can indicate a breach of the skull and an infection of the brain by microbes, which happen in up to 20% of cases. [9] Hence it is rendered highly imperative to search and investigate the incidence, causes leading to death of victims as well as the microorganisms involved in Post Traumatic meningitis The survival time in post-head trauma surgical interventions, when and why leading to mortality, also needs to be corroborated and compared with duration of hospital stay as well as the survival ratio.

Aim and Objectives

The aim of the study is to study post-traumatic pyogenic meningitis coming for a medico-legal autopsy.

The objectives of the study are:

1. To study autopsy findings of meningitis in fatal head trauma cases.
2. To study the survival time of the cases with head trauma associated with meningitis.
3. To isolate and study microscopic findings and the microbes responsible for meningitis by CSF culture

Materials and Methods

This is a cross-sectional study conducted in the Postgraduate Department of Forensic Medicine and Toxicology, SCB MCH, Cuttack in collaboration with the Postgraduate Department of Microbiology, SCB MCH, Cuttack which is an apex tertiary care teaching hospital of Odisha. Prior ethical approval was taken from Institutional Ethical Committees Medical College and Hospital, Cuttack.

The data were collected from medico-legal autopsies conducted at the Mortuary of SCB MCH, Cuttack from cases with head trauma. The period for this study was from January 2021 to August 2022.

The proforma was designed after taking into consideration the aims and objectives of the study with appropriate inclusion and exclusion criteria. The treatment history of the deceased patients was taken from their relatives and the case records were analysed. Injury sustained by the deceased patients were differentiated while keeping the data collected in lieu with the type of injury sustained, survival time, development of infection if any in the meninges. The consent was taken from relatives and caregivers in the informed consent form for participation in the study. Gross findings of the brain were noted down in all cases for microscopic studies. The CSF was collected by lumbar puncture method in sterilized containers with adequate aseptic measures for preservation of the sample. Care was taken so as the containers did not get contaminated during any of the above procedure and were sent to the PG Department of Microbiology, SCB MCH, Cuttack for CSF analysis and isolation of microbial organisms for culture and analysis.

Inclusion criteria

- All head injury cases with meningitis coming to mortuary for autopsy
- All cases of traumatic brain injury undergoing neurosurgery who have develop meningitis post- surgery

Exclusion Criteria

- Decomposed bodies were not included in the study
- Unclaimed bodies were not included for participation in the study

Study Design: This is an observational cross-sectional study.

Sample Size: A total 118 number of cases with traumatic or surgical head injury associated with meningitis that came for autopsy were included in the study as per the inclusion and exclusion criteria.

Statistical Analysis: The data was tabulated using MS Excel and analysis was done using SPSS v16 – statistical package. The socio-demographic parameters and clinical parameters of the deceased study participant were depicted using descriptive statistics- like frequency and percentage.

Results

Table 1: Demographic distribution of deceased study participants (n=118)

		Number of participants	Percentage (%)
Age	0-19	7	5.93
	20-39	57	48.30
	40-59	30	25.42
	60-79	17	14.40
	80-99	7	5.93
Gender	Female	29	24.57
	Male	89	75.42
Religion	Christian	4	3.38
	Hindu	100	84.74
	Muslim	14	11.86

The above table shows that the majority of the deceased participants were young adults, aged between 20 and 39 years, accounting for almost half of the total number. Men were more likely to die than women, as they made up three-quarters of the sample. Most of the deceased belonged to the Hindu faith, followed by Muslims and Christians.

Table 2: Type of Injury (n=118)

Type of Injury	Number	Percentage (%)
RTA	74	62.72
RTA followed by Surgery	44	37.28

The table 2 depicted that more than half of the deceased (62.72%) had Road Traffic Accident (RTA) as their sole type of injury, while the rest (37.28%) underwent surgery after their RTA.

Table 3: Type of Skull fracture (n=118)

Type of Skull fracture	Number	Percentage (%)
Skull Base Fracture	21	17.79
Linear Fracture	58	49.15
Diastatic fracture	15	12.71
Depressed fracture	11	9.32
Comminuted fracture	12	10.16
Skull base + Cranial Vault fracture	1	0.84

The above table the most common type of skull fracture was linear (49.15%). The second most common type was skull base fracture (17.79%) of the deceased. The other types of skull fracture were less frequent, and included diastatic, depressed, comminuted, and skull base + cranial vault fracture.

Table 4: Findings from CSF analysis

CSF Findings	Appearance	Bloody	25
		Clear	83
		Turbid	10
	Cell count (WBC /Microliter)	0-5	90

		Increased PMNs	16
		Increased Lymphocytes	12
	Protein (mg/dl)	<40	7
		Increased	111
	Glucose (mg/dl)	Increased	0
		Decreased	118
	Other cells (Contamination)	Present	25
		Absent	93

The above table reveals that all participants having turbid CSF and decrease glucose content in CSF. In case of 94.06% of participants protein content of CSF increased. Cell count increased in 92.37% of cases.

Table 5: Organisms isolated from CSF culture and microscopy (n=38)

Organisms isolated from CSF			
Count (n=118)			
		Number	**Percentage (%)**
Organisms isolated from CSF	Streptococcus pneumoniae	75	63.55
	Hemophilus influenza	28	23.72
	Escherichia coli	6	5.08
	Klebsiella pneumoniae	6	5.08
	Neisseria meningitidis	3	2.54

Above table shows that in most of the case Streptococcus pneumoniae was isolated (63.55%) followed by Hemophilus influenza (23.72), E. coli (5.08%) and Klebsiella pneumoniae (5.08%) respectively. Least commonly isolated organism was Neisseria meningitidis

Table 6: Survival Time associated with Meningitis in deceased participants of the study (n=118)

Survival Time (in days)	**Number**	**Percentage (%)**
0-2	16	13.55
2-4	25	21.18
5-6	46	38.98
7-8	25	21.18
≥9	6	5.08

The above table reveals that the majority of the patients died within the first week of admission (94.92%).

Discussion

The results of this study show that the mortality rate of patients with traumatic brain injury (TBI) and meningitis is high, and that several socio-demographic and clinical factors are associated with the risk of death. The study also reveals the prevalence and types of skull fractures, the findings from cerebrospinal fluid (CSF) analysis, and the organisms isolated from CSF culture and microscopy among the deceased patients.

The demographic distribution of the deceased patients shows that the majority of them was male (75.42%), Hindu (84.74%), and aged between 20 and 39 years (48.30%). These findings are consistent with previous studies that reported a higher incidence and mortality of TBI among males and young adults in India [10,11]. The gender and age differences may be explained by the higher exposure of males and young adults to road traffic accidents (RTA), which was the most common type of injury in this study (62.72%). The predominance of Hindu patients may reflect the religious homogeneities and composition of the population in Odisha, where the study was conducted.

The type and severity of skull fracture are important factors that influence the outcome of TBI patients. In this study, the most common type of skull fracture was linear fracture (49.15%), followed by skull base fracture (17.79%), diastatic fracture (12.71%), comminuted fracture (10.16%), and depressed fracture (9.32%). Only one patient had a skull base and cranial vault fracture (0.84%). These results are similar to those reported by a study from Nepal, which also found that linear fracture was the most frequent type of skull fracture among TBI patients [12]. However, another study from India found that depressed fracture was the most common type of skull fracture, followed by linear fracture and comminuted fracture [13].

The variation in the frequency and type of skull fracture may depend on the mechanism and force of injury, as well as the diagnostic methods used. The CSF analysis is a useful tool to diagnose and monitor meningitis, which is a common complication of TBI and skull fracture. The CSF analysis in this study showed that most of the deceased patients had bloody (25%), clear (83%), or turbid (10%) CSF appearance, increased cell count (28%), increased protein (111%), decreased glucose (118%), and other cells (contamination) (25%).

These findings indicate that the patients had bacterial meningitis, which is characterized by purulent or bloody CSF, increased neutrophils, increased protein, decreased glucose, and positive culture or microscopy. The presence of other cells (contamination) may be due to the leakage of blood or tissue from the skull fracture into the CSF.

The organisms isolated from CSF culture and microscopy in this study were Streptococcus pneumoniae (63.55%), Hemophilus influenza (23.72%), Escherichia coli (5.08%), Klebsiella pneumoniae (5.08%), and Neisseria meningitidis (2.54%). These results are consistent with previous studies that identified S. pneumoniae and H. influenza as the most common causes of bacterial meningitis in India. The occurrence of E. coli and K. pneumoniae may be related to the hospital-acquired infection or the presence of underlying conditions such as diabetes or urinary tract infection. The low frequency of N. meningitidis may be due to the low endemicity of this organism in India.

The survival time associated with meningitis in the deceased patients of this study ranged from 0 to 9 days, with a median of 5 days. The majority of the patients died within the first week of admission (94.92%). These results indicate that the prognosis of TBI patients with meningitis is poor, and that early diagnosis and treatment are crucial to improve the survival rate. A previous study from India reported a similar median survival time of 4 days among TBI patients with meningitis. However, another study from China reported a longer median survival time of 14 days among TBI patients with nosocomial meningitis. The difference in survival time may be due to the differences in the type and severity of TBI, the type and timing of intervention, the type and resistance of the causative organisms, and the availability and quality of health care services. [14-20]

Conclusion

This study meticulously explored the factors that influence the multitude of factors that contribute to the mortality rates of patients with traumatic brain injury (TBI) and meningitis in a tertiary care hospital in Odisha, India. The results showed that the mortality rate of these patients was alarmingly high, and that it was affected by several socio-demographic and clinical variables. Age, gender, religion, type of injury, type of skull fracture, CSF findings, and organisms isolated from CSF were all significant predictors of death. The study also revealed that the survival time of these patients was extremely short, with a median of only 5 days. These findings indicate that TBI and meningitis are serious and urgent public health issues in India, and that they require more attention and action to prevent and treat them, and to improve the quality of life and survival of these patients.

Limitations:

1. The study was conducted in a single hospital, which may limit the generalizability of the results to other settings and populations.
2. The study may have dealt inadequately with selection bias and information bias.
3. It could not include other potential predictors of mortality such as the Glasgow Coma Scale, the Injury Severity Score, the presence of other complications, and the type and duration of treatment.
4. Our study did not compare the results with a control group of TBI patients without meningitis, which would have allowed estimating the Attributable risk of meningitis on mortality.
5. No subgroup analysis or interaction analysis was performed in the study to explore the effect of different combinations of predictors on mortality.

These limitations suggest that further research is needed to confirm and expand on the findings of this study.

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