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Original Research Article

INCIDENCE OF POST TRAUMATIC HYDROCEPHALUS IN PATIENTS UNDERGOING DECOMPRESSIVE CRANIECTOMY

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Abstract: *Decompressive craniectomy is a surgical procedure often employed in traumatic brain injury cases to alleviate intracranial pressure. Post-traumatic hydrocephalus, though a rare complication, can occur following this procedure, significantly impacting patient outcomes.* ***Objective:*** *This study aimed to investigate the incidence of post-traumatic hydrocephalus in patients undergoing decompressive craniectomy.* ***Methods:*** *A prospective cross-sectional study was conducted at the Emergency and Neurosurgery Department of Shaheed Mohtarma Benazir Bhutto Trauma Centre (SMBBIT) from June 1, 2022, to December 30, 2022. Demographic and clinical data were collected, including age, gender, Glasgow Coma Scale (GCS) at presentation and time of decompressive craniectomy, type of craniectomy, development of postoperative hydrocephalus, and complications.* ***Results:*** *The majority of patients (55%) were aged 10-15, with males comprising 75% of the cohort. Upon emergency presentation, only 4% of patients exhibited hydrocephalus, with most presenting a GCS between 9 and 13 (56%). Post-craniectomy, hydrocephalus developed in 32% of individuals, with the majority (18%) experiencing onset after 14 days. Significant associations were found between hydrocephalus development and craniectomy size (p=0.04) and distance from the midline (p=0.05).* ***Conclusion:*** *Patients undergoing decompressive craniectomy, particularly those with a superior limit too close to the midline, may be at risk of developing hydrocephalus. Therefore, we advocate for broader craniectomies exceeding 25 mm from the midline to potentially reduce the incidence of post-traumatic hydrocephalus and improve patient outcomes.*

Keywords: Traumatic brain injury, hydrocephalus, decompressive craniectomy, GCS

Introduction

Traumatic brain injury (TBI) is a significant contributor to illness and death in the general population and is a significant global medical and social concern with substantial cost implications (1). Survivors of the original traumatic event generally experience significant impairments in both their physical and mental health, leading to long-term disabilities (2). The weight of this problem is often intensified by the lack of consistent healthcare availability at the local, national, and international levels, as well as the insufficient evidence regarding the medical, surgical, and rehabilitative treatment of patients with traumatic brain injury (3). Decompressive craniectomy (DC) is a commonly employed procedure to alleviate medically resistant intracranial hypertension in individuals with head injuries (4). DC can reduce intracranial pressure, leading to an improvement in cerebral perfusion pressure and oxygen supply. Furthermore, a significant cranial defect may also result in disruption of cerebrospinal fluid (CSF) flow and blood supply to the brain due to exposure to atmospheric pressure (5).

Post-traumatic hydrocephalus (PTH) is a severe complication that occurs after decompressive craniectomy (DC). It is often characterised by an abnormal buildup of CSF, which disrupts the average circulation of CSF and causes various diseases. PTH can impact the functioning and metabolic processes of the central nervous system, leading to clinical improvement and influencing the outcomes of patients (6). To alleviate hydrocephalus, a ventriculoperitoneal shunt (VPS) must be inserted. Hence, early detection and treatment of PTH are crucial to minimise additional neurological complications in these individuals (7).

VPS and cranioplasty (CP) are efficacious approaches for treating PTH resulting from DC. Nevertheless, there remains ongoing debate regarding the optimal approach to treating hydrocephalus and cranial abnormalities. Based on specific reviews, the combined one-stage operation of VPS and cranioplasty showed a greater incidence of complications than performing the surgeries separately (8). The objective of the present study was to determine the incidence of post-traumatic hydrocephalus in patients undergoing decompressive craniectomy.

Methodology

After the ethical approval from the institutional review board, this prospective cross-sectional study was carried out at the Emergency and Neurosurgery Department of Shaheed Mohtarma Benazir Bhutto Trauma Centre (SMBBIT) from 01/June/2022 to 30/December/2022. Through non-probability, Convenience sampling of 73 patients between the ages 10-60 years, both genders, undergoing hemi-decompressive or bifrontal decompressive craniectomies due to traumatic closed injuries or non-traumatic causes were included in the present study. Patients with previous cranial surgeries and had hydrocephalus before decompressive craniectomy were excluded from the present study. All patients presenting to SMBBIT, fulfilling inclusion criteria, were evaluated for enrolment in the study by complete history and physical examination done by emergency doctors and Neurosurgery residents on duty, and

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informed consent was taken. CT scans were performed by designated technicians working in the setup. After decompressive craniectomy, the CT scan was repeated in case of 2 2-point drop in GCS, development of new-onset neurological deficit, seizures, new onset pupillary asymmetry or gross tension on palpation of the flap. Clinical and demographic parameters were recorded in a predesigned proforma that includes age, gender, GCS at presentation and time of decompressive craniectomy, type of craniectomy, development of post-op hydrocephalous, and complications. The data were analysed utilising the statistical software SPSS version 21. The mean ± standard deviation was computed for quantitative variables. Categorical characteristics, such as gender, type of trauma, etc., were analysed to determine their frequency and percentage. The study stratified the development of hydrocephalus according to type of injury, size of craniectomy, and midline distance to identify any potential effect modifiers. A post-stratification chi-square test was conducted, with a significance level of $P \leq 0.05$. The findings were displayed in the form of charts and graphs.

Results

Table 1 shows the clinical and demographic characteristics of the study participants. The majority of the recruited patients were in the age group 10-15 years (55%), followed by the age group 16-30 years (23%), and among the recruited patients, the majority were males (75%). 67% of the patients were presented to the emergency as a road traffic accident victim. At the time of emergency presentation, only 4% of the patients have hydrocephalus, with the majority of the patients having GCS between 9-13 (56%). 48% of the individual's contusions were the cause of decompressive craniectomy. 75% of the patients have undergone Hemidecompressive craniectomy. 27% of the patients have a GCS score between 5-8 at the time of craniectomy. In 32% of the individuals, hydrocephalus developed after craniectomy, and in the majority of the patients (18%), hydrocephalus developed after 14 days. In 25% of the patients, the size of craniectomy was bi-frontal and <12cm, while in 45%, the individual distance from the midline was >2.5cm. Table 2 shows the stratification of hydrocephalus development according to type of injury, GCS at the time of hydrocephalus development, size of craniectomy, and distance from midline. A significant association was observed between the development of hydrocephalus with the size of craniectomy (p=0.04) and distance from the midline (p=0.05).

Table 1: Clinical and demographic parameters of participants

Parameters	N (%)
Age (years)	
10-15	40 (55%)
16-30	17 (23%)
30-45	15 (21%)
45-60	11 (15%)
Gender	
Male	55 (75%)
Female	18 (25%)
Aetiology	
Traumatic	70 (96%)
Non-traumatic	3 (4%)
Mechanism of trauma	
RTA	49 (67%)
Assault	8 (11%)
Fall	15 (21%)
Other	1 (1%)
Was hydrocephalus present at the time of presentation or first scan?	
yes	3 (4%)
no	70 (96%)
GCS at the Time of Presentation	
14-15	18 (25%)
9-13	41 (56%)
05-8	10 (14%)
<5	4 (5%)
Cause of decompressive craniectomy/ findings on initial CT	
MCA infarct	3 (4%)
Acute SDH	25 (34%)
IC bleed	7 (10%)
Contusions	35 (48%)
Generalised oedema	14 (19%)
EDH	15 (21%)
IVH	20 (27%)
Type of decompressive craniectomy	
Hemidecompressive craniectomy	55 (75%)
Bifrontal decompressive craniectomy	18 (25%)
The time lapse between the development of edema to decompressive craniectomy	
<4 hours	13 (18%)
4-24 hours	40 (55%)
>24 hours	20 (27%)
GCS at the time of development of hydrocephalus	
14-15	7 (10%)
9-13	11 (15%)
05-8	4 (5%)
<5	1 (%)
No HCP	50 (68%)
GCS at the time of craniectomy	
14-15	10 (14%)
9-13	31 (18%)
5-8	20 (27%)
<5	12 (16%)
Did the patient develop hydrocephalus?	
Yes	23 (32%)
No	50 (68%)

Time of development of hydrocephalus post craniectomy	
within three days	
3-7 days	4 (5%)
7-14 days	6 (8%)
>14 days	13 (18%)
No HCP	50 (68%)
Size of craniectomy	
<12cm	18 (25%)
12-15	26 (36%)
>15cm	11 (15%)
Bifrontal	18 (25%)
Distance from midline	
<2.5cm	24 (33%)
>2.5cm	33 (45%)
NA	16 (22%)
Dural repair after craniectomy	
Repaired	3 (4%)
Not repaired	70 (96%)
Other complications after decompressive craniectomy	
Subdural effusion	21 (29%)
Extradural hematoma	3 (4%)
Expansion of contusion	15 (21%)
CSF leak from the wound	12 (16%)
Meningitis	9 (12%)
Sunken brain syndrome	1 (1%)
None	15 (21%)
Glasgow Outcome Score	
1 (death)	5 (7%)
2 (persistent vegetative state)	6 (8%)
3 (severe disability requiring daily care)	23 (32%)
4 (moderate disability with some independence)	27 (37%)
5 (good recovery)	12 (16%)
Methods employed to treat hydrocephalus	
pharmacological (AZM, Mannitol)	Nil
VP shunt	8 (11%)
EVD placement	3 (4%)
Repeated LPs	12 (16%)
No hcp	50 (68%)
Post management status	
Persistent hydro	Nil
Hydro resolved/improved	23 (32%)
No HCP	50 (68%)

Table 2: Stratification groups

Parameters	**Development of hydrocephalus**		**P value**
Trauma Type	**Yes**	**No**	
RTA	18 (37%)	31 (63%)	0.51
assault	2 (29%)	5 (71%)	
fall	3 (20%)	12 (80%)	
Other	0	1 (100%)	
GCS at the time of development of hydrocephalus	**Yes**	**No**	
14-15	7 (41%)	10 (69%)	0.637
9-13	11 (27%)	30 (73%)	
05-8	4 (40%)	6 (60%)	
<5	1 (25%)	3 (75%)	
Size of craniectomy	**Yes**	**No**	
<12cm	3 (17%)	15 (83%)	0.048
12-15	8 (31%)	18 (69%)	
>15cm	2 (18%)	9 (82%)	
bifrontal	10 (56%)	8 (44%)	
Distance from midline	**Yes**	**No**	
<2.5cm	10 (53%)	14 (47%)	0.05
>2.5cm	5 (15%)	28 (85%)	
NA	8 (50%)	8 (50%)	

Discussion

Decompressive craniectomy is a highly effective procedure used to relieve ICP in cases of severe intracranial hypertension, potentially saving lives. The "syndrome of the trephined" and hydrocephalus are the predominant problems that arise following decompressive craniectomy after head trauma, resulting in neurological symptoms (9).

Prior research has shown that hydrocephalus occurred in 11.9% to 36% of patients following decompressive craniectomy. Several literature investigations have indicated a strong correlation between traumatic hydrocephalus following DC and an unfavourable prognosis (10, 11). Researchers demonstrated that decompressive craniectomy resulted in a transition of the cranial box from a closed system to an open one. This change led to increased brain compliance and decreased ICP (12, 13). Post-traumatic hydrocephalus may develop after one month as a result of changes in the circulation of blood and cerebrospinal fluid caused by the open box system (14). The literature research proposed various explanations, such as arachnoid adhesions causing the disturbance of cerebrospinal fluid (CSF) circulation, disruption of CSF dynamics, and impaired venous outflow to the sagittal sinus. The majority of the recruited patients fell within the age range of 10-15 years (55%), with the next largest group being those aged 16-30 years (23%). Among the recruited patients, the majority were males (75%). 67% of the patients arrived at the emergency department as road traffic accident casualties. Only 4% of the patients exhibit hydrocephalus during the emergency presentation, whereas most patients have a Glasgow Coma Scale (GCS) score between 9 and 13 (56%). Decompressive craniectomy was the cause of discolorations in 48% of the individuals. Three-quarters of the patients have undergone Hemidecompressive craniectomy. At the time of craniectomy, 27% of the patients exhibit a Glasgow Coma Scale (GCS) score ranging from 5 to 8. Hydrocephalus occurred in 32% of individuals following craniectomy, with the majority of patients (18%) developing hydrocephalus within 14 days. 25% of the patients underwent a bi-frontal craniectomy with a size smaller than 12cm, whereas 45% had an individual distance from the midline more than 2.5cm. Table 2 presents the categorisation of hydrocephalus progression based on the kind of injury, Glasgow Coma Scale (GCS) score at the onset of hydrocephalus, size of craniectomy, and distance from the midline. A vital correlation was seen between the occurrence of hydrocephalus, the magnitude of the craniectomy (p=0.04), and the distance from the midline (p=0.05).

Literature is scarce on PTH. The occurrence of PTH in our study was lower than previously reported. Prior research indicates that the prevalence of patients experiencing) varies from 0.7% to 51.4% (15-17). A recent study conducted in Taiwan analysed a large group of patients (n=23,775) and found that the incidence of PTH was 0.48% for patients without traumatic subarachnoid haemorrhage (SAH) and 1.98% for patients with traumatic SAH (16). The study encompassed patients with varying degrees of Traumatic Brain Injury (TBI). The prevalence of PTH was most frequent within the initial three months following head trauma. However, the specific duration between the damage and the onset of PTH was not documented. According to Wettervik et al. (17), 3.5% of patients (n = 836) treated in the neurointensive care unit suffered PTH.

Conclusion

A craniectomy with a superior limit too close to the midline can increase the likelihood of hydrocephalus in patients undergoing decompressive craniectomy. Consequently, we propose utilizing wide DCs positioned more than 25 mm from the midline, as they offer improved performance.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department Concerned. (KKPFP-ERC-21-0069)
Consent for publication
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Not applicable

Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

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Study Design, Review of Literature.
Conception of Study, Development of Research Methodology Design, Study Design, Review of manuscript, final approval of manuscript.
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Manuscript revisions, critical input.
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***ATIQ AHMED KHAN (*Professor & HOD of Neurosurgery)**
Conception of Study, Development of Research Methodology Design, Study Design, Review of manuscript, final approval of manuscript.

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