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Original Article

Surgery Section

Surgical Outcome Following Early Decompressive Hemicraniectomy in Patients of Severe Traumatic Brain Injury: A Retrospective Study

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ABSTRACT

Introduction: Traumatic Brain Injury (TBI) has become an epidemic and remains the leading cause of death and disability in people of 2nd to 4th decade. Road Traffic Accidents (RTA) are responsible for the majority of cases. Primary brain injury sustained on impact and secondary brain injury that develops in following hours and days contribute together to overall injury and decides ultimate outcome. The goal of management in any TBI patient aims to prevent secondary brain injury. Understanding the importance of Intracranial Pressure (ICP) is key to minimise secondary injury. Decompressive hemicraniectomy is a novel technique of reducing ICP in patients of severe brain injury. It's judicious and timely performance not only saves life but also prevents the dreaded consequences of raised ICP.

Aim: To evaluate the role of early decompressive hemicraniectomy in improving the survival rate among patients of severe TBI and analysing the important factors (glasgow coma scale, airway status, timing of surgery) affecting the surgical outcome.

Materials and Methods: It was a retrospective study conducted at the Department of Neurosurgery, Veer Surendra Sai Institute of Medical Sciences and Research, Burla, Odisha, India between September 2016 to March 2020. Case records of 60 patients of TBI who had undergone unilateral Decompressive Craniectomy (DECRA) were analysed. The decision for decompressive hemicraniectomy was purely based upon Glasgow Coma Scale GCS) and Computed Topography (CT) findings. The presence of an evacuable mass lesion, diffuse oedema and obliteration of basal cistern in CT was considered to be the most important criteria for the early decompressive procedure. Patients were assessed until their discharge from ward. Statistical analysis was performed by statistical package for science version 12.

Results: A total of 60 patients with severe TBI, who underwent DECRA were analysed. Road Traffic Accident (RTA) was the predominant mechanism of injury. All had presence of a surgically evacuable mass lesion along with compression/obliteration of the basal cistern. The majority of mass lesions (n=42) were frontotemporal contusions (70%). Forty patients of total achieved good surgical outcome (66.67%) and rest 20 patients (33.33%) had poor outcomes. Overall incidence of complications was around 40%. The most important factors associated with good outcomes were GCS of 7 and and above, patent airway, and early surgery.

Conclusion: Decompressive hemicraniectomy is a novel technique of reducing ICP which acts by directly breaking the rigid box phenomenon of Monro-Kellie doctrine. However patient selection, prompt decision, earliest intervention, adoption of standard technique of DECRA and post operative critical care management are important aspects behind the successful outcome.

Keywords: Advanced trauma life support, Early decomressive craniectomy, Glasgow outcome scale, Intracranial pressure

INTRODUCTION

The Traumatic Brain Injury (TBI), now an epidemic and a leading cause of death & disability, predominantly affected young males in their productive age group. It also imparts a significant socio-economic burden upon modern society [1,2]. In the world statistics, India is the capital of head injury and every five minutes there is a death in India due to head injury. As far as the management of TBI is concerned, prevention is always better than cure. Primary prevention of head injury should be the policy of a nation although the incidence cannot be zero. Once the head injury has happened, i.e., the primary injury has occurred, the goal of management becomes the prevention of secondary brain injury [3,4].

Due to a cascade of biochemical reactions after TBI, the brain swells inside the rigid box of skull. The two important mechanisms come to play into action to maintain the physiological and anatomical integrity of the brain to the maximum extent. Firstly, cerebral auto regulation tries to maintain cerebral perfusion pressure and thereby, cerebral blood flow over a range of mean arterial pressure and secondly, brain compliance which prevents an increase in ICP to a certain point till the buffering mechanism of the brain is exhausted and there is an exponential rise of ICP to cause cerebral herniation and its dreaded consequences [5]. So, those patients with low Glasgow Coma Score (GCS) and CT scan showing surgically evacuable mass lesions with severely compressed basal cisterns and midline shift, an early decision for surgical evacuation of haematoma is warranted with the additional aim of breaking the Monro-Kellie doctrine by removing a portion of calvarium with the hope of providing additional space for the angry brain to expand post-operatively, thereby preventing internal herniation [5,6]. Though, DECRA is the last tier of therapy in the management of raised ICP, and there is no class 1 evidence to support its utilisation, it can still be offered as an early modality of treatment in some situations like in institutions where ICP monitoring facility is not available and it is firmly judged from the clinico-radiological study that the raised ICP would be refractory and is not amenable to control by conservative therapy alone. The aim of this study was to evaluate the role of early decompressive hemicraniectomy in improving the survival rate among patients of severe TBI and analysing the important factors affecting the surgical outcome.

MATERIALS AND METHODS

This was a retrospective study conducted at the Department of Neurosurgery, Veer Surendra Sai Institute of Medical Sciences and Research, Burla, Odisha, India from September 2016 to March 2020. Case records of patients with TBI during the above period, in whom surgical intervention was planned and carried out, were initially retrieved. These records were critically analysed on basis of various clinical, radiological and operative parameters. Sixty patients were included in the study.

Inclusion criteria: Preoperative GCS, <9, presence of an evacuable mass lesion, patients with obliteration of basal cisterns in CT scan were included.

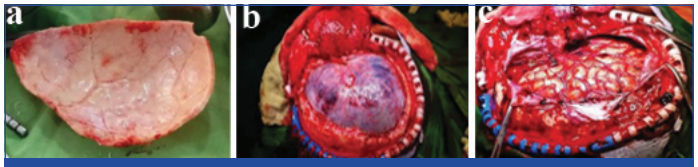
Exclusion criteria: Patients having very low GCS (≤4), patients with bilateral fixed and dilated pupil and patient with multiple traumas were excluded.

Study Procedure

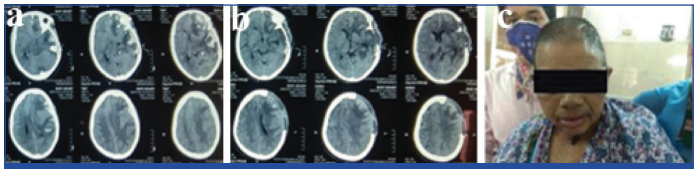
All the patients included in the study had undergone thorough assessment and managed according to the prescribed guideline of Advanced Trauma Life Support (ATLS). [7] Airway status at the time of admission had been assessed through clinical examination and recording of oxygen saturation. Objective signs of airway compromise like agitation, obtundation, cyanosis, abnormal breath sound, deviated trachea were taken into consideration for assessing the airway patency.

Decompressive Craniectomy was performed in all selected patients. As far as the technical aspect is considered the standard technique [Table/Fig-1a-c] had been assessed except mild deviation in two situations. Firstly, limited contusectomy was performed in left-sided lesion (being the dominant side) and secondly, the size of the bone flap was comparatively made smaller in the elderly (limited DECRA) compared to the younger population thinking concomitant brain atrophy in elderly will allow the injured brain to accommodate after limited DECRA [8]. Due to the unavailability of ICP monitoring facility, no one had undergone ICP monitoring. The decision for the procedure was based upon the clinical severity and radiological evidence of marked rise of ICP [Table/Fig-2a]. Postdecompressive ICP assessment was made indirectly by looking for radiological evidence of reduced ICP like opening up of basal cisterns and return of midline shift in follow-up CT scan [Table/Fig-2b].

Patients who underwent surgery within 24 hours of admission were taken in early group and those who underwent surgery after 24 hour were grouped as late. Patients were assessed until their discharge from the ward. The variables obtained were clinical status using the Glasgow Coma Scale, status of the air way, Marshall CT grading [9], complications and neurological outcome at discharge using Glasgow Outcome Scale (GOS). The overall clinical outcome of patients were analysed in terms of survivality and quality of survival [Table/Fig-2c].



[Table/Fig-1]: Standard technique of DECRA.



[Table/Fig-2]: (a): Preoperative scan showing mass lesion with obliteration of basal cistern; (b): Postoperative scan following limited DECRA with open-up basal cistern; (c): Post-operative status with GOS-3 at the time of discharge.

The following definitions were defined:

a. TBI (Traumatic Brain Injury) which includes injury to the calvarium, meninges, brain parenchyma and cerebral blood vessels.

b. GCS [10]- a scale to assess level of consciousness with a minimum score of 3 and maximum score of 15.

c. GOS [11]- a scale to assess the quality of life after TBI i.e., 1-Death, 2-Persistent Vegetative State, 3-Severe Disability, 4-Moderate Disability, 5-Good recovery

d. Intracranial Pressure (ICP)- assessed directly by special monitors and indirectly through clinico-radiological study.

e. Paroxysmal Sympathetic Hyperactivity (PSH) [12]- also known as sympathetic storm, a clinical state after severe head injury manifested by paroxysmal manifestation of sympathetic hyperactivity (tachycardia, hypertension, tachypnoea, hyperthermia, diaphoresis) and increased muscle tone.

f. Decompressive Craniectomy (DECRA)- a procedure where a portion of the calvarium is removed along with dural opening with or without dural enhancement.

g. Blindness- Technically defined as visual acuity 6/60 with best possible spectacle correction. Absolute blindness is defined as no perception to light. In this analysis, blindness due to raised ICP had been considered excluding direct ocular trauma as causative factor.

STATISTICAL ANALYSIS

The results of the study were analysed by SPSS version 12 software. Analysis included measure of central location (mean), measure of dispersion- standard deviation. The quantitative variables were expressed as mean±SD. Qualitative variables were expressed as percentages. Pearson chi-square test and odds ratio were used to determine association between qualitative variables. Binary logistic regression was used to identify independent complications associated with the outcome of patients. For all analysis, p-value ≤0.05 was considered statistically significant.

RESULTS

A total of 60 patients with severe TBI, who underwent DECRA were analysed. Males out numbered female patients (46/14). The patient demographics and other clinical radiological characteristics of the population of the present study are presented in frequency distribution. It was observed that among the studied population, Marshall Level V was predominant (96.7%). Only two patients, who had diffuse cerebral swelling (Marshall level-IV) in initial CT, showed developing frontotemporal contusions in repeat CT and later on were considered for DECRA [Table/Fig-3]. The mean age of patients was 41.38 years with SD of 12.97. The age range was 15 to 75 years with a median age of 40 years [Table/Fig-4].

RTA accounting for the predominant cause of trauma in males (73.3%) while in females out of 14 patients 11 sustained head injury due to fall from two-wheelers (78.6%).

Among the evacuable intracranial pathology majority (n=42) were contusions in the frontotemporal location (70%), few (n=16) were Acute Subdural Hematoma (ASDH) (26.7%) and rest (n=2) were mixed lesions (contusion with overlying ASDH). Decompressive hemicraniectomy was performed as a primary intervention except in one case that was subjected to craniotomy and evacuation of ASDH alone in the first instance but later on subjected to DECRA because of clinical deterioration after expansion of a pre-existing small contusion (releasing effect).

In this study, the most important prognostic factor was found to be pre-operative GCS score. Patients who had GCS 7 and above had a statistically significant less mortality rate than those with low GCS <7 score. The odds ratio of mortality in patients with GCS <7 was 6.67 compared to patients with GCS 7 or more [Table/Fig-5]. Similarly, a comparative analysis of airway status at admission

Variables	Number	Percentage (%)
Sex		
Male	46	76.7
Female	14	23.3
Mechanism of injury		
Road Traffic Accidents (RTA)	54	90.0
Fall from height	5	8.3
Assault	1	1.7
Pre operative GCS		
<7	31	51.7
>7	29	48.3
Marshall CT Grade		
Grade 4	2	3.3
Grade 5	58	96.7
Airway status		
Normal	33	55.0
Compromised	27	45.0
Complications		
Fever	13	21.7
Paroxysmal Sympathitic Hyper (PSH) activity	4	6.7
Posterior Cerebral Artery infarction (PCA)	3	5
Chest infection	3	5
External cerebral herniation	1	1.7
Blindness	1	1.7
Nil	35	58.33
Outcome		
Recovered	40	66.7
Death	20	33.3

[Table/Fig-3]: Demographic and clinico-radiographic profile of patients.

Age group (in years)	Number	Percentage
15-30	13	21.7
31-45	26	43.3
46-60	16	26.7
61-75	5	8.3
Total	60	100

[Table/Fig-4]: Age distribution of cases.

and GCS revealed that patients having compromised airway had 11.73 times more chance of being in low GCS (<7) as compared to those with patent airway [Table/Fig-6]. Patency of airway also has a significant association with GOS (OR-14.5) [Table/Fig-7].

Pre operative GSC	Outcome		Total	
	Death	Recovered		
<7	16	15	31	OR-6.67 CI=-1.87-23.71 p=0.05
>7	4	25	29	
Total	20	40	60	

[Table/Fig-5]: Pre-operative GCS and outcome.
Pearson chi square test was used; GCS: Glasgow coma score

Per operative GCS	Airway status		Total	
	Compromised	Normal		
<7	22	9	31	OR=-11.73 CI=-3.4-40.41 p=0.05
>7	5	24	29	
Total	27	33	60	

[Table/Fig-6]: Pre-operative GCS and airway status.
Pearson chi-square test was used

The overall incidence of post-operative complications and its association with poor outcome was analysed by Chi-square test and

Airway status	GOS at discharge		Total	
	<3	≥3		
Compromised	18	9	27	OR=-14.5 CI=-3.89-54.1 p=0.05
Normal	4	29	33	
Total	22	38	60	

[Table/Fig-7]: GOS at discharge and airway status.
Pearson chi square test was used; GOS: Glasgow outcome scale

was statistically significant (Chi-square test=41.87, df=6, p=0.001) [Table/Fig-8]. Post-operative high-grade fever and PSH were the two most important complications that were associated with mortality 45% and 20% respectively. By application of binary logistic regression analysis the overall association of complications with mortality was though significant but individually found to be statistically insignificant [Table/Fig-8].

It was observed that those who were subjected to surgery early showed better GOS score at the time of discharge [Table/Fig-9].

Complications	Outcome		Logistic regression analysis	
	Death	Recovered	OR	p-value
Nil	1 (5.0%)	34 (85%)	Ref.	******
Fever	9 (45%)	4 (10%)	4.7×10^{7}	1.0
Chest infection	3 (15%)	0	3.6×10^{8}	1.0
Brain herniation	0	1 (2.5%)	2.61×10^{18}	0.99
PCA infarction	3 (15%)	0	1.0	1.0
PSH	4 (20%)	0	2.61×10^{18}	0.99
Blindness	0	1 (2.5%)	2.61×10^{18}	0.99
Total	20 (100%)	40 (100%)	-	-

[Table/Fig-8]: Complication and outcome.
PCA: Posterior cerebral artery; PCH: Paroxysmal sympathitic hyper

Timing of surgery after admission	GOS on discharge		Total
	≥3	<3	
Early (<24 hours)	18	5	23
Late (>24 hours)	20	17	37
Total	38	22	60

[Table/Fig-9]: Outcome in relation to timing of surgery.
OR=3.06 with 95% CI (p=0.05) and ranges between lower CI 0.93 and upper CI 9.99

DISCUSSION

After the advancement of neuroimaging techniques and neurocritical care, the interest in performing decompressive procedures has remarkably increased over the period of time. Still the procedure is not free of controversies despite the publication of results of two large randomised trials (DECRA trial and RESCUEicp trial) [6] and till now there is no level I evidence in favour of it. Even though there is no level I evidence for the execution of primary DECRA still there are many situations in which DECRA is practiced in different clinical settings by many neurosurgeons throughout the world [8,13]. This is an aggressive procedure with many associated risks with literature supporting its use only in cases with refractory ICP but our small experience supports its role as an initial treatment option in selected group of patients with severe TBI having evacuable mass lesion and obliterated basal cisterns in a set up where ICP monitoring facility is not available [11]. After analysing four RCTs, five retrospectives studies Zhang D et al., concluded DECRA in TBI patients significantly lowers ICP and reduce mortality rate [14]. Early surgery within 36 hours resulted in improved outcomes [15]. Another study by Zhang K et al., concluded early DECRA is helpful to improve long term outcome in patients with refractory ICP after moderate to severe head injury [16]. The result of early DECRA is as good as or even better than reported in literature from developed countries was also published by Pattnakar S and Mishra BK [17]. The study of Ojo O et al., also gave conclusion in favour of early DECRA without ICT monitoring as a justifiable alternative in resource constraint centres [18].

In this study, low incidence of immediate external cerebral herniation (n=1) is noteworthy compared to study of Grille P and Tommasino N, (n=17, 33%) which indicates the absence of post-operative intracranial hypertension which largely depends upon the adoption of standard surgical techniques [19]. Also, the incidence of arterial infarction (n=3, 5%) is much less compared to the study of Grille P et al., (n=8, 16%) [19].

Our study showed a high incidence of post-operative fever mostly secondary to chest complications starting from atelectasis to ventilator-associated pneumonia. Chest complications were confirmed by radiological examination and microbiological assay of throat secretions. It contributed significantly towards poor outcomes in that subset of patients. In our opinion hyper pyrexia, a preventable complication should be addressed promptly with due insight and active management for avoiding secondary brain injury.

Paroxysmal sympathetic over activity, a well-known complication of severe TBI mostly seen in young individuals was found to be associated with poor prognosis. In fact, PSH was controlled to some extent by drugs like gabapentine and labetolol but ultimately it contributed to poor outcome in all four patients of our study.

The strength of the present study is timely decision for early DECRA in resource limited setup like us which gives a satisfactory outcome in severe TBI patients. It recommends detail meta-analysis on same prospective in forthcoming studies before making it a general practice guide line.

Limitation(s)

As far as the limitations of our study are considered, it was a retrospective study. The sample size was also not very big. There was no control group for comparison of the result. It has been conducted in a single centre reducing its clinical significance. The study population was also heterogeneous. The study did not keep a follow-up of patients after their discharge to evaluate a long term neurological outcome. It only tracked the patient until discharge from the ward.

CONCLUSION(S)

Importance of time cannot be over-emphasised in patients of TBI as it is traditionally taught that time is brain and brain is time. So, making further delay in a set up where ICP monitoring facility is not available does not seem to be wise rather it seems to be justified to plan for an early decompressive procedure in properly selected group of patients based on initial GCS and the radiological evidence of severely raised ICP than to wait and see when the patient deteriorates to an irreversible state. No doubt post-operative care and managing the complications are important aspects for overall good prognosis.

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