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Original Research Article

Analysis of prognostic factors and complications following decompressive craniectomy for traumatic brain injury

Ranjith Chittikappil Gopalan*, Shaji Urambath Abu, Lijo John Kollannur, Rony Louis

Department of Neurosurgery, Government Medical College, Thrissur, Kerala, India

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***Correspondence:**
Dr. Ranjith Chittikappil Gopalan,
E-mail: ranjithcg@gmail.com

ABSTRACT

Background: Traumatic brain injury (TBI) is a leading cause of morbidity and mortality. Decompressive craniectomy (DC) is a common surgery done for patients with TBI. An analysis of factors that determine the outcome and complications will go a long way in improving the prognosis of such patients.
Methods: This is a single-center, retrospective study of TBI patients who underwent DC from March 2016 to February 2020 at a tertiary care hospital in South India. Demographic profile, clinical data, radiological findings, intraoperative observations, postoperative complications, and Glasgow Outcome Score (GOS) at discharge were noted.
Results: 164 patients underwent DC. Road Traffic Accident was the most common cause (116 patients) 71%. The mortality rate among patients with a motor score of M1 was 73.8%, 77.8% in the M2 group, 54.4%, 34.6%, and 10.6% in M3, M4, and M5 groups respectively. The survival rate among patients with bilaterally dilated pupils was 18.1%. 48.3% and 62.1% in those with unequal and equal reactive pupils respectively. The most common pathology was subdural hemorrhage in 108 (65.9%). External cerebral herniation was seen in 62 cases (37.8%). The mortality rate was 39% (64 patients). Persistent vegetative state was noted in 6.1% (10 patients) and severe disability in 24.4% (40 patients). Poor outcome was seen in 69.5% (114 patients). Primary DC was done in 113 patients (68.9%) with a mortality rate of 39.8% (45 patients) and secondary DC in 51 patients (31.1%) with a mortality rate of 37.2% (19 patients).
Conclusions: Preoperative low motor score and dilated pupils were associated with higher mortality rate. The most common pathologies were subdural hemorrhage (SDH) and contusion and external cerebral herniation was the most common complication. Primary DC had a higher mortality rate than secondary DC.

Keywords: Traumatic brain injury, Decompressive craniectomy, Prognostic factors, Complications

INTRODUCTION

Traumatic Brain Injury (TBI) is a leading cause of death among trauma-related injuries and its major burden is experienced by low and middle income countries (LMIC). The mean in-hospital mortality rate for TBI in India is 24.6%.[1] But this has not been systematically assessed nationwide. Economic growth, rapid urbanization, and change in lifestyle in LMICs had lead to a surge in the incidence of TBI which poses a major socio-economic burden for these countries. Hence high-quality research is needed to formulate treatment guidelines in this field.

Traumatic brain injury leads to the development and propagation of brain swelling and increase in intracranial pressure (ICP) which eventually culminates in brain ischemia and death. Hence controlling ICP is the main goal in the clinical management of head injury. The relationship between high ICP and poor outcomes has been demonstrated in many studies.[2] Approaches for reducing ICP include reduction of the volume of intracranial contents (blood, brain, or CSF), reduction of cerebral metabolic demands and increase in the cranial volume through decompressive craniectomy (DC). DCs a proven treatment for reducing ICP.[3] Decompressive surgery leads to improvement in intracranial compliance, resulting in an increase in cerebral blood flow and subsequently better cerebral perfusion pressure and cerebral microcirculation, which facilitates improved Brain tissue oxygenation. Thus, DC should be associated with improved outcomes if the risk-benefit ratio is acceptable and patients are selected appropriately.

The timing of decompressive surgery is important prognostically. Early DC (within 4 hours of injury) results in decrease in the mortality rate and improvement in functional outcome.[4] Decompressive surgery should be considered very shortly after the failure of maximal medical therapy for ICP control. ICP can be monitored by various methods. These methods can confirm the diagnosis of raised ICP. But its effectiveness in improving outcomes of patients with TBI has been questioned by a randomized controlled trial by Chesnut et al.[5]

DC undertaken in comatose patients with an acute extra-axial or intraparenchymal hematomas and associated brain swelling in the early phase of injury without prior ICP monitoring is termed Primary DC. DC can also be undertaken in comatose patients who have parenchymal hemorrhage or contusions with mass effect and midline shift (>5 mm) and/or uncal herniation in CT. Such patients may initially receive ICP monitoring (if available) and shall proceed to a DC later if their ICP becomes difficult to control. This type of DC is termed Secondary DC.

Since DC is effective in controlling ICP, there is a drastic rise in the use of this procedure worldwide. While the procedure is technically straightforward compared to other complicated neurosurgical procedures, it is not without complications some of which proves a therapeutic challenge to treating surgical team and can negatively impact the outcome. Hence treating surgeons must be aware of potential complications to properly advise the patients and relatives about the procedure.

The objective of this study is to analyze the clinical characteristics, complications, and factors associated with the prognosis of patients undergoing DC for TBI at a tertiary facility like ours in the context of a developing country.

METHODS

This is a single-center retrospective study of TBI patients who underwent DC from March 2016 to February 2020 at Government Medical College Thrissur, Kerala state with 1400 beds which is a tertiary care hospital in south India. The institutional ethical committee clearance was taken before the commencement of this study. The records of these patients were collected retrospectively from the hospital record library.

All head injury patients who underwent DC for trauma in the department of neurosurgery, Government medical college, Thrissur during the specified time period were included in the study. Cases without the required data in the records, DC done for non traumatic causes, DC done from other centres and referred to our institute were excluded from the study.

Collected case sheets were analysed. The baseline demographic profile, mode of injury, the preoperative clinical examination findings and radiological findings were noted. Clinical examination findings included pulse, blood pressure, oxygen saturation, Glasgow coma scale and state of pupils. Radiological findings included Cerebral herniation, midline shift, size of hematoma and presence or absence of infarction. Patients who underwent primary or secondary DC were noted.

We followed the same surgical technique for all patients. Large frontotemperoparietal skin flap was raised and frontotemperoparietal bone flap of size 12 cms were removed. Temporal bone up to the skull base was nibbled which gave adequate decompression of temporal lobe thus relieving the uncal herniation. Hemostasis prior to dural opening was norm and base of dural opening was toward the sphenoid ridge. After hematoma evacuation, lax dural closure was done with synthetic fabric patch. Wound closure was done in layers after placement of suction drain below the flap which is maintained post operatively upto 48 hours.

Post-operative radiological findings, postoperative complications, length of hospital stay and GOS at discharge were noted in a pre-prepared proforma. Data were analysed using Statistical package statistical package Social sciences (SPSS) software version 20.

RESULTS

A total of 164 patients underwent DC in our institution during the study period. Age distribution of patients who underwent DC is given in Table 1.

Table 1: Age distribution.

Age group (years)	Number	%
11 -20	4	2.4
21-30	26	15.8
31-40	45	27.4
41-50	37	22.5
51-60	26	15.8
61-70	23	14.0
71-80	3	1.8
Total	164	-

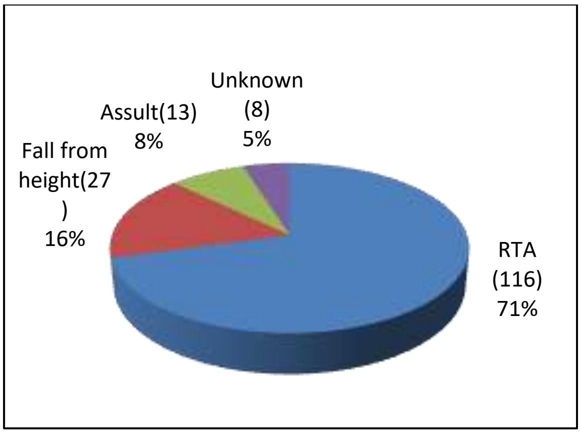

Figure 1: Mode of injuries.

Table 2: Pre-operative motor score.

Motor score	Number	%
M1	42	25.6
M2	9	5.4
M3	21	12.8
M4	26	15.8
M5	66	40.2
Total	164	-

Table 3: Types of pathologies.

Types of pathology	Number	%
Subdural hemorrhage	108	65.9
Contusion	103	60.9
Subarachnoid hemorrhage	69	42.1
Brain edema	57	34.7
Fractures	49	29.8
Intraparenchymal hematoma	20	12.2
Extradural hemorrhage	17	10.3
Infarct	13	7.9
Diffuse axonal hemorrhage	8	4.8

138 patients had severe head injury (GCS <8) prior to surgery and 26 patients had moderate head injury (GCS 9-12). The preoperative motor score of patients and their relative distribution is given in Table 2.

The pupils were equal and reactive in 95 cases, unequal in 58, and dilated bilaterally in 11. Hypotension was noticed in 22 cases The radiological evidence of a subdural hemorrhage, contusional hemorrhage, mixed types, intraparenchymal hemorrhage, subarachnoid hemorrhage, edema, and midline shifts were noted. Types of pathology seen in patients who underwent DC are given in Table 3.

113 patients underwent primary DC (68.9%) and secondary DC was done in 51 patients. Injury to surgery time interval was evaluated and showed that 24 patients (14.6%) had surgery within 6 hours, 126 patients (76.8%) between 6 to 12 hours, and 14 patients (8.5%) had surgery after 12 hours of injury. Postoperative neurological complications are included in Table 4.

Table 4: Postoperative neurological complication.

Neurological complications	Number	%
External cerebral herniation	62	37.8
Infarcts	38	23.17
Contusion expansion	27	16.46
Subdural collection	19	11.58
Hydrocephalus	13	7.9
Wound infections	10	6.09
CNS infections	7	4.26

Table 5: Glasgow outcome score at discharge.

GOS	Number	%
Death	64	39.0
Vegetative state	10	6.1
Severe disability	40	24.4
Light disability	31	18.9
No disability	19	11.6
Total	164	

Out of the 13 patients who developed hydrocephalus during ICU stay, a ventriculoperitoneal shunt was done in 6 patients based on clinical findings. The mortality rate during the hospital stay in this study was 39% (64 patients). Glasgow outcome score of patients at the time of discharge from our hospital is shown in Table 5.

Poor neurological outcome (GOS of 1, 2 and 3) was seen in 114 patients and good outcome (GOS 4 and 5) in 50 patients.

DISCUSSION

Our hospital is a tertiary level center in the state of Kerala and we cater the needs of 4 districts. The majority of cases of TBI treated at our institute were referred from local hospitals. The most common age group who underwent DC for TBI at our institution was between 31 to 40 yrs. This age distribution is higher than the study by Sharda at el.[6] On analyzing factors for TBI, road traffic accidents were the most common cause in our study accounting for 70.7% of cases which is higher than the study by Tiret et al from France (60%).[7] Most of our patients were referred from local hospitals, some reaching after initial treatments from multiple centers. Most of the severe TBI patients who reached our hospital were already intubated, ventilated and sedated from local hospitals. In such cases, GCS recorded in referral letters were taken into consideration for decision making. After primary assessment in the Casualty, vital parameters are monitored with multiparameter monitors and clinical parameters by elaborate head injury charts. Severe TBI patients with GCS 8 or less were intubated endotracheally to keep the airway patent and prevent aspiration. CT brain was taken for all patients immediately, if not done from a peripheral hospital. If the

CT and clinical examination findings were indicative of life-threatening head injury, a decision regarding early DC was made without delay. Such primary DC accounted for the majority of DC 113 cases (68.9%) in our study. If the initial GCS was 8 or less with severe diffuse brain edema, without any debridable contusion or evacuable hematoma, such patients were usually started on high dose Mannitol to lower intracranial pressure and antiepileptics to avoid early seizures. Clinical and vital parameters like heart rate, Blood pressure, pupillary size, etc were charted and progress monitored closely. A repeat CT scan of the brain was taken about 6 hours post-resuscitation. If the repeat CT indicated enlargement of hematoma or increase in brain edema and brain herniation, decision for operative management was made. Such secondary DC was done in 51 patients. Mean time interval between injury and surgery was 9.01 hours and varied between 4 to 32 hours.

The Preoperative GCS ranged between 3 and 11 with a GCS score of 5.65 as the mean value. There were 138 patients (84.2%) with severe GCS (<8), 26 patients (15.8%) with moderate GCS (9 to 12), and none with mild GCS (>12). On evaluating preoperative motor response, mean score was 3.39. The mortality rate among patients operated with a motor score of M1 was 73.8 %, 77.8 % in the M2 group, 54.4%, 34.6%, and 10.6 % in M3, M4, and M5 groups respectively. A slight increase in mortality among M 2 group patients compared to M1 patients may be because most of our patients in the M1 group were intubated, heavily sedated, and referred from peripheral hospitals and we relied on referral letters for the preoperative score. GCS at admission is considered one of the most important parameters to predict outcomes in TBIs.[8] Study by Reith et al showed that In the range 3-7, the sum score is primarily determined by the motor component and not by verbal response or eye response.[9] In concordance with the above studies, a trend in decrease in mortality rate with improved motor score was observed in our study as well.

Preoperative state of pupils in patients evaluated showed bilaterally dilated in 11 cases (6.7 %) without loss of brainstem reflexes. DC was done on them as they were in the younger age group or these findings were recent-onset during transportation from peripheral hospitals. Only 2 patients survived among those with bilaterally dilated pupils (18.1%) while survival rates among patients with unequal and equal reactive pupils were 48.3% (n 28) and 62.1% (n 59) respectively. Thus, the state of pupils were a good predictor of outcome in our study and correlated with results of data analyzed from 11 studies.[10] Mortality rate among patients with hypotension at presentation was 27.3%.

Regarding timing of surgery, 24 patients (14.6%) were operated within 6 hours, 126 patients (76.9%) between 6 to 12 hours, and 14 patients (8.5%) were operated in later than 12 hours. Our data showed SDH as the most common pathology (65.9 %) followed by contusions, subarachnoid hemorrhage and brain edema of varying severity. The decision for performing primary or secondary DC was based on clinical and radiological findings. Primary DC was performed in 113 cases (68.9%).

Although decompressive craniectomy is a relatively simple procedure, various complications may arise. Various studies have shown a high incidence of neurological complications.[11,12] Our study is not an exception. Postoperative neurological complications included external cerebral herniation, infarcts, contusion expansion, subdural collection, hydrocephalus and infections. External cerebral herniation, as defined by Yang et al as brain tissue in the center of the bone defect >1.5 cm above the plane where the outer table of the cranium would normally lie, was seen in 37.8% of cases (n 62) in our postoperative CT findings as compared to 26% cases as observed in another study.[13,14] Postoperative notes showed adequate bone flap size of 12 cms size except in few cases with EDH and IPH (7 and 6 numbers). The decision for large bone flap for evacuable lesions were taken based on CT findings of brain edema, basal cisterns effacement, midline shift more than the thickness of bleed in SDH, contusion, IPH, and EDH.

Postoperative contusion expansion was noted in 16.5 % cases (27 patients). The Study by Ban et al showed contusion expansion incidence of 12.4% and concluded it as significantly affecting outcome in DC.[15] Contusion expansion was defined as an enlarged non-hemorrhagic or hemorrhagic contusion ipsilateral or contralateral to the decompressed hemisphere on serial cranial CT scans. Communicating hydrocephalus was another complication noted in 7.9% (13 patients) cases, incidence of which varied in the literature from 0.7 to 86 % depending on diagnostic criteria.[16] Superficial wound infections including surgical site infections, wound breakdown and necrosis occurred in about 10% of patients. Similar findings are observed in a systematic review by Kurland et al which is much higher than standard craniotomy for a general neurosurgical procedure.[17] This may be attributed to a large skin flap compared to standard craniotomy, increased probability of injury to the superficial temporal artery during emergency procedure predisposing the wound edges to ischemia, and brain bulge aggravating the flap ischemia. Deep-seated infections encountered were brain abscess, meningitis, and ventriculitis. Surgical intervention was required in 2 cases of brain abscess.

GOS at discharge evaluated in our patients showed 10 patients (6.1%) with a persistent vegetative state (GOS 2), 40 (24.4%) with severe disability (GOS 3), and a mortality rate (GOS 1) of 39% (64 patients). Hence poor outcome (GOS 1,2, and 3) was seen in 69.5% (114 patients) and favorable outcome among 50 patients (30.5%). There is wide variability in outcomes in the literature on DC in TBI, with favorable outcome rates in the adult population reported to range from 30% to more than 70%.[18-20] We assessed GOS at discharge rather than GOS at 6 months as there is no statistical difference between these among severe head injury patients as shown in the study by

Agarwal et al.[21] Mortality rates after decompressive craniectomy vary widely from a mean mortality rate of 12%, to as high as 40%.[22,23] Even though conflicting results are there in the literature regarding mortality rates between primary DC and secondary DC, primary DC at the same time as the evacuation of a hematoma is the most frequent scenario for performing DC.[24] Al-jishi et al found a significant difference in outcome with primary DC showing 45.5% good outcome and 40.9% mortality and secondary DC showing 73.1% good outcome and 15.4% mortality.[25] Similarly study by Albanèse et al showed a Mortality rate of 50% in primary DC and 20% in secondary DC.[26] In our study primary DC was done in 113 patients (68.9%) with mortality in 45 patients (39.8%) while secondary DC was done in 51 patients (31.1%) with mortality in 19 patients (37.2%). The lower mortality rate among primary DC in our study as compared to the above-mentioned studies may be becauce of more evacuable lesions in our patient group.

Limitations

We recognize various limitations in our study. It is a retrospective study with a small sample size, without a control group conducted in a single tertiary care center. Despite these limitations, our study population was heterogeneous and represented the spectrum of pathologies for which DC is routinely carried out for TBI in low and middle-income countries.

CONCLUSION

Our results show that preoperative low GCS, dilated pupils, and hypotension was associated with a higher mortality rate. The most common pathologies were SDH and contusion and external cerebral herniation the most common complication. Primary DC had a higher mortality rate than secondary DC.

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