Outcome analysis of decompressive craniectomy in a tertiary center in Nepal

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ABSTRACT

Introduction

Decompressive Craniectomy (DC) is used as a surgical procedure to treat intractable intracranial hypertension when all other treatments have failed. Role of DC for various pathologies still is uncertain. Our study's aim was to describe the demographic, clinical, and operative characteristics of patients who underwent DC for various conditions at our tertiary care center and to identify subpopulations that benefit the most from surgical intervention.

Materials and Methods

All patients who underwent DC in Department of Neurosurgery, Green City Hospital, Kathmandu, Nepal from January 1, 2018 to December 31, 2020 were included in this study. This was a retrospective study and different variables affecting the outcome were analyzed. The follow up period was six months.

Results

During the course of our study, 68 patients underwent DC with age 21-77 years with a mean age of 46.0 ±13.3 years. The gender ratio was 1.6:1. (42 males to 26 females). Glasgow Outcome Scale (GOS) was used to assess patient outcome. There was better outcome of DC in age <50 years in our study. Patients with GCS less than 8 had unfavorable outcomes in 70.3% of cases, while patients with GCS > 8 had unfavorable outcomes in 32.2% of cases (p=0.0018). Favorable outcomes were more common in DC performed for trauma, aneurysm, and sinus thrombosis than ischemic stroke and hemorrhagic stroke. Favorable outcome was seen with intact bilateral pupillary reflexes (59%; p=0.022) in our study.

Conclusions

The outcome of decompressive craniectomy was better in patients with trauma, cerebral venous thrombosis and aneurysmal subarachnoid hemorrhage than in patients with intracerebral hemorrhage and ischemia. The preoperative pupillary status (bilateral equal and reactive), GCS > 8 and age less than 50 were the variables associated with a favorable outcome in these patients.

Keywords: **Decompressive Craniectomy, GOS**

Introduction

Decompressive craniectomy (DC) is a neurosurgical procedure that removes a portion of the skull bone to prevent pathological increases in intracranial pressure (ICP), brain herniation, and brain tissue ischemia. The procedure improves cerebral hemodynamics and brain oxygenation in patients with high ICP, which may reduce mortality and disability in some cases[1]. Despite significant advances in neurosurgery, the mortality and morbidity associated with increased intractable intracranial pressure (ICP) have remained a source of concern[2,3]. Several intracranial conditions can cause high ICP, and treating these emergencies as soon as possible is critical to preventing intracranial hypertension, which causes hypoxia, ischemia, and cerebral herniation[4,5]. The primary treatment option is to address the underlying cause and use modalities to reduce the elevated ICP. All efforts should be made to reduce the elevated ICP as early as possible[3,6].

Although DC is an option for lowering elevated ICP, it has its own set of complications, including seizure, subdural hygroma, hydrocephalus, and infection. Currently, DC is used as a surgical procedure to treat intractable intracranial hypertension when all other treatments have failed[7]. DC has been shown to increase cerebral perfusion and oxygenation in patients with raised intracranial pressure (ICP), leading to improved clinical outcomes in patients with intractable hypertension[8,9].

The role of DC in ischemic stroke is becoming clearer, as evidenced by the DECIMAL, HAMLET, and DESTINY trials, which confirmed mortality benefits compared to best medical management in patients with malignant Middle Cerebral Artery (MCA) infarction under the age of 60[10-12].

Two new trials (DECRA and RESCUEip) regarding the outcome have addressed the role of DC in Traumatic Brain Injury (TBI) [13-14]. The DECRA trial found no advantage to surgery over medical management in patients with TBI, but rather increased the debate about surgery, indications, timing, and candidates for DC in patients with TBI. The RESCUEicp trial found that patients had a lower mortality rate after DC compared to medical management, but at the expense of higher levels of vegetative and severe disability. Thus, despite the completion of the two largest randomized controlled trials comparing the efficacy of DC vs. medical management for patients with TBI, there is still clinical uncertainty about the role of DC in the management of refractory ICH[13,14].

In patients with space-occupying MCA infarction, TBI, aneurysmal subarachnoid hemorrhage (aSAH), and cerebral venous thrombosis (CVT), DC can be lifesaving[13,15-16]. However, many survivors do not regain independence in daily activities. As a result, the value of DC in daily clinical practice remains unknown. DC has been used in a variety of other conditions, including postoperative brain swelling after tumor removal, aneurysm surgery, and intracerebral hematomas. A 3-month follow-up study conducted by Shah et al. in Nepal revealed a favorable outcome in 39% of patients following DC in TBI[17]. Another study looked at the outcome for ischemic stroke patients and found that 35.5% had a favorable outcome after six months[18].

Our study's aim was to describe the demographic, clinical, and operative characteristics of patients who underwent DC for various conditions at our tertiary care center. In order to identify subpopulations that benefit the most from surgical intervention, we analyzed the neurological outcome in a cohort of consecutive DC patients, as well as patient characteristics for predictors of outcome.

Methods

This retrospective case series included all patients with ischemic stroke, TBI, CVT, aSAH, intracerebral hemorrhage (ICH), or other conditions who underwent DC at Green City Hospital in Kathmandu, Nepal between January 1, 2018 and December 31, 2020. Patients were selected from a retrospective operative database that included all patients undergoing DC during the 2-year time frame. Additional patient information was obtained from OPD charts and over the phone. The follow-up period was up to six months.

The following variables were assessed- age, sex, preoperative diagnosis, preoperative Glasgow Coma Scale (GCS), co-morbidities, imaging findings (diagnosis, degree of midline shift), intraoperative findings, type of procedure (primary or secondary), the timing of DC from presentation, length of intensive care unit (ICU) stay, length of hospital stay, additional procedures done, and complications. Computer tomography studies were evaluated to determine the nature of the underlying pathology, the extent of midline shift, and any associated intracranial injuries. In all patients, the GCS and pupillary light reflexes at the time of injury/ictus could not be determined. As a result, we recorded GCS scores and pupillary light reflexes at the time of diagnosis and again immediately before surgery to document any deterioration.

The outcome in six months was assessed using Glasgow Outcome Scale (GOS) [19]. Unfavorable outcomes were defined as GOS scores 1-3 (death, persistent vegetative state, or severe disability); favorable outcomes were defined as GOS scores 4-5 (moderate or low disability, i.e. independence in activities of daily living). Clinician notes from six months after surgery were used to assess outcome using the Glasgow Outcome Scale (GOS). DC was classified as primary when performed within 24 hours of onset, or secondary when performed more than 24 hours after onset or not performed at the initial surgery. The STROBE guidelines were followed in order to accurately and completely report this observational study[20].

The demographic and clinical characteristics of patients and outcome of DC were reported using median or mean for continuous variables and frequencies for categorical variables. Statistical analyses were performed using SPSS Statistics 23.0, IBM, Armonk, New York, USA. We applied the Chi-square test when applicable. Results with a $p<0.05$ were considered statistically significant.

Management Protocol

Patients who presented with TBI, stroke (hemorrhagic or ischemic), or other mass lesions and had a poor GCS or asymmetrical pupils were subjected to DC; otherwise, patients who could be managed medically were admitted and started on ICP lowering strategies. Patients who were neurologically worsening or had worsening changes on imaging despite maximal ICP lowering strategies were candidates for DC. The relevant mass, which included intracranial abnormalities causing coma, was surgically removed. When the neurosurgeon encountered significant intraoperative brain swelling that made it impossible to safely replace the bone flap in some of these patients, DC was performed in the same operation. Secondary DC was performed in other cases during a subsequent operation when neurological deterioration occurred.

The patients underwent either a frontotemporoparietal craniectomy or a bifrontal craniectomy based on the site and nature of the lesion. Additionally, depending on the timing of the surgery it could be a primary or a secondary craniectomy. In primary DC, the craniotomy bone flap was not replaced after the completion of the primary surgery and the secondary DC was a procedure performed as a last-tier intervention in patients with severe intracranial hypertension refractory to medical management. Frontotemporoparietal DC consisted of the excision of a large bone flap and duraplasty. In de novo patients undergoing supratentorial DC, a large skin incision, in the shape of a question mark based at the ear, was made. A bone flap with a diameter of at least fifteen by twelve cm including frontal, temporal and parietal bone was created, with special effort to extend the craniectomy down toward the temporal skull base. The dura was opened widely to ensure maximal decompression. The cortical surface was covered with the unapproximated dural flaps and pericranium, absorbable hemostatic cellulose, after which only the skin was closed. In patients who had previously undergone supratentorial craniotomy for epidural hematoma (EDH), subdural hematoma (SDH) evacuation, aneurysm clipping, and ICH evacuation, the existing bone flap was removed and extended if deemed necessary by the neurosurgeon. After surgery, all patients were admitted to the intensive care unit for supportive therapy.

Results

During the course of our study, 68 patients underwent DC. The minimum age of the patient was 21 years and the maximum age was 77 years with a mean age of 46.0 ±13.3 years. The gender ratio was 1.6:1. (42 males to 26 females). 32 patients (47%) were hypertensive, and 5 (7%) were diabetic.

15 (22%) presented with trauma and 53 (78%) patients were non-traumatic. The median time of presentation from the onset of symptoms was 22 hours for non-trauma patients and five hours for trauma patients. Similarly, for non-traumatic patients, the median time from presentation to surgery was two hours, and for traumatic patients, it was 90 minutes.

Of the total patients who underwent DC, 37 (54.4%) patients had a GCS < 8 and 31(45.6%) had GCS $\geq$ 8. The lowest GCS of the patient was 3 and the highest GCS was 13. Twenty nine (42.6%) patients had unequal pupils prior to DC. The majority of the patients who underwent DC for TBI had acute subdural hematoma (SDH) with contusion as shown in Table 1.

Table 1: Imaging characteristics of the patient with trauma

Imaging Diagnosis	Number of Patients
Acute SDH with contusion	10
Acute EDH with contusion	2
Contusion	3
Total	**15**

SDH – Subdural hematoma, EDH- Epidural hematoma

A total of 53 (78 %) patients underwent DC for non-traumatic conditions. Eleven (20%) of them had an acute ischemic stroke and 8(14.5%) had an intracranial tumor as shown in Table 2.

Table 2: Imaging characteristics of the patients with non-trauma

Imaging Diagnosis	Number of Patients
Hemorrhagic stroke	41
Aneurysm	2
Ischemic stroke	8
Sinus thrombosis	2
Total	**53**

Primary DC was performed on 47 patients (69.1%), while secondary DC was performed on 21 patients (30.9%). Primary DC was performed on 7 (46.7%) of the 15 patients who underwent DC for trauma. 5 (62.5%) of the 8 patients with ischemic stroke received primary DC, while 33 (80.4%) patients with primary haemorrhagic stroke received primary DC.The mean duration of ICU stay was 12.4+5.1 days (Range 3 - 45 days) and the median duration of hospital stay was 22 days.

The outcome of the patients was analysed using the GOS at 6 months. 36 (53 %) patients had an unfavorable outcome at six months. (Table 3)

Table 3: Proportions of the patients as per the GOS

GOS	Number of Patients
1	7
2	5
3	24
4	20
5	12
Total	**68**

There were 32 (47%) patients below the age of 50 who underwent DC and 18 (32.7%) of them had a favorable outcome. However, only 5 (9.09%) of the 18 (32.7%) patients had a favorable outcome above the age of 50 years as shown in Table 4.

Table 4: Relation between age and outcome

Age	Favorable	Unfavorable	
<50	20	12	***p* value = 0.016**
>50	12	24	
Total	**32**	**36**	

There were 29 (42.6%) patients with unequal pupils and 20 (69%) of them had an unfavorable outcome. Of the total 39 (57.4%) patients with equal pupils, 23 (59 %) had a favorable outcome as in Table 5.

Table 5: Relation between pre-operative pupillary status and outcome

Pupils	Favorable (%)	Unfavorable	
Equal	23 (59)	16	*p* value = 0.022
Unequal	9 (31)	20	
Total	**32**	**36**	

Of the total 15 patients with trauma, 11 (73.3%) had a favorable outcome. Similarly, 4 patients with ischemic stroke and 13 of the patients with hemorrhagic stroke had a favorable outcome. Patients with trauma, aneurysm and sinus thrombosis had better outcome in our series

Table 6: Relation between etiology and outcome

Etiology	Favorable (%)	Unfavor-able
Trauma	11 (73.3)	4
Ischemic stroke	4 (50)	4
Hemorrhagic stroke	13 (31.7)	28
Aneurysm	2 (100)	0
Sinus thrombosis	2 (100)	0
Total	**32**	**36**

There were 37 (54.4%) patients with a preoperative GCS < 8 and 26 (68.4%) of them had an unfavorable outcome. Of the total 31 (45.6%) patients with GCS ≥ 8, 21(67.7) had a favorable outcome. However, there was difference in outcome based on the preoperative GCS as in Table 7.

Table 7: Relation between preoperative GCS and outcome

GCS	Favorable (%)	Unfavorable	
<8	11(29.7)	26	*p* value = 0.0018
≥8	21(67.7)	10	
Total	32	36	

Discussion

In our retrospective study of 68 patients, 15 (22%) presented following trauma and 53 (78%) presented with non-traumatic conditions. In our study, favorable outcomes were more common in DC performed for trauma, aneurysm, and sinus thrombosis. The role of DC in treating trauma and large hemispheric ischemic stroke is widely established and is recommended by the related guidelines[3,21]. Decompressive hemicraniectomy has been shown in studies to reduce intracranial pressure and improve perfusion and blood flow in acute ischemic stroke and traumatic brain injury[22-23]. In acute ischemic stroke this is true not only in ipsilateral penumbral tissue but in the contralateral hemisphere as well[22].

In this study, the favorable outcome in DC for hemorrhage was minimal. The best treatment for patients with spontaneous intracerebral hemorrhage is still being debated, and the role of DC is not well understood[24]. Raised ICP is a well-known cause of brain injury in hemorrhage. The most commonly studied and practiced surgical method for lowering elevated ICP is immediate hematoma evacuation[25]. However, hematoma evacuation may not be enough to relieve elevated ICP. Soon after bleeding occurs, a series of negative pathogenic mechanisms are activated which can result in the loss of auto-regulatory function in the brain. As a result, even if the hematoma is evacuated early, ICP can rise again and reach dangerous levels within a few hours herniating the brain tissue[26]. Decompressive hemicraniectomy has been considered as an option to resolve this problem[25,26]. However, the outcomes are not as predicted in theory. STICH I and II randomized trials comparing surgery to conservative management did not show a clear benefit for surgical intervention[27,28]. Furthermore, the generalizability of these trials' findings is called into question because patients at risk of herniation were excluded. Based on these studies, the current AHA/ ASA ICH guideline provide Class IIb (Level of Evidence C) recommendation for DC with or without hematoma evacuation for patients with supratentorial ICH who are in a coma, have large hematomas with significant midline shift, or have elevated ICP refractory to medical management[29]. The SWITCH trial (ClinicalTrials.gov Identifier: NCT02258919) is ongoing and will attempt to further define the role of decompressive hemicraniectomy in patients with supratentorial ICH. The result of SWITCH trial is expected to be completed in 2023.

There was better outcome of decompressive hemicraniectomy in age <50 years in our study. Study done by Nepal et al. showed that there was no role of age stratification (< 50 or >50) for the outcome of DC in patients with malignant MCA infarction[18]. In another study, Shah et al. found that favorable outcomes were significantly higher in patients under the age of 50 who underwent DC for TBI[17]. As a result, we need to conduct another large cohort study to validate our findings. Several factors, including admission mRS, cognitive status, and socioeconomic status are known to mediate the influence of age on clinical outcome following DC. While the decline of neuroplasticity in elderly patients may reduce the chances of good clinical recovery, advanced age is not regarded as a limiting factor in brain injury rehabilitation. Functional outcome is a complex measurement, particularly in elderly patients, because the ability to perform daily activities deteriorates with age, and thus the functional outcome score may vary with the patient's age[30]. Although the modified Rankin scale and GOS are widely used as a basic standard scale in neurological diseases, it has limitations in that it only shows motor functional independence and is unrelated to cognitive and psychological aspects. In the elderly, cognitive and psychological aspects are usually affected. As a result, outcome measures for DC in older patients should include both stroke assessment tools and age-appropriate assessment tools such as the Stroke Impact Scale and the Assessment of Motor and Process Skills[31].

Patients with GCS less than 8 had unfavorable outcomes in 70.3% of cases, while patients with GCS $\geq$8 had unfavorable outcomes in 32.2% of cases, and the difference was statistically significant in our study (p=0.0018). These findings are consistent with those of Shah et al. from Nepal, who found that preoperative GCS was associated with better outcomes in their study[17]. GCS can stratify risk and prognosis in patients with brain injury, but with caution because these patients often have polytrauma, and other injuries can alter morbidity and mortality. The favorable outcome with intact bilateral pupillary reflexes (59%; p=0.022) in our study was consistent with the findings of Shah et al[17].

There are several limitations to our research. This is a single-center retrospective study of DC patients with varying baseline conditions and etiologies. A larger sample size is recommended for a prospective study to assess the overall status of decompressive craniectomy in our population.

Conclusions

The outcome of decompressive craniectomy was better in patients with trauma, cerebral venous thrombosis and aneurysmal subarachnoid hemorrhage than in patients with intracerebral hemorrhage and ischemia. The preoperative pupillary status (bilateral equal and reactive), GCS > 8 and age less than 50 were the variables associated with a favorable outcome in these patients.

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