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# Severe Traumatic Brain Injury: Clinical Outcome of 30 Cases Managed by Decompressive Craniectomy

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## Abstract

*Background:* Severe traumatic brain injury is correlated to increased incidence of mortality and severe disability. In the acute phase, medical and surgical management is aimed to prevent intracranial hypertension and to maintain adequate cerebral perfusion pressure. Decompressive craniectomy is a surgical intervention that revealed much interest in the management of refractory intracranial hypertension after severe traumatic brain injury.

*Aim of Work:* To evaluate the clinical outcome of decompressive craniectomy in management of severe traumatic brain injury either performed immediately in the acute phase or after failure of the initial medical therapies to control the elevated intracranial pressure.

*Subjects and Methods:* This retrospective study included thirty patients. All patients operated upon by Decompressive craniectomy after severe traumatic brain injury in the period between 2013 and 2017. Patients were divided into 2 groups according to the indications of Decompressive craniectomy. First group included patients whom initially treated by medical treatment and operated upon in a context of refractory intracranial hypertension. The second group patients were operated upon immediately for evacuation of compressive hematoma accompanied with decompressive craniectomy due to severe edema, making it impossible to replace the bone flap. Upon admission, all patients underwent a complete physical and neurological examination. Initial imaging examinations were reviewed with description of the lesions, measurement of midline shift and classification of lesions according to Marshall's classification. Intracranial pressure and cerebral perfusion pressure were monitored and analyzed during management. Clinical outcome for both groups was graded using the Glasgow Outcome Scale 3 months after operation and at long term follow-up.

*Results:* Twenty patients (67%) in the first group underwent delayed decompressive craniectomy within 7 days after trauma. In the second group, 10 patients (33%) operated upon immediately with decompressive craniectomy within 6 hours after injury. Favourable functional outcome was achieved in 9 patients (45%) among the first group and 3 patients (30%) in the second group at 3 month post-operatively. At 24 month follow-up, 12 patients (60%) and 3 patients (30%) showed favourable outcome in the two groups respectively. Radiologically, midline shift decreased and visibility of the mesencephalic cisterns was improved after the Craniectomy. Complications occurred in three (14%) of the survived 21 patients included in the study.

*Conclusion:* DC could have beneficial role in improving functional outcome, lowering ICP and mortality in management of severe traumatic brain injury. Additionally, it shows increased incidence of complications. Further exploring of long term effects of DC and its influence on prognosis is recommended.

***Key Words:*** *Decompressive craniectomy – Severe traumatic brain injury – Refractory intracranial hypertension.*

## Introduction

**TRAUMATIC** Brain Injury (TBI) is a serious condition; it leads to elevated Intracranial Pressure (ICP) which increases the incidence of death and severe disability. TBI can be resulted from an open or closed head injury. Based on the severity of head injury, TBI is classified into mild, moderate, or severe injury [1].

A severe brain injury is typically associated with Glasgow Coma Score (GCS) ranging from 3 to 8 (typically in a coma) [2]. Both medical and surgical management of TBI are aiming to reduce the elevated intracranial pressure and to maintain adequate cerebral perfusion pressure. Medical treatment for severe TBI as mannitol therapy, hyperventilation, sedation, barbiturate coma, and ventricular drainage showed an effective role to reduce ICP, some patients are not responding and suffer from continues brain swelling and refractory intracranial hypertension. Decompressive craniectomy may need to be considered when the medical therapy fails to control ICP [3].

Many studies mentioned the effectiveness of DC in reducing ICP and improving mortality from severe TBI, others researches questioned its overall usefulness referring to high accompanying compli-

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cation rate. Thus DC for management of refractory intracranial hypertension in severe TBI is a controversial issue in the literature. The main parameter to be considered is not the survival rate after craniectomy, but the functional outcome of these patients **[4]**. The intracranial pressure can be reduced by DC but not at the expense of cerebral perfusion which shows an improvement. Careful selection of patients assigned to DC may result in overall better functional outcomes **[5,6]**.

The aim of this review is to evaluate the clinical outcome of decompressive craniectomy in management of severe traumatic brain injury either performed when medical therapies failed to control ICP or early craniectomy.

## Subjects and Methods

This retrospective study included thirty patients. All patients were operated upon by decompressive craniectomy after severe traumatic brain injury in the period between 2013 and 2017 in Cairo University Hospitals. Patients were divided into 2 groups. First group enrolled patients whom initially treated by medical therapy and operated upon in a context of refractory intracranial hypertension. Medical therapies included sedation, hyperosmoler therapy, hyperventilation, hypothermia, barbiturate coma and ventricular drainage. The second group patients were operated upon immediately for evacuation of compressive hematoma accompanied with decompressive craniectomy due to severe edema, making it impossible to replace the bone flap. Dc was performed on the lesion affected side for all patients; the flap dimension is ranged of 8-10cm X 12-15cm, Duroplasty was carried out during all decompressive surgery procedures. The bone flap is stored in a tissue bank for 2-3 months to be used later in cranioplasty Figs. (1,2).

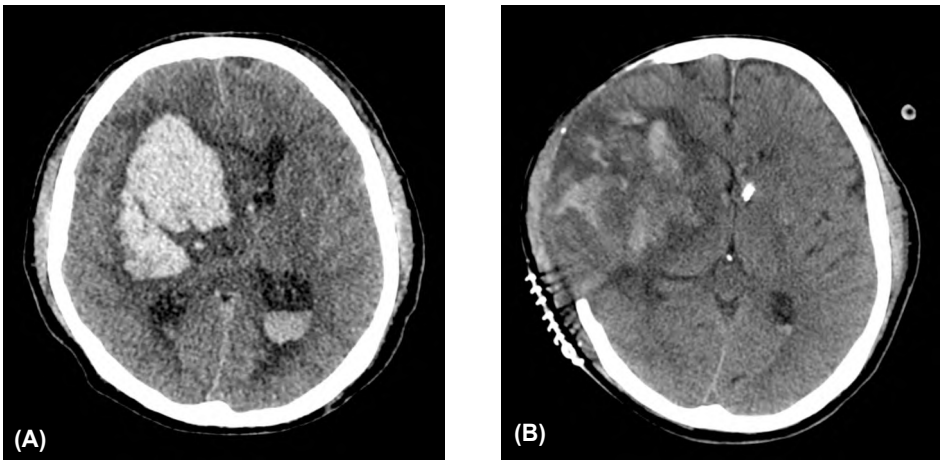


Fig. (1): (A): Pre-operative Axial CT Scan showing traumatic hemorrhagic brain injury with marked midline shift. (B): Axial CT scan of the same case after decompressive hemicraniectomy.

Fig. (2): Axial CT scan of the same case 3 month later after Cranioplasty showing improving of midline shift and brain compression.

The inclusion criterion was the presence of patients operated upon after failure of medical therapy with ICP monitoring, as well as patients operated on immediately because of a surgical posttraumatic lesion without in ICP monitoring. Patients presented with bilateral fixed dilated pupils and absences of oculocephalic reflex were excluded. Complete physical and neurological examination was performed to the enrolled patients upon admission. After patient's stabilization, initial imaging examinations were reviewed with description of the lesions, measurement of midline shift and classification of lesions according to Marshall's classification. Post-operative images including Computed Tomography (CT) and MRI of the brain was performed immediately after surgery, three month later and at longer follow-up. ICP was

monitored during management by an intraparenchymal probe placed in the more severely affected side in the first group. Patients were monitored by invasive arterial pressure measurement and mean arterial pressure was measured up to the brain for calculation of CPP. Clinical outcome for both groups was graded using the Glasgow Outcome Scale 3 months after operation and at long term follow-up.

## Results

Thirty cases were studied including eight females and twenty two males; they all had severe traumatic brain injury, on admission all patients had a Glasgow Coma Score (GCS) ranging from 3 to 8. The mean age ranged between eighteen and fifty four years. Causative trauma included road accident, fall from a height. Initial abnormal computed tomography showed a variety of lesions as haematomas, contusions, swelling, herniation, or compressed basal cisterns. DC was performed for 20 patients (67%) in the first group for refractory ICP (sustained above 20mmHg more than 15 minutes within a 1-hour period) after maximal medical interventions, Craniectomy performed within 7 days after trauma. In the second group, 10 patients (33%) operated upon immediately with decompressive craniectomy after evacuation of compressive hematoma within 6 hours after injury. Patient characteristics are shown in (Table 1).

Table (1): Patient characteristics.

| Data | Group 1 | Group 2 |
|---|---|---|
| No. of patients | 20 | 10 |
| *Sex:* | | |
| Male | 15 | 7 |
| Female | 5 | 3 |
| *Pre-operative pupillary abnormality:* | | |
| No | 11 | 1 |
| Unilateral dilated | 6 | 5 |
| Bilateral dilated (absent corneal reflex) | 3 | 4 |
| *Multiple trauma:* | | |
| Yes | 8 | 4 |
| No | 12 | 6 |
| *Initial CT analysis of the lesions according to the Marshall classification:* | | |
| I | 7 | |
| II | 6 | – |
| III | 1 | |
| IV | 6 | 2 |
| V | – | 8 |
| VI | – | – |

Favourable functional outcome included Glasgow outcome scores 4 and 5 while unfavorable one included scores 2 and 3. Nine patients (45%) among the first group and three patients (30%) in the second group at 3 month post-operatively showed favourable functional outcome. At 24 month follow-up, 12 patients (60%) and 3 patients (30%) showed favourable outcome in the two groups respectively. Control imaging series after surgery revealed reduction of the midline shift and improvement of the visibility of the mesencephalic cisterns. Mortality occurred in four patients (20%) in first group and five (50%) in the second. Complications reported in three of the survived patients, two (13%) in the first group had hemorrhagic contusion ipsilateral to the craniectomy and subdural hygroma. One patient (20%) in the second group experienced tiny cerebral contusions. Functional outcome of the patients evaluated by GOS at 3 and 24 months after craniectomy are shown in (Table 2).

Table (2): Functional outcome of the patients evaluated by GOS at 3 and 24 months after craniectomy.

| Data | Group 1 No. (%) | Group 2 No. (%) |
|---|---|---|
| *GOS at 3 months:* | | |
| 1- Death | 4 (20%) | 5 (50%) |
| 2- Persistent vegetative state | 2 (10%) | |
| 3- Severe disability | 5 (25%) | 2 (20%) |
| 4- Moderate disability | 6 (30%) | 2 (20%) |
| 5- Low disability | 3 (15%) | 1 (10%) |
| *GOS at 24 months:* | | |
| 1- Death | 4 (20%) | 5 (50%) |
| 2- Persistent vegetative state | 2 (10%) | |
| 3- Severe disability | 2 (10%) | 2 (20%) |
| 4- Moderate disability | 7 (35%) | 1 (10%) |
| 5- Low disability | 5 (25%) | 2 (20%) |

## Discussion

TBI is associated with increased rates of mortality and morbidity in all populations worldwide.

The prognosis of TBI is mainly depending upon the initial injury severity and history of neurotrauma **[7,8]**.

Severe TBI usually complicated with brain Swelling and intracerebral haemorrhage leading eventually to elevated Intracranial Pressure (ICP) **[9]**.

In TBI, intracranial hypertension is diagnosed when the ICP is above the values of 20-25mmHg. Several studies stated that values of ICP between 20mmHg and 25mmHg, and values of CPP below 50-55mmHg, accompanied with higher mortality rate in patients suffering from TBI. When ICP is uncontrolled, ICP rises to equal the MAP; autoregulation fails to maintain CBF which forms a serious

threat to the damaged brain and causes brain ischemia. Therefore, monitoring and reversing of ICP are Crucial in the treatment of severe TBI [10,11].

Rise of ICP in severe TBI requires aggressive treatments. These include a range of medical and surgical managements. Medical therapies such as hyperventilation, hypothermia, sedation barbiturate coma and CSF draining, have all been contributed to reduce ICP but without improving the functional outcomes. That might be due to persisting cerebral hypoxia and inadequate perfusion [12].

DC becomes an option when ICP is refractory. DC is considered the last resort for refractory intracranial hypertension when medical treatment failed; some numerous publications stated that DC could reduce ICP and prevent secondary brain injury [13].

Delayed DC is used as part of therapeutic protocols for refractory intracranial hypertension in presence of severe brain edema after failure of medical therapy to control raised ICP. In acute phase of severe TBI, many surgeons perform immediate DC after evacuation of a mass lesion either due to severe edema or to avoid postoperative worsening due to IH depending on preoperative radiological features [14].

DC procedures had several types including unilateral or bilateral frontal and subtemporal DC, craniectomy should be at least 10cm in diameter to achieve adequate decompression, thus reduces ICP. DC has contributed to lower the therapeutic intensity level and the brain ischemic burden more than barbiturate coma and hypothermia [15].

In the surgical procedure, extensive durotomy followed with duroplasty is performed. 4-12 weeks later when the brain swelling is improved, cranioplasty is performed to reconstruct the cranial defect. Timing of cranioplasty can be prolonged if the procedure is complicated with brain infection. Decompressive craniotomy bypasses the problems of DC such as the need for subsequent cranioplasty, exposure to fluctuations of atmospheric pressure and venous obstruction and infarction if adequate wide craniectomy is not properly performed [16].

Several researches mentioned that the size of the craniectomy affects the extent of ICP reduction and the procedure outcome [17]. In our study, the flap dimension is ranged of 8-10cm X 12-15cm to ensure significant effect of lowering ICP; Duroplasty is performed using autologous material or artificial dura.

Clinical outcomes were assessed using the Extended Glasgow Outcome Scale. Hutchinson et al. [18], mentioned in his series which enrolled 201 patients operated upon by DC, overall favourable functional outcome was achieved in 86 patients (43%) while 115 patients (57%) had unfavourable outcome at 6 month follow-up after craniectomy. After 12 month, 45% of patients had favourable functional outcome and 55% showed unfavorable outcome. In our study overall favourable functional outcome at 3 month postoperatively was 37.5% while at 24 month it was improved to be 45%.

The overall mortality after DC was 35% in our cohort, that agrees with Nirula study done on 2014 which presented 30% overall mortality rate after Craniectomy [19]. Good outcomes after DC for management of severe TBI vary from 7%-70% and mortality ranges from 13%-90% [20].

Complications of DC includes developing of depressed concavity at the craniectomy site which might be profound if associated with secondary brain atrophy, temporalis muscle compromise, hemorrhagic contusions ipsilateral to the craniectomy, infection, acute subdural hematoma and subdural hygroma. Overall complication rate in our study was 16.5% while other studies showed 16% complication rate after DC in severe TBI [21].

Although the surgery of DC is relatively simple but it shows evident adverse outcomes, it's complications is increased in relation to the severity of the injury, usage of aspirin or other anticoagulants and advancing age [22].

*Conclusion:*

The role of DC in management of severe TBI is still controversial. Our findings supports the fact that DC has an effective role in improving the functional outcome, reducing ICP and mortality.

But it has increased incidence of adverse effects. Long-term follow-up are needed to confirm the impact of DC on prognosis and quality of that survival.

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# إصابات دماغية حادة: نتيجة سريرية لثلاثين حالة تتم علاجها بوا سطة إستئصال القحف اللاضغطى

ترتبط إصابات الدماغ الحادة بإزدياد معدل الوفيات والإعاقة الشديدة. إستئصال القحف اللاضغطى هو تدخل جراحى كشف عن الكثير من الإهتمام بإدارة إرتفاع ضغط المخ داخل الجمجمة بعد إصابة دماغية حادة.

الهدف من هذه الدراسة هو تقييم النتيجة السريرية لإستئصال القحف اللاضغطى فى علاج إصابات الدماغ الحادة إما على الفور فى المرحلة الحادة آو بعد فضل العلاجات الطبية الآولية فى السيطرة على الضغط المرتفع داخل الجمجمة.

هذه الدراسة تمت بآثر رجعى وشملت ثلاثين مريضا. جميع المرضى تم علاجهم عن طريق إستئصال القحف اللاضغطى بعد إصابات الدماغ الحادة. تم تقسيم المرضى إلى مجموعتين وفقا لمؤشرات إستئصال القحف وشملت المجموعة الآولى المرضى الذين عولجوا فى البداية عن طريق العلاج الطبى والجراحة بعد إرتفاع ضغط المخ المقاوم داخل الجمجمة. تم إجراء الجراحة للمجموعة الثانية من المرضى على الفور لإجلاء تجمع دموى إنضغاطى مصحوبا بإستئصال القحف اللاضغطى.

تم تحقيق نتائج وظيفية إيجابية فى تسعة مرضى بين المجموعة الآولى وثلاثة مرضى فى المجموعة الثانية فى ثلاثة آشهر بعد العمل الجراحى. فى آربع وعشرين شهرا من المتابعة، آظهر إثنا عشر مريضا وثلاثة مرضى نتائج إيجابية فى المجموعتين على التوالى.

يمكن آن يكون لدى إستئصال القحف اللاضغطى دور مفيد فى تحسين النتائج الوظيفية، وخفض معدل الوفيات فى حالات إصابات الدماغ الحادة، وبالإضافة فإنه يظهر زيادة نسبة حدوث المضاعفات. يوصى بمزيد من إستكشاف الآثار طويلة الآجل لإستئصال القحف اللاضغطى وتآثيرها على التكهن.