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The Use of Hinged Craniotomy in Comparison to Cisternostomy for Avoiding Bone Flap Replacement Second Surgery in Cases of Decompressive Craniotomy in Traumatic Brain Injury

Ahmed El-Fiki*, Ehab Abd-Haleem

Department of Neurosurgery, Cairo University, Cairo, Egypt
Email: *asfiki@yahoo.com

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Abstract

Introduction: Acute post traumatic subdural hematoma is a clinical condition with increased morbidity and mortality despite the developments in neurosurgery and urgent intervention is required to have best clinical outcome. We will evaluate hinged craniotomy technique in terms of offering adequate brain decompression plus avoiding removal of bone flap which requires second replacement surgery in comparison to cisternostomy effect. **Material and Methods:** A prospective study was conducted over 30 patients with traumatic acute subdural hematoma presented to neurotrauma unit in Cairo University hospitals from January 2017 to February 2018, operated by hinged craniotomy plus evacuation of hematoma and duroplasty. We avoid rapping the head with elastic bandage post-operative. Generous subcutaneous dissection (5 - 7 cm) all around skin flap was done routinely. Effect of brain decompression was evaluated by measuring the level of brain in relation to skull in post-operative computerized topography. **Results:** Twenty-one patients operated with initial GCS less than eight. Ten cases (33%) show that cortical surface in relation to skull bone was at inner table, nine cases (30%) at diploid layer and two cases (6.7%) at outer table in post-operative CT brain. Twenty patients died (66.7%); eight patients (26.6%) became fully conscious and two patients (6.7%) had vegetative outcome. No re-operation was done in any of our patients. **Conclusion:** Hinged craniotomy may be a safe and effective alternative technique with comparable results to cisternotomy in cases of traumatic brain injury that require decompression to avoid second surgery, especially in centres lacking cisternostomy experience. Although gaining cisternostomy experience may help in other indications, future prospective studies with larger number are required.

Keywords

Decompression, Subdural Hematoma, Cisternostomy, Traumatic Brain Injury

1. Introduction

Traumatic brain injury (TBI) is still a major universal health problem with nearly the same epidemiology in the last three decades [1]. The increasing incidence of death or handicapped life for TBI victims was mentioned in World Health Organization report [2]. And it is expected to be a major cause of mortality and disabilities.

Currently, decompressive craniectomy is a well-established operation for different indications in cases of increased intracranial pressure (ICP) [3]-[8].

Removal of large craniotomy bone flap with duroplasty and proper haemostasis leads to better brain compliance, cerebral perfusion, thus, lowering ICP with possible reduction in secondary brain insults [9] [10].

Decompressive craniotomy (DC) operation in cases of TBI becoming popular in developing countries recently [11] may be due to higher incidence of TBI than in developed countries.

There are several technical notes during DC operation which are not usually applicable in developing countries with limited resources service [12] [13] [14] [15] [16].

One of these logistic difficulties is the storage place of harvested bone flap, especially in absence of bone bank in many of developing countries [17].

Lype Cherian recommends doing cisternotomy to avoid post decompression hemicraniectomy morbidities and second bone re-positioning surgery [18].

Leaving the bone flap in place but loosely fixed is recently done to solve this problem and is known as hinge craniotomy (HC) [19] [20].

We will present our experience in HC with special focus on surgical tricks that would make it efficient in improving radiological singes of increased intracranial pressure in cases of TBI, and subsequently avoiding second surgery for bone defect.

2. Patients and Methods

We retrospectively analysed the data of thirty patients presented to our neurotrauma unit at Cairo University Emergency hospital with traumatic brain injury in the form of acute traumatic subdural haematoma during the period from January 2017 to February 2018.

Demographic data from hospital records, GCS on presentation, site of subdural hematoma, relation of the cortical surface in relation to skull, Glasgow

Outcome Score and mechanism of injuries were collected. Routine pre-operative laboratory investigations were sampled.

After resuscitation of the clinical condition according to advanced trauma life support (ATLS) guide lines [20] and radiological confirmation for surgical indication to do decompression craniotomy (midline shift more than 5 mm or hematoma thickness more than 1 cm), inclusion criteria include age between 15 - 65 years ,moderate and severe head injury and free chronic medical association and we excluded patients with age out of range ,subdural hematoma with no symptoms and patients with high risk medical conditions. Patients were transferred to operation room.

1) Pre-operative considerations:

– Endotracheal intubation and hyperventilation for cases with Glasgow Coma Scale GCS below 8.
– Intravenous anti-epileptic drug (phenytoin sodium) was administrated with loading dose (15 - 18 mg/kg) and maintenance dose (5 - 7 mg/kg).
– Intravenous mannitol 20% (0.5 mg/kg) followed by frusemide (0.25 mg/kg) were given routinely pre-operative as trial to lower ICP.
– Head elevation and neck extension to facilitate venous drainage and subsequent decrease in ICP.

2) Operative tricks:

– Head tilt to the opposite side 20 degree and large trauma skin flap is done.
– Large frontotempropariental bone flap with imaginary line connecting the following burr holes;
✧ temporal burr hole just above middle fossa base.
✧ posterior temporal burr hole just 5 - 7 cm behind the temporal one.
✧ parietal burr hole at the parietal eminence.
✧ three parasagittal burr holes one cm lateral to sagittal suture.
✧ frontal burr hole one cm above supraorbital ridge.
✧ key burr hole.
– Subgaleal dissection 5 - 7 cm around the skin flap which helps the scalp to accommodate for the hinge craniotomy during closure and decrease its hard pressure on expected swollen brain.
– Large duroplasty using pericranium over the bone flap; together with large bone flap (>12 × 15 cm) decrease the incidence of mushrooming effect of brain oedema and possible ischemia or haemorrhage at cortical edges.
– We usually use giggly saw to do craniotomy and we intentionally do bevelling in all bone flap limbs to prevent sinking of bone flap if later the ICP was normalized.
– Re-positioning of the bone flap and loose fix with vicryl sutures, putting suction drain between temporalis muscle and bone flap.

3) Post-operative tricks:

– We don't use crepe bandage to avoid pressure over the loose bone flap with no risk of subgaleal collection formation especially with suction drain.

Follow up CT scan was done 24 hours postoperative. All survivors were followed up 30 days after operation with CT scan and complete neurologic examination.

Approval was obtained from the research ethical committee (ERC) of the faculty of medicine of Cairo University to perform this study. All patients had signed the consent of the operation.

3. Results

This study included 30 patients with traumatic acute subdural hematoma showing male predominance eighteen males (80%) and twelve females (20%), the mean age was 46.92 years.

Microsoft excel 2013 was used for data entry and the statistical package for social science (SPSS version 24) was used for data analysis. Statistical methods: Mann-Whitney and Kruskal-Wallis test were used to compare non-normally distributed quantitative data. Descriptive statistics is used to summarize a sample rather than using the data to learn about the population that the sample of data is thought to represent. In this study; sample size in important subgroups and their demographic data such as the mean of age was represented by mean and standard deviation, while frequency and percentage distribution are used to describe different qualitative and non-numeric variables such as gender and clinical presentation. The level of significance was set at probability (P) value < 0.05.

Twenty-seven patients (90%) were simple acute traumatic subdural hematoma. While three patients (10%) were complicated subdural hematoma with either contusions or extradural hematoma or depressed fracture, in the simple hematoma group sixteen patients (59.25%) were males and eleven patients (40.74%) were females. While in the complicated hematoma group two patients (66.6%) were males and one patient (33.3%) was female as showed in **Table 1**.

The mean presenting GCS is 8 while the mean Glasgow outcome score is 2 and this is expressed in **Table 2** in relation to age of patients.

The primary cause of ASDH were motor car accidents affecting sixteen patients (53.3%), fall affecting nine patients (30%), blunt impact injuries affecting three patients (10%), and assaults (other factor) affecting two patients (6.66%). There was no observable difference in mortality and functional recovery rate regardless of injury mechanism (**Figure 1**).

Patients was assessed preoperatively according to the Glasgow Coma Scale patients presenting with GCS (4) was in six patients (20%), GCS (5) was in seven patients (23.3%), GCS (8) was in nine patients (30%), GCS (13 - 14) was in five patients (16.7%), GCS (15) was in three patients (10%).

Regarding the surgical outcome according to Glasgow outcome scale, twenty patients (66.7%) were dead, eight patients (26.7%) with good recovery and two patients (6.7%) were persistent vegetative state of coma (**Figure 2**).

Nineteen patients (86.3%) their post-operative CT scan showed improvement in the midline shift with cortical surface related to inner table of the skull or

Table 1. Results with percentages according to age, diagnosis, presenting GCS, Glasgow outcome scale and cortical surface in relation to skull bone.

		Count	Column N %
Sex	Male	18	60.0%
	Female	12	40.0%
Presenting GCS	Extension (4\15)	6	20.0%
	Fully conscious (FC) (15\15)	2	6.7%
	FC & right sided weakness G3 (15\15)	1	3.3%
	Flexion (5\15)	7	23.3%
	Localizing (8\15)	8	26.7%
	Localizing, sp. Movements (9\15)	1	3.3%
	Confused (14\15)	5	16.7%
Cortical surface in relation to skull bone (in post-operative CT)	Diploid	9	30.0%
	Inner table	10	33.3%
	Not available	8	26.7%
	Outer table	2	6.7%
	Outside the skull	1	3.3%
Diagnosis	Left frontotemproparietal ASDH	7	23.3%
	Left parietal ASDH & compound depressed fracture	1	3.3%
	Left EDH + ASDH	1	3.3%
	Left parietal ASDH	3	10.0%
	Left temporoparietal ASDH	1	3.3%
	Right frontotemproparietal ASDH	7	23.3%
	Right frontotemporal ASDH	1	3.3%
	Right parietal ASDH	3	10.0%
	Right parietal EDH + ASDH + Contusion	1	3.3%
	Right temporal ASDH	2	6.6%
	Right temporoparietal ASDH	3	9.9%
Glasgow Outcome Scale	Dead	20	66.7%
	good recovery	8	26.7%
	persistent vegetative state of coma	2	6.7%
Outcome	Dead	20	66.7%
	FC & Full Motor power (FMP)	7	23.3%
	FC & same motor power	1	3.3%
	Vegetative	2	6.7%

Table 2. Mean age in relation with presenting GCS and Glasgow outcome scale.

	Mean	Median	Mini.	Maxi.	Standard Deviation	Percentile 25	Percentile 75
Age	46.92	52.00	0.66	80.00	22.50	29.00	68.00
Presenting GCS score	8	9	4	15	4	5	10
Glasgow Outcome score	2	1	1	5	2	1	5

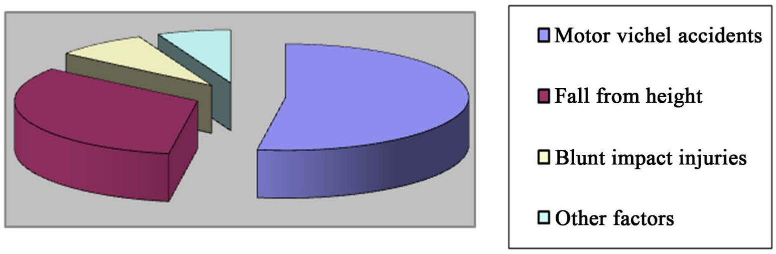

Figure 1. A graph showing the incidence of different mechanisms of injury.

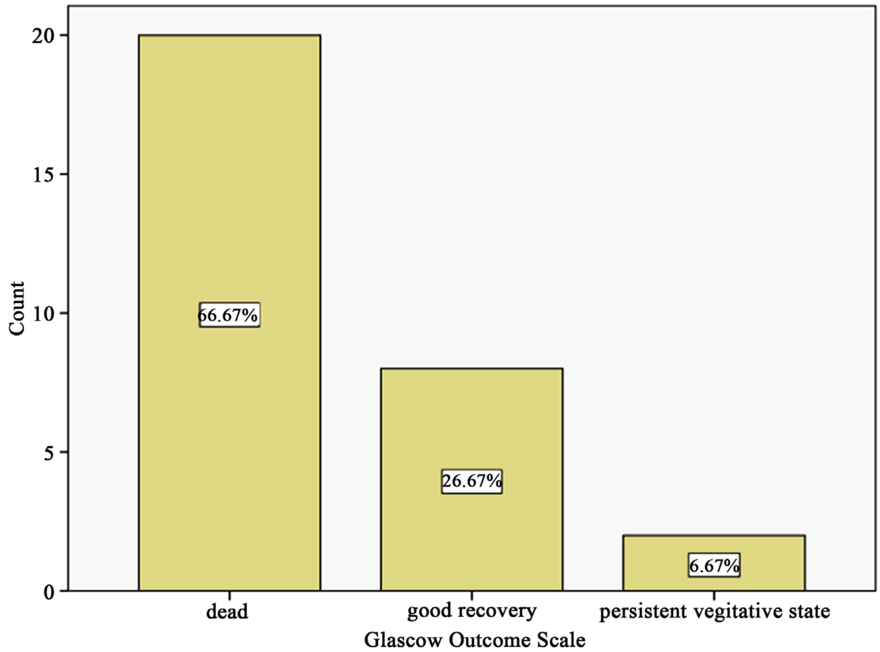

Figure 2. Bar chart showing the Glasgow outcome score.

diploe while three patients (13.6%) showed no improvement in the midline shift with cortical surface related to outer table of skull or outside the skull. Eight patients were dead before doing CT scan post-operative but the total dead cases were 20 patients (Table 1 and Figure 3).

The duration of operation ranged from 2 to 4 hours with average of three hours, and we encountered three cases of wound infection; two cases responded to antibiotic course for one week according to culture and sensitivity and another one required debridement.

4. Discussion

Kocher and Cushing were the first to introduce decompressive craniectomy as a solution to decrease increased ICP in TBI patients in beginning of 20th century.

Many complications can follow decompression craniectomy operation including ischemia, mushrooming of oedematous brain, subdural collections, infections and syndrome of trephined [10]. Many technical new trials aim to lower these morbidities [20].

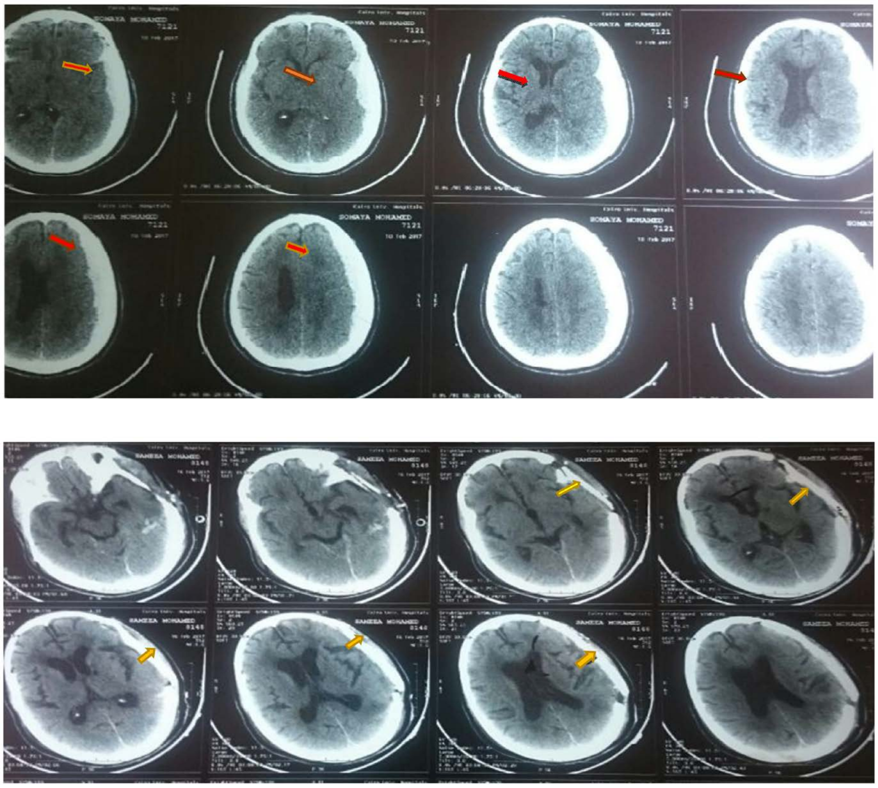

Figure 3. Pre (above with red arrows) and post (below with orange arrows) operative CT scan for left frontotemproparietal subdural hematoma shows midline shift improvement.

Our technique in hinge craniotomy ensuring large bone flap with the above-mentioned burr hole sites plus generous subgaleal dissection which facilitate the created pocket to accommodate for the return of bone flap with minimal pressure on both; oedematous brain and skin flap.

Doing hinge craniotomy in our series allowed our patients to achieve lowered intracranial pressure proved by improvement of midline shift in 19 cases (86.3%) in post-operative CT brain and this was interestingly enough to avoid another surgery to replace previously removed bone flap in classic decompressive hemicraniectomy and comparable to what Iype Cherian proposed about adding cisternostomy as a step in decompressive craniotomy to avoid second surgery [19]. Plus, that cisternostomy operation need learning curve with skull base and vascular surgery skills which may not be available in the majority of neurotrauma centres 24 hours.

These steps are effective in cost benefit burden especially in developing countries in comparison with other techniques which can help in avoiding second surgery like titanium devices that can be used to hinge the bone flap [22].

Seelig *et al.* described 82 patients with ASDH, the average age was 15 years old and he concluded that the outcome wasn't affected by the age [23]. The mean age of our patients was 46.9 years.

In our study regarding the surgical outcome according to Glasgow outcome scale, 20 patients (66.7%) were dead, 8 patients (26.7%) with good recovery and

2 patients (6.7%) were persistent vegetative state of coma. There was significant difference with Iype Cherian *et al.*, 2013 results which revealed that 34.8% mortality in decompressive craniotomy group and 26.4% mortality in decompressive craniotomy in addition to cisternostomy group. And this may be explained by low GCS in most of our cases (8 and below) in 21 patients (70%) but in spite of that the majority of our cases (86.3%) show signs of improvement ICP and midline shift in post-operative CT scan.

In our study the time taken in decompressive craniotomy operation starting from the anaesthesia till the recovery of the patient was average of 3 hours taking in considerations absence of facilities (e.g.: craniotome) while Iypecherian only commented on the time taken for the entire cisternostomy from dural opening after the learning curve to be about 10 - 20 min depending on the case, surgeon and the facilities.

In our series, Motor car accidents occurred in (53.3%), of our patients with ASDH and ranked first in mortality while the falls occurred only in (30%) of the cases, which was like what was found by Seelig *et al.* [23]. There was no difference in the outcome and prognosis between different mechanisms of injury.

The incidence of TBI has increased in middle-income, low-income countries and developing countries which are mostly attributable to inadequate motor vehicle and traffic laws and safety regulations.

Our study limitations include small sample size and that we focused on cases of traumatic brain injury with acute subdural hematoma where GSC was usually low and that was reflected on outcome. Long term follow up is needed to check delayed complications.

5. Conclusion

Hinge craniotomy may be a safe and effective alternative technique for cisternotomy in traumatic brain injury cases that require decompression to avoid second surgery especially in centres lacking cisternostomy experience. Although gaining cisternostomy experience may help in other indications, future prospective studies with larger number are required.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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