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Decompressive Hemicraniectomy for Management of Massive Middle Cerebral Artery Territory Infarction: Pharmacological, Perioperative and Anesthetic Techniques

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ABSTRACT

Background and Purpose: Massive, space-occupying middle cerebral artery infarct is a life-threatening vascular event with unsatisfactory therapeutic options. Despite full supportive care in the intensive care unit and traditional forms of therapy for cerebral edema, the mortality rate due to cerebral herniation remains very high. Our objective is to determine the beneficial effects of decompressive hemicraniectomy on mortality and morbidity rates in those patients.

Methods: In this prospective study, hemicraniectomy was performed in eleven Egyptian patients with acute complete middle cerebral artery infarction after optimum medical management; surgical intervention was done whenever the first signs of herniation had occurred. Initial clinical presentation was assessed by the National Institute of Health Stroke Scale (NIHSS), and the Glasgow Coma Scale (GCS). All survivors were reexamined 3 months after surgical decompression, with the clinical evaluation graded according to Barthel Index (BI).

Results: The mean age of included patients was 52.54 ± 6.5 years, 45.45% of them were under 50 years of age. The mean duration of conservative therapy was 60 ± 20.78 hours. We recorded 18.18% mortality rate, with a 44.44% at least one of non-fatal post-operative complications. There was an improvement of neurological status on NIHSS post-operatively when compared with that pre-operatively. At 3 months follow up, the mean Barthel Index for the survived patients was 60, and among the patients with dominant hemisphere stroke, the speech function improved in most. A statistically significant improvement on NIHSS score post-operatively and a significantly higher BI score were detected in younger age group.


INTRODUCTION

Life-threatening, complete middle cerebral artery (MCA) territory ischemic stroke is a well-recognized vascular syndrome, which accounts for about 5 to 10% of all ischemic strokes¹, and it could be associated with concomitant anterior cerebral artery (ACA) territory involvement². This massive MCA insult is characterized by hemiplegia, hemianopia, hemianesthesia, forced eye and head deviation, and aphasia (in dominant hemisphere involvement)³. It can lead to rapid development of fatal brain edema that results in progressive deterioration in consciousness within first 2 days and, thereafter, unilateral pupillary dilatation indicating rostro-caudal herniation within 2 – 4 days³. This clinical presentation is accompanied by early CT signs of major infarct during the first 12 hours after stroke³. The prognosis of such insults is grave, and carry a mortality rate of 50% to 80%³. The principal cause of death in patients with this “malignant MCA syndrome” is focal brain edema associated with increase in the intracranial pressure (ICP) resulting in compartmental shift and herniation⁴,⁵,⁶.

Owing to the high mortality rate and the poor functional outcome among survivors, aggressive therapeutic maneuvers should be considered for this catastrophe; and one of these proposed therapies is decompressive hemicraniectomy⁸,⁹. The conventional therapies in this condition, as in other
conditions of increased ICP, consist of mechanical ventilation, osmotherapy, and barbiturate administration; however, these modalities have their limitations\textsuperscript{11,12,13}. Because of these limitations, there have been proposals for decompressive surgery in patients with elevated ICP for a variety of neurological disorders, such as head trauma, encephalitis, subdural hematoma, and the space-occupying hemispheric infarction\textsuperscript{3,14,15}. This surgical management is directed towards improving cerebral perfusion and preventing ischemic damage and mechanical compression of the brain against the rigid intracranial structures\textsuperscript{16}.

Over the last two decades, several authors worldwide have shown that decompressive hemicraniectomy can not only reduce mortality, but can also result in good functional outcome, especially in younger adults; and it could be undertaken as a second line treatment in the case of clinical deterioration after conservative therapies\textsuperscript{3,17}–\textsuperscript{21}. Despite these encouraging results, hemicraniectomy has not gained widespread acceptance, especially in developing countries, where the incidence of stroke in the young is much higher than in the developed countries\textsuperscript{5}.

Another considerable issue in deciding surgical intervention in patients with marked cerebral edema and severe increase of ICP is the peri-operative management of increased ICP that includes pre-operative fluid and pharmacological management of cerebral edema, induction and maintenance of anesthesia that might affect cerebral autoregulation and hence ICP, intra-operative monitoring, and post-operative recovery care that helps early and adequate neurological assessment. Thus the choice of anesthetic techniques and drugs should ensure a safe control of ICP, and a faster post-operative recovery\textsuperscript{22}.

The aim of this study is to assess the value of surgical intervention in a prospective series of eleven patients treated with decompressive surgery as a second line treatment after optimum medical management of massive increase of ICP associated with malignant MCA stroke whenever the first signs of herniation had occurred and its impact on neurological status and functional outcome; and also to identify factors associated with favorable outcomes.

### SUBJECTS AND METHODS

#### Study Design and Patient Selection

This was a prospective trial on value of decompressive craniectomy in patients with complete middle cerebral artery territory infarction caused by occlusion of the proximal middle cerebral artery trunk (with or without affection of ACA). In all patients, embolic infarction was presumed. It included 11 Egyptian patients drawn between August 2002 and April 2004, the patients were followed up for at least three months. They were eligible for the present study if the following inclusion criteria were fulfilled: (1) patients younger than 65 years; (2) patients with clinical and radiological evidence of acute, complete MCA infarction (with or without ACA involvement), which consisted of an early, large parenchymal hypodensity [i.e., more than 50\% of the MCA territory] according to the criteria of Wardlaw and Sellar\textsuperscript{23} on a late CT scan that revealed infarct size, with a neuroradiological evidence of local brain swelling such as compression of the basal cisterns and effacement of sulci; (3) patients with stroke in the non-dominant hemisphere or those with only incomplete aphasia before deterioration.

#### Exclusionary Criteria

(1) Bilateral cerebral infarcts; (2) previous disabling neurological diseases, or intracerebral hemorrhage; (3) significant complicated co-morbid medical diseases; (4) seizures; and (5) missing long-term follow-up after surgical treatment (at least three months), but early mortality after decompression was not a reason for exclusion.

#### Patient Evaluation.

All patients enrolled in this study were submitted to a conjoint assessment composed of neurologist, neurosurgeon, and anesthesiologist. All of them had their routine hematological and biochemical profile, ECG and trans-thoracic echocardiography, Doppler studies of the carotid and vertebral arteries, and unenhanced cranial CT scans that were obtained on admission, 72 hours after stroke onset to reveal infarct size, after clinical deterioration, and post-operatively (Fig. 1).
Fig. (1): Non-contrast enhanced cranial CT scans of 62 years old patient 7 days after hemicraniectomy. The infarcted tissue bulges through the craniectomy defect. No midline shift and the brainstem cisterns are visible. The patient recovered rapidly after decompression and 3 months later showed only a mild dependency, with an BI score of 70; and speech function markedly improved.

Neurological Assessment
Neurological signs and symptoms [conscious level assessed by the Glasgow Coma Scale (GCS)\(^{24}\), hemiparesis, aphasia, equality of pupils] were frequently rated to detect any signs of clinical deterioration. Pre-existing medical conditions, and risk factors were recorded. Neurological status of the included patients was measured on admission and preoperatively using the National Institute of Health Stroke Scale (NIHSS)\(^{25}\), which was repeated one week after surgery. Functional outcome was quantified on the Barthel index\(^{26}\) three months later.

Conservative Treatment
All patients received maximum medical management of intracranial hypertension and systemic support, which included the routine intensive care monitoring, standardized conservative management included normalizing the blood volume, hyperosmolar treatment (mannitol, or glycerol) to achieve a serum osmolality of 300 mOsm, the mean arterial blood pressure level was above 90 mm Hg according to what was reported by Schwab et al.\(^{16}\). Mechanical ventilation was used...
whenever indicated\textsuperscript{22}. Invasive monitoring of ICP was not part of routine management in our patients. Decompressive hemicraniectomy was performed when a significant neurological deterioration was reported. “Significant deterioration” was defined as a further decrease in consciousness, and/or the development of inequality of pupils. The decision to perform craniectomy was made in consultation with the patients’ relatives, and informed consent was obtained from them.

Surgical Technique

Decompressive craniectomy was done by removing parts of the frontal, parietal, temporal, and occipital squama, resulting in a large bone flap with a diameter of 12 – 14 cm. The dura was incised but no duroplasty performed. Temporalis fascia was placed over the arachnoid overlying the dural defect. Infarcted brain tissue was not excised. Post-operatively, the patients were managed in the intensive care unit. Cranioplasty was done about three months after discharge.

Anesthetic Technique (Narcotic-Based Anesthetic Technique)

- \textit{Posture}. Patients’ head was elevated to about 30°, and neck was kept in a neutral position.
- \textit{Induction of Anesthesia}. (1) Slow intravenous injection of propofol at dose of 1 – 2 mg/kg till loss of verbal contact (if present), avoiding undue decrease in systemic blood pressure that will exaggerate cerebral ischemia, pre-oxygenation and subsequent hyperventilation with 100% O\textsubscript{2} was instituted to avoid hypoxia and hypercarbia during induction; (2) The narcotic analgesic (Fentanyl) is then given at a dose 2 – 5 mcg/kg to provide adequate sound analgesia and to blunt increases in blood pressure and ICP associated with induction of anesthesia and endotracheal intubation; (3) Then 2 – 3 times the median effective dose (ED 95) of atracurium besylate (ED 95 = 0.45 mg/kg) is used to produce profound muscle relaxation and facilitate intubation; and this was used to maintain muscle relaxation intra-operatively at rate 5 – 10 mcg/kg / min; (4) Intravenous injection of lidocaine 1.5 mg / kg is used 90 seconds prior endotracheal intubation to attenuate hypertension response to laryngoscopy and intubation, (5) Mechanical hyperventilation was instituted with the aim of keeping PaCO\textsubscript{2} at a level of 25 – 30 mmHg.

- \textit{Maintenance of Anesthesia}. Anesthesia was maintained by the volatile anesthetic (isoflurane) at 0.6 MAC in 100% O\textsubscript{2} supplemented by additional opioids as needed.

\textbf{Intra-operative Monitoring}

(1) Continuous invasive monitoring of systemic BP via a catheter in a peripheral artery for rapid detection of undesirable changes; (2) caprography to achieve the desired degrees of hyperventilation; (3) nasopharyngeal temperature monitoring as unexpected changes in patients’ body temperature are possible; (4) urinary catheter if drug induced diuresis is planned during the peri-operative period; (5) ECG to detect arrhythmias related to increase ICP and to surgical manipulations; (6) peripheral nerve stimulation to monitor skeletal muscle drug induced relaxation and prevent sudden undesirable movement or strain; and (7) CVP line.

\textbf{Post-operative Recovery Management}

Anesthetics are withheld, so that their effects are dissipated and muscle relaxation is reversed to facilitate neurological status assessment and recognizing any adverse surgical effects. Intravenous lidocaine at dose of 0.5 – 1.5 mg/kg was administered to attenuate the hypertensive reaction to the tube while patient is awakened. Extubation was performed as early as possible guided by patients’ conscious level, presence of the protective airway reflexes, spontaneous ventilation that was sufficient enough to prevent hypercarbia, and body temperature which should be not less than 36 before extubation; as post-operative hypothermia (less than 34) leads to delayed recovery.

\textbf{Peri-operative Fluid Management}

Saline or glucose 5% in saline 0.9% is administered at rate of 1 – 3 ml/kg/hr with avoidance of excess fluids as this might increase the brain water content regardless the selected crystalloid. Whole blood or colloid solution was used to compensate for intra-vascular volume depletion which could take place intra-operatively. Intravenous Furosemide at dose 1 mg/kg is used to reduce cerebral water content and hence the ICP.
Statistical Analysis
Data analysis was carried out with the Statistical Package for Social Sciences (version 10.0, 1999; SPSS Inc. Chicago, IL, USA). Descriptive Statistics: Mean±SD, number and percentage; Analytic tests using the one sample t-test and independent t-test, Pearson correlation coefficient (r) was done for all continuous data and the probability (p) was obtained from the tables according to the degree of freedom and so significance was calculated. P-value < 0.05 was considered significant.

RESULTS
Patient Characteristics
There were eleven patients included in this study; all of them had complete MCA territory infarction (with or without ACA affection), and subjected to decompressive craniectomy whenever a clinical deterioration was observed. They were 8 (72.73%) males and 3 (27.27%) females, their age ranged from 42 to 61 years with a mean age of (52.54±6.5) years. Five patients (45.45%) were under 50 years of age.

The mean interval between first clinical symptoms and admission to hospital was (18.64±13.52) hours, with a range from 24 to 96 hours, and the mean overall time from stroke onset to surgery was (78.64±32.72) hours, with a range from 27 to 144 hours.

Two patients (18.18%) died in the post-operative period (within one week following surgery), their age was above 50 years; one patient (9.09%) died from acute respiratory distress syndrome, and the other died from a presumed brain herniation with documented evidence of brain stem compression (enlarged pupil, deepening of coma, and loss of brain stem reflexes) preceding death, for this patient post-operative CT scan could not be done because he was on mechanical ventilation.

For the other 9 patients (81.82%) who survived; the mean duration of hospital stay was (17.22±4.44) days with a range from 10 to 24 days. During the hospital course period, 4 patients (4 / 9) (44.44%) suffered from at least one of non-fatal post-operative complications, the frequency of these complications is shown in table (4).

Follow up and Functional Outcome
The mean post-surgical follow up period was (26.67±10.86) weeks, with a range from 16 to 52 weeks. The NIHSS scores on hospital admission, prior to surgery, and a week after surgery were recorded and are shown in table (5). There was a statistically significant improvement of neurological status on NIHSS post-operatively when compared with that pre-operatively or on admission.

At 3 months follow up, the mean Barthel Index for the nine survived patients was 60 (SD 16; range 35 – 75), and among the patients with dominant hemisphere stroke, the speech function improved in most.

Considering a Barthel index of > 70 points to be a good outcome, 36.36% of the patients (n = 4) made a good recovery, as compared with 45.45% (n = 5) with an unfavorable outcome (Barthel index <70).

We compared the post-operative NIHSS scores and BI score after 3 months among patients under 50 and those above 50 years of age; application of independent t-test revealed a statistically significant improvement on NIHSS score post-operatively and a significantly higher BI score for the below 50 years
group when compared to those for the above 50 years group. This is shown in table (6).

No significant difference was found between clinical improvement (assessed by post-operative NIHSS and BI) and gender, presence of other risk factors, or the side afflicted. Also, we found that though higher GCS scores on admission and preoperatively were associated with a favorable outcome, yet the correlation was not of statistical significance.

Upon correlating the neurological status (assessed by post-operative NIHSS score) and the functional outcome 3 months later (assessed by BI) on one side to both the duration between stroke onset and hospitalization, and the interval between stroke onset and decompression, we found that earlier hospitalization and earlier surgical intervention were associated with a statistically significant favorable outcome. This is demonstrated in table (7).

Table 1. Clinical data of included patients at time of admission and preoperatively.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Admission</th>
<th>Preoperatively</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCS (mean ± SD)</td>
<td>8.18 ± 1.83</td>
<td>5.82 ± 1.78</td>
</tr>
<tr>
<td>Hemiplegia/Severe hemiparesis (%)</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Forced eye deviation (%)</td>
<td>63.64%</td>
<td>81.82%</td>
</tr>
<tr>
<td>Aphasia (%)</td>
<td>27.27%</td>
<td>27.27%</td>
</tr>
<tr>
<td>Anisocoria (%)</td>
<td>18.18%</td>
<td>45.45%</td>
</tr>
</tbody>
</table>

Table 2: Detectable source of embolization.

<table>
<thead>
<tr>
<th>Presumed Source of Embolization</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rheumatic Heart Disease with subsequent dysrhythmia</td>
<td>5</td>
<td>45.45</td>
</tr>
<tr>
<td>Coronary Artery Disease and mural thrombi detected by (Trans-thoracic Echo “TTE”)</td>
<td>3</td>
<td>27.27</td>
</tr>
<tr>
<td>Lone AF</td>
<td>1</td>
<td>9.09</td>
</tr>
<tr>
<td>Artery to artery embolization</td>
<td>2</td>
<td>18.18</td>
</tr>
</tbody>
</table>

Table 3. Frequency of other risk factors.

<table>
<thead>
<tr>
<th>Other Risk Factors</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>4</td>
<td>36.36</td>
</tr>
<tr>
<td>Diabetes</td>
<td>5</td>
<td>45.45</td>
</tr>
<tr>
<td>Smoking</td>
<td>5</td>
<td>45.45</td>
</tr>
<tr>
<td>Truncal obesity</td>
<td>5</td>
<td>45.45</td>
</tr>
<tr>
<td>Peripheral Vascular Diseases</td>
<td>1</td>
<td>9.09</td>
</tr>
</tbody>
</table>

Table 4. Frequency of post-operative complications.

<table>
<thead>
<tr>
<th>Post-operative Complications</th>
<th>N (n=9)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding into the infarct area (detected by CT scan)</td>
<td>1</td>
<td>11.11</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>3</td>
<td>33.33</td>
</tr>
<tr>
<td>Gastrointestinal bleeding</td>
<td>1</td>
<td>11.11</td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>1</td>
<td>11.11</td>
</tr>
</tbody>
</table>
Table 5. NIHSS Scores on hospital admission prior to surgery and post-operatively.

<table>
<thead>
<tr>
<th>NIHSS Scores</th>
<th>Range</th>
<th>Mean</th>
<th>SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIHSS Scores on hospital admission (n=11)</td>
<td>15 – 24</td>
<td>18.64</td>
<td>2.73</td>
<td>0.000*</td>
</tr>
<tr>
<td>NIHSS Scores prior to surgery (n=11)</td>
<td>16 – 26</td>
<td>20.18</td>
<td>3.12</td>
<td></td>
</tr>
<tr>
<td>NIHSS Scores a week after surgery (n=9)</td>
<td>11 – 22</td>
<td>16.22</td>
<td>3.35</td>
<td></td>
</tr>
</tbody>
</table>

* Significant

Table 6. Post-operative NIHSS Scores and the BI score among patients under 50 and those above 50 years.

<table>
<thead>
<tr>
<th></th>
<th>Below 50 years</th>
<th>Above 50 years</th>
<th>P – value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIHSS Score</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>The BI Score</td>
<td>72</td>
<td>4.47</td>
<td>45</td>
</tr>
</tbody>
</table>

* Significant

Table 7. Correlation between clinical scale and the duration between stroke onset and both hospitalization and surgery.

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>P</th>
<th>r</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIHSS Score</td>
<td>0.845</td>
<td>0.004</td>
<td>0.946</td>
<td>0.000*</td>
</tr>
<tr>
<td>The BI Score</td>
<td>- 0.857</td>
<td>0.003</td>
<td>- 0.867</td>
<td>0.002*</td>
</tr>
</tbody>
</table>

* Significant

**DISCUSSION**

The management of patients with space occupying MCA infarction remains a particularly difficult challenge for clinicians charged with their care. Small and heterogeneously composed study groups, inadequately defined selection criteria, the absence of long term follow up evaluation, and ongoing uncertainties over the influence of treatment-independent prognostic factors hamper the comparative analysis of various treatment strategies. However, because those patients are at high risk of fatal brain edema, they are considered potential candidates for aggressive treatments, such as hemicraniectomy. Though over the past two decades, several studies documented that decompressive surgery is a possible treatment strategy for the uncontrollable raised ICP after severe hemispheric stroke with subsequent significant reduction in mortality and morbidity, yet there is no evidence from the extant literature of an evidence basis for the use of this procedure.

Our aim in the current study was to evaluate mortality and functional outcome scores for 11 patients who underwent decompressive hemicraniectomy for malignant MCA infarction (which was used as a second line treatment); we also set out to investigate whether there were prognostic factors independent of treatment that could predict the functional outcome. The principal aim of surgery was to save life, since 45.45% of our patients were under 50 years and did not have a concomitant serious medical illness.

All patients included in the present study received the optimum medical therapy in an intensive care unit, and the decision of surgery was done after they developed the first signs of neurological deterioration, with mean time to surgery after stroke onset was (78.64 ± 32.72) hours, and we recorded 18.18% mortality (2/11) in the post-operative period; on this context, the mean time to surgery in various reports ranges from 18 to 98 hours, and the mortality rates vary from 0% to 34.4% (table 8).
Table 8. Studies on hemicraniectomy in space-occupying MCA infarction.

<table>
<thead>
<tr>
<th>Author (Ref. No.)</th>
<th>Year</th>
<th>No. of Patients</th>
<th>Mean Age (Years)</th>
<th>Time to Surgery (hrs)</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rengachary et al. (17)</td>
<td>1981</td>
<td>3</td>
<td>31</td>
<td>76</td>
<td>0</td>
</tr>
<tr>
<td>Young et al. (18)</td>
<td>1982</td>
<td>1</td>
<td>59</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>Kondziolka &amp; Fazl (19)</td>
<td>1988</td>
<td>5</td>
<td>40</td>
<td>52.8</td>
<td>0</td>
</tr>
<tr>
<td>Delashaw et al. (15)</td>
<td>1990</td>
<td>9</td>
<td>57</td>
<td>76.4</td>
<td>11</td>
</tr>
<tr>
<td>Kalia &amp; Yonas (20)</td>
<td>1993</td>
<td>4</td>
<td>34.3</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>Rieke et al. (3)</td>
<td>1995</td>
<td>32</td>
<td>48.8</td>
<td>39</td>
<td>34.4</td>
</tr>
<tr>
<td>Carter et al. (21)</td>
<td>1997</td>
<td>14</td>
<td>49.2</td>
<td>98</td>
<td>21</td>
</tr>
<tr>
<td>Schwab et al. (16)</td>
<td>1998</td>
<td>31</td>
<td>50.3</td>
<td>21</td>
<td>16</td>
</tr>
<tr>
<td>Holtkamp et al. (30)</td>
<td>2001</td>
<td>12</td>
<td>64.9</td>
<td>42.4</td>
<td>33</td>
</tr>
<tr>
<td>Pranesh et al. (2)</td>
<td>2003</td>
<td>19</td>
<td>46.5</td>
<td>60.3</td>
<td>5.2</td>
</tr>
<tr>
<td>Present Study</td>
<td>2004</td>
<td>11</td>
<td>52.54</td>
<td>78.64</td>
<td>18.18</td>
</tr>
</tbody>
</table>

These mortality rates are far less than what was reported for this distinct syndrome of malignant MCA infarction under full supportive medical therapy, which was estimated by Hacke et al.\(^1\), and Ropper and Shafran\(^31\) to be 80% under optimum medical therapy; obviously; this achieve our primary goal in mortality reduction of those patients subgroup. Also this is consistent with studies in several cohorts of patients with large MCA infarction have shown that decompressive surgery can reduce mortality to less than 50%\(^{3,17,19,21}\).

Overall, 44.44% of the survived patients suffered from at least one postoperative complication, with pulmonary problems being the most common cause (33.33% of all complications) and 11.11% of the complications were directly related to surgery; this goes in accordance with what was reported by Uhl et al.\(^{28}\) in their database analysis, they recorded 42.4% overall post-operative complications, 39% of all complications were related to pulmonary problems, and 17.8% surgically-related complications.

Furthermore; we detected an improvement of neurological status on NIHSS post-operatively when compared with that pre-operatively or on admission; also we recorded a good functional outcome (Barthel index of ≥ 70 points) in 36.36% of our patients 3 months after the acute insults. Our study adds to the previous findings that suggest both mortality and functional outcome may be better after surgery\(^{2,3,17-21}\).

Among the patients with dominant hemispheric stroke (n=3), the speech function improved and they regained the capability of comprehension and they could communicate usefully with only minor degree of expressive dysphasia; this goes in accordance with several studies that reported good language recovery in some patients with dominant hemispheric strokes\(^{2,16,20}\). On the other hand; various studies have emphasized that hemicraniectomy must be offered only to patients with non-dominant hemispherical strokes, the reason being that speech is unaffected and functional outcome would therefore be better\(^{15,17-19,21}\). However; it is noteworthy that in the current study we selected patients with only incomplete aphasia before their clinical deterioration, which could explain the better language outcome.

Moreover, the functional outcome was better in younger age group (< 50 years), when compared to that of the above 50 years group; on the other view; we did not recognize significant difference between clinical improvement and gender, presence of other risk factors, or the side afflicted, and though higher GCS scores on admission were associated with a favorable outcome; yet the correlation was not of statistical significance. These results goes in accordance with several reports that documented a
better functional outcome in younger age group, and emphasized that age is the most important prognostic factor for clinical improvement following surgical decompression.2,16-21,23-29

Another considerable issue is the favorable post-operative neurological status and functional outcome in patients with earlier hospitalization and earlier surgical intervention. This goes in accordance with Schwab et al.16 who recommended early surgical intervention in those patients since delay in the surgical decision could allow mesencephalic ischemia to occur and potentially it would worsen prognosis; they also reported that the clinical course of patients with severe MCA stroke is highly predictable and therefore, waiting for a pupillary dilation causes an unnecessary delay. Further support for earlier intervention was proposed by Frank4 and Doerfler et al.32 who hypothesized that through decompressive surgery, the vicious circle of extensive edema, which causes ischemia of neighboring brain tissue and further infarction could be interrupted, and this might then increase cerebral perfusion pressure, thus allowing functionally viable brain to survive. Another obtained data from neuroradiological studies recognized that "early visual radiolucency" in the CT examination is a negative outcome predictor. Von Kummer et al.5 demonstrated that large (>50%) or total hypodensity in the MCA territory predicted fatal outcome in 85% of cases (11/13), with a high specificity (94%) but moderate sensitivity (61%). Taking into consideration both clinical course and neuroradiological data; Schwab et al.16 reported that early selection of patients for decompressive surgery led to a reduction in mortality in their series to only 16%. On the other view; Koh et al.27 recommended that decompressive craniectomy in the setting of acute brain swelling from cerebral infarction is a life-saving procedure and should only be considered in younger patients who have a rapidly deteriorating neurologic status. Furthermore; Gupta et al.33 found that the timing of surgery, presence of signs of herniation before surgery, and involvement of other vascular territories did not significantly affect outcome; and this was also emphasized by Uhl et al.28 who considered age as the most important pretreatment prognostic factor, and they reported that there is no definite conclusions can be drawn at present as to the optimum timing of surgical treatment.

Regarding the anesthetic techniques used for patients in the current study, the aim was to choose a technique that would help reducing ICP, yet having a minimal effect on cerebral perfusion pressure (CPP) and in the same time allowing early recovery from the effects of anesthetic drugs helping early post-operative neurological status assessment. Patients’ position was maintained while their head elevated to about 30° to help in lowering ICP by encouraging venous outflow from the brain, thus lowering ICP while not affecting CPP, cerebral blood flow (CBF), or cerebral O2 extraction; the neck was kept in a neutral position to prevent kinking of jugular veins and obstruction of venous return. A combination of propofol with narcotic analgesic (Fentanyl) was used during induction of anesthesia as a safe maneuver to block the increase of ICP in response to tracheal intubation. This was documented by Tseitlin et al.11 who added that this combination does not only block ICP increase in response to laryngoscopy and tracheal intubation, but also does not appreciably decrease CPP. The usage of atracurium was safe as ICP is not altered after its administration, despite its potential role in histamine release and subsequent stimulation of central nervous system.35 On the other hand; because Succinylcholine can transiently increase ICP, thus it was not used routinely unless specifically indicated. Intravenous injection of lidocaine was used before intubation and during recovery to effectively attenuate increases in systemic blood pressure and ICP that might occur in response to endotracheal intubation.36 During mechanical hyperventilation; positive end expiratory pressure (PEEP) was not utilized as it could impair cerebral venous drainage, leading to increase ICP.

Moreover, the initiation of hyperventilation during maintenance of anesthesia simultaneously with introduction of the volatile anesthetic (isoflurane) into inspired gases prevent the increase in ICP that occurs at normocarbia, as it does not alter the production of CSF.7 Also it produces reduction in CMRO2 that exceeds those produced by an equivalent MAC concentration of halothane.32 The greater decrease in CMRO2 produced by isoflurane may explain why CBF increases are minimal, as decreased cerebral metabolism results in lesser production of CO2, which thus opposes cerebral vasodilatory effects of isoflurane. All volatile anesthetics reduces CMRO2 but only isoflurane does so to an extent similar to intravenous anesthetics.
An adequate depth of anesthesia and profound skeletal muscle paralysis was required, as perception of noxious stimulation can abruptly increase the cerebral metabolic O₂ requirement (CMRO₂), CBF, and ICP. Abrupt, sustained increases in ICP observed in continuous monitoring are known as “Plateau Waves” that characteristically occur when ICP increases to as high as 100 mmHg; during these increases patients might become symptomatic and spontaneous hyperventilation can occur. Typically plateau waves last for 10 to 20 minutes, after which ICP rapidly decreases to level below that present before their onset; it is thought that abrupt increases in intracranial blood volume may be responsible for the occurrence of plateau waves. Events that can initiate these “Plateau Waves” include anxiety, painful maneuvers, and induction of anesthesia; these factors could elicit large increases in oxygen consumption and CBF with subsequent increases in ICP. These increases of ICP on top of an already elevated ICP can lead to abrupt elevations of ICP. Therefore; noxious stimuli should be avoided in patients with elevated ICP regardless the level of consciousness, and hence liberal use of analgesics to avoid or treat pain even in the unresponsive patients is indicated.

In conclusion; decompressive hemicraniectomy is a life-saving procedure, and should be considered as a second line therapy in patients with massive MCA infarction in non-dominant hemispheric affection or in dominant one but with incomplete aphasia. It is recommended for those patients whenever a rapidly deteriorating neurological status is detected. Age is a crucial factor in predicting functional outcome after surgery. Safe techniques to obtain an adequate depth of anesthesia; yet, ensuring faster post-operative recovery are mandatory.

REFERENCES


الملخص العربي

القطع القحفى (الجمجمى) النصفي في علاج الانسداد المستفحل (الكامل) للشريان المخى الأوسط

يُعتبر القطع القحفى النصفي أحد خطوات علاج السكتات الدماغية الناشئة من الانسداد الكامل الحاد للشريان المخى الأوسط، و قد زاد الاهتمام حديثاً بالدور الذي يمكن أن يلعبه هذا التجفيف الجراحى ليس فقط في تقليل نسبة الوفيات بل و في تحضير درجة الإعاقة و تحسین المال الوظيفي لل환اء المرضى.

وقد أُستشهدت هذه الدراسة تحديد فائدة التجفيف الجراحى بالقطع القحفى النصفي و دوره في علاج هذا النوع من السكتات الدماغية. هذا و قد أنشئت هذه الدراسة على أحد عشرة مرضى تتراوح أعمارهم ما بين 42 عاماً و 61 عاماً (بمتوسط عمر 52.54 عاماً). و قد أجري تقييم حالة المرضى من خلال الفحص السريري والذي شمل التقييم العصبي مع استبان السكتات الدماغية لتحديد درجة الإعاقة الحركية و إجراء مقياس جلاسجو للذكاء و معدل بارتل بالإضافة إلى الأشعة المقطعية على المخ. هذا و قد تم استيعاب تقييم حالة المرضى عبر طرق معدل بارتل بعد 3 أشهر من التجفيف الجراحى. و قد تم اتخاذ قرار التجفيف الجراحى بعد ظهور أول أعراض الإفراط المخى و ذلك بعد فترة من إعطاء العلاج الدوائي المثالي لحالاتهم، و قد تراوحت فترة العلاج التحفظي من 24 ساعة حتى 96 ساعة.

و قد أظهرت النتائج أنه حدوث وفيات في 18.18% مع ظهور واحداً من المضاعفات غير المميتة على الأقل في 4.44% من المرضى. وقد تحسنت حالة المرضى من حيث درجة الوعي و درجة الإعاقة الحركية و الكلام (في حالة وجود الحبسة الكلامية) بعد الجراحة مقارنة بما قبلها بفارق ذئ دلالة إحصائية و كان هذا التحسن واضح في الفئة العمرية الأقل من خمسين عاماً.