Complications of Decompressive Craniectomy

Sandra Ho, BS
Jefferson Medical College, sandra.ho@jefferson.edu

Yinn C. Ooi, MD
UCLA, yooi@mednet.ucla.edu

Muhamad A. Sheikh, MBBS
Dow Medical College, Karachi Pakistan, muhamad.sheikh@jefferson.edu

Mitchell Maltenfort, PhD
Rothman Institute, mmalten@gmail.com

Jack Jallo, MD, PhD
Thomas Jefferson University, jack.jallo@jefferson.edu

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Resolution of CCFs has been reported after angiography, where a clot developed during the procedure in the internal carotid artery, possibly occluding the arteriovenous connection in a similar mechanism as just described. Similar events have been described soon after gamma knife radiotherapy, also potentially secondary to a thrombolytic event from the angiography used during the treatment planning, and not from an acute radiation effect.

Bujak et al. reported 2 patients with dural CCF causing severe clinical manifestations that spontaneously resolved before endovascular intervention. Unlike the present case, obliteration of the CCF was associated with a concomitant resolution of orbital signs and symptoms. Sergot and colleagues reported 2 patients with CCF that developed spontaneously and thrombosis of the SOV with an acute worsening of symptoms. In contrast to our case, however, thrombosis of the SOV in these 2 patients was not associated with an obliteration of the fistula. One case is therefore unique, since there was an acute worsening in the orbital signs and symptoms caused by a spontaneous thrombosis of the SOV and an angiographically documented complete cure of the CCF. Acute thrombosis of SOV with probable extension proximally into the cavernous sinus accounted for the resolution of the CCF. Since the SOV provides the major drainage pathway for the cavernous sinus, acute thrombosis and subsequent cavernous sinus occlusion might explain this case. In addition, since the orbital veins are valvule less, some orbital drainage may occur in an antegrade fashion from the SOV to the facial venous system and inferiorly through connections with the pterygoplatine venousplexus, even with an active CCF. Subsequent thrombosis of the SOV may temporarily block off these alternate drainage routes.

Thrombosis of the SOV in all likelihood resulted in stagnation of abnormal blood flow within the cavernous sinus, precipitating the occlusion of the orbital venous outflow from the cavernous sinus to the facial venous system and inferiorly through connections with the pterygoplatine venousplexus, even with an active CCF. Subsequent thrombosis of the SOV may temporarily block off these alternate drainage routes. Acute thrombosis of SOV is a gold standard for diagnosis, there is no role for endovascular therapy and the management is focused on managing the acute arteriovenous shunt and raised intracranial pressure.

References

Complications of Decompressive Craniectomy

Sandra Ho, BS1; Yinn Cher Ooi, MD2; Muhammad Adil Sheikh, MBBS3; Mitchell Maltenfort, PhD4; Jack Jalal MD, PhD5
1Jefferson Medical College, Philadelphia, Pennsylvania
2Neurosurgery Department, UCLA, Los Angeles, California
3Doe Medical College, Karachi, Pakistan
4Rothman Institute, Philadelphia, Pennsylvania
5Jefferson Department, Thomas Jefferson University, Philadelphia, Pennsylvania

Introduction

Persistent elevation of intracranial pressure (ICP), if untreated, may lead to brain ischemia or lack of brain oxygen and even brain death. 1-3 When standard treatments for elevated ICP are exhausted without any signs of improvement, decompressive craniectomy can be an effective alternative solution. 4,5 Decompressive craniectomies (DC) have been used as a method of controlling intracranial pressure in patients with cerebral edema secondary to cerebral ischemia, subarachnoid hemorrhage (SAH), and traumatic brain injury (TBI), among others. 6-8 Several studies over the years have demonstrated the efficacy of this procedure. 9,10 However, consensus is still lacking in the utility of DC as an effective first tier treatment for intractable intracranial pressure due to the rudimentary neurological outcome assessments, and the many complications associated with this procedure. 11,12

There are a limited number of studies that have looked at complications secondary to the procedure itself. 13-17 The majority of these studies only investigated the impact of this procedure in patients with traumatic brain injury. The purpose of this study is to investigate the rates of various complications associated with the decompressive craniectomy procedure in patients that did not suffer from traumatic brain injury, and to determine whether the same associations between preoperative parameters and development of complications can be made.

Methods

A retrospective review of a prospectively collected data set of patients who had a decompressive craniectomy done at our institution between January 2003 and January 2010 was performed. Electronic charts were reviewed to obtain the following data: patient age, gender, diagnosis, type of decompressive craniectomy, any complications following the procedure, patient outcome as measured by Glasgow coma scale (GCS) as discharge, time period between craniotomy and craniectomy and type of flap used for cranioplasty. Rates of various complications were tabulated and we investigated the association of several patient parameters with patient outcome, and rates of the various complications. These factors included age, gender and preoperative GCS.

Appropriate statistical tests were used to determine the strength of associations. Spearman’s p, Student’s t-test and multivariate regression were performed using the JMP statistical package (version 7.02; SAS Institute, Cary NC).

Results

191 patients were identified, including 89 females, 91 males. The mean age was 50 years old (range 17-85). The mean preoperative GCS score was 8 (range 3-15). 70 patients had intracerebral hemorrhage (36.6%), 60 had ruptured aneurysm (31.4%), 21 had brain edema secondary to a prior elective brain surgery (11%), 15 had stroke (7.8%), 11 had closed head trauma (5.7%), 4 had thrombosed aneurysm (2.1%), 3 had ruptured arteriovenous malformation (AVM) (1.6%), 2 had penetrating trauma (1.0%), 1 had tumor (0.5%), and 3 were unreported (1.6%). A bifrontal craniectomy was performed on 4 cases (2.1%) and 187 were unilateral craniectomies (97.9%). The incidences of complications are summarized in Table 1.

Table 1. Complications following Decompressive Craniectomy

<table>
<thead>
<tr>
<th>Complication</th>
<th>N (%)</th>
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<tbody>
<tr>
<td>Hydrocephalus</td>
<td>55 (28.7)</td>
</tr>
<tr>
<td>Fibrin sift</td>
<td>47 (24.9)</td>
</tr>
<tr>
<td>Herniation</td>
<td>40 (21.9)</td>
</tr>
<tr>
<td>Vasospasm</td>
<td>10 (5.2)</td>
</tr>
<tr>
<td>Subdural hygroma</td>
<td>18 (9.4)</td>
</tr>
<tr>
<td>Seizures</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Suture flap</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Flap resorption</td>
<td>0</td>
</tr>
<tr>
<td>Increased ICP</td>
<td>4 (2.1)</td>
</tr>
<tr>
<td>Infarct</td>
<td>2 (1.0)</td>
</tr>
</tbody>
</table>

Pneumonia was the commonest infection in this study

101 of the 191 patients (53%) had at least one complication. 42 patients died despite the procedure. Of the survivors (n = 149), a significant number were discharged to rehabilitation (n=121), 8 were discharged to full time nursing facilities, 2 remained in the hospital, 1 was discharged to hospice, and the rest returned home (n = 13). Three cases did not report discharge destination. There was no correlation between age and mortality. 10 patients had a preoperative GCS score ranging from 6 to 6, 40 were between 6-8 and 68 patients had scores greater than 8. Mean preoperative GCS scores were 3.8±1.0 (mean±SD) above preoperative GCS scores. Patients with higher pre-op GCS scores or older age tended to have higher GCS upon discharge (r=0.99). Female patients and patients that had one or more complications had lower GCS scores upon discharge (p<0.001). Neither gender nor age was associated with either incidence or total number of complications. Patients that had a

Conclusions

Paradoxical worsening ofocular symptoms in presence of complete obliteration of a CCF is extremely rare and possibly triggered by thrombosis of the SOV. Although DSA is the gold standard for diagnosis, there is no role for endovascular therapy and the management is focused on managing the acute arteriovenous shunt and raised intracranial pressure.
fewer number of complications had a higher GCS score upon discharge (Spearman’s rho = -0.1717, p=0.064).

As a priori analysis comparing various patient parameters (age, gender, diagnosis, initial GCS and delta GCS) against rate of individual complications and total number of complications per patient did not reveal any statistically significant associations.

Cranioplasty was performed in 90 patients, with 19 patients needing to undergo reoperation due to infection that required bone flap removal. In 62 patients, autologous bone flap was used. Eleven patients used a synthetic bone flap made of either titanium mesh or methylmethacrylate.

The average time between craniotomy and cranioplasty was 156 days and ranged from 11-540 days. Table 2 shows the data for the patient population who underwent cranioplasty after decompressive craniectomy.

Discussion

Brain edema requiring medical intervention occurs in a variety of conditions and may cause ICP elevation. Persistent ICP elevations have been associated with poor clinical outcomes after aneurysm rupture.12,13 Decompressive craniectomy is a relatively quick surgical procedure that is able to relieve elevating pressures. However, despite many studies demonstrating its efficacy in reducing ICP, there remain questions about the complications of this surgical approach and whether certain preoperative parameters can better predict the chances of developing complications.12-14

Despite many studies looking into the efficacy of the procedure, limited studies have attempted to look at the complications following decompressive craniectomies and its association with preoperative measurements such as age, gender and preoperative GCS score.15,16 Table 3 summarizes the complications from different studies. Among the studies, the most common complications were subdural effusions and hydrocepha.14,15,16,17,18 Unlike prior studies that investigated patients with traumatic brain injury, our study consists mainly of patients who suffered from subarachnoid hemorrhage.

Complications

Complications such as herniation, subdural effusion, seizures, hydrocephalus, hematomas and infections have been found consistently across different studies. The fluctuation in rates between inciting injury and the infection have been found consistently across different studies. The fluctuation in rates between the studies may indicate the differences in the development of persistent hydrocepha.19

Subdural effusion or hydrocepha Subdural effusions have been found to be very common after decompressive craniectomy.20,21 The incidence rate across different studies has been found to range from 26% to 60%.22,23 We found that 9% of our patients had subdural hygromas at a mean post-operative day of 16, which was consistent with data from previous studies by Yang et al. and Stiver et al., which reported effusions occurring around 8-30 days post-operation. Studies have attributed the occurrence of subdural effusions to altered CSF dynamics after decompressive craniectomy.20,24 However, many studies show that intervention with hygromas are not needed and many resolve on their own. Yang et al. found that 20 out of 23 hygromas resolved on their own without any neurological deficits.22 Aarabi et al. and Stiver had similar results.25,26

Herniation

Herniations, defined as brain expansion outside the skull, like subdural hygromas, are a common complication following decompressive craniectomy. They can be a result of hyperperfusion of brain tissue or an increased transcapillary leakage due to the drop in intracranial hydrostatic pressure.21 This can cause pinching of cortical veins or laceration of brain tissue near the defect opening, resulting in ischemia and necrosis of herniated tissue.22 Larger openings have been shown to allow the brain to expand outward with less constriction and can reduce the risk of problems associated with this type of herniation.23

Seizures

Our low rates of seizures (1%) could be attributed to the fact that all patients undergoing decompressive craniectomies were placed on an anti-seizure medication, Dilantin (Phenytoin). This was in contrast to Honeybul et al., who found 22% of patients had seizures following decompressive craniectomies, but anti-seizure medication was not a contraindication to cranioplasty, unless the patient was already on such medication.24 Ban et al. also used prophylactic antiepileptic medication and had lower rates of seizures.25

Syndrome of the Trephined Syndrome of the trephined, or sinking flap syndrome is characterized by a group of symptoms such as dizziness, seizures, headaches and mood changes.26 The absence of the bone flap after decompressive craniectomy can cause the scalp to sink into the defect, resulting in the aforementioned early complications. Early cranialplasty, performed before the flap has sunk has been recommended, but there has not yet been definitive evidence demonstrating whether this is more beneficial than a later cranialplasty.27,28 An alternate procedure known as hinge craniotomy that does not require a subsequent cranialplasty could prevent this syndrome from occurring, and has been suggested to be just as efficacious as traditional cranialplasties.27,29

Parameters affecting cranialplasty outcomes

The literature has demonstrated two major methods for preserving the bone flaps after decompressive craniectomy, either in the freezer or subcutaneously.30-34,35,36 In addition, there has been a method described where the bone flap is replaced as part of the procedure and connected to the rest of the skull in a hinge fashion. There have been limited studies looking at the complications of this method compared to traditional cranialplasty after decompressive craniectomy. Of the studies that did, both demonstrated that hinge craniotomy was just as efficacious as traditional craniotomy and eliminated the need for a cranialplasty procedure.37,38 In this study, we looked at infection rates following cranialplasty and differences in bone flap preservation across multiple studies (Table 4). Our infection rate (21%) was higher than other studies. This could be attributed to our method of storing bone flaps in the freezer, in addition to the high rate of synthetic bone flap use, which has been shown to be associated with higher rates of infection.39

Table 2. Literature Summary of Complications following Decompressive Cranietomy

<table>
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<tbody>
<tr>
<td>Herniation</td>
<td>40 (21%)</td>
<td>30 (28%)</td>
<td>21 (51%)</td>
<td>43 (26%)</td>
<td>20 (26%)</td>
<td>25 (50%)</td>
</tr>
<tr>
<td>Subdural effusion</td>
<td>17 (9%)</td>
<td>29 (33%)</td>
<td>23 (21%)</td>
<td>25 (62%)</td>
<td>80 (49%)</td>
<td>10 (26%)</td>
</tr>
<tr>
<td>Seizures</td>
<td>4 (1%)</td>
<td>4 (4%)</td>
<td>3 (3%)</td>
<td>6 (14%)</td>
<td>36 (22%)</td>
<td>2 (6%)</td>
</tr>
<tr>
<td>Hydrocepha</td>
<td>55 (29%)</td>
<td>10 (11%)</td>
<td>10 (9%)</td>
<td>5 (11%)</td>
<td>23 (14%)</td>
<td>3 (6%)</td>
</tr>
<tr>
<td>Bone flap infection</td>
<td>15 (14%)</td>
<td>15 (11%)</td>
<td>20 (12%)</td>
<td>9 (17%)</td>
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<td>2 (6%)</td>
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<td>Infection</td>
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<td>3 (3%)</td>
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<td>7 (11%)</td>
<td>2 (5%)</td>
</tr>
<tr>
<td>Bone flap resorption</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Mean age</td>
<td>50 ± 51</td>
<td>64 ± 50</td>
<td>44 ± 32</td>
<td>32 ± 25</td>
<td>43 ± 25</td>
<td>43 ± 25</td>
</tr>
</tbody>
</table>

*Includes Pneumonia, urinary tract infection, sepsis, and staphylococcal infection.

Table 3. CranioPlasty Patient Characteristics

<table>
<thead>
<tr>
<th>N (%)</th>
<th>Total cranioPlasty procedure</th>
<th>Autologous flap</th>
<th>Synthetic flap</th>
<th>Not recorded</th>
</tr>
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<tbody>
<tr>
<td>59 (100%)</td>
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Table 4. Complication Details in Multiple Studies

<table>
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<td>2 (6%)</td>
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<td>3 (3%)</td>
<td>6 (17%)</td>
<td>7 (11%)</td>
<td>2 (5%)</td>
</tr>
<tr>
<td>Bone flap resorption</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
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</tbody>
</table>
A short time between craniectomy and cranioplasty has been associated with poorer outcomes. 45, 46 Bob et al. found that cranio- plasties taking place 1-6 months after craniectomy had the highest complication rate (79%) compared to those performed 12-18 months after craniectomy (4.5%). 47 However, Beauchamp et al. found that earlier cranio- plasties taking place 2-6 weeks rather than the more typical 3-6 months did not produce significantly more complications. They also found that there were higher rates of infection in those with synthetic materials compared with those with autograft material. 48

**Limitations**

There was no randomization in this study. Most of the patients used in this study did not suffer from traumatic brain injuries. The low percentage of bone flap resorption may be attributed to limited follow-up. As a result of limited follow-up, no measure of long-term outcomes were made. We used GCS as an outcome measure, which could be argued to be a fairly vague neurological assessment. The differences in time between craniectomy and cranioplasty were due to inter-surgeon variations on the best time to perform a cranioplasty. The vast majority of patients in this study were SAH patients, with very few TBI patients. There may be differences in the outcome of decompressive craniectomy in SAH versus TBI patients.

**Conclusions**

Decompressive craniectomy is a proven method used to reduce intractable intracranial pressure. However, there are a number of complications associated with this procedure. This study, unlike many prior studies that included patients with traumatic brain injury, mainly had patients that suffered from subarachnoid hemorrhage. Also, unlike the other studies that found associations between preoperative GCS scores, age, and the development of complications, our study did not find any significant associations between age, gender, diagnosis and preoperative GCS score with the incidence or total number of complications. Such results argue against the possibility of potential predictors of complications in patients that suffer from subarachnoid hemorrhage and suggest that predictors of complications may depend on the type of injury.

There was no correlation between age and death from decompressive craniectomy. Older patients generally tended to have better GCS scores upon discharge, but female patients and patients with any complication tended to have lower GCS discharge scores.

In comparing our data along with the other studies utilizing freezor storage with studies utilizing subcutaneous bone flap storage there was a higher rate of infection in patients that had their bone flaps stored in a freezer compared to those that were stored subcutaneously. Certainly, larger scale prospective studies are warranted to determine the risk and benefits of both bone flap storage methods.

**References**


