Complications of Decompressive Craniectomy

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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 manner as just described. Significant events have been described soon after gamma knife radiotherapy, also potentially secondary to a thromboembolic event from the angiogram 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. Sargent and colleagues reported 2 patients with CCF that developed spontaneous 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 resolu-
tion of the CCF. Since the SOV provides the major outflow for the conjunctival and episcleral venous plexus, an acute thrombosis may result in rapid occlusion of the orbit.

Worsening of the orbital and ocular symptoms does not always represent persistence or progression of the arterio-venous fistula, as in this case illustrates. In cases of presumed sponta-
eneous SOV thrombosis, the use of DSA has been questioned, since the diagnosis of SOV thrombosis can be made with MRI. However, the MRI signal characteristic of thrombosis evolve over time and may be difficult to interpret accurately in the SOV. The clinician is then left in a quandary of “wasting out” a possible thrombosis and delaying DSA or proceeding with timely DSA to confirm thrombosis or treat a worsening CCF. Despite the inherent risks of DSA, we support the use of this modality in cases of acute worsening of orbital signs, since spontaneous SOV thrombosis is a rare event, and delay in definitive care in the face of an acute, severe ORCS may result in permanent visual loss.

Conclusions
Paradoxical worsening of sicca 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 options and the management is focused on managing the acute optic neuropathy and raised intracranial pressure.

References

Figure 4
MRI Gradient Echo sequence showing arrow depicts SOV compatible with thrombosis within

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Introduction
Persistent elevation of intracranial pressure (ICP), if untreated, may lead to brain ischemia or lack of brain oxygen and even brain death.1-5 When standard treatments for elevated ICP are exhausted without any signs of improvement, decompressive craniectomy can be an effective alternative solution.1-7,8 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.1-4 Several studies over the years have demonstrated the efficacy of this procedure.9-11,26 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.1,2,3,5,6,7,8,9,10,11,26,28,29 There are a limited number of studies that have looked at complications secondary to the procedure itself.11-12 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) at discharge, time period between craniotomy and cranial flap 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 ρ, 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 99 females, 91 males. The mean age was 50 years old (range 17-84). The mean preoperative GCS score was 8 (range 3-15). 70 patients had intracerebral hemorrhage (41.9%), 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 thalamotomy aneurysm (2.1%), 3 had ruptured arteriovenous malformation (AVM) (1.6%), 2 had penetrating trauma (1.4%), 1 had tumor (0.5%), and 3 were unreported (1.6%). A bilateral craniectomy was performed on 4 cases (2.1%) and 187 were unilateral craniectomies (97.9%).

In the postoperative period, 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.

19 patients had a preoperative GCS score ranging from 1 to 5. 8 patients ranged from 6-9 and 33 patients were greater than 9. The mean preoperative GCS score was 8. Twelve patients had a postoperative GCS score of 6 or less, 40 were between 6-9 and 68 patients scored greater than 9. Mean postoperative GCS scores were 3.8±1.49 (mean±SD) above preoperative GCS scores. Patients with higher pre-op GCS scores or older age tended to have higher GCS upon discharge (p=0.091). Female patients and patients that had one or more complica-
tions had lower GCS scores upon discharge (p=0.016). Neither gender nor age was associated with either incidence or total number of complications. Patients that had a

| Table 1. Complications following Decompressive Craniectomy |
|----------------------|----------------------|----------------------|----------------------|
| Complication          | N (%)               | N (%)               | N (%)               |
| Hydrocephalus         | 35 (22.7)           | 6 (3.1)             | 29 (15.2)           |
| Herniation            | 17 (11.4)           | 3 (1.6)             | 14 (7.8)            |
| Vertebralspasm        | 40 (25.9)           | 10 (5.2)            | 30 (16.5)           |
| Subdural hygroma      | 18 (9.4)            | 2 (1)               | 16 (8.9)            |
| Seizures              | 2 (1)               | 5 (2.7)             | 1 (0.5)             |
| Sudden flap           | 2 (1)               | 7 (4.7)             | 5 (2.7)             |
| Flap resorption       | 0                   | 0                   | 0                   |
| Increased ICP         | 4 (2.7)             | 0                   | 4 (2.7)             |
| Infection*            | 42 (21.9)           | 1 (0.5)             | 41 (22.7)           |

*Pneumonia was the commonest infection in this study.
It could also be attributed to high rates of subarachnoid hemorrhage, which has been shown to be associated with increased rates of hydrocephalus.\textsuperscript{44-46} Waitzi et al. have found a strong correlation between prolonged time to replacement of the bone flap and persistence of hydrocephalus and recommend that early cranioplasty be performed to restore normal intracranial pressure and prevent the development of persistent hydrocephalus.\textsuperscript{47}

Subdural effusion or hygroma

Subdural effusions have been found to be very common after decompressive craniectomy.\textsuperscript{5,8,12} The incidence rate across different studies has been found to range from 20% to 60%.\textsuperscript{38,39,40,41,42} 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.\textsuperscript{43,44} 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.\textsuperscript{45} Ahari et al. and Stiver have had similar results.\textsuperscript{46,47}

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 hyperextension of brain tissue or an increased transcapillary leakage due to the drop in intrastitial hydrostatic pressure.\textsuperscript{48} This can cause pinching of cortical veins or laceration of brain tissue near the defect opening, resulting in ischemia and necrosis of herniated tissue. Langer openings have been shown to allow the brain to expand outward with less constricting and can reduce the risk of problems associated with brain herniation.

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 in contrast to Honeybol et al. who found 22% of patients had seizures following decompressive craniectomies, but anti- seizure medication was not used in this patient, unless the patient was already on such medication.\textsuperscript{49} Ban et al. also used prophylactic anti-epileptic medication and had lower rates of seizures.\textsuperscript{50}

Syndrome of the Transtentorial Syndrome of the transtentorial, or sinking flap syndrome is characterized by a group of symp- toms such as dizziness, seizures, headaches and mood changes.\textsuperscript{40} The absence of the bone flap after decompressive craniectomy can cause the scalp to sink into the defect, resulting in the aforementioned early complications. Cranio-ulcer, 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 cranio-ulcer.\textsuperscript{41,42} An alternate procedure known as hinge cra- nioplasty that does not require a subsequent cranioplasty could prevent this syndrome from occurring, and has been suggested to be just as effective as traditional cranioplasty.\textsuperscript{43}

Parameters affecting cranioplasty outcomes

The literature demonstrates two major methods for preserving the bone flaps after decompressive craniectomy, either in the freezer or subcutaneously.\textsuperscript{15,43,44,50,51} In addi- tion, there has been a method described where the bone flap is replaced as part of the proce- dure 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 cranioplasty after decompressive craniectomy. Of the studies that did, both demonstrated that hinge crani- oplasty was just as effective as decompressive craniectomy and eliminated the need for a cranioplasty procedure.\textsuperscript{15,45}

In this study, we looked at infection rates following cranioplasty and differences in bone flap preservation across multiple studies (Table 4). Our infection rate (7%) 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.\textsuperscript{52,53}
A short time between craniectomy and cranioplasty has been associated with poorer outcomes.

Rob et al. found that cranioplasties taking place 1-6 months after craniectomy had the highest complication rate (79%) compared to those performed 12-18 months after craniectomy (4.5%). However, Beauchamp et al. found that earlier cranioplasties taking place 2-6 weeks rather than the more traditional 3-6 months did not produce significantly more complications. They also found that there were higher rates of infection in patients that had their bone flaps stored in a freezer compared to those that were stored subcutaneously.

Conclusions

Decompressive craniectomy is a proven method used to reduce intracranial pressure. However, cranioplasty and cranioplasty associated complications have a significant impact on patient outcomes. This study shows a potential correlation between age and death from decompressive craniectomy. Older patients generally tended to have better grades of decompression upon discharge, but female patients were more likely to have complications with any patients with any complication tended to have lower GCS discharge scores.

In comparing our data along with the other studies utilizing freezere 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