Decompressive craniectomy with massive intractable intraoperative cerebral edema: utilization of silicone sheet for temporary scalp closure

Case report

AMIR AHMADIAN, M.D.,1 ALI A. BAAJ, M.D.,1 MICHAEL GARCIA, M.D.,2 CAROLYN CAREY, M.D.,1,3 LUIS RODRIGUEZ, M.D.,1,3 BRUCE STORRS, M.D.,1,3 AND GERALD F. TUTTE, M.D.1,3

1Department of Neurosurgery, University of South Florida, Tampa; and 2Department of Anesthesia and 3Neuroscience Institute, All Children’s Hospital, Saint Petersburg, Florida

The authors present a case of extreme brain herniation encountered during decompressive craniectomy in a 21-month-old boy who suffered a trauma event that necessitated temporary scalp closure in which a sterile silicone sheet was placed. Although the clinical situation is usually expected to lead to brain death or severe disability, the patient’s 3-year follow-up examination revealed a highly functional child with a good quality of life. The authors discuss the feasibility and advantages of temporary scalp expansion as a treatment option when extreme brain herniation is encountered during craniotomy.

(http://thejns.org/doi/abs/10.3171/2012.6.PEDS11567)

Key Words • decompressive craniectomy • cranioplasty • cerebral edema • scalp closure • silicone • trauma

Decompressive craniectomy is a well-established technique in the management of elevated ICP and the prevention of brain herniation. It has been used in a variety of conditions associated with increased ICP (for example, tumor, encephalitis, stroke, and traumatic brain injury) in conjunction with maximal medical therapy for refractory persistently elevated ICP. The acute benefits of decompressive craniectomy are well established in the literature, but more recent studies question the long-term outcomes.

The surgical technique for decompressive craniectomy is surgeon dependent, and no standard guidelines exist regarding type or size of the craniectomy, the performance of durotomy, and/or the type of duraplasty. Intraoperative cerebral edema can usually be managed with CSF drainage, head elevation, hyperventilation, mannitol, and hypertonic saline boluses. Strategic regional lobectomy can be performed when intraoperative brain swelling precludes scalp closure. In the present report, we describe a case of massive intraoperative cerebral edema that was refractory to conventional measures and necessitated the temporary augmentation of the scalp with a sterile silicone substitute to allow for adequate closure. To the best of our knowledge, this treatment has not been previously described in the literature.

Case Report

Clinical Presentation to Another Facility and First Operation. This 21-month-old boy, victim of suspected nonaccidental trauma, presented to an outside hospital with a closed-head injury, maxillofacial fractures, multiple rib fractures, pulmonary contusion, and a suspected liver laceration. He was unconscious, with a Glasgow Coma Scale score of 5, and he had a dilated nonreactive left pupil. The patient immediately underwent craniotomy for evacuation of an acute subdural hematoma (Fig. 1). At the time of his initial operation, the surgeons noted persistent oozing from the parasagittal subdural space and significant brain swelling even after the large hemispheric subdural hematoma was evacuated. Medial packing of hemostatic material in the subdural space stopped the bleeding. The craniotomy flap was left out, and a contralateral ICP monitor was placed prior to his care being transferred to one of the authors (G.F.T.).

This article contains some figures that are displayed in color online but in black-and-white in the print edition.
Transfer of Care and Clinical Course in the First 6 Hours. After the first operation, the child remained intubated and ventilator dependent. He was unresponsive to verbal stimulation. He briskly localized to painful stimuli with his left hemibody and withdrew on the right side. His pupils were symmetrical, reactive, and his gaze was conjugate. His ICP was initially 15–20 mm Hg. His incision site oozed blood, and he showed signs of DIC (prothrombin time 18.2 seconds, platelet count 84,000 thrombocytes/ml³). Despite receiving a transfusion of packed red blood cells, replacement of coagulation factors, treatment of a gradual rise in ICP with hypertonic saline, sedation, and mannitol, the patient’s status declined over the ensuing 4 hours. His ICP climbed into the 25–40 mm Hg range, and he developed a dense right hemiplegia with an associated 6-mm nonreactive left pupil. Head CT scanning revealed severe swelling and hypodensity in the left hemisphere, evidence of herniation, and a large subdural hematoma along the left medial, inferior, and posterior intracranial spaces (Fig. 2).

Second Emergency Operation and Application of Silastic Sheet. As the child was being transported to the operating room for reexploration, both pupils became fixed and dilated. On skin incision, the patient’s brain dramatically herniated through the skin, and we observed associated diffuse bleeding consistent with the clinical picture of DIC. The child became profoundly hemodynamically unstable, and the bleeding sites were packed with hemostatic agents for approximately 15 minutes while the anesthesiologists resuscitated the child with more blood products, fresh-frozen plasma, cryoprecipitate, factor VII, and vasoactive agents. Once the blood pressure was in an acceptable range, the hemicraniectomy was significantly enlarged and several sites of bleeding were identified medially, including 2 large draining veins and a partial tear of the superior sagittal sinus, all believed to be related to the initial trauma.

Despite removing the majority of the recurrent subdural hematoma, identifying and stopping the original sites of bleeding, draining CSF from the ventricular system, and removing the anterior temporal lobe, the brain continued to be dramatically edematous and protuberant, making primary skin closure impossible. Further brain resection was not possible or prudent in the setting of continued DIC. For these reasons, a sterile Silastic sheet, typically used for temporary abdominal closure (SIL-TEC, Technical Products, Inc.), was sewn to the skin edges to provide a covering over the herniating brain (Fig. 3). In a running fashion, 3-0 nylon suture was used to secure the Silastic sheet to the skin circumferentially.

Hospital Course After Second Operation and Use of Silastic Sheet Skin Patch. After the second operation, the patient’s ICP remained normal; his pupils were 3 mm and reactive, and he continued to have a dense right hemiplegia. The Silastic sheet was kept clean, and routine postoperative care ensued. Brain CT scans confirmed the intraoperative findings of a severely injured and hemorrhagic left hemisphere with marked herniation of the brain outside the usual confines of the skull (Fig. 4).

After 2 weeks of supportive care, the patient was taken back to the operating room for partial hemispherectomy of the persistently swollen and necrotic brain, allowing removal of the Silastic sheet and primary closure of the skin. The child remained on broad-spectrum intravenous antibiotic agents while the Silastic sheet was in place and for 2 weeks after its removal. Staphylococcus epidermidis grew from a superficial swab of the brain tissue at the time of partial hemispherectomy, but the patient did not develop a systemic infection or a brain abscess.

Fig. 1. Preoperative CT scans of the head obtained at the referring hospital. Left and Right: Axial images at presentation to the original emergency department indicating left frontal acute-on-chronic subdural hematoma with extension to the parafalcine region. There is associated mass effect and midline shift with effacement of bitemporal sulci.

Fig. 2. Axial CT scan obtained after the initial craniotomy. Note the left frontotemporal craniectomy. Mass effect is still present with extracranial herniation through craniectomy site. Parafalcine hematoma is again noted. Monitoring of ICP indicated an intractable increase.
The patient remained in the hospital for 5 weeks after his trauma and was awake, interactive, and had right hemiplegia with global aphasia on transfer to an inpatient rehabilitation facility.

After completing 6 months of inpatient rehabilitation, the patient underwent cranioplasty with a custom-made hard-tissue replacement polymer implant composed of polymethylmethacrylate, polyhydroxyethylmethacrylate, and calcium hydroxide (Biomet Microfixation). A synthetic implant was used because portions of the original craniotomy bone were not stored. Serial imaging over the past 3 years has shown injury to the entire left hemisphere with cystic encephalomalacia. The patient did not develop hydrocephalus (Fig. 5).

Clinical Outcome at 3.5 Years Postoperatively. At 5 years of age the patient is developmentally delayed and has a right hemiparesis, but he carries out most activities of daily living appropriate for his age and has fluent language abilities (Fig. 6). He is conversant and is beginning to read. He walks with a limp but without any assistance. He has limited movement of the fingers on his right hand. His parents feel that he has an excellent quality of life, and they have no regrets about pursuing extreme surgical measures rather than withdrawing care in the face of such an extreme injury.

Independent speech and physical therapy evaluations were recently performed. The patient’s normative standard scores for self-care (34), mobility (31), and social functional skills (31) on the Pediatric Evaluation of Disability Inventory fall within the low average range for his age. His raw scores on the stationary (41), locomotion (127), and object manipulation (36) components of the Peabody Developmental Motor Scale were below average, making this 5-year-old boy’s motor abilities similar to those of a typical 3- to 4-year-old.

Speech evaluation with the Preschool Language Scale indicates an auditory comprehension and expressive communication standard score of 70 for both, which correlates with an age equivalence of 4 years and 3.75 years, respectively. Overall, the patient exhibits a moderate receptive and expressive language disorder with a total language standard score of 67.

Discussion

The use of a silicone sheet to augment skin closure in the face of extreme brain swelling encountered during decompressive craniectomy has not been previously described in the English-language literature. We used this technique in an unusual clinical scenario involving a young child with uncontrolled intracranial bleeding and precipitous neurological deterioration after craniotomy, despite maximal medical treatment for raised ICP. Based on his rapid progression to bilaterally fixed and dilated pupils in the face of DIC and uncontrolled intracranial bleeding, we have no doubt that the child’s status would have progressed to brain death if a second operation had not been performed. The use of the Silastic sheet to augment closure was the only viable option left for closure in the second craniotomy after CSF was drained, the craniotomy was extended, the source of the bleeding was identified and stopped, and noneloquent brain tissue was resected. The operating surgeon (G.F.T.) used the Silastic sheet as an alternative to terminating care, to performing a contralateral craniectomy, or to resecting potentially eloquent cortex in a child in whom coagulopathy and hemodynamic instability continued despite a massive transfusion of blood and multiple coagulation factors. This salvage procedure was thought to be a reasonable alternative in such a young patient with potential for transfer of neu-
rological function to the contralateral hemisphere, which appeared to be viable based on the child’s preoperative clinical examination and imaging studies.

Avoiding Silastic Sheets During Decompressive Craniectomy

We do not recommend routine use of a silicone sheet to augment skin closure during decompressive craniectomy due to concerns of infection, potential damage secondary to overexpansion of the brain, and the need for further surgery. When an extremely swollen brain is anticipated, some authors have recommended only partial dural opening to avoid excessive brain herniation. However, in our situation the durotomy was already performed at the time of the initial surgery.

It could be argued that the status of the patient described in this report approached that of a near–brain dead patient who would be unlikely to have a reasonable functional outcome after any surgery or other intervention. Some surgeons would have considered this a hopeless clinical situation and offered only nonoperative treatment. We offered surgery and ultimately the use of a Silastic sheet to close the skin defect because we had confidence in the restorative abilities of such a young child’s brain in the presence of a unilateral hemispheric injury and because the family had realistic expectations of the child’s likely outcome if he did survive. We would not have considered such a course of action if the patient had a bilateral injury, if the neurological deficits had been long standing, or if the patient had been older, with less chance for transfer of neurological function from one side of the brain to the other.

Other Considerations

Our situation was unusual because, at the time of the initial surgery, intracranial bleeding was not definitive-
Use of a silicone sheet for temporary scalp closure

**Fig. 6.** Clinical follow-up. Moderate right facial weakness is only present when patient is asked to smile. Right hemiplegia persists as documented using the Developmental Motor Scale.

...ly identified or stopped, the initial craniotomy diameter provided only a limited decompression, and the patient’s neurological decline was precipitous in the presence of DIC. The combination of these factors led to a situation that necessitated extreme measures not typically necessary. For this reason, strong consideration must be made before proceeding with a high-risk surgical intervention. In our case the patient’s age, acuity of neurological decline, availability of timely surgical response, and realistic family expectations were considerations made prior to intervention. One of the most important factors was the family’s understanding of realistic survival and functional outcomes. Given our patient’s young age, we relied on preservation of the contralateral hemisphere to provide for a reasonable long-term functional outcome.6,9

**Conclusions**

The use of a Silastic sheet to augment skin closure in the face of extreme brain swelling during decompressive craniectomy in a young child with an extensive unilateral hemispheric traumatic brain injury resulted in a reasonable functional outcome. This technique may be considered a viable option in the rare circumstance of extreme brain swelling unresponsive to standard treatments and as an alternative to resection of potentially viable brain tissue.

**Disclosure**

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation

include the following. Conception and design: Tuite, Ahmadian, Garcia. Acquisition of data: Tuite, Ahmadian. Analysis and interpretation of data: Ahmadian, Baaj. Drafting the article: Ahmadian, Baaj. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Tuite.

**References**

5. Cushing H: The establishment of cerebral hernia as a decompressive measure for inaccessible brain tumors; with the description of intermuscular methods of making the bone defect in temporal and occipital regions. Surg Gynecol Obstet 1:297–314, 1905


Please include this information when citing this paper: published online July 13, 2012; DOI: 10.3171/2012.6.PEDS11567.

Address correspondence to: Gerald Tuite, M.D., Neuroscience Institute, All Children’s Hospital, 601 5th Street South, Suite 511, Saint Petersburg, Florida 33701. email: geraldtuite@gmail.com.