Commentary

Decompressive craniectomy in pediatric patients

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Abstract

More frequently than adults, pediatric victims of severe traumatic brain injury experience diffuse severe cerebral edema without mass lesions. These patients require methods to reduce intracranial pressure quickly and reliably. Surgical decompression provides rapid relief of increased intracranial pressure and is an alternative to maximal medical therapy for these individuals. Based on previous trials, most of which are anecdotal but now include attempts at case controlled and cohort matched investigations, Ruf and colleagues describe a series of six pediatric patients treated with a prospectively implemented protocol of decompressive craniectomy for severe traumatic brain injury. The heterogeneous approaches presented (which include hemicraniectomy, bifrontal craniectomy, and suboccipital craniectomy) undermine the applicability of the results. However, this report, coupled with similar papers, does highlight the need for a true controlled trial of this modality to examine whether craniectomy can emerge as more than a second line option for the management of increased intracranial pressure.

Keywords craniectomy, intracranial pressure monitoring, intracranial pressure, traumatic brain injury

Introduction

The modern concept of decompression for traumatic brain injury (TBI) was introduced by Harvey Cushing before World War I [1,2]. The rationale was entirely intuitive. The Monro-Kellie hypothesis dictates that the amount of space within the skull is constant; therefore, when the pressure is raised death occurs by herniation when the capacity for adjustment by fluid shifts from the cerebrospinal fluid and vascular compartments are already maximized. Increasing the skull size by removing bone and opening the dura delays or prevents these limits from being reached. However, in the 90 years since Cushing made these observations, medical, radiographic, and surgical advances in the management of TBI have obviated the need for an aggressive surgical approach in all but a minority of cases.

In spite of the ability to control intracranial pressure (ICP) elevation in most cases with removal of mass lesions, osmotic diuretics, ventricular drainage, sedative/hypnotic agents, and prevention of hypercapnea, occasional cases occur in which ICP elevation accelerates in spite of maximal conservative medical therapy, and then so-called heroic measures are employed. These currently include barbiturate coma, hypothermia, and decompressive craniectomy. These are considered at the ‘option’ level in the American Association of Neurological Surgeons criteria for management of severe brain injury [3] because no large randomized trial has proven their efficacy. In the pediatric population, Ruf and colleagues [4] as well as Taylor and associates [5] have addressed the issue of using decompressive craniectomy as a more formal part of a head injury protocol before going to other ‘option’ therapies once ICP elevation is affirmed.

There are many different approaches grouped under the term ‘craniectomy’. Bifrontal decompressive craniectomy is an aggressive approach described by Kjellberg and Prieto [6] before the era of modern neuroimaging with computed

ICP = intracranial pressure; TBI = traumatic brain injury.

tomography. Venes and Collins [7] described this strategy as well. This approach is particularly useful in the pediatric population, in which diffuse injury without mass lesions and with ICP elevation is relatively common. Hemicraniectomy represents a large cranial and dural decompression, often associated with removal of mass lesions such as subdural hematoma or traumatic intracerebral hematoma. Bitemporal decompressions are unilateral or bilateral bony decompressions designed to take the pressure off the temporal lobes to prevent uncal herniation, and have been used in other cranial conditions such as pseudotumor cerebri. Gower and coworkers [8] reported 40% mortality and 50% favorable outcome in a study of subtemporal decompression for ICP control in 10 patients with closed head injury who had failed medical therapy, including barbiturate coma. Cerebellar decompression for mass lesion is a standard neurosurgical response to any process in the posterior fossa (hemorrhage, tumor, infection, or stroke) that threatens cerebellar tonsillar herniation.

Trials of decompressive craniectomy in pediatric patients

The paper by Ruf and colleagues [4] purports to be a pilot study employing decompressive craniectomy in a standardized approach following development of medically refractory ICP in the pediatric population. Of the six cases presented, three involve bifrontal craniectomies: two unilateral and one cerebellar. The patients underwent surgery between hospital days 1 and 6 and had ICP as low as 20 and as high as 70 mmHg. Glasgow Outcome Scale findings are not provided; however, at least four of the patients appeared to have no more than a mild disability.

Taylor and colleagues [5] devised a randomized trial of bitemporal craniectomy for pediatric TBI. They randomly assigned 27 patients to craniectomy or medical management alone and found that the craniectomy patients obtained lower ICP and better outcomes. In the control group only 14% of children had a favorable outcome, as indicated by 6-month Glasgow Outcome Scale scores. Of the operated group 54% had a favorable outcome. That study suggested (as statistical significance was not met because of the small numbers) that aggressive early decompressive craniectomy may benefit this patient group.

Polin and colleagues [9] explored the use of decompressive bifrontal craniectomy in victims of TBI. This group used a cohort control matching protocol employing the Traumatic Coma Databank to match subjects based on age, ICP, radiographic findings, and admission Glasgow Coma Scale score. In a conditional logistic regression analysis comparing all 92 control patients with the craniectomy population, those investigators detected a significant influence of the operation on favorable outcome (Wald $\chi^2 = 6.097$; $P = 0.014$). Medical management alone carried a 3.86-fold greater risk for unfavorable outcome than did decompressive craniectomy. A pediatric subgroup was identified that appeared to benefit from the procedure ($P = 0.025$). The authors further identified a subgroup of patients who received surgery within 48 hours and who never had sustained ICP elevation over 40 mmHg. The pediatric patients in this subset had favorable outcomes in 8 out of 10 cases, with statistically improved outcomes compared with control individuals.

Discussion

We think it unlikely that decompressive craniectomy will become a commonplace management scheme for TBI. Standard medical management allows control of ICP while preserving the ability to conduct a neurologic examination. The role of decompression as compared to that of other ‘option’ therapies, such as hypothermia and barbiturate coma, is still evolving. The advantage of decompressive craniectomy over these other therapies is the rapid and generally permanent decline in ICP, maintenance of neurologic status, and even the ability to obtain a neurologic examination after the procedure is performed. The disadvantages are the need for at least two surgeries (one to replace the bone flap) and the theoretical development of bifrontal contusions after decompression [10]. Bitemporal decompression has similar advantages and disadvantages.

Decompressive hemicraniectomy and duraplasty for evacuation of mass lesions and management of unilateral hemispheric swelling is more widely accepted in head injury management. Most surgeons have first hand experience with delayed cerebral swelling after removal of a subdural hematoma, presumably caused by venous infarction and/or cerebral contusion. Some will remove the bone flap prophylactically after such operations and others will replace the flap but reoperate as needed in the face of ICP elevation. Suboccipital decompression for posterior fossa pathology is not controversial.

The paper by Ruf and colleagues [4] provides more ammunition for the argument that decompressive craniectomy is a safe and effective method of ICP reduction in severe TBI with associated ICP elevation refractory to standard management. However, this approach remains a second tier strategy recommended only at the option level. For this scheme to become more prevalent, a large-scale multicenter trial such as that being planned by Coplin and colleagues [11] would be necessary.

Competing interests

None declared.

References

1. Cushing H: **The establishment of cerebral hernia as a decompressive measure for inaccessible brain tumor; with the description of intramuscular methods of making the bone defect in temporal and occipital regions.** *Surg Gyn Obstet* 1905, **1:**297-314.
2. Cushing H: **Subtemporal decompressive operations for the intracranial complications associated with bursting fractures of the skull.** *Ann Surg* 1908, **47:**641-644.

3. Anonymous: **Guidelines for the management of severe head injury. Brain Trauma Foundation, American Association of Neurological Surgeons, Joint Section on Neurotrauma and Critical Care.** *J Neurotrauma* 1996, **13:**641-734.
4. Ruf B, Heckman M, Schroth I, Hügens-Penzel M, Reiss I, Borkhardt A, Gortner L, Jödicke A: **Early decompressive craniectomy and duraplasty for refractory intracranial hypertension in children: results of a pilot study.** *Crit Care* 2003, **7:** R133-R138
5. Taylor A, Butt W, Rosenfeld J, Shann F, Ditchfield M, Lewis E, Klug G, Wallace D, Henning R, Tibballs J: **A randomized trial of very early decompressive craniectomy in children with traumatic brain injury and sustained intracranial hypertension.** *Childs Nerv Syst* 2001, **17:**154-162.
6. Kjellberg RN, Prieto A: **Bifrontal decompressive craniotomy for massive cerebral edema.** *J Neurosurg* 1971, **34:**488-493.
7. Venes JL, Collins WF: **Bifrontal decompressive craniectomy in the management of head trauma.** *J Neurosurg* 1975, **42:**429-433.
8. Gower DJ, Lee KS, McWhorter JM: **Role of subtemporal decompression in severe closed head injury.** *Neurosurgery* 1988, **23:**417-422.
9. Polin RS, Shaffrey ME, Bogaev CA, Tisdale N, Germanson T, Bocchichio B, Jane JA: **Decompressive bifrontal craniectomy in the treatment of severe refractory posttraumatic cerebral edema.** *Neurosurgery* 1997, **41:**84-92.
10. Cooper PR, Hagler H, Clark WK, Barnett P: **Enhancement of experimental cerebral edema after decompressive craniectomy: implications for the management of severe head injuries.** *Neurosurgery* 1979, **4:**296-300.
11. Coplin WM, Cullen NK, Policherla PN, Vinas FC, Wilseck JM, Zafonte RD, Rengachary SS: **Safety and feasibility of craniectomy with duraplasty as the initial surgical intervention for severe traumatic brain injury.** *J Trauma* 2001, **50:**1050-1059.