ARTICLE OF THE MONTH

Trial of Decompressive Craniectomy for Traumatic Intracranial Hypertension

N Engl J Med 2016; 375:1119-1130.

Welcome to the July 2018 SNACC Article of the Month!

This month's commentary focuses on the implications of performing craniectomies in patients with traumatic brain injury as a last resort. The results of this RESCUEicp trial are discussed in contrast to the decompressive craniectomy trial (DECRA) that was published in 2011.

The commentary is provided by Matthew Dorazio and David Slottje under the mentorship of Dr. David Wyler. Matthew Dorazio graduated from Touro College of Osteopathic Medicine and is now in his second year of anesthesia residency at Thomas Jefferson University. David Slottje graduated from Cornell University and is currently a neurological surgery resident at Rutgers, New Jersey Medical School (PGY 6). He has completed a neurocritical care fellowship at Thomas Jefferson University and has a special interest in traumatic brain injury.

David Wyler is a trained neuroanesthesiologist and neurointensivist and the director of anesthesiology in neurocritical care at Thomas Jefferson University. He has a particular interest in improving communication between anesthesiologists and neurosurgeons.

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Nina Schloemerkemper, MD; Oana Maties, MD; Adrian Pichurko, MD

Commentary on RESCUEicp

Matthew Dorazio DO, David Slottje MD, David Wyler MD

Elevated intracranial pressure is an often-encountered sequela in patients following traumatic brain injury (TBI) and has been shown to be an independent predictor of mortality in this population.[1] Accordingly, the Brain Trauma Foundation currently recommends the treatment of intracranial pressure (ICP) >22mmHg in light of evidence suggesting values above this threshold are associated with an increased risk of death (Level IIB evidence).[2] The initial management of elevated ICP consists mainly of medical therapies targeted at maintaining adequate cerebral perfusion pressure, normoglycemia, normothermia, and mild hypocapnia.[3] Failure of these initial measures to control ICP prompts second stage interventions that include (in addition to initial treatments) aggressive blood pressure augmentation, therapeutic hypothermia, and osmotherapy. Despite these staged interventions, a proportion of patients will remain refractory to therapy. In 2011, the randomized Decompressive Craniectomy (DECRA) trial evaluated the effect of early surgical intervention as a means of

reducing intracranial pressure on the outcome of patients following failure of initial stage treatment measures. Data from this study showed an increase in unfavorable outcomes from decompressive craniectomy (DC) compared to standard therapy when utilized as a second-tier intervention. In contrast to DECRA, the Randomized Evaluation of Surgery with Craniectomy for Uncontrollable Elevation of Intracranial Pressure (RESCUEicp) trial assessed the use of DC as a measure of last resort in patients with refractory intracranial hypertension despite first and second tier interventions. The results of this trial are the focus of this review.

In an attempt to examine the long-term outcomes of surgical versus medical interventions for refractory intracranial hypertension following TBI, Hutchinson et al conducted an international, multicenter, parallel-group, superiority, randomized trial that compared last-tier secondary decompressive craniectomy with continued medical management in patients age 10-65 with TBI. (A secondary decompressive craniectomy was defined as a craniectomy performed for the purpose of controlling ICP after failure of medical therapies, in contradistinction to primary decompressive craniectomy which would be done at the time of presentation to evacuate a hematoma and relieve mass effect.)[3] The primary outcome was measured at 6 months post-randomization using the Extended Glasgow Outcome Scale. This scale includes the mortality rate as well as measures of disability and function ranging from vegetative state (unable to follow commands) to upper good recovery (no issues). There are several intermediate categories in between such as upper severe and lower severe disability. Comparison of results between the groups showed a mortality rate among the surgical group of approximately half that of the medical group (26.9% vs. 48.9%, p <0.001). Among survivors at 6 months, the surgical group was found to have higher rates of vegetative state, lower severe disability, and upper severe disability compared to the medical group (8.5%, 21.9%, and 15.4% vs. 2.1%, 14.4%, and 8.0%, p <0.001). Interestingly however, rates of moderate disability and good recovery were similar (23.4% and 4% in the surgical group vs. 19.7% and 6.9% in the medical group, p <0.001).

Several thought-provoking conclusions can be derived from the results of the RESCUEicp trial. First, contrary to previous results obtained from the DECRA trial, craniectomy did provide a survival benefit over standard therapy as well as comparable rates of moderate disability and good recovery between groups. One major distinction between the two studies which may account at least in part for the observed difference are the surgical techniques utilized for craniectomy. The RESCUEicp trial patients received either a large unilateral frontotemporoparietal hemicraniectomy (for unilateral hemisphere swelling on imaging) or a large bilateral frontotemporoparietal craniectomy with a wide dural opening and optional division of the falx anteriorly (for diffuse brain swelling affecting both hemispheres on imaging).[3] DECRA patients, regardless of the location of swelling seen on imaging, underwent a single bilateral frontotemporal decompressive craniectomy with dural opening either by cruciate incision bilaterally or by a large L shaped incision without division of the falx or sagittal sinus.[4] A second important distinction between trials was the timing of surgical intervention in response to failed initial management. A more aggressive approach was evaluated in DECRA in which surgery was offered as a second-tier treatment for elevated ICP whereas in RESCUEicp craniectomy was offered only when all other treatment options (with the exception of barbiturates) had failed. Perhaps the more targeted surgical approach in RESCUEicp provided a superior space for brain parenchymal expansion with a subsequent reduction in axonal stretch or perhaps exhausting all medical techniques prior to surgery conferred a protective benefit that resulted in more favorable neurologic outcomes. In DECRA, the early use of craniectomy likely meant that many patients who could have improved with medical therapy alone were subjected to surgery. The more stringent surgical criteria of RESCUEicp may have avoided some of this unnecessary surgical morbidity. These hypotheses and others however were not the subject of investigation and remain to be validated.

With several caveats, the results of the RESCUEicp trial are generally supportive of the practice of performing decompressive craniectomy in the setting of refractory intracranial hypertension due to diffuse brain swelling after exhausting medical interventions.

Importantly, the results of the study do not suggest that decompressive craniectomy can increase the likelihood of recovering to the level of functional independence outside the home. The percentage of patients recovering to this level or better was similar in the surgical and medical arms of the study, suggesting that this group has a less severe degree of injury and would have done well regardless of surgical intervention. With that being said, the survival advantage of decompressive craniectomy was conferred to both dependent and independent living and not merely an increase in patients remaining in a vegetative state.[3]

One of the most significant findings of the study is that at 12 month follow-up, the percentage of patients with upper severe disability (defined as functional independence within the home) was 13.4% in the surgical arm compared to 3.9% in the medical arm.[3] In other words, decompressive craniectomy allows for functional independence within the home of 10% of patients who would otherwise have died or been dependent on others for their care. From one philosophical vantage point, salvaging these 10% of patients comes at the expense of increasing the number of patients who are kept alive in a vegetative state (6.2% compared to 1.7%) or with such severe disability that they are totally dependent on others for their care (18.0% compared to 14.0%)3, with the attendant socioeconomic, personal financial, and emotional costs

incurred as a result of this. This dilemma underscores a daily challenge confronted by Neurosurgical and Neurocritical Care specialists in "goals of care" discussions across the world in the modern era of Perioperative Medicine.

An important limitation of the study, is that its conclusions cannot be extrapolated to the population of TBI patients younger than 10 or older than 65, since these individuals were excluded from the trial.[3]

Ultimately, the decision to offer decompressive craniectomy requires a nuanced and individualized approach tailored to the specific patient's wishes and accounting for their general state of health. More research will be required to elucidate the underlying causes of the observations of the RESCUEicp trial and to refine treatment protocols that increase favorable outcomes for patients following TBI.

References

1. Badri S, Chen J, Barber J, et al. Mortality and long-term functional outcome associated with intracranial pressure after traumatic brain injury. *Intensive Care Med* 2012; 38:1800-9.

2. Carney N, Totten AM, et al. Guidelines for the management of severe traumatic brain injury, fourth edition. *Neurosurgery* 2017;80(1):6-15.

3. Hutchinson PJ, Kolias IS, et al. Trial of decompressive craniectomy for traumatic intracranial hypertension. *N Engl J Med* 2016; 375:1119-1130.

4. Cooper DJ, Rosenfeld JV, et al. Decompressive craniectomy in diffuse traumatic brain injury. *N Engl J Med* 2011; 364:1493-1502.

Difference in surgical technique

(RESCUEicp) The original protocol stated "For bilateral diffuse hemisphere swelling a large bilateral fronto-temporo-parietal craniectomy from the frontal sinus anteriorly to the coronal suture posteriorly and pterion laterally with a wide dural opening (pedicles based on the superior sagittal sinus medially and division of the falx anteriorly)". The latest protocol states "For bilateral diffuse hemisphere swelling a large bilateral frontotemporo-parietal craniectomy from the skull base anteriorly to the coronal suture posteriorly and pterion laterally with a wide dural opening (pedicles based on the superior sagittal sinus medially) and optional division of the falx anteriorly". Justification: in keeping with the pragmatic nature of the study, division of the falx was left at the discretion of the operating neurosurgeon.

(DECRA) The technique described by Polin et al will be used. The operation will comprise bi-frontal decompressive craniectomies with a single fronto-temporal bone flap extending across the midline. The temporalis muscles will be reflected inferiorly. Burr holes are located either side of the sagittal sinus at the posterior extent and bilaterally at the keyhole and at the root of the zygoma. This will create a large bifrontal craniectomy defect extending posteriorly to the coronal sutures. Bilateral large sub-temporal decompressions will be performed down to the skull base. The final bone cut is made along the supraorbital ridges with an attempt to preserve the frontal sinus. Burr holes will be placed either side of the sagittal sinus inferiorly and the bone will be lifted out. The dura will be opened in one of two alternative ways: 1. The dura is opened with a cruciate incision bilaterally. OR 2. A large L shaped incision with the lower corner of the L facing laterally. The advantage to this method is that the cerebral veins are not disturbed medially by this incision. The dural opening should be covered with a dural or facial patch, so that the brain does not adhere to the scalp. Water tight dural closure is not necessarily aimed for. For patients receiving EVD monitoring, an ICP monitor with ventricular catheter (± optional PO2 and temperature monitor) may be placed prior to closure. Some patients will have been randomized to parenchymal catheter only. These patients will not have an EVD inserted.