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## Intracranial Pressure Rescued by Decompressive Surgery after Traumatic Brain Injury

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Hutchinson et al.<sup>1</sup> report in the *Journal* the results of the Randomised Evaluation of Surgery with Craniectomy for Uncontrollable Elevation of Intracranial Pressure (RESCUEicp) trial, which compared decompressive craniectomy with continued medical management for refractory elevation of intracranial pressure after severe traumatic brain injury. Urgent treatment of patients with such an injury focuses on minimizing secondary brain injury, particularly from increased intracranial pressure. When common medical interventions fail to control intracranial pressure, decompressive craniectomy to prevent herniation may be considered. This surgery addresses a physiological problem (refractory elevation of intracranial pressure) and has a proven benefit in the management of malignant cerebral edema after ischemic stroke.<sup>2</sup> Craniectomy may be performed in isolation for intracranial-pressure control or with the simultaneous evacuation of acute intracranial mass lesions. In the RESCUEicp trial, craniectomy was performed specifically for the purpose of lowering the intracranial pressure, although patients could be enrolled if refractory intracranial-pressure elevation had developed after a preceding surgery to evacuate an intracranial hematoma during which the bone flap had been replaced.

Guidelines for the management of traumatic brain injury are based on limited evidence,<sup>3</sup> and trials in the past several years have caused con-

troversy.<sup>4-6</sup> In 2011, the Decompressive Craniectomy in Diffuse Traumatic Brain Injury (DECRA) study, the results of which appeared in the *Journal*, showed that there was no benefit from bifrontal surgical decompressive craniectomy to reduce intracranial pressure, although the restrictive entry criteria of that trial raised questions regarding the generalizability of the negative results, and the definition of refractory intracranial pressure was called into question.<sup>6,7</sup> The RESCUEicp trial addressed these concerns by including more commonly encountered types of patients with traumatic intracranial mass lesions and by refining the definition of refractory intracranial-pressure elevation (>25 mm Hg for 1 to 12 hours, as compared with >20 mm Hg for 15 minutes within a 1-hour period in the DECRA study).<sup>6</sup>

Patients in the surgical group of the RESCUEicp trial underwent either unilateral hemicraniectomy or bifrontal craniectomy on the basis of computed tomographic imaging and at the discretion of the surgeon. Patients in the medical group received continued medical therapy with the optional addition of barbiturate therapy to reduce intracranial pressure; patients could undergo delayed decompression if further deterioration occurred. The primary-outcome measure was the 6-month Extended Glasgow Outcome Scale (GOS-E) rating (on an 8-point scale, ranging from death to upper good recovery [no injury-related problems]). The trial showed better intra-

cranial-pressure control, lower mortality, and higher rates of vegetative state, lower severe disability, and upper severe disability in the surgical group than in the medical group; the rates of moderate and good recovery were similar in the two groups.

In a prespecified sensitivity analysis, the authors compared the proportion of patients in each group who had outcomes of upper severe disability or better (GOS-E score of 4 to 8), which were defined as “favorable outcomes.” In keeping with other studies, the RESCUEicp trial included upper severe disability as a favorable outcome; patients in the upper-severe-disability category may be independent in the home but rely on others for assistance outside the home.<sup>2,5,8</sup> The dichotomized GOS-E results did not show a significantly higher percentage of patients with a favorable outcome in the surgical group than in the medical group at 6 months (42.8% and 34.6%, respectively;  $P=0.12$ ), but there was a significant difference at 12 months (45.4% vs. 32.4%;  $P=0.01$ ).

Some key elements of the RESCUEicp trial design should be emphasized. First, a widely accepted definition of refractory intracranial-pressure elevation was used, and surgery was performed rapidly after randomization. Second, the trial allowed for provider discretion in clinical decision making within certain limits, including allowing surgeons to choose the method of decompression. Interestingly, bifrontal approaches were used 63% of the time and unilateral approaches only 37%, which in our experience is opposite to the practice pattern in the United States (where very few patients were enrolled). Another important observation is that 37% of patients in the medical group had treatment failure and ultimately underwent decompression owing to clinical deterioration. As the authors mention, this percentage of crossover could dilute the observed treatment effect. In comparison, only 9% of patients in the surgical group did not have their intracranial pressure controlled and required barbiturate infusion. These results suggest that maximal medical therapy is often not adequate to control intracranial pressure.

Finally and most importantly, the RESCUEicp trial showed that decompressive surgery in patients with traumatic brain injury and raised intracranial pressure was associated with lower mortality than medical management. However,

more survivors in the surgical group than in the medical group were dependent on others, a finding that emphasizes the fact that lifesaving procedures may not ensure a return to normal functioning. In particular, the larger proportion of survivors in the vegetative state in the surgical group than in the medical group is noteworthy. The findings of this trial argue for more investigation into the nuances of selecting patients for decompressive craniectomy after traumatic brain injury and for the development of more refined clinical decision-making tools. Quality of life is an individual determination, and it is important to engage patients' surrogates in discussions that focus on the patients' previously stated wishes and personal values. We must acknowledge the importance of shared decision making in discussions with surrogates about potential outcomes of therapeutic options, prolonged recovery times, and the expected quality of life after neurologic injury.<sup>9</sup>

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