Commentary on:
Nationwide Survey of Decompressive Hemicraniectomy for Malignant Middle Cerebral Artery Infarction in Japan
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Decompressive Hemicraniectomy for Malignant Middle Cerebral Artery Infarction: Are We Shepherds or Wolves?

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In his Address at a Sanitary Fair, in April 1864, Abraham Lincoln adapted the parable of the Good Shepherd from the Gospel of John to convey criticism of the Confederacy regarding the position of the southern states on slavery before the end of the American Civil War. "The shepherd drives the wolf from the sheep's throat, for which the sheep thanks the shepherd as a liberator, while the wolf denounces him for the same act as the destroyer of liberty," he said (10). Although the arc of history has confirmed what Lincoln knew then, that liberty has but one true definition regarding the equality of men; how individuals define and enjoy their personal freedom to live fulfilling lives is widely varied.

The essence of the debate surrounding the role of decompressive hemicraniectomy (DHC) to treat malignant middle cerebral artery (MCA) infarction is similarly captured by the former leader's sentiment. Although DHC improves survival after large, MCA territory infarction, concerns over a poor functional outcome that strips a large proportion of surviving patients of their independence and quality of life have called into question the utility of DHC. Put bluntly, whether the lives we save are worth living is entirely dependent on the survivor's unique definition of a fulfilled, dignified existence.

Cushing published the first description of decompressive craniectomy to treat intractable intracranial hypertension from unresectable brain tumors in 1905 (3). By the 1950s, case series of decompressive surgery in the setting of ischemic, supratentorial infarction were reported (8, 11). The rationale for DHC as part of the treatment armamentarium for large, space occupying, MCA territory infarction is straightforward. A large, frontotemporoparietal craniectomy and duraplasty are performed to allow for extracranial expansion of edematous, necrotic brain to mitigate the life-threatening effects of increased intracranial pressure, and transtentorial herniation (5, 6, 13). The frequency of DHC in the management of acute infarction increased

Key words
- Decompressive hemicraniectomy
- Elderly patients
- Functional outcomes
- Malignant middle cerebral artery infarction
- Mortality
- Nationwide survey

Abbreviations and Acronyms
DECIMAL: Sequential-design, Multicenter, Randomized, Controlled Trial of Early Decompressive Craniectomy in Malignant Middle Cerebral Artery Infarction Trial
DESTINY: Decompressive Surgery for the Treatment of Malignant Infarction of the Middle Cerebral Artery Trial
DHC: Decompressive hemicraniectomy
HAMLET: Hemicraniectomy After Middle Cerebral Artery Infarction with Life-threatening Edema Trial
MCA: Middle cerebral artery
mRS: Modified Rankin Scale

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dramatically in the 1980s and 1990s. Although observational and cohort studies have consistently documented improved survival, functional outcome was variable across cohorts (1, 2, 9). Specifically, the published literature generally support that younger patients derive the most benefit from surgical decompression (2), whereas older patients have poor functional outcomes (9). On this basis, 3 concurrent, prospective, randomized, controlled trials, all of which enrolled patients 60 years of age or younger, were initiated throughout Europe to evaluate the benefit of DHC in combination with maximal medical management versus medical management alone (6, 7, 13).

A pooled analysis of the 3 trials, DESTINY (Decompressive Surgery for the Treatment of Malignant Infarction of the Middle Cerebral Artery Trial), DECIMAL (Sequential-design, Multicenter, Randomized, Controlled Trial of Early Decompressive Craniectomy in Malignant Middle Cerebral Artery Infarction Trial), and HAMLET (Hemicraniectomy After Middle Cerebral Artery Infarction with Life-threatening Edema Trial), was published in 2007 (12) while HAMLET was still enrolling and after poor enrollment and significant mortality benefit in the DHC group at interim analysis stopped DECIMAL and DESTINY, respectively. Ultimately, the published results of the 3 individual trials were consistent with significant overall survival benefit at 6 months and 1 year for the DHC group. None of the individual trials revealed statistically significant morbidity benefit at 1 year when the Modified Rankin Scale (mRS) was dichotomized such that scores of 0–3 were considered "good outcomes" (the primary end point in each trial) and 4–6 were considered "poor outcomes" (5, 6, 13). However, statistically significant reduction in morbidity was demonstrated at 1 year when the mRS was dichotomized to $\leq$4. Analysis of pooled data from 3 trials confirmed the results from the individual trials (12). See **Figure 1** for composite outcome data from the pooled analysis.

Two prospective, randomized trials in which patients up to 80 years of age were treated with DHC plus maximal medical therapy versus medical therapy alone have been conducted, with similar outcomes. DESTINY II (7) exclusively enrolled patients age 61–80 years, whereas a recently published trial from China (14) enrolled all patients ages 18–80 and performed subgroup analysis on the patients older than 60. The results were similar to that of the DESTINY, DECIMAL and HAMLET. In DESTINY II, a significant survival benefit at 1 year was revealed for those in the DHC group, although less so than in any of the 3 previous trials, or in the pooled data (absolute risk reduction for mortality at 12 months in DESTINY II was 33%, vs. 49% in the pooled trial data; **Figure 1**). Additionally, at 12 months, not a single patient in either group in DESTINY II achieved a mRS of 0–2 and DHC did not significantly affect the number of patients with a mRS of 3 (**Figure 1**). As in the antecedent trials, patients who underwent DHC in the DESTINY II trial were statistically more likely to achieve functional status equivalent to mRS of 4 at 12 months.

Published this month in **WORLD NEUROSURGERY**, Suyama et al. present data from a large series of retrospectively reviewed patients who underwent DHC for malignant MCA infarction over a 1-year period in Japan. Solicitations for data regarding all patients who underwent DHC in the study period were sent to all academic neurosurgical centers with at least 3 members of the *Japanese Society of Neurosurgery* (n = 556 centers). Approximately half of the centers responded, and more than 48,000 patients diagnosed with an ischemic stroke were identified. Of the 48,000 patients, 4092 were deemed to have suffered a malignant MCA infarction (by standard clinical trial criteria), of which 355 underwent DHC. The included patients' median age was 69 years, and 80% were older than 60 years. Suyama et al.'s data are not entirely comparable with DESTINY II or the Chinese trial, given the inherent limitations of the retrospective study and the specific design. Potential selection bias among those institutions that reported data, the large number of patients lost to follow-up, lack of a control group and, in particular, that mortality was analyzed at 30 days and morbidity analyzed at 3 months distinguish this study from those previously discussed. However, the results overall are in keeping with previously published data—at 3 months, 45% of patients available for follow-up had died, 50% achieved a mRS of 4 or 5, whereas only 5% had achieved a mRS of 3.

Data from both observational and randomized, controlled trials that compare cohorts of patients who underwent DHC plus medical management for malignant, MCA territory infarction clearly and consistently demonstrate survival benefit over patients treated with medical therapy alone, irrespective of age. However, caution must be taken when discussing therapeutic options with patients and their families regarding functional outcome. The treating surgeon's role is to provide accurate DHC outcome data, in a comprehensible fashion, to help the patient and his or her family decide whether to undergo surgery. A major concern in the analysis of morbidity data after DHC in all of the aforementioned trials and studies is the definition of "good outcome." Although the primary end point in all trials was defined as mRS $\leq$3 [mRS 3: moderate disability; requiring some help, but able to walk without assistance (4)], in none of the trials were the patients in the DHC group statistically more likely to achieve a mRS of $\leq$3 at 12 months. To achieve statistical significance in *ad hoc* analysis, the authors define "good outcome" as mRS$\leq$ 4 [mRS 4: moderately severe disability; unable to walk or attend to bodily needs without assistance (4)], which is misleading.

In the pooled DESTINY, DECIMAL, and HAMLET data, although the absolute risk reduction for death was 49% in the DHC cohort, 55% of survivors achieved a mRS $\leq$3 compared with 75% in the exclusively medically managed group. Looked at another way, the likelihood of living with moderately severe (mRS 4) or severe disability [mRS 5: bedridden, incontinent and requiring constant nursing care (4)] after DHC is nearly double (45% DHC vs. 25% medical; **Figure 1**). The absolute risk reduction for death in DESTINY II was more modest at 33%, but the likelihood of regaining functional independence among survivors was very poor in both groups (mRS 3: 20% and 11% vs. mRS 4 or 5: 80 and 89% for the med and DHC groups respectively; **Figure 1**). Indeed, only 5% of patients in the cohort presented by Dr. Suyama achieved mRS $\leq$3 at 3 months.

Ultimately, the level of morbidity and dependency that a patient is willing to accept after a large hemispheric stroke is a highly personal decision that reflects the most basic foundation of patient autonomy and individual liberty. In the end, whether the