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Decompressive hemicraniectomy with or without clot evacuation for large spontaneous supratentorial intracerebral hemorrhages

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ABSTRACT

Objective: The management of patients with supra-tentorial intracerebral hemorrhage (ICH) remains controversial. Here we critically evaluate the safety, feasibility, and outcomes following decompressive hemicraniectomy (HC) with or without clot evacuation in the management of patients with large ICHs.
Methods: We analyzed data from 73 consecutive patients managed with a HC for a spontaneous ICH. All relevant patient variables at initial presentation and management were compiled. Variables were modeled as independent regressors against the three-month Glasgow Outcome Score using a multivariate logistic regression model.
Results: Over 7 years, HC was performed in 73 patients with clot evacuation in 86% and HC alone in 14%. The average ICH volume was 81 cc and the median HC surface area was 105 cm^2. 26 patients were comatose at initial presentation. Three-month functional outcomes were favorable in 29%, unfavorable in 44% and 27% of patients expired. Admission Glasgow Coma Scale ($p = 0.003$), dominant hemisphere ICH location ($p = 0.01$) and hematoma volume ($p = 0.002$) contributed significantly to the outcome, as estimated by a multivariate analysis. Eight surgical complications occurred.
Conclusions: Early HC with or without clot evacuation is feasible and safe for managing spontaneous ICH. Our experience in this uncontrolled retrospective series, the largest such series in the modern era, suggests that it may be of particular benefit in patients with large non-dominant hemisphere ICH who are not moribund at presentation. Our findings suggest that a prospective randomized trial of HC vs. craniotomy for ICH be conducted.

1. Introduction

Spontaneous intra-cerebral hemorrhage (ICH), accounts for 10–15% of all strokes in western countries, with a higher incidence in Asian and African-American populations. It is associated with a one-month fatality rate of around 40% [1]. The dismal outcome of patients with ICH, results from the structural loss of essential deep nuclei and from white matter tract disruption, caused by direct injury caused by hematoma [2], loss of cerebral auto regulation and delayed brain swelling. The management strategies for patients with spontaneous supra-tentorial ICH are still controversial and the role of surgical intervention remains uncertain, despite the advent of minimally invasive techniques. The results of the Surgical Trial in Intra-cerebral Hemorrhage (STICH) [3] and other randomized controlled trials suggest that surgery does not appear to offer any great advantage over conservative medical management in these patients [3–5]. Other randomized studies and several meta-analyses [6–12] have not yet been able to clearly elucidate the role of surgical management for this condition. Most recently, the STICH II trial data suggests that early surgery may have a small but clinically relevant survival advantage for patients with superficial hemorrhages without intra-ventricular hemorrhage (IVH) [13]. Minimally invasive surgical therapies for ICH, using recombinant tissue plasminogen activator (rtPA), and locally delivered ultrasound and thrombolytics are being currently evaluated (MISTIE, CLEAR and SLEUTH trials) [14–16], as is the use of the PPAR gamma agonist – pioglitazone [17,18]. The utility of

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these minimally invasive approaches is still being characterized, and the optimal management of ICH is still far from clear.

Yet, several patients with large ICHs present a management dilemma in that they may have a reasonable neurological examination at presentation that worsens despite maximal medical management, or may be young, or may have hemorrhages in the non-dominant hemisphere. In such young patients, and even in older patients with large hematomas, significant delayed edema is often seen after an ICH, adding to the elevated intracranial pressure (ICP) and compounding the neural insult. In these situations, there is often no equipoise regarding medical vs. surgical management and instead, management decisions center around urgent surgical intervention vs. a determination of futility. These situations raise important, unanswered questions about the role, timing, nature and outcomes following surgical intervention.

A variety of experimental studies have suggested several phases of edema formation following ICH [19]. Peri-hematoma edema volume in humans increases by approximately 75% during the first 24 h after ictus, and the edema around the clot can eventually occupy a volume larger than that of the hematoma itself [20,21]. The cascade of events resulting from worsening edema lead to increased mass effect with damage to adjacent structures/white matter tracts; consequences that could be prevented by an early decompression of the brain by a hemicraniectomy (HC). HC for ICH has previously been reported as small retrospective studies, and by anecdotal case reports [22–27]. These studies have suggested improvements in postoperative mortality and morbidity, as well as improved frequency of good functional outcomes. Furthermore, there are instances where clot removal is difficult due to its deep location, or is incomplete after an attempted clot removal. In both of these instances, technical approaches that mitigate against (ICP) elevation are potentially useful. This is the motivation for this analysis of our experience with the use of early HC in the management of spontaneous supratentorial ICH at our center.

2. Materials and methods

A prospectively compiled database of stroke patients was used to identify patients with spontaneous ICH who underwent HC at a single institution from April 2004 to September 2011, within 96 h of the ictus, excluding those with vascular or neoplastic etiology. The local institutional Committee for Protection of Human Subjects approved study design and execution.

From the electronic medical record, we compiled demographics, data regarding admission Glasgow Coma Scale (GCS) [28], hemorrhage location (lobar, basal ganglia or both), hemorrhage hemisphere (right vs. left), volume (cc), total craniectomy surface area (cm^2), presence or absence of IVH, whether or not an external ventricular drain (EVD) was placed, whether clot evacuation or only a HC was performed, the number of days between admission and surgery, length of stay (LOS) in the intensive care unit, total hospital LOS and Glasgow Outcome Scale (GOS) 37 at discharge. Patients were also categorized as having a good or a poor prognosis using the median prognostic score computed by the following equation which has previously been used in the STICH trial as a prognostication tool following ICH [3]:

$$\text{Prognostic score} = (10 \times \text{admission GCS}) - \text{age (years)} - (0.64 \times \text{volume [ml]}).$$

Surgical complications were also assessed, and data regarding the need for ventriculo-peritoneal shunt (VPS) placement, as well as complications from the cranioplasty procedure were compiled. ICH volume was calculated using the ABC/2 method [29], and the total HC size was estimated by a neurosurgeon by measuring the distance between the posterior and anterior margins of the bone defect on serial 5 mm CT slices. The total area of cranial decompression was calculated by multiplying this value by the slice thickness and then summating it across all slices [30]. Decompressive HC was performed in the fronto-temporo-parietal region. Large bone flaps were removed in each case, followed by a wide non-constricting expansive duraplasty using a reconstituted bovine collagen allograft. A trans-cortical approach to the ICH was used in all cases in which the clot was evacuated. Bone flaps were stored in the tissue bank (<70 °C) until the time of re-implantation.

Patient outcome was classified according to the GOS at discharge and at three-month follow up by review of inpatient and outpatient clinic notes: Patients were scored from 1 to 5 by the GOS as follows: (1) Dead, (2) persistently vegetative, (3) severely disabled (able to follow commands, but unable to live independently), (4) moderately disabled (able to live independently, but unable to return to work or school), and (5) good recovery (able to return to work or school) [31]. Patients with a GOS of 4–5 were classified as having a favorable outcome and those with a GOS of 1–3 were labeled as having an unfavorable outcome. Data were analyzed using Stata/IC 10.0 for Mac (Stata Corporation, College Station, TX). Univariate Spearman correlations were performed between all the independent variables (age, gender, GCS at admission, craniectomy surface area, number of days till evacuation of clot, left vs. right hemisphere, superficial vs. deep clot location, ICH volume) and the GOS at f/u. Corrections were made for multiple comparisons. Additionally, a multivariate logistic regression model using all of these variables modeled concurrently against the GOS at f/u was computed. A corrected P value of $\leq .05$ was considered as statistically significant.

3. Results

A total of 73 patients underwent HC for the treatment of ICH over a time interval of 90 months. The mean age was 52 (range 21–80 years) and 29 patients (40%) were female. 26 patients (36%) were comatose (GCS ≤ 8) at initial presentation, 21 patients (28%) had a GCS score at admission between 9–12 and 26 patients (36%) had a GCS of 13 or greater. The hematoma was located in the left hemisphere in 25 patients and in the right hemisphere in 48. The hematoma was in the basal ganglia in 36 patients (49%), lobar in 30 (41%) and both lobar and subcortical in 7 patients (10%). 40 patients (55%) had an intra-ventricular extension of the hemorrhage on the pre-operative CT scan. The average ICH volume was 81 cc (SD 37); volume was <50 cc in 17 patients (23%), between 50 and 100 cc in 36 patients (50%), and greater than 100 cc in 20 patients (27%) (Table 1).

The etiology of the hemorrhage was essential hypertension in the majority of cases (62 patients, 85%). Six patients had been therapeutically anticoagulated with warfarin or dabigatran; one patient suffered ictus a day after clopidogrel and reteplase administration for a myocardial infarction; one developed an ICH two days after ipsilateral carotid endarterectomy. Three patients had evidence of cerebral amyloid deposition on pathology reports, though no evidence of this disease was noted pre-operatively.

Most patients 63/73 (86%) underwent clot evacuation in addition to HC. In 10 cases (14%), the clot was not evacuated at the time of decompression – this decision was surgeon specific and generally based on the notion that the clot was deep and not easily accessible. The median HC surface area for the 73 cases was 105 cm^2, (interquartile range was 26). All procedures were performed within 96 h of the ictus (mean was 1 day). 38 of 40 patients with IVH (52% of the total) required EVD placement during their postoperative course. The average LOS was 10 days (SD 6) in the intensive care unit and a total acute hospital LOS of 18 days (SD 13).