Decompressive craniectomy for intracerebral hemorrhage

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A consensus on decompressive craniectomy for intracerebral hemorrhage (ICH) has not yet been established. Decompressive craniectomy seems to increase shunt-dependent hydrocephalus among patients undergoing surgical ICH evacuation. The decision to perform a craniectomy for patients with ICH should be carefully individualized while considering the risk of hydrocephalus [1)]

Intracerebral hemorrhage is often complicated by secondary haematoma expansion and perihemorrhagic edema.

After few small previous studies had suggested advantages by the combination of decompressive hemicraniectomy with haematoma removal, decompression on its own has been investigated within the last 5 years. Two case series and one case-control study in altogether 40 patients with severe spontaneous intracerebral haemorrhage have shown mortality rates ranging from 13 to 25% and favourable outcome from 40 to 65%.

Decompressive hemicraniectomy appears to be a feasible and relatively well tolerated individual treatment option for selected patients with spontaneous intracerebral haemorrhage. Data are insufficient to judge potential benefits in outcome. A randomized trial is justified and mandatory [2)].

Decompressive hemicraniectomy with hematoma evacuation for large intracerebral hemorrhage might be a safe and effective procedure in patients with severely disturbed consciousness and large hematoma volume [3)].

Decompressive hemicraniectomy without clot evacuation appears feasible in patients with large ICH

and deserves further investigation, preferably in a randomized controlled setting [4) 5)].

Complications

Among patients who suffered from spontaneous supratentorial hemorrhage and need to receive emergent craniectomy, physicians should be reminded that postoperative hydrocephalus followed by ventriculoperitoneal shunting may be necessary for the future [6)].

Decompressive craniectomy seems to increase shunt-dependent hydrocephalus among patients undergoing surgical intracerebral hemorrhage evacuation. The decision to perform a craniectomy for patients with intracerebral hemorrhage should be carefully individualized while considering the risk of hydrocephalus [7)].

Systematic review

Yao et al. conducted a systematic review to verify the effects of decompressive craniectomy (DC) on improving outcome in spontaneous intracerebral hemorrhage.

Through searching several electronic databases, they screened eligible publications. Respective risk ratio (RR) and its 95% confidence interval (CI) were calculated, data were synthesized with a fixed-effect model, and sensitivity analyses and subgroup analyses were performed. Publication bias was measured with Begg and Egger tests.

Overall effect showed that DC significantly reduced the poor outcome compared with the control group (RR, 0.91; 95% CI, 0.84-0.99; P = 0.03). But in the subgroup analyses, only studies published after 2010, studies using hematoma evacuation as control, and studies measuring outcome with Glasgow outcome score showed better outcomes in the DC group than in the control group. The other subgroup analyses and sensitivity analyses achieved inconsistent results. Compared with the control group, DC effectively decreased mortality (RR, 0.67; 95% CI, 0.53-0.85; P = 0.0008). The sensitivity analyses and subgroup analyses achieved consistent results.

The application of DC effectively reduced mortality in patients with sICH. DC might improve functional outcomes in certain populations and needs further verification. DC is not associated with increased incidences of postoperative rebleeding and hydrocephalus [8)].

Experimental work

Marinkovic et al. from Helsinki, Finland, used the model of autologous blood injection into the basal ganglia in rats. After induction of ICH and then magnetic resonance imaging, animals were randomly allocated to groups representing no craniectomy (n = 10) or to craniectomy at 1, 6, or 24 hours. A fifth group without ICH underwent craniectomy only. Neurological and behavioral outcomes were assessed on days 1, 3, and 7 after ICH induction. Furthermore, terminal deoxynucleotidyl transferase

dUTP nick-end labeling-positive cells were counted.

After 7 days, compared with the ICH + no craniectomy group, all craniectomy groups had strikingly lower mortality ($P < 0.01$), much better neurological outcome ($P < 0.001$), and more favorable behavioral outcome. A trend occurred in the ICH + no craniectomy group toward more robust apoptosis.

Decompressive craniectomy performed up to 24 hours improved outcome after experimental ICH, with earlier intervention of greater benefit [9].

Case series

Lee et al. retrospectively enrolled 458 patients with supratentorial intracerebral hemorrhage who underwent surgical hematoma evacuation between April 2005 and December 2021 at two independent stroke centers. Multivariate analyses were performed to characterize risk factors for postoperative shunt-dependent hydrocephalus. Propensity score matching (1:2) was undertaken to compensate for group-wise imbalances based on probable factors that were suspected to affect the development of hydrocephalus, and the clinical impact of craniectomy on shunt-dependent hydrocephalus was evaluated by the matched analysis.

Overall, 43 of the 458 participants (9.4%) underwent shunt procedures as part of the management of hydrocephalus after ICH. Multivariate analysis revealed that intraventricular hemorrhage (IVH) and craniectomy were associated with shunt-dependent hydrocephalus after surgery for ICH. After propensity score matching, there were no statistically significant intergroup differences in participant age, sex, hypertension status, diabetes mellitus status, lesion location, ICH volume, IVH occurrence, or IVH severity. The craniectomy group had a significantly higher incidence of shunt-dependent hydrocephalus than the non-craniectomy group (28.9% vs. 4.3%, $p < 0.001$; OR 9.1, 95% CI 3.7-22.7), craniotomy group (23.2% vs. 4.3%, $p < 0.001$; OR 6.6, 95% CI 2.5-17.1), and catheterization group (20.0% vs. 4.0%, $p = 0.012$; OR 6.0, 95% CI 1.7-21.3).

Decompressive craniectomy seems to increase shunt-dependent hydrocephalus among patients undergoing surgical ICH evacuation. The decision to perform a craniectomy for patients with ICH should be carefully individualized while considering the risk of hydrocephalus [10].

Rasras et al. from the Department of Neurosurgery, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran, sought to assess the preliminary utility of decompressive hemicraniectomy (DHC) without clot evacuation in patients with deep-seated supratentorial ICH.

Patients with deep seated spontaneous intracerebral hemorrhage who were admitted to the Golestan Hospital, of Ahvaz, from November 2014 to February 2016, were prospectively enrolled in a study. A prospective clinical trial where 30 patients diagnosed having large hypertensive ICH was randomly allocated to either group A or B using permuted-block randomization. These patients ($n = 30$), who all had large deep seated supratentorial ICH with surgery indications, were randomly divided to two groups. ultimately, in one group ($n = 13$), large DHC was performed without clot evacuation, while in the other ($n = 17$), craniotomy with clot evacuation was done. Data pertaining to the patients characteristics and treatment outcomes were prospectively collected.

There was no statistically significant difference between two treatment groups ($P > 0.05$). No

significant difference was observed between the two groups in terms of mortality and GOS at 6 months ($P > 0.05$); nevertheless, the good outcome (Glasgow Outcome Scale = 4-5) for patients with hematoma evacuation was slightly higher (35.3%) as compared to the DHC patients without clot evacuation (30.7%).

Decompresive craniectomy without clot evacuation in deep seated ICH can be accomplished with identical mortality and outcome in comparison to patient that undergone clot evacuation [11].

A total of 54 eligible patients with spontaneous supratentorial hemorrhage (median age, 55 years; interquartile range, 47-64 years) who underwent decompressive craniectomy were retrospectively matched to 72 patients managed with best medical treatment (median age, 58 years; interquartile range, 32-74 years). Glasgow Outcome Scale (GOS) scores were dichotomized into favorable and unfavorable outcomes. Survival and functional outcomes were analyzed at discharge, 3, 6, and 12 months.

Survival in the craniectomy group was significantly higher compared with the medical treatment group at 30 days, 6, and 12 months (76%, 70%, and 70% vs. 60%, 57%, and 52% respectively; all $P \leq 0.05$). There was no difference in functional outcomes at discharge, 3, 6, or 12 months after hemorrhage (all $P > 0.05$). Decompressive craniectomy was associated with longer hospital stay (median of 30 days vs. 7 days in the control group; $P < 0.001$). Hospital adverse events were more frequent in the craniectomy group than in the control group (76% vs. 33%; $P < 0.001$), the commonest adverse events being pneumonia and urinary tract infections.

They showed that decompressive craniectomy significantly improved survival compared with medical treatment with lasting benefits. This improvement came at a cost of increased length of hospital stay and related adverse events. There was no improvement in functional outcome [12].

Decompressive craniectomy is associated with a significant increase in perihematomal edema compared to patients who have been treated conservatively. Perihematomal edema itself lasts about 60 days if it is not treated, but decompressive craniectomy ameliorates the mass effect exerted by the intracerebral hemorrhage plus the perihematomal edema, as reflected by the reduced midline shift [13].

The experience of Esquenazi et al. in an 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. These findings suggest that a prospective randomized trial of DH vs. craniotomy for ICH be conducted.

Over 7 years, DH was performed in 73 patients with clot evacuation in 86% and DH alone in 14%. The average ICH volume was 81 cc and the median DH 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. [14].

Of 21 patients who underwent DC for hemispheric hypertensive ICH in the Department of Neurosurgery, National Defense Medical College, Tokorozawa, Saitama, Japan, eleven of the patients were male and 10 were female, with an age range of 22-75 years (mean, 56.6 years). Their preoperative Glasgow Coma Scale scores ranged from 3 to 13 (mean, 6.9). The hematoma volumes ranged from 33.4 to 98.1 mL (mean, 74.2 mL), and the hematoma locations were the basal ganglia in 10 patients and the subcortex in 11 patients. Intraventricular extensions were observed in 11 patients. With regard to the complications after DC, postoperative hydrocephalus developed in ten patients, and meningitis was observed in three patients. Six patients had favorable outcomes and 15 had poor outcomes. The mortality rate was 10 %. A statistical analysis showed that the GCS score at admission was significantly higher in the favorable outcome group than that in the poor outcome group (P = 0.029). Our results suggest that DC with hematoma evacuation might be a useful surgical procedure for selected patients with large hemispheric hypertensive ICH [15].

Fung et al. compared consecutive patients (November 2010-January 2012) with supratentorial ICH treated with DC without hematoma evacuation and matched controls treated by best medical treatment. DC measured at least 150 mm and included opening of the dura. We analyzed clinical (age, sex, pathogenesis, Glasgow Coma Scale, National Institutes of Health Stroke Scale), radiological (signs of herniation, side and size of hematoma, midline shift, hematoma expansion, distance to surface), and surgical (time to and indication for surgery) characteristics. Outcome at 6 months was dichotomized into good (modified Rankin Scale 0-4) and poor (modified Rankin Scale 5-6).

Twelve patients (median age 48 years; interquartile range 35-58) with ICH were treated by DC. Median hematoma volume was 61.3 mL (interquartile range 37-83.5 mL) and median preoperative Glasgow Coma Scale was 8 (interquartile range 4.3-10). Four patients showed signs of herniation. Nine patients had good and 3 had poor outcomes. Three patients (25%) of the treatment group died versus 8 of 15 (53%) of the control group. There were 3 manageable complications related to DC.

DC is feasible in patients with ICH. Based on this small cohort, DC may reduce mortality. Larger prospective cohorts are warranted to assess safety and efficacy [16].

Records of 12 consecutive patients with hypertensive ICH treated with decompressive hemicraniectomy were reviewed. The data collected included Glasgow Coma Scale (GCS) score at admission and before surgery, ICH volume, ICH score, and a clinical grading scale for ICH that accurately risk-stratifies patients regarding 30-day mortality. Outcome was assessed as immediate mortality and modified Rankin Score (mRS) at the last follow-up.

Of the 12 patients with decompressive hemicraniectomy, 11 (92%) survived to discharge; of those 11, 6 (54.5%) had good functional outcome, defined as a mRS of 0 to 3 (mean follow-up: 17.13 months; range: 2-39 months). The mean age was 49.8 years (range: 19-76 years). Three of the 7 patients with pupillary abnormalities made a good recovery; of the 11 patients with intraventricular extensions (IVEs), 7 made a good recovery. The clinical finding (which was present in all 3 patients with mRS equal to 5 and which was not present in patients with mRS less than 5) was abnormal occulocephalic reflex. Of the 10 patients with an ICH score of 3, 9 (90%) survived to discharge, 4 (44%) had good

functional outcome (mRS: 1-3). Hematoma volume was 60 cm3 or greater in eight patients, four (50%) of whom had good functional outcome (mRS: 0-3).

Decompressive hemicraniectomy with hematoma evacuation is life-saving and improves unfavorable outcomes in a select group of young patients with large right hemispherical ICH [17].

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