Decompressive Craniectomy for Stroke: Early Cranioplasty Is a Predictor for Postoperative Complications

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BACKGROUND: **Previous clinical studies assumed that early cranioplasty (CP) was mandatory for a favorable neurologic recovery after decompressive craniectomy (DC) for malignant stroke. However, the appropriate timing of the CP procedure after DC remains controversial. This study assessed patients who underwent DC because of cerebral ischemia to determine the appropriate time point of CP and surgical-associated complications.**

METHODS: **Data from the period 2007–2014 were retrospectively evaluated. CP was performed in 75 patients who previously underwent DC because of supratentorial cerebral infarction. Patients were divided into 2 groups (early CP vs. late CP) according to the time from DC to CP (<3 months vs. ≥3 months). Patient characteristics, timing of CP, and postoperative complications associated with CP were analyzed.**

RESULTS: **CP was performed early in 12 patients (16%) and late in 63 patients (84%). The complication rate after CP was 18%; complications included wound healing disturbance in 8 patients (11%), epidural hematoma or subdural hematoma in 4 patients (4%), and others in 2 patients (3%). Patients with early CP experienced significantly more complications compared with patients with late CP after initial DC (5 of 12 patients [42%] vs. 8 of 63 patients [13%]; $P = 0.02$). In multivariate analysis, early CP was a significant predictor of postoperative complications after CP (odds ratio = 6.04; 95% confidence interval, 1.4–24.9; $P = 0.01$).**

CONCLUSIONS: **The present data suggest that patients who underwent DC for stroke might benefit from CP performed >3 months after DC owing to a lower rate of wound infection.**

INTRODUCTION

Decompressive craniectomy (DC) as a lifesaving procedure is often performed in patients with space-occupying lesions of various underlying pathologies,[1-4] especially during the treatment of space-occupying ischemic stroke (SIS).[4] Published randomized controlled studies have demonstrated an increased survival rate for DC after SIS.[5-7] This fact argues in favor for early DC, and consequently a growing number of survivors require cranioplasty (CP) at a later treatment stage. Patients who underwent stroke-related DC generally have several comorbidities and take antiplatelet medication, which might have an impact on postoperative complications and the surgical outcome of CP. A broad range (16%–33%) is given in the literature for the incidence of CP-related postoperative complications.[8-13] Timing of CP has been discussed as a possible predictor for the incidence of CP-related postoperative complications.[11,12,14,15] Several previous reports suggested a favorable outcome of CP performed early in terms of reduced postoperative morbidity and improved neurologic outcome.[14,16,17] Nevertheless, optimal timing of CP after DC still requires refinement. Previously published data included a heterogeneous study population consisting of patients with ischemic and/or hemorrhagic stroke and other supratentorial lesions. The aim of the present study was to analyze patients who underwent CP after DC in a homogeneous population (SIS) to determine the optimal timing of CP with regard to CP-related postoperative complications.

Key words
- Complications
- Cranioplasty
- Stroke
- Decompressive craniectomy

Abbreviations and Acronyms
CI: Confidence interval
CP: Cranioplasty
DC: Decompressive craniectomy
mRS: Modified Rankin Scale
OR: Odds ratio
SIS: Space-occupying ischemic stroke

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Citation: World Neurosurg. (2016) 92:83-88.
http://dx.doi.org/10.1016/j.wneu.2016.04.113

*Journal homepage: **www.WORLDNEUROSURGERY.org***

*Available online: **www.sciencedirect.com***

MATERIALS AND METHODS

A retrospective analysis comprising 75 patients in whom CP was performed after DC for supratentorial SIS during the time period January 2007 to April 2014 was performed. Patients with infratentorial stroke were not included in this study. Patient characteristics, including clinical features on admission and during the course of treatment, radiologic findings, modality of DC and CP, duration of the surgical procedures of DC and CP, time from DC to CP, postoperative complications of DC and CP, and neurologic functional outcome, were entered into a prospectively conducted database (IBM SPSS Statistics for Windows, version 22.0; IBM Corporation, Armonk, New York, USA).

Initial DC was performed in patients with malignant brain swelling after SIS, and the site of DC was determined by location of brain ischemia. The size of DC was at least 11 × 16 cm, and surgery was performed according to a standardized operative procedure as previously described.[18,19] The bone flap was frozen and stored under sterile conditions at −80°C immediately after DC.

Neurologic Functional Outcome

Functional outcome in patients who underwent CP after DC for ischemic stroke was assessed according to the modified Rankin scale (mRS) on admission for the CP. Functional outcome was further stratified into favorable (mRS score ≤4) and unfavorable (mRS score >4) outcome.[5-7]

Cranioplasty

CP was performed as an elective procedure in clinically stable patients after resolution of brain edema. Oral anticoagulation or antiplatelet drugs were withdrawn 7 days before surgery. There was no specific protocol with regard to the timing of CP secondary to lack of data. Based on personal experience and recommendations of the attending neurosurgeon, CP was performed either early, defined as <3 months after DC, or late, defined as >3 months after DC. The surgical procedures for CP were performed as previously described.[12] According to our institutional guidelines, all patients received a single intravenous dose of 2 g ceftriaxone before surgery as perioperative infection prophylaxis. In patients with hydrocephalus, a lumbar drain was inserted preoperatively and was removed immediately after CP. A routine computed tomography scan was performed on the first postoperative day to rule out CP-related complications and to verify proper positioning of the autologous bone flap.

According to previously published studies, we defined the cutoff time point for early and late CP at 3 months after the initial DC.[10,14,16,17,20,21] Patients were divided into 2 groups according to the time period from DC to CP: early CP (<3 months) versus late CP (≥3 months). Postoperative complications related to CP that warranted repeat surgery were assessed and analyzed.

Statistical Analysis

Statistical analysis of data was performed using IBM SPSS Statistics for Windows, version 22.0. Associations between parametric variables were analyzed using unpaired, 2-tailed Student *t* test. Mann-Whitney test was used for analysis of associations between nonparametric variables. Associations of categorical variables were compared using χ^2 test or Fisher exact test. Results with $P < 0.05$ were considered to be statistically significant. For identification of independent predictors for complications after CP, a multivariate analysis was performed including the variables with significant P values in univariate analysis. We also included variables that had been suggested to be relevant in the literature (age >65 years,[13,22] sex,[22] presence of ventriculoperitoneal shunt[11,12]). A binary logistic regression model was used. Significance was established at the 95% level.

RESULTS

Patient Characteristics

In the studied period between 2007 and 2014, DC for ischemic stroke was performed in 93 patients. We identified 75 patients who underwent CP after DC for SIS. Patient characteristics, including mean age, sex, neurologic functional outcome, and data related to the CP procedures are shown in Table 1.

Complications of CP

CP-related complications occurred in 13 of 75 patients (18%). Complications were wound healing disturbance or infection in 8 patients (11%), bleeding complications (epidural hematoma or subdural hematoma) in 3 patients (4%), and other complications (bone flap dislocation) in 2 patients (3%) (Table 2). The overall complication rate in patients with early CP was significantly higher compared with patients with late CP (42% vs. 13%; odds ratio [OR] = 4.9; 95% confidence interval [CI], 1.3–19.3; P = 0.02).

Time to CP

The mean time (±SD) to CP was 145 days ± 65. There were 12 patients (16%) with early CP in the cohort and 63 patients (84%) with late CP. The mean duration of the CP procedure was 112 minutes ± 38 in the early CP cohort versus 125 minutes ± 34 in the late CP cohort (P = 0.2). There was no significant difference between cohorts according to age, sex, and duration of the CP procedure (Table 3).

Neurologic Functional Outcome

Patients in both the early CP group and the late CP group achieved a median mRS score of 4. A favorable outcome was achieved by 10 of 12 patients in the early CP group compared with 50 of 63 patients in the late CP group (83% vs. 79%; P = 1.0).

Impact of Timing of CP on Postoperative Complications

Procedure-related complications according to the timing of CP are shown in Figure 1. The overall complication rate in patients with early CP was significantly higher compared with patients with late CP (5 of 12 patients [42%] vs. 8 of 63 patients [13%]) (OR = 4.9; 95% CI, 1.3–19.3; P = 0.02) (Tables 2 and 3). Wound healing disturbance was the most common complication in both patients with early CP and patients with late CP. Patients with early CP had significantly more complications related to wound healing disturbance compared with patients with late CP (4 of 12 patients [33%] vs. 4 of 63 patients [6%]) (OR = 7.4; 95% CI, 1.5–35.5; P = 0.01) (Table 2). There was no difference regarding bleeding complications between patients with early CP and