Original Article

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Factors Associated with Non-Hemorrhagic Extra-Axial Fluid Collection after Cranioplasty

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Abstract

Aim: Even though, cranioplasty (CP) is an easy surgery to perform, reoperation rate is high because of complications like infection, new-onset seizure, bone flap resorption, hydrocephalus, intracranial hemorrhage, and extra-axial fluid collection (EAFC). Epidural fluid collection is not well described in the literature. In this context, we aimed to evaluate non-hemorrhagic EAFC collections seen after CP procedure.

Methods: From May 2016 to December 2021, Patients with or without EAFC who have undergone CP were retrospectively evaluated with the parameters of age, gender, first surgical diagnosis, the material used in CP, sinking skin flap presence, midline shift (MS), comorbidity factors, pre-operative duration, length of hospital stay in the first surgery, pre-and post-operative Glasgow outcome scores, bleeding in the surgical site, EAFC, infection, hydrocephalus, CP area, new-onset seizure after CP, reoperation risk and reoperation time.

Results: A total of 106 patients, 70 male, and 36 female, with a mean age of 39.13±17.86 were included in the study. The number of patients with EAFC is 49 and the number of patients without EAFC is 57. The mean hospital stay day of EAFC (+) group (38.28±36.54) is longer and statistically significant compared to the EAFC (-) group (22.19±24.87) (p=0.009). Time interval between surgeries for EAFC (+) group was 215.51±284.28 days and EAFC (-) group was 226.26±509.36 days. Re-operations were performed in 16 of 49 patients who developed EAFC (32.6%) (p=0.022). Infections 68% (n=11), intracerebral hemorrhage 6.2% (n=1), seizure (6.2%), MS (6.2%), subgaleal effusion (6.2%), hydrocephalus (6.2%). Re-operation time EAFC (+) is 5.2±5.41 months and EAFC (-) 20.55±21.3 months (p=0.041).

Conclusion: Particularly in frail patients with a longer hospital stay, after CP, EAFC cases should be closely follow up due to the risk of re-surgery as a result of infection.

Keywords: Cranioplasty, epidural fluid collection, complication

Introduction

Cranioplasty (CP) is a surgical procedure performed to cosmetically close cranial bone defects to both create a physical barrier and normalize the cerebrospinal fluid (CSF) and brain-blood circulation in patients who have undergone decompressive craniotomy or craniectomy (DC) to reduce the increased intracranial pressure following a traumatic brain injury, cerebral infarct, subarachnoid bleeding, intracranial hematoma, encephalitis, sinus vein thrombosis, tumor or aneurysm surgery (1-5).

Although CP is technically an easy surgery to perform, it has up to 45.3% complication rates including infection, new-onset seizure, bone flap resorption, hydrocephalus, intracranial hemorrhage (ICH), and extra-axial fluid collection (EAFC) (2-11).

Shepetovsky et al. (7) found in their review conducted with 636 patients that the EAFC complication, among others, ranged between 1.1% and 37.3% with an average of 6.0%. Jeong et al. (12) evaluated the surgical intervention rate as 20% for patients who developed EAFC. In addition, Kim et al. (13) associated EAFC with surgical site infection after CP. The fact that EAFC requires surgical re-intervention and its possible relationship with infection suggested that further investigation is required.

In this study, we aimed to retrospectively evaluate the relationship between non-hemorrhagic EAFC and the patient's age, gender, first surgical diagnosis, the material

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used in CP, presence of sinking skin flap (SSF), midline shift (MS), comorbidity factors, pre-operative duration, duration of hospital stay at first surgery, pre-and post-operative Glasgow outcome score (GOS), bleeding in the surgical site, epidural collection, infection, CP area, new-onset seizure after CP, and hydrocephalus, and to examine potential predisposing factors.

Methods

Compliance with Ethical Standards

Ethical permission was obtained from Clinical Research Ethics Committe of University of Health Sciences Turkey, Istanbul Haseki Training and Research Hospital (approval number: 91- 2022, date: 11/5/2022).

Patient Selection

Patients who have undergone CP between 2016 and 2021 were retrospectively evaluated.

Inclusion Criteria

Decompressive surgery history, over the age of 18, SSF or trephined syndrome, midline brain shift, patients were included.

Exclusion Criteria

Cranioplasty patients with history of infections, seizure, and hydrocephalus, craniosynostosis, lineer skull fracture, lower Karnofsky performance score (<40) were excluded from the study.

Surgical Procedure

Following the application of appropriate prophylactic antibiotics and positioning of the patient appropriately, the surgical site was cleaned with baticon, the old incision line was opened sterilely, and the dura and layers were dissected. In cases with porencephalic cyst, the cyst was aspirated and duraplasty was performed. Tissue adhesive was used after controlling CSF leakage by applying positive end-expiratory pressure to the patients during the operation. The surgical site was washed with gentamicin and saline solution. If there was an autogenous bone, it was removed from its place in a sterile manner and re-planted after washing with gentamicin and saline solution. However, if the bone flap was severely resorbed or infected, CP was performed with titanium plaque or methyl methacrylate. Drains were used routinely in the epidural and subgaleal area.

We used Osirix MD to calculate the CP area according to the CT. The patients were followed up with CT in the early postoperative period, and EAFC that continued after the 10th day after CP were considered positive in these follow-ups (Figures 1-3).

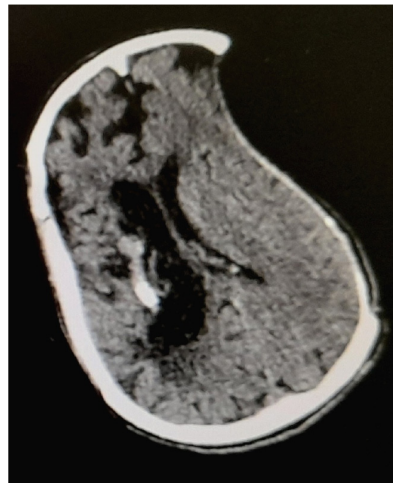

Figure 1. Preoperative CT
CT: Computed tomography

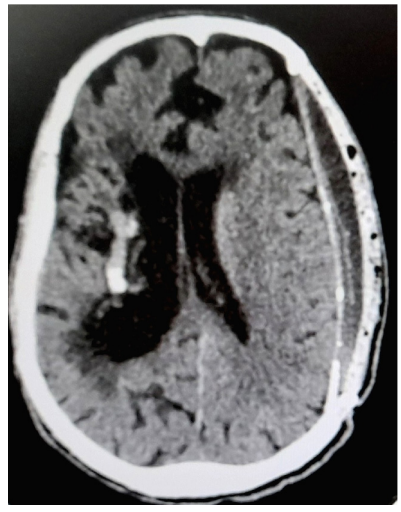

Figure 2. Postoperative CT with EAFC (+)
CT: Computed tomography, EAFC: Extra-axial fluid collection

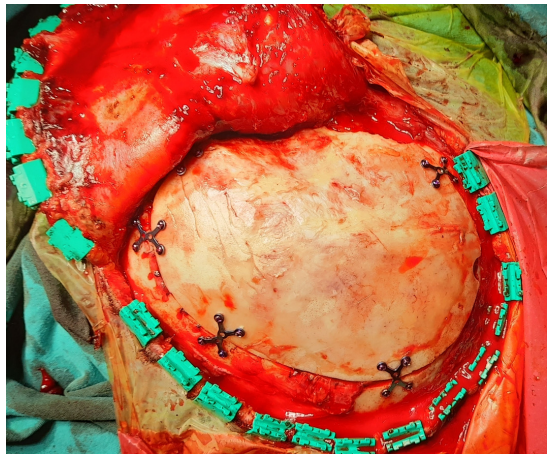

Figure 3. Cranioplasty restored bone flap with titanium screw and miniplate

Statistical Analysis

Statistical analysis was performed using the SPSS v20.0 software package (SPSS Inc., Chicago, IL, USA). Descriptive data were expressed in frequency, cross table, rate, arithmetic mean, and standard deviation. Data were analyzed with the Student's t-test and correlation. The groups were compared with test variables using independent samples t-test and multinominal logistic regression. A p-value of $p \leq 0.05$ was considered statistically significant.

Compliance with Ethical Standards

Ethical permission was obtained from Clinical Research Ethics Committe of University of Health Sciences Turkey, Istanbul Haseki Training and Research Hospital (approval number: 91-2022, date: 11/5/2022) and written informed consent was collected from all participants.

Results

A total of 106 patients, 70 male, and 36 female, with a mean age of 39.13±17.86 were included in the study. The number of patients with EAFC is 49 and the number of patients without EAFC is 57 (Table 1).

No significant relationship was found between EAFC and age, gender, first surgical diagnosis, the material used in CP, SSF, MS, comorbidity factors, pre-operative time, pre-and post-operative GOS, bleeding in the surgical site, epidural collection, infection, CP area and new-onset seizure after CP, and hydrocephalus. However, a positive relationship was found between the patients with a long hospital stay, surgical reoperation and reoperation time and EAFC development (Tables 1 and 2).

Discussion

While the rate of EAFC after CP ranged from 1.1% to 37.3% in a review of 636 patients by Shepetovsky et al. (7), Kim et al. (14) found this rate to be 41% in their study conducted with 117 patients (10). This rate was found as 46% in our study consisting of 106 patients.

Although EAFC is mostly asymptomatic, Jeong et al. (12) reported that 13 patients, among 65, who have undergone DC followed by CP had symptomatic EAFC, and therefore, surgical intervention was performed. Similarly, Lee et al. (15) reported in their study including non-traumatic patients that 22 of 59 CP patients developed EAFC and that surgical procedure was performed in 5 (22.7%) of those patients. Kim et al. (14) with a similar patient group reported that 48 of the 117 CP patients developed EAFC and 19 (38.8%) patients underwent surgical procedures. In our study, surgical procedures

Table 1. The age, gender, comorbidities, primary diseases, and comorbidity

	EAFC (+) (n=49) Mean ± SD	EAFC (-) (n=57) Mean ± SD	p-value
Age	41.44±17.2	37.14±18.2	0.217
Gender			0.504
Male	34	36	0.504
Female	15	21	0.504
Comorbidity			0.139
DM	1	0	0.431
HT	6	12	0.199
CAD	4	1	0.704
DM and HT	6	5	0.424
HT and CVD	2	1	0.667
HT, CVD, DM	1	0	0.283
No	29	38	0.433
Indication for craniectomy/craniotomy			0.872
Cerebral infarct	5	8	0.525
Trauma	20	21	0.529
Tumor	15	18	0.672
Aneuyrsm	3	0	0.06
ICH	5	7	0.872
Growing skull fractures	1	3	0.65

DM: Diabetes mellitus, HT: Hypertension, CAD: Coronary artery disease, CVD: Cerebrovascular disease, EAFC: Extra-axial fluid collection, SD: Standard deviation

Table 2. Peroperative and postoperative patient's status			
	EAFC (+) (n=49) Mean ± SD	**EAFC (-) (n=57) Mean ± SD**	**p-value**
GOS			
Preoperative GOS	4.06±0.89	4.22±0.73	0.295
Postoperative GOS	4.51±0.61	4.63±0.48	0.260
Hospital stay day	38.28±36.54	22.19±24.87	0.009
SSF and MS	0.93±1.73	0.57±1.32	0.229
Time interval between surgeries	215.51±284.28	226.26±509.36	0.89
Cranioplasty area			0.066
100 cm^2>	24	38	0.066
100 cm^2≤	25	19	0.068
Epidural air			0.130
(+)	42	42	0.130
(-)	7	15	0.124
Cranioplasty materials			0.561
Autogenous bone	26	31	0.594
MMA	17	16	0.595
Titanium	2	3	0.834
Combination	4	5	0.949
Reoperation	16	8	0.022
Reoperation time (month)	5.2±5.41	20.55±21.3	0.041

GOS: Glasgow outcome scores, cranioplasty materials, MMA: Methyl methacrylate, time interval between surgeries (day), hospital stay day, SSF: Sinking skin flap presence, MS: Midline shift, SD: Standard deviation, EAFC: Extra-axial fluid collection, N: number, Cranioplasty area, epidural air, reoperation and reoperation time (month). Independent samples t-test used between EAFC (+) and (-) groups, p-value, Mean

were performed in 16 of 49 patients who developed EAFC and the rate was found to be 32.6%. The evaluation of patients who underwent surgery showed that the rate of reoperation due to MS 6.2% (1/16), seizure (6.2%), ICH (6.2%), subgaleal effusion (6.2%), hydrocephalus (6.2%) and 68% (11/16) infection. In their study investigating the predisposing factors using parameters such as age, comorbidity, the material used, first diagnosis, GOS, and timing of CP which can be associated with infection after CP, Kim et al. (13), EAFC was considered as the only factor associated with infection. Although the risk of reoperation is statistically significant for EAFC group, infection rates was high but it was not significant for reoperation in our patient group (p=0.179). Although this situation gives rise to the thought of whether EAFC is a cause or result, we believe that EAFC becomes complicated by acting as a medium for the microorganism that may have an asymptomatic course.

In their study evaluating the relationship between age, gender, first diagnosis, CP timing, duration of surgery, bone flap length, CP material used, presence of shunt, epidural air, dural calcification, and the EAFC, Kim et al. (14) found a relationship between epidural air and dural calcification and EAFC. Lee et al. (15) examined the relationship between these parameters and EAFC, and found that EAFC is associated with male gender, epidural air, and dural calcification. Similarly, Jeong et al. (12) evaluated age, gender, first diagnosis, CP timing, CP material used, and CSF fistula during surgery in cases with EAFC grouped as symptomatic and asymptomatic, and found that the size of the bone flap and the presence of CSF fistula during CP were associated with symptomatic EAFC. Again, in the same study, they found that the presence of epidural air was 70% in the symptomatic EAFC group while 40% in the asymptomatic EAFC group, and reported that this was not associated with EAFC (12). In our study, presence of epidural air was 85.1% in EAFC (+) and 73.6% in EAFC (-) patients, and there was no statistical relationship between these groups. Although there is a statistically significant relationship in wide craniotomy defects in the study by Jeong et al. (12), no significant relationship was found with the CP area in our study, even though 25 of the 49 patients who developed had a CP area of more than 100 cm^2 (p=0.66). Epidural efusion may be an allergic reaction to the CP material (10), but we found no statistically difference between CP materials (p=0.56).

As dural calcification was observed in only 3 patients, no statistical evaluation could be performed. In our study, we evaluated that the duration of hospital stay before CP is associated with EAFC which is different from the literature. Decompressive craniotomy is performed frequently in trauma and ischemia cases, and the post-surgery intensive care and length of hospital stay are longer compared to other patient groups due to severe neurological deficits in patients (12). The mean hospital stay of our EAFC (+) patients is longer and statistically significant compared to the EAFC (-) patients (p=0.009). While Chun and Yi (16) found that the EAFC ratio was 7% in patients who have undergone CP within the first month, those who have undergone CP after 3 months had a ratio of 46.7%. They explained this situation with the resolution of brain edema and the increase in the permanent dead space in the late period (16). However, the CP procedure was performed between 3 and 6 months the earliest following the stabilization of the general status of our patients, and the patients with EAFC (n=26) (53.06%) were operated on within the 90 days-early periods. Although all EAFC (+) patients were operated on at an average of 215.51±284.82 days later, no statistically significant results were found. This suggested that other factors requiring a longer hospital stay should be examined rather than the duration.

Study Limitations

The main limitation of the current study is its retrospective and it is obvious that evaluations with larger series are needed. Despite these limitations the longer hospital stay is statistically significant a predisposition factor of EAFC. There are only a few series reporting EFCs following CP. We believe that using a shared definition of EAFC to get more efficient results will contribute to obtaining more valuable results in future studies.

Conclusion

Extra-axial fluid collection developing after the CP procedure is mostly asymptomatic and spontaneous resorption is observed frequently. Particularly in frail patients with a longer hospital stay, post-CP EAFC cases should be monitored closely due to the risk of re-surgery as a result of infection.

Ethics

Ethics Committee Approval: Ethical permission was obtained from Clinical Research Ethics Committe of University of Health Sciences Turkey, Istanbul Haseki Training and Research Hospital (approval no: 91-2022, date: 11.05.2022).

Informed Consent: Written informed consent was collected from all participants.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: A.A., Concept: A.A., T.T., Design: A.A., Data Collection or Processing: A.A., T.T., Analysis or Interpretation: A.A., T.T., Literature Search: A.A., T.T., Writing: A.A., T.T.

Conflict of Interest: The authors have no conflicts of interest to declare.

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