ORIGINAL ARTICLE

Retrospective analysis of decompressive craniectomy performed in pediatric patients with subdural hematoma

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ABSTRACT

BACKGROUND: The impact of decompressive craniectomy (DC) on the overall outcome of pediatric acute subdural hematoma patients has not been fully determined to date. In this paper, we aimed to investigate the role of decompressive craniectomy performed to treat traumatic subdural hematoma in patients from the pediatric age group.

METHODS: We described our experience with DC in pediatric acute subdural hematoma patients and analyzed the outcomes.

RESULTS: Eleven (7 unilateral and 4 bilateral) DCs were performed. The patients' ages ranged from 8 months to 15 years. The mean GCS score at admission was 7.8. All patients underwent DC with duraplasty within 2 hours of injury. All the patients were admitted to the intensive care unit for 10 days postoperatively. The mean hospital stay was 22 days and the mean follow-up period was 3.7 years.

CONCLUSION: Early DC for pediatric subdural hematoma patients, independent of their initial GCS, was recommended. Larger studies are needed to define the indications, surgical techniques, and timing of DC in the pediatric population.

Keywords: Acute subdural hematoma; decompressive craniectomy; head injury.

INTRODUCTION

Head injury is the leading cause of disability and death in children and adolescents.[1] In the United States, more than one million head injuries happen in the pediatric age group.[2] Motor vehicle crashes, falls, sports, and abuse/assault are the most frequent causes of head injury.[2] Despite advances in brain monitoring and medical management of intracranial hypertension, the morbidity and mortality rates are still high.[3]

Acute subdural hematoma (SDH) results in approximately one-third of the total traumatic head injuries.[4] Its mortality rate ranges from 40–60% and functional recovery rate ranges from 19–45%.[5]

Recent trauma guidelines for surgical management of SDH stated that surgical evacuation of an acute SDH is indicated if its thickness exceeds 10 mm or the midline shift exceeds 5 mm regardless of the Glasgow Coma Scale (GCS) score. In patients with a GCS score of less than 9, evacuation may be indicated independent from the volume of SDH.[6]

Decompressive craniectomy includes elevating a bone flap, evacuating the hematoma, and storing the bone flap to accommodate the expansion of edematous cerebral tissue. This facilitates the management of intracranial pressure (ICP), which is the preferred management strategy for SDH.[7]

Many studies have previously researched the role of decompression craniectomy (DC) for SDH but few studies were done for the pediatric age group. In this manuscript, we aimed to investigate the role of decompressive craniectomy at traumatic subdural hematoma in the pediatric age group.

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MATERIALS AND METHODS

This study was performed with the permission of the Ethical Committee of Uludag University School of Medicine, Bursa, Turkey (2018-13/9).

We retrospectively reviewed the clinical records of 11 children with SDH who were treated with DC in a tertiary university hospital during a period of 18 years (2000–2018). Descriptive statistics included age and sex, mechanism of injury, Glasgow Coma Scale (GCS) score on arrival at the hospital, minimum GCS score, neurological examination on admission, and computed tomography (CT) findings. The variables related to DC included indications for the procedure, timing of the surgery, surgical technique, and the area of decompression. Outcome variables consisted of modified Rankin score (mRS) and the immediate and long-term complications associated with the intervention.

Surgical Procedure

Out of 11 patients, 7 patients (63%) underwent unilateral frontotemporoparietal craniectomy. Bifrontal craniectomy was performed in 4 cases (36%). The dura mater was opened and duraplasty was performed with galea or artificial prostheses in all cases. ICP was not monitored because of the urgency of the condition. The bone fragment was stored cold at -19.5 °C in a deep freeze dedicated as the bone bank. The bone fragments were replaced in the first month in 1 patient, in the second or third month in 3 patients, and after the sixth month in 4 patients.

Case Presentation

A 20 month-old female infant was admitted to the emergency department following a head injury due to a fall from the second floor (patient #6). She was intubated, unconscious, and had no response to light in both pupils. Her GCS was 3. A right frontotemporoparietal subdural hematoma was detected and she was operated with a right frontotemporoparietal craniectomy. The hematoma was evacuated and an intracranial pressure monitoring kit was placed (Codman® MicroSensor, Codman & Shurtleff Inc, Raynham, MA, USA). The opening pressure was 3 mmHg. The cold stored bone flap was replaced 1.5 months after the operation. At the 4-year follow-up, she was neurologically intact and her only complaint was of a headache (Fig. 1).

RESULTS

We performed a total of 11 DCs. None of the patients died and the outcome was favorable in the survivors (Table 1).

The patients' ages ranged from 8 months to 15 years (median age: 48 months). Out of 11 patients, 5 patients (45.5%) were boys and 6 (54.5%) were girls. The causes of injury were as follows: fall from a height (4 patients), traffic accident (5 patients), and hit by an object (1 patient). On admission, 6 patients had a GCS score of ≤8 (54.5%) and 5 patients had a GCS score of >9. The mean GCS score in our sample was 7.8. One patient (9.09%) presented with initial anisocoria. All patients underwent DC with duraplasty within 2 hours of injury. All the patients were followed-up at the intensive care unit for 10 days postoperatively. The fastest time taken to perform DC was 1 hour and the longest was 7 hours (median DC time: 4 hours). The median decompression area was calculated as 325 cm2 (157.50:792). The median cranioplasty time was 4.50 months (1:12) after the operation and the mean hospital stay was 22 days. The mean follow-up period was 3.7 years. The mRS ranged from 1–4 (median mRS score: 3) at discharge and the median mRS was 1.6 at follow-up.

Complications

The most frequent complications were seizure and infection. Two patients developed meningitis and wound infection was detected in 2 patients. Seven patients (63%) experienced aseptic resorption of the bone flap. Three patients required an additional cranioplasty (Table 1).

Statistics

Due to the young patient age, the preoperative GCS, decompression time, decompression area, mRS score, and cranioplasty time did not follow normal distribution according to

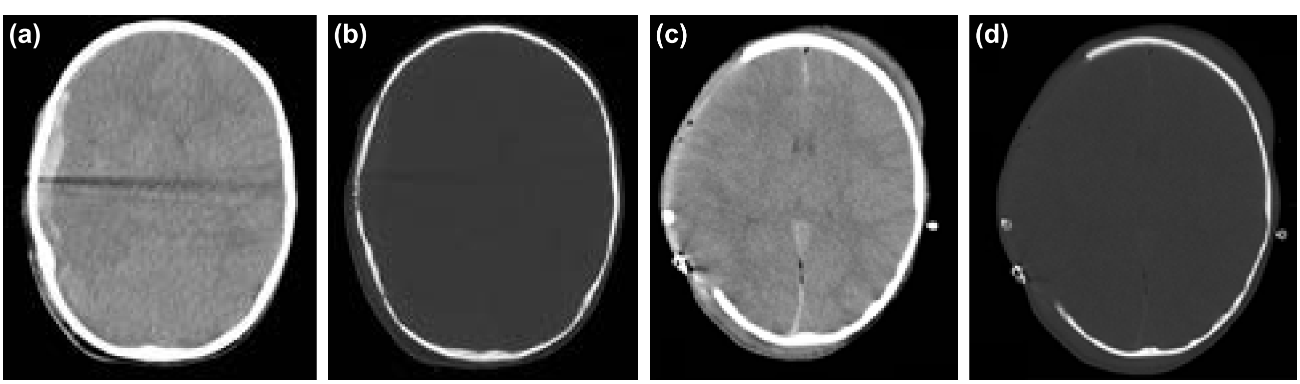

Figure 1. (a, b) Preoperative CT showing right frontotemporoparietal subdural hematoma; **(c, d)** Postoperative CT with parenchyma and bone window presenting decompression.

Table 1. Demographic findings of the patients

Age (months)	Gender	Complaint	Preoperative GCS	Decompression time	DC side	Decompression area (cm^2)	mRS_d	mRS_f	Complication	Cranioplasty time	Follow-up (years)
48	Male	Fall from height	11	4	Right	229	1	0	–	2	14
13	Female	Fall from height	6	2	Right	235	3	0	Wound infection		2
180	Male	Traffic accident	3	1	Bilateral	325	3	3		3	0.5
160	Male	Traffic accident	4	1	Bilateral	792	2	2	Meningitis	5*	3
71	Male	Hit by rigid object	14	4	Bilateral	432	1	0	Meningitis	6	2
20	Female	Fall from height	3	1	Right	480	4	2	Hygroma	1.5	4
146	Female	Traffic accident	3	1	Bilateral	572	3	3	–	12*	1
23	Female	Fall from height	14	7	Bilateral	157.5	4	2	–	5*	5
8	Female	Late onset hemorrhagic disease of newborn	15	4	Left	210	3	2	Wound infection	1	1
46	Male	Traffic accident	4	4	Left	720	3	2	–	4	3
156	Female	Traffic accident	9	6	Right	288	4	2	Focal seizure	12	6

mRS_d: Modified Rankin score at discharge; mRS_f: Modified Rankin score at follow-up; GOS: Glascow outcome score; *: Artificial cranioplasty.

Table 2. The relation between mRS and age, decompression time, cranioplasty time, preoperative Glasgow Coma Scale, and decompression area

	mRS	
	r_s	p
Decompression time	0.19	0.571
Cranioplasty time	0.21	0.556
Preoperative Glasgow Coma Scale	-0.18	0.599
Decompression area	-0.21	0.531
Age	-0.24	0.484

mRS: Modified Rankin score; r_s: Spearman correlation coefficient.

Shapiro Wilk test and median (minimum: maximum) values were used to express these variables. Categorical variables were expressed as n (%). The relation between mRS and age, decompression time, cranioplasty time, preoperative GCS, and decompression area findings were assessed using correlation analysis and Spearman correlation coefficient (rs) was computed (Table 2). SPSS (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.) was used for statistical analysis and the level of significance was set at α=0.05.

DISCUSSION

Several authors have examined the usefulness of DC in children, but its role is still controversial. The indications and results of DC are unclear to date.

There have only been a few studies that evaluated the clinical results of DC in pediatric patients.[8–12] Most of these studies had a limited number of patients and heterogeneous indications for DC. DC is indicated within 4 hours after the trauma or secondary clinical deterioration. DC is not recommended in patients with ICP maintained over 40 mmHg.[13] In the guidelines for the acute medical management of severe traumatic brain injury in infants, the treatment threshold for children and adolescents was considered when ICP was at 20 mmHg.[6] ICP monitoring kit was placed in 7 patients in our series but only 1 of these was preoperatively placed, while 6 were placed after DC for clinical follow-up. Mean ICP opening pressure for postoperative DC was 6 mmHg, representing the usefulness of decompression.

It has been shown that there is a 60% mortality gap between the patients operated within 4 hours and more than 4 hours after injury.[14] However, there was no statistically significant relation was determined between mortality, morbidity, and time from injury to operative evacuation on an hourly basis.[15]

Brain Trauma Foundation guidelines recommend DC in the first 48 hours after onset of ICP elevation[6] but there are many studies stating that early DC is considered to improve prognosis.[10,11] Kan et al.[16] presented a very high mortality rate with early DC performed after 6 hours from the time of the trauma, however, 23.5% of cases were due to nonaccidental trauma and the mean preoperative Glasgow Coma Scale (GCS) score was 4.6 in that series. Better outcomes might be achieved with earlier surgery but further prospective studies are needed to detect the best timing for surgery. Our mean preoperative time from admission to the operation was 3.18 hours, which supports the practice of earlier surgery.

Several authors used different surgical techniques for the treatment of SDH. Bifrontal craniotomy with dural grafts, bitemporal craniectomy without dural opening, or unilateral frontotemporoparietal flaps with duraplasty can be used for DC. None of these techniques has proven to have better outcomes, however, dural opening reduces ICP significantly better than bone elevation alone.[17] We performed 5 bilateral DCs in this series and duraplasty was added to all DCs.

The mortality rate has been detected to be lower than the nonsurgical group in two studies.[8,18] Low GCS score, fixed pupils, and severe damage on the CT scan are the factors that were associated with increased mortality.[19] There were 6 patients with a GCS ≤8 but there was no excitus in our series. That situation could be the result of very early intubation and sedation in the emergency room that can affect the real GCS of the patient.

Aneed for a second surgery for cranioplasty is a handicap for DC. There are many techniques for preserving the bone flap including deep freezing, immersion in bactericidal solutions, subgaleal pouch preservation, abdominal pocket, or sterilization.[20] We kept the bone flaps at -19.5 °C in a deep freeze dedicated as the bone bank. Comparing to preservation of subgaleal pouch or abdominal pocket, the high rate of graft resorption is the biggest handicap of this storage technique and avoiding the second incision is the biggest priority. Hygroma and hydrocephalus are the most frequent complications of this surgery followed by infection and bone flap resorption. Sinking skin flap syndrome did not occur in our reviewed cases. Posttraumatic hydrocephalus after severe traumatic brain injury (TBI) was reported as 20%.[21] The high rate of complications reflects the severity of the disease. In contrast to the literature, there was only one subdural hygroma in our series (9.09%). There were 2 (18.1%) meningitis and 2 (18.1%) wound infections in our series but there was no correlation between these and the craniectomy size and time of surgery.

Long-term follow-up examinations of previous studies revealed that 59% of the patients were completely independent where 5% of them were severely disabled.[10,11] In our series, all the survivors had a favorable long-term result.

Suárez et al.[19] stated that to demonstrate a 10% reduction in mortality of DC by 80%, a 294-patient clinical study should be performed.

In an adult trauma series, Sedney et al.[22] mentioned that there was no relationship between craniectomy size and outcome, or complication rate. Their average craniectomy area was 124 cm^2 which was far smaller than our average craniectomy size of 403.6 cm^2, which was calculated by using the equation of De Bonis.[23] Studies focusing on the craniectomy size in TBI patients mentioned that there was an improved outcome with the larger craniectomy size and an increased complication rate,[24,25] while others pointed that smaller craniectomies (<180 cm^2) are equally effective in relieving intracranial hypertension as the larger ones (≥180 cm^2).[26] In our series, we did not find a correlation between higher complication rate and larger craniectomy size, which this may be due to the small sample size.

The DECRA trial, one of the most effective studies of these days, showed that DC lowers the mortality while absolutely increasing the morbidity. However, this trial focused on diffuse intracranial hypertension and patients were excluded if they had dilated or unreactive pupils, surgically removable intracranial mass lesions, spinal cord injuries, or cardiac arrest at the scene of injury.[27] The pathology treated with DC in this study is completely different from the DECRA trial and that can be the cause of the differences between the two studies.

Suárez et al.[19] mentioned that all the pediatric head injury patients in their series were evaluated as moderately disabled or independent at the 2-year follow-up. The mRS at the time of discharge was considered favorable in our series. Three of our patients were considered as moderately severe disable. The mean mRS changed from 2.8 to 1.6 at follow-up, which is similar to the literature.

Cranioplasty is associated with high rates of bone resorption and surgical site infection in children.[28] In a very large retrospective study, Rocque et al.[28] concluded that younger age at cranioplasty is the dominant risk factor for bone resorption but there is no consensus about the time of cranioplasty. The mean cranioplasty time was 4.2 months. We used artificial cranioplasty material in 3 patients and in contradiction to the Rocque et al.,[28] our patients' mean age was 109.6 months.

The limited patient group is the main limitation of this study. In contrast to the adult group, we recommend early DC for pediatric subdural hematoma patients independent from initial GCS. In the future, we need larger studies to define the indications, surgical techniques, and timing of DC in the pediatric population.

Conflict of interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZET*

Akut subdural hematom nedeni ile pediyatrik yaş grubunda dekompresif kraniyektomi uygulanan hastaların geriye dönük analizi

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AMAÇ: Dekompresif kraniyektominin (DK) pediyatrik subdural hematom hastalarındaki sonuca etkisi tam olarak belirlenmemiştir. Bu çalışmada pediyatrik yaş grubunda travmatik subdural hematom hastalarında DK rolünü araştırmayı amaçladık.
GEREÇ VE YÖNTEM: Pediyatrik akut subdural hematom hastalarında DK deneyimimiz sonuç analizleri ile açıklandı.
BULGULAR: On bir (7 tek taraflı ve 4 iki taraflı) DK uygulandı. Hastaların yaşları 8 ay ile 15 yaş arasında idi. Ortalama Glasgow koma skoru (GKS) başvuru anında 7.8 idi ve hastaların tümü ilk iki saat içinde duraplasti ile birlikte DK ameliyatına alındı. Tüm hastalar ameliyat sonrası dönemde 10 gün yoğun bakım ünitesinde izlendi. Hastaların ortalama hastanede kalış süreleri 22 gün ve ortalama takip süreleri 3.7 yıl idi.
TARTIŞMA: Pediyatrik subdural hematom hastalarında erken DK hastaneye başvuru anındaki GKS'den bağımsız olarak yararlıdır. Pediyatrik yaş grubunda endikasyonlar, cerrahi teknik ve DK'nın zamanlaması için daha geniş hasta sayılı çalışmalara ihtiyaç vardır.
Anahtar sözcükler: Akut subdural hematom; dekompresif kraniyektomi; kafa travması.

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