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Management of Hydrocephalus After Decompressive Craniectomy

Dekompresif Kraniyektomi Sonrasında Hidrosefali Yönetimi

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ABSTRACT

AIM: We set out to investigate the optimal timing for shunt placement in patients with hydrocephalus after decompressive craniectomy (DC).

MATERIAL and METHODS: We studied 63 consecutive patients that underwent DC because of traumatic brain injury, middle cerebral artery infarct or intracerebral hemorrhage. Hydrocephalus was diagnosed in 23/63 patients. The 23 patients were divided into two groups. The first group (A) consisted of 11 patients in whom a ventriculoperitoneal shunt was placed simultaneously or before cranioplasty. In the second group (B) of 12 patients, we performed cranioplasty and a ventriculostomy with monitoring of intracranial pressure was placed simultaneously. After 3 to 5 days, a ventriculoperitoneal shunt was placed with the most appropriate opening pressure.

RESULTS: In group A, nine out of the eleven patients experienced complications, mainly hygromas or hematomas that required reoperation. In group B, none of the patients was reoperated. The use of programmable valves allowed for non-invasive revision of the opening pressure when required.

CONCLUSION: Cranioplasty and ventriculostomy followed by a second stage placement of a ventriculoperitoneal shunt are associated with fewer complications in the treatment of hydrocephalus after DC.

KEYWORDS: Cranioplasty, Decompressive craniectomy, Hydrocephalus

ÖZ

AMAÇ: Dekompresif kraniyektomi (DK) sonrasında hidrosefali hastalarında şant konulması için optimum zamanı belirlemeye çalıştık.

YÖNTEM ve GEREÇLER: Travmatik beyin hasarı, orta serebral arter infarktı veya intraserebral kanama nedeniyle DK yapılan arka arkaya 63 hastayı çalışmaya aldık. Hidrosefali 23/63 hastada mevcuttu. Bu 23 hasta iki gruba bölündü. Birinci grup (A) ventrikülperitoneal şantın kraniyoplastiyle aynı zamanda veya öncesinde konulduğu 11 hastadan oluşmaktaydı. İkinci grup (B) kraniyoplasti yapılan ve aynı zamanda ventrikülostomi ile intrakraniyal basıncın izlendiği 12 hastadan oluşmaktaydı. 3 ila 5 günden sonra en uygun açılış basıncından bir ventrikülperitoneal şant kateteri yerleştirildi.

BULGULAR: Grup A'da, on bir hastanın dokuzu, temel olarak tekrar ameliyat gerektiren hematomlar veya higromalar olmak üzere komplikasyonlar yaşadı. Grup B'de, hiçbir hasta tekrar ameliyat edilmedi. Programlanabilir pompaların kullanılması gerektiğinde açılış basıncının invazif olmayan bir şekilde revizyonunu mümkün kıldı.

SONUÇ: Kraniyoplasti ve ventrikülostomi ve sonrasında ventrikülperitoneal şantın ikinci evrede yerleştirilmesi, DK sonrasında hidrosefali tedavisinde daha az komplikasyonla ilişkilidir.

ANAHTAR SÖZCÜKLER: Kraniyoplasti, Dekompresif kraniyektomi, Hidrosefali

INTRODUCTION

Decompressive craniectomy (DC) has been shown to improve survival in selected cases of traumatic brain injury (TBI), cerebral infarction and subarachnoid hemorrhage (14). Hydrocephalus and especially post-traumatic hydrocephalus after DC is not an uncommon finding, with an incidence of 0.7-86% (1). Nevertheless, only 8-11% of these patients require intervention (1). Furthermore, the development of hydrocephalus after DC is not fully understood (2,12). In the present study we set out to investigate the optimal timing for shunt placement in patients with hydrocephalus after DC.

MATERIAL and METHODS

We retrospectively studied 63 consecutive patients (mean age 40 years, range 16 to 65 years) that underwent DC because of intracranial hypertension due to TBI, intracerebral hemorrhage or middle cerebral artery infarct, between January 2005 and January 2010. The time interval between admission to ICU and DC ranged from 2 to 72 hours. In 23 patients (36.5%) the diagnosis of "hydrocephalus" was established based on serial CT findings, namely progressive enlargement of anterior horns of lateral ventricles, enlarged temporal horns, enlarged 3rd ventricle, absent sulci and periventricular hypoattenuation, and the deterioration of the clinical condition, when it could

be evaluated. The DC had been performed because of TBI in 8 patients, middle cerebral artery infarct in 7 patients and because of intracerebral hemorrhage in the remaining 8 patients. Of the 23 consecutive patients, the first 11 made up group A and the remaining 12 patients made up group B. In group A, a V-P shunt (Codman-Medos programmable V-P shunt, Medos, SA, Le Loche, Switzerland) was initially placed at an opening pressure of 120 mmH_2O and cranioplasty was performed simultaneously or at a second stage (15-60 days). For the cranioplasty, we used computer-guided synthetic flaps in all cases. The high complication rate of group A made us change our management strategy. The first stage included reestablishment of the bone flap and placement of a ventriculostomy, with an external CSF reservoir or monitor in order to measure the intracranial pressure in the remaining 12/23 patients (group B). A programmable valve at the most appropriate opening pressure was placed in a second stage after 3 to 5 days of serial pressure measurements and follow-up CT scans.

Surgical Procedure

The patient was positioned supine with lateral rotation of the head according to the side of DC. A large trauma scalp flap was then raised. Next, a fronto-temporo-parietal craniectomy to the level of the zygoma was performed. The mean size of the craniectomy reached 10x14 cm. The dura was opened in a cruciate fashion and with "vascular tunnels" were created around the main vessels in order to avoid compression between the craniectomy edge and brain tissue. Next, the dural collagen graft matrix was placed and followed by rapid trauma closure. The bone flap was discarded. When bilateral craniectomy was performed, a bone ridge of 4-5 cm over the superior longitudinal sinus was preserved.

RESULTS

Table I summarizes patients' data. From the 63 patients that underwent DC, 23 (36.5%) developed hydrocephalus. There were 15 male and 8 female patients (mean age 40.9, range 17-65 years). Nine patients (82%) from group A experienced treatment-related complications (Figure 1A,B; 2A-D). Three patients had immediate overshunting or undershunting problems that required revision of the valve's opening pressure. Three patients developed a subdural hygroma/hematoma and required a burr-hole drainage and upgrade of the valve's opening pressure. Two patients were reoperated by craniotomy because of epidural fluid collections and one patient did not require the shunt. No patient in group B required reoperation. Two patients did not require shunt placement. The revision of the valve's opening pressure with external device was the only intervention in the postoperative period (Figure 2A-D). No patient had flap infection.

Table I: Detailed Patients' Data

		Group A	Group B
Sex	Male	7 (63.6%)	8 (66.7%)
	Female	4 (36.4%)	4 (33.3%)
Age		39.6±15.8	42.3±18.2
DC Aetiology	TBI	5 (45.4%)	3 (25%)
	MCA infarct	3 (27.3%)	4 (33.3%)
	ICH	3 (27.3%)	5 (41.7%)

DC: *decompressive craniectomy,* ***TBI:*** *traumatic brain injury,* ***MCA:*** *middle cerebral artery,* ***ICH:*** *intracerebral hemorrhage.*

DISCUSSION

Hydrocephalus remains one of the great challenges in neurosurgery. The clinical entity of hydrocephalus after DC was first recognized in 1914 by Dandy and Blackfan who described a case of hydrocephalus developing in child after a severe fall (4). The alterations in CSF hydrodynamics and the uncertainty over the best treatment make the topic important, especially during the last few years, when DC has been applied widely to treat life-threatening increased intracranial pressure (13).

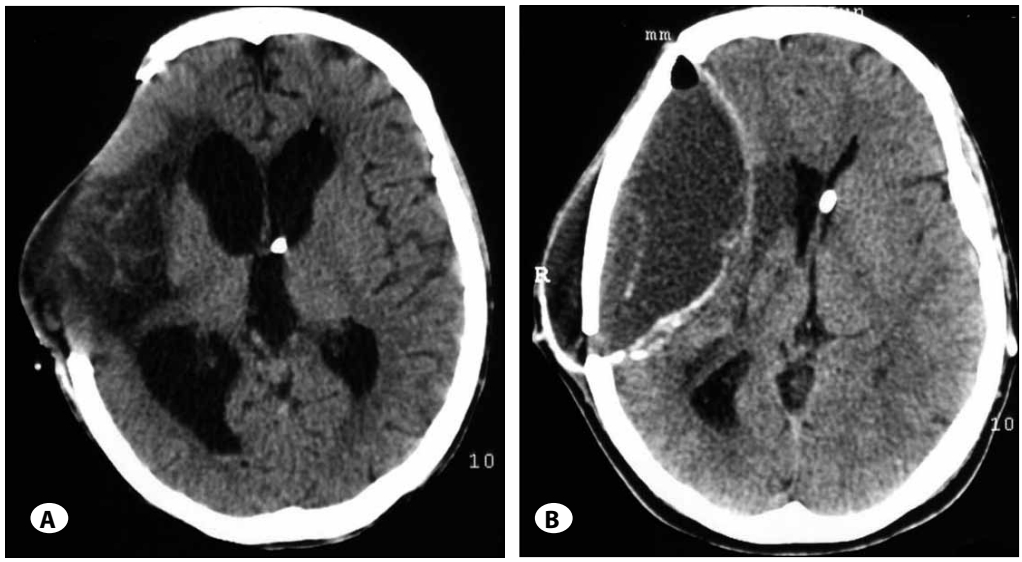

Figure 1: A) Post decompressive craniectomy hydrocephalus in a 26-year-old patient treated initial with a VP shunt placement. **B)** Cranioplasty 2 months later resulted in the development of an epidural hygroma.

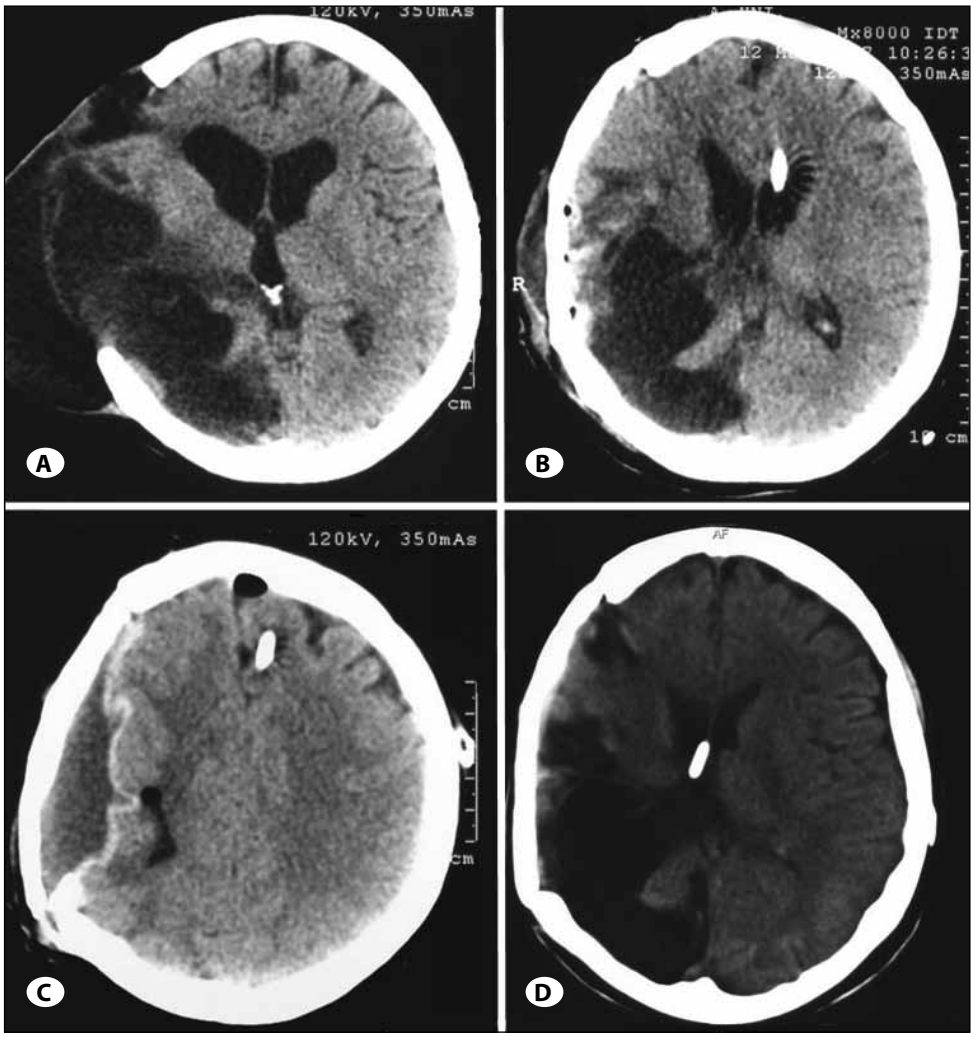

Figure 2: A) Post decompressive craniectomy hydrocephalus in a 40-year-old woman. **B)** Cranioplasty and simultaneous ventriculostomy placement. **C)** Development of epidural hygroma. **D)** The opening pressure was raised and a VP shunt was placed 4 days later.

Decompressive craniectomy has been associated with an increased complication rate in patients with head injury (15). As an emergent surgical procedure, expansion of oedematous tissue, herniation of brain through craniectomy site, epidural hematoma, subdural fluid collections or hydrocephalus can be observed (1,13). Hydrocephalus in these patients has an atypical presentation and demands a high level of clinical suspicion. Clinical symptoms include continuous headaches, morning vomiting, dementia, incontinence, difficulty in walking. Papilledema is not usually seen on funduscopic examination. CT is usually performed when hydrocephalus is suspected after DC. The reported incidence of ventriculomegaly after DC varies between 30-80% (1). The enlargement of the ventricular system must also be accompanied by periventricular oedema predominantly located in the white matter. This form of oedema corresponds to increased interstitial pressure and fluid accumulation after disruption of ependymal surface and CSF extravasation (1). In the present study 36.5% of patients developed hydrocephalus after DC.

The development of hydrocephalus after DC has been attributed to (a) focal destructive lesions or ischemic insults lead to neuronal loss and severe atrophy of brain parenchyma, (b) adhesive arachnoiditis of basal cisterns, (c) blood blocking and dysfunction of arachnoid granulations, (d) gradient between atmospheric pressure and intracranial pressure lead to inward displacement of scalp and decrease of CSF flow over the convexity (5, 9, 10). DC affects CSF flow, elastic properties of brain parenchyma and ventricular system. DC especially decreases to half the resistance to CSF outflow, while it leads to an increase of the compliance (3). Increased intracranial pressure may also be the result of increased venous pressure and increased extraparenchymal CSF volume (6,11).

In the present study, group A included more complicated cases that required reoperation. Longer hospital stay and rehabilitation were therefore required. Shunt placement in this group increased the pressure gradient and had the risk of inward displacement of skin flap and midline shift. Cranial vault reestablishment changed rapidly the intracranial environment. The results were subdural or epidural fluid collections. Group B underwent a step-by-step surgical procedure. Cranioplasty, ventriculostomy, ICP monitoring and V-P placement were performed within a few days and

none of the patients required re-intervention. We preferred programmable valves for better quality of life and for the revision of the opening pressure in order to avoid excessive brain collapse (8). Programmable shunt valve have been proven to be comparable to conventional valves in the overall population of patients with hydrocephalus and the shunt revision rates were similar in both cases (9). Programmable valves give the surgeon the benefit of adjusting the opening pressure setting noninvasively according to the clinical or radiological findings during the postoperative period. In addition, a shunt system with a programmable valve allows for continued treatment of the patient›s known hydrocephalic condition.

The present study has several limitations. The first is the limited number of patients that were evaluated. Furthermore, the diagnosis of hydrocephalus was established based on clinical and serial CT findings that may not be reliable in all cases. Nevertheless, the results of the present study have shown that simultaneous cranioplasty and ventriculostomy followed by the subsequent placement of a ventriculoperitoneal shunt within few days is associated with lower complication rates for the treatment of hydrocephalus after decompressive craniectomy.

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