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The Conundrum of Ventricular Dilatations Following Decompressive Craniectomy: Is Ventriculoperitoneal Shunt, the Only Panacea

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ABSTRACT

Ventriculomegaly and hydrocephalus (HCP) are sometimes unexpected complications after decompressive craniectomy. The distinguishing characteristics between the two are less well characterized. The majority of studies cited in the literature define HCP radiologically rather than taking into account the patient's clinical situation. As a result, several patients have been treated with permanent cerebrospinal fluid (CSF) diversion surgeries. We suggest that asymptomatic ventriculomegaly caused by DC should be aspirated with cranioplasty and monitored regularly. Assess the effectiveness of ventriculoperitoneal (VP) shunts in managing ventricular dilatation following decompressive craniectomy, focusing on outcomes such as reduction in ventricular size, symptom relief and overall patient recovery. The present study was an Retrospective Cohort Design. Department Of Neurosurgery, RG KAR Medical College and hospital. There were 21 patients who developed ventriculomegaly after DC. There were ten patients in Group One and eleven in Group Two. The average follow-up period ranged from 6 months to 2 years. Two patients in the shunt group (group 1) developed over drainage and needed revision. One patient in the aspiration group (group 2) needed permanent CSF diversion. Cranioplasty with aspiration is a potential therapy for a restricted set of individuals who have ventriculomegaly but no HCP-related signs or symptoms.

INTRODUCTION

The incidence of ventriculomegaly/hydrocephalus (HCP) after decompressive craniectomy (DC) is estimated to range between 10% and 45%[1-4]. These statistics vary substantially due to the many parameters used to determine HCP after DC. Most studies have used radiological criteria to predict the beginning of HCP after DC[5]. However, this alone, combined with clinical indications of HCP, should define the course of treatment. Our hospital has used a therapy protocol to address patients with post-DC HCP (PDCH)/post-DC ventriculomegaly (PDCV). Patients with ventricular enlargement and clinical manifestations of HCP, such as poor MMSE, gait disturbances and papilledema, underwent ventriculoperitoneal shunt (VPS), whereas those without symptoms and papilledema but with ventriculomegaly had a ventricular puncture and aspiration of the lateral ventricle performed during cranioplasty. This ventriculostomy allowed the brain to shrink back into the boundaries of the cranial defect, making it easier to precisely anchor the bone flap.

Decompressive craniectomy (DC) is a surgical procedure employed to relieve elevated intracranial pressure (ICP) in patients with severe traumatic brain injury (TBI), stroke, or malignant cerebral edema. By removing a portion of the skull, DC creates additional space for the brain to swell, thereby mitigating the risk of herniation and facilitating pressure relief. Despite its critical role in acute brain injury management, DC is not without complications. One notable sequela is the development of post-craniectomy ventricular dilatation.

Ventricular dilatation following decompressive craniectomy is characterized by an abnormal enlargement of the brain's ventricles. This condition arises due to several factors, including brain atrophy, altered cerebrospinal fluid (CSF) dynamics and disruption of normal brain structure and function. The resultant ventriculomegaly can lead to a spectrum of symptoms, from cognitive and motor deficits to significant functional impairment.

The management of post-craniectomy ventricular dilatation poses a substantial challenge. While ventriculoperitoneal (VP) shunting is commonly employed to address this issue, its effectiveness is variable and its role as a definitive treatment remains debated. VP shunting aims to divert excess CSF from the ventricles to the peritoneal cavity, thereby reducing ventricular size and alleviating associated symptoms. However, the success of this approach is not guaranteed for all patients and complications such as infection, shunt malfunction, or over drainage can occur.

MATERIALS AND METHODS

Study population: Adults aged 18 years or older. Patients who have undergone decompressive craniectomy for severe traumatic brain injury, stroke, or malignant cerebral edema.

Study design: Retrospective Cohort Design.

Period of study: June 2022-May 2024

Inclusion criteria:

- Adults aged 18 years or older
- Patients who have undergone decompressive craniectomy for conditions such as severe traumatic brain injury, stroke, or malignant cerebral edema
- Documented post-craniectomy ventricular dilatation as confirmed by neuroimaging (CT or MRI) performed after decompressive craniectomy
- Documented post-craniectomy ventricular dilatation as confirmed by neuroimaging (CT or MRI) performed after decompressive craniectomy

Exclusion criteria:

- Individuals younger than 18 years of age
- Patients with incomplete or inadequate medical records related to post-craniectomy ventricular dilatation or its management
- Cases where ventricular dilatation is due to conditions other than post-craniectomy complications, such as congenital hydrocephalus or infections unrelated to the craniectomy
- Studies or patients where management does not focus on ventriculoperitoneal shunting or recognized alternatives for post-craniectomy ventricular dilatation
- Studies with less than six months of follow-up data or those lacking sufficient data to assess treatment outcomes and complications
- Non-peer-reviewed articles, editorials, opinion pieces, or conference abstracts lacking comprehensive data
- Studies that do not specifically address the management of post-craniectomy ventricular dilatation or fail to provide detailed outcome measures

Statistical analysis: For statistical analysis, data were initially entered into a Microsoft Excel spreadsheet and then analyzed using SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) and GraphPad Prism (version 5). Numerical variables were summarized using means and standard deviations, while categorical variables were described with counts and percentages. Two-sample t-tests, which compare the means of independent or unpaired samples, were used to assess

differences between groups. Paired t-tests, which account for the correlation between paired observations, offer greater power than unpaired tests. Chi-square tests (χ^2 tests) were employed to evaluate hypotheses where the sampling distribution of the test statistic follows a chi-squared distribution under the null hypothesis; Pearson's chi-squared test is often referred to simply as the chi-squared test. For comparisons of unpaired proportions, either the chi-square test or Fisher's exact test was used, depending on the context. To perform t-tests, the relevant formulae for test statistics, which either exactly follow or closely approximate a t-distribution under the null hypothesis, were applied, with specific degrees of freedom indicated for each test. p-values were determined from student's t-distribution tables. A $p \leq 0.05$ was considered statistically significant, leading to the rejection of the null hypothesis in favour of the alternative hypothesis.

RESULTS

Between 2014 and 2016, 210 patients underwent decompressive craniotomies. The majority of the patients suffered from traumatic brain damage, middle cerebral artery infarction, or intracerebral hematoma. Twenty-six patients died and were removed from the research. Of the remaining 174 patients who were followed up and scheduled for cranioplasty, 21 (12.07%) had ventricular dilatations. The study included 14 males and seven girls. There were 12 cases of acute subdural hematoma, 4 malignant middle cerebral artery infarctions and 5 intracerebral hematomas. The average age of the patients was 37.1±13.4 years (Table 1).

The shunt group had a significantly higher mean Evan's index (38.58±1.69) compared to the aspiration group (33.75±1.46) (Table 2).

Ten patients with ventriculomegaly had a low GCS and had papilledema. These individuals had a VPS, followed by a cranioplasty. The remaining 11 patients received lateral ventricle aspiration and cranioplasty. ICP was evaluated in five patients from Group 2. The average ICP was 50 mm of CSF. Poor follow-up during the first period led to a variation in the average time between cranioplasty and injury. The average time to cranioplasty was 4.2 months for the shunt group and months for the aspiration group (Table 3).

DISCUSSION

Decompressive craniectomy (DC) has become a critical treatment for refractory elevated intracranial pressure (ICP), especially in regions lacking ICP monitoring capabilities. Initially used primarily for trauma, its application has expanded to include conditions like spontaneous intracerebral hematoma, cerebral venous sinus thrombosis, malignant middle cerebral artery infarction and subarachnoid hemorrhage[6].

Table 1: Clinical profile, etiology, glasgow coma scale at admission, cranioplasty and discharge along with time to cranioplasty of patients who underwent ventriculoperitoneal shunt and cranioplasty (group 1)

Age	Sex	Etiology	GCS at admission	GCS at procedure	GCS at discharge	Time to cranioplasty (months)
31	Female	ASDH	6	8	9	5
60	Female	ICH	10	10	11	2
42	Female	ICH	9	10	11	4
25	Male	ASDH	10	12	13	5
35	Female	ASDH	12	13	14	3
61	Female	ASDH	12	12	12	1
22	Male	ICH	10	10	12	6
36	Male	ICH	13	13	14	14
50	Male	ASDH	10	11	12	1
38	Male	ASDH	10	12	14	2

Table 2: Clinical profile, etiology, Glasgow coma scale at admission, cranioplasty and discharge along with time to cranioplasty of patients who underwent aspiration and cranioplasty (group 2)

Age	Sex	Etiology	GCS at admission	GCS at procedure	GCS at discharge	Time to cranioplasty (months)
40	Male	ASDH	12	14	14	2
60	Male	MMCAI	13	15	15	7
40	Female	ASDH	11	15	15	4
19	Male	ASDH	9	15	15	10
43	Male	MMCAI	9	15	15	4
42	Female	ASDH	11	15	15	2
50	Male	MMCAI	10	14	14	9
42	Male	MMCAI	12	15	15	6
38	Male	ASDH	9	10	12	7
22	Male	ASDH	10	14	14	15
36	Male	ICH	12	14	14	13

Table 3: Clinical profile of patients with etiology, cerebrospinal fluid pressure and fundus examination

Age	Sex	Primary injury	MMSE	CSF pressure mm of CSF	Fundus
19	Male	ASDH	28	46	Temporal pallor+
42	Male	ASDH	30	52	Normal
43	Male	MMCAI	29	54	Normal
50	Male	MMCAI	28	42	Normal
36	Male	ICH	26	56	Normal

However, the broader use of DC has introduced new challenges, including a condition known as post-decompressive craniectomy hydrocephalus (PDCH). Hypotheses for PDCH include changes in brain pulse wave pressure or decreased venous outflow at the craniectomy's edges. The incidence of PDCH varies widely in studies, from 0.7-86%, largely due to differences in defining and diagnosing the condition, particularly the reliance on CT scan findings rather than clinical symptoms[7].

In the reported series, ventriculomegaly (an enlargement of the ventricles) was observed in about 10% of patients post-DC, despite craniectomy margins being adequately spaced from the midline. This condition, although often asymptomatic, can sometimes require permanent cerebrospinal fluid (CSF) diversion. Interestingly, patients undergoing DC for malignant middle cerebral artery infarction did not develop shunt-dependent hydrocephalus in this series, contrasting with other studies showing variable rates of hydrocephalus post-DC for this condition[8].

Efforts to reduce complications from DC include performing a cisternostomy and restoring the bone flap after craniotomy, which has been shown to decrease the incidence of hydrocephalus[9,10]. Additionally, some patients with ventriculomegaly and no symptoms might not require permanent CSF diversion. Innovations such as controlled reduction duroplasty and external lumbar drains are being explored to manage post-DC brain swelling and improve outcomes.

Overall, while post-cranioplasty resolution of hydrocephalus is well-documented, follow-up is crucial as hydrocephalus can develop later. Managing PDCH effectively often requires careful monitoring and sometimes the use of programmable shunts to address complications like over-drainage. The socioeconomic status of patients can impact the choice of treatment options, with programmable shunts offering advantages but potentially being less accessible in certain settings.

CONCLUSION

Not all cases of PDCH warrant permanent CSF diversion surgery such as VPS. The strategy of aspiration with cranioplasty is a valid option in the management of PDCV. By the described procedure, a permanent VPS may be avoided in a selected group of patients with craniectomy-related HCP who undergo cranioplasty. However, these patients need to be followed up to detect the possibility of development of late HCP.

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