ORIGINAL ARTICLE

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Outcomes of severe head injury patients undergoing cisternostomy at tertiary care hospital in Nepal

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ABSTRACT

Introduction: Cisternostomy incorporates micro-neurosurgery to unfold the brain, allowing wider access to optico-carotid window. The cisterns are drained after opening the membrane of lillequest, significantly reducing the intra-parenchymal pressures due to CSF-shift edema in moderate to severe traumatic brain injury.

Methods: A retrospective study was conducted between January to September 2018 including 50 severe traumatic brain injury patients. They were performed cisternostomy as the primary surgical management for decreasing intra-parenchymal pressures secondary to severe traumatic brain injury. Outcomes were assessed at 2 months of follow-up using Glasgow Outcome Scale GOS).

Results: In almost all patients (n = 48), bone flap was replaced after complete brain relaxation was achieved. Post-operative CT scans showed opening of suprasellar cisterns (n = 45). The average ICU days and ventilator days were approximately 3 and 2, respectively. Follow-up on 2 months using GOS showed a good recovery (n = 38), moderate disability (n = 4), severe disability (n = 3) and dead (n = 5)

Conclusion: Cisternostomy provides promising outcomes in severe brain injuries by effectively decreasing intraparenchymal pressures and preventing axonal injury which manifest as a later sequel in brain trauma.

Keywords: cisternostomy, CSF-shift edema, subarachnoid hemorrhage, suprasellar cistern, traumatic brain injury

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INTRODUCTION

The cerebrospinal fluid (CSF) communicates with the brain parenchyma via aquaporin channels lining the Virchow-Robin spaces (paravascular spaces).[1] This circulation is crucial for the continuous cooling and cleaning of the brain in normal physiological states. The CSF, through its communication with the brain parenchyma via paravascular spaces absorbs the heat arising in the metabolic active brain and also removes metabolic toxins.[2] The CSF also act as a buffer to maintain the physiologic cerebral environment. In pathological states, such as trauma or hemorrhage, disruption of this circulation can be a possible mechanism for the development of cerebral edema in moderate to severe traumatic brain injuries. It also could happen in subarachnoid hemorrhage secondary to aneurysm rupture. Irrespective of the etiology, increasing pressures of the cisternal compartment of the brain will force the CSF to "leak" out of the cisterns through altered expression of aquaporin channels lining the paravascular spaces. This condition increases the interneuronal spaces, causing an exponential increase in the intraparenchymal pressures at a certain volume.[3] This effect is called the CSF-shift edema and it forms the underlying anatomical and physiological basis of cisternostomy. Cisternostomy is defined as "letting out" of CSF from the suprasellar cisterns to reverse the on-going CSF-shift edema. Reversing this edema through CSF drainage from cisterns immediately reduces the pressure and permits the brain to regain its physiologic state (**Figure 1**). The continuous cooling and cleaning mechanism driven by three-to-four-fold of CSF turn-over which effectively helps remove metabolic heat and toxin accumulation.[2]

In this article, we aimed to describe the surgical outcomes following cisternostomy in patients with moderate to severe brain trauma at a tertiary care center in Nepal.

METHODS

This is a descriptive study including 50 patients undergoing cisternostomy as primary acute surgical intervention to decrease intraparenchymal pressure. Patient records were collected for a period of nine months between January to September 2018.

The inclusion criteria in this study were

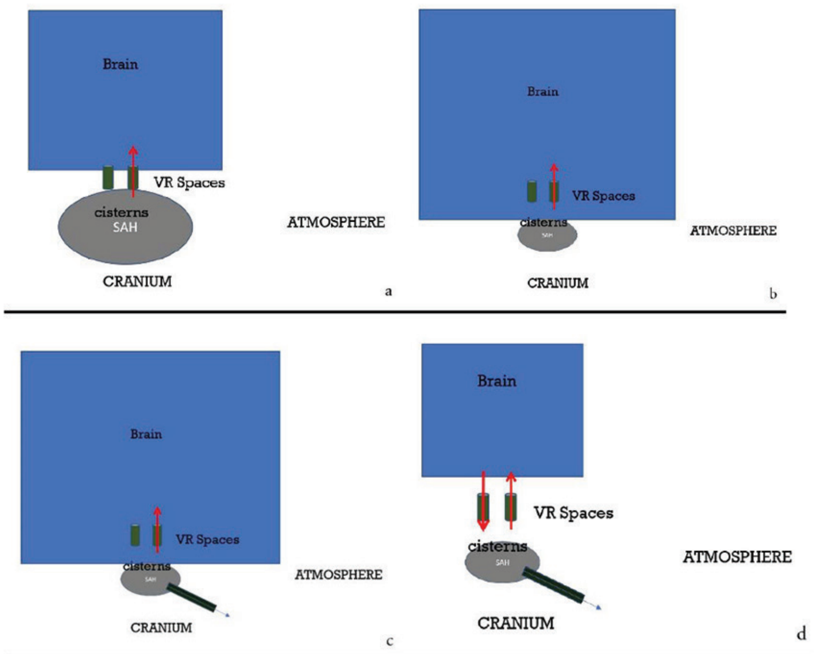

Figure 1. The circulation of CSF between cistern and brain parenchym is accomodated by aquaporin channel in virchow-robin spaces. **A.** In pathological state, increasing pressure of cistern push the CSF into the brain parenchym. **B.** The accumulation of CSF increases interneuronal spaces causing increase of intraparenchymal pressure. **C.** Cisternostomy drains the CSF in the cistern to the atmospheric pressure. **D.** The circulation of CSF between brain parenchyma and cistern get back to physiological state after cisternostomy.

Table 1. Description of sample characteristic

Variable	Percentage	N
Gender		
Male	70%	
Female	30%	
Age		
< 20 years	26%	
21 – 40 years	38%	
41 – 60 years	24%	
61 – 80 years	12%	
Preoperative pupil reactivity		
Reactive		33
Unilateral dilated		11
Bilateral dilated		4
Bone flap replacement		
Yes		48
No		2
Follow up on 2 months		
Good recovery	76%	38
Moderate disability	8%	4
Severe disability	6%	3
Death	10%	5

severe head injuries patients with acute Subdural Hematoma (SDH) and brain edema, presence of impending or frank herniation of temporal lobe as shown by unilateral or bilateral pupil dilatation, widened of ipsilateral cerebellopontine (CP) angle cisterns or absence of basal cistern, presence of brain torsion and brainstorm. In case of presence of additional superficial contusions, removal was recommended.

The exclusion criteria in this study were evidence of ischemic hemorrhage on imaging examination, motor score of 2 or less combined with suspected or confirmed ischemia according to radiology, severe and prolonged hypotension and/or hypoxia, multitrauma with very poor prognosis, bleeding diathesis, subdural hematoma with sinus bleeding as the predominant factor, and age more than 80 years.

All patient data upon admission, preoperative clinical and radiological presentation, and surgical procedure performed (bone flap replacement) were recorded. Postoperative changes on CT imaging, length of stay and ventilator use were also recorded. The outcomes were assessed by phone or outpatient consultation at 2 months after surgery using Glasgow Outcome Scale (GOS).

RESULTS

In this study, 50 patients were performed cisternostomy. Seventy percent were males and 30% were females. The age distribution showed an equal pattern with 26% were under twenty years old, 38% were between 21 to 40 years old, 24% were 41 to 60 years old and the remaining 12% formed the old age group (61 to 80 years). All of the patients presented with severe head injuries as indicated by the Glasgow Coma Scale (GCS) score of less than 8. Out of these, 4 patients had bilaterally non-reactive pupils (**Table 1**). Preoperative CT scans revealed partially or fully obliterated basal cisterns (n = 47), widening of CP angle cistern (n = 30), midline shift (n = 45), subarachnoid hemorrhage (n = 30) and subdural hematoma (n = 20) (**Table 2**). In almost all patients (n = 48) bone flap was replaced after complete brain relaxation was achieved upon opening the cisterns. Postoperative CT scans showed opening of suprasellar cisterns in 45 samples (**Table 3**). A decrease in average cisternal drain pressures was observed from day 1 to day 5 which was 9.3 and 7.0 mmH_2O respectively (**Figure 2**). The average length of stay in Intensive Care Unit (ICU) was 5 days with average of 4 days of intubation. Two months of follow up using Glasgow Outcome Scale (GOS) showed a good recovery in 38 patients (76%), moderate disability in 4 (8%), severe disability in 3 (6%) and mortality in 5 patients (10%) (**Table 1**).

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Table 2. Descripition of preoperative CT scan findings

Variable	N = 50
Obliterated basal cistern	
Yes	47
No	3
Widening of CP angle cistern	
Yes	30
No	20
Midline shift	
Yes	35
No	15
SAH	
Yes	30
No	20
SDH	
Yes	20
No	30
Contusion	
Yes	40
No	10

Table 3. Description of postoperative CT scan findings

Variable	N = 50
Blooming of contusion	
Yes	40
No	10
Opening of suprasellar cistern	
Yes	45
No	5

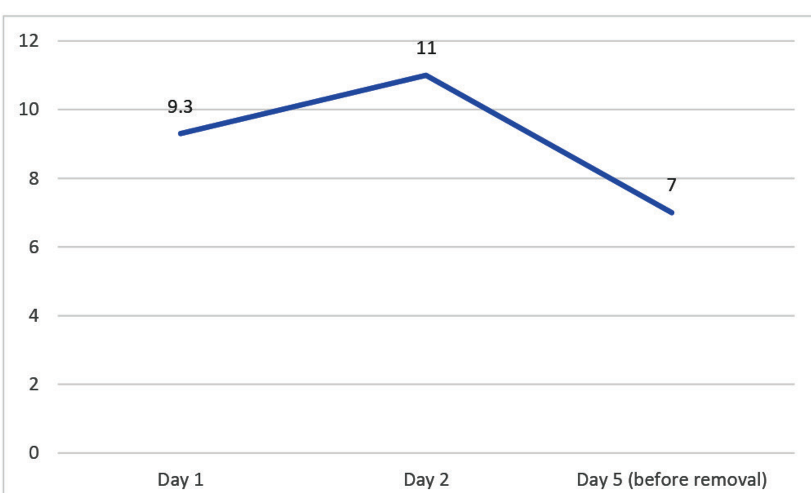

Figure 2. Average cisternal drain pressure in mmH_2O (as measured by height of oscillating water column.

DISCUSSION

Access to the basal cisterns is through an anterolateral skull base approach using keyhole craniotomy after a subfascial dissection. In addition to the standard sylvian dissection which provides an intradural oblique exposure, the frontal and temporal lobes are "unlocked" extra-durally from each other in axial and sagittal planes by drilling off the sphenoid ridge and sharp dissection of the meningo-orbital band (MOB), respectively. This provides a better exposure to achieve cisternal access. The MOB is a dural fold which runs along the lateral border of the superior orbital fissure and contains few small dural veins and the orbitomeningeal artery. MOB detachment provides a wider exposure, and better orientation thus facilitating relatively easy approach to paraclinoid and cavernous sinus region. The present microsurgical technique helps to preserve the true cavernous membrane and thereby providing almost bloodless dissection of the cavernous sinus. The same technique can be used to uncover the anterior clinoid process laterally, posteriorly, superiorly, and also in the inferolateral region thereby decreasing the risk and time of clinoidectomy.[4] This "unlocking" technique allows for a widened surgical corridor to access the basal cisterns. The anterior clinoid process (ACP) is drilled off and the optic strut is removed to expose the optico-carotid window in both, extra and intra dural planes. A basal dural opening is performed as opposed to the standard C-shaped opening in order to approach the optic nerve via lateral sub-frontal route. The sub-dural hematoma is evacuated and the basal cisterns are opened by cutting the Liliequist membrane and a number 8 feeding tube is inserted to drain the CSF. An immediate decrease in cerebral edema and intracranial pressures occurs as seen by the relaxation and regained pulsatility of the brain tissue. In contrast to an external ventricular drain (EVD), which only helps in increasing the compliance of the ventricular system, placing a cisternal drain will help to tremendously decrease and even measure the ICP, allowing for decreased incidence of vasospasms as otherwise seen in later sequel of a subarachnoid hemorrhage. The dura is then closed and the bone flap is replaced after achieving complete brain relaxation. Often, a hybrid approach is performed where the bone flap is not replaced, and this is known as "cisternostomy with decompression". There are two reason for this; first is the brain does not achieve complete relaxation enough to close the cranial vault, and second, perhaps more common is the case where the operating surgeon is skeptical about the outcomes. In such cases, a decompression can be performed after cisternal drainage. However, results

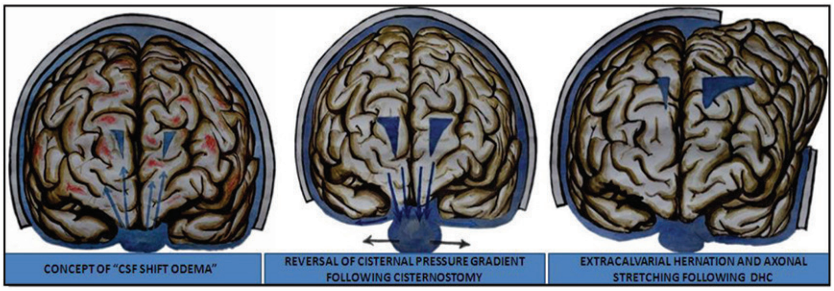

Figure 3. The concept of cisternostomy. Notice the integrity of the brain fibers in cisternostomy versus the extensive stretching of fibers in decompressive hemicraniectomy.[6]

are comparable between cisternostomy alone and cisternostomy with decompression.[5] Cisternal drain is kept until five days post-operatively so as to monitor the changes in cisternal pressures.[6]

Cisternostomy is a microsurgical management for acute trauma, that not only decreases the intracranial pressures, but also prevents progression to cytotoxic brain injury if performed within the time window. Obliterated basal cisterns on CT imaging are a clear indication on herniated brain which may lead to serious consequences including coma and death.[7,8] Prior to the event of obliterated cisterns, the presence of ipsilateral cerebellopontine angle cisterns dilatation to the lesion are a clear sign of impending uncal herniation.[9,10] It warrants immediate surgical intervention. In our study, 47 out of 50 patients (94%) presented with partially or fully obliterated suprasellar cisterns, whereas 30 patients (58%) showed dilatation of CP angle cisterns at the same side as the expanding lesion. The signs were clinically correlated with pupillary asymmetry and reactivity.

The concept of CSF drainage is not uncommon in neurosurgical practice. Studies have identified the use of lumbar drainage to minimize the risk of cerebral herniation but only in cases where basal cisterns are open.[11] However, its implementation as primary management for acute brain trauma has been a topic of debate. The fully established pathophysiological mechanism of cerebral edema secondary to CSF shift from cisterns to brain parenchyma provide evidence of how important this management can be in terms of prognosis and outcomes.[12] The rapid expansion of the edematous brain following decompressive hemicraniectomy alters the topography of the cortical and sensory fibers, resulting in increased axonal stretch and irreversible damage. This later presents as severe brain atrophy on the same side and manifests as a persistent vegetative state and severe disabilities that impact the psychosocial and economic states of the patient and his care-takers. Clinical trials studying the outcomes of decompressive hemicraniectomy show the increased frequency of disabilities arising in patients undergoing decompression.[13] By replacing the bone flap, cisternostomy not only increases the compliance of the cranial vault through cisternal opening at atmospheric pressures, but also prevents this anatomical distortion of brain fibers seen post hemicraniectomies (**Figure 3**).

The results from multiple centers performing cisternostomy have shown commendable patient outcomes and prognosis.[5,14] As observed from the outcomes of this study, the post-operative period was unremarkable with average of 5 ICU days and 4 days on ventilator. The prognosis after cisternostomy is good, in part because the integrity of the brain remains intact and also in part, because of the microsurgical nature of this procedure compared to the gross removal of brain flap during decompressive hemicraniectomy.

This study showed outcomes of cisternostomy in 50 patients from only one center. This is the limitation of the study. A larger number of patients with multiple centers and a prospective study is warranted to conclude better outcomes.

CONCLUSIONS

Cisternal drainage of cerebrospinal fluid provides an efficient way of reducing the intracranial pressures secondary to traumatic brain injury. Cisternostomy has proven to improve outcomes in patients following severe brain trauma and also validates the hypothesis of the CSF shift edema. It is recommended to be practiced as the primary surgical procedure in patients falling under the inclusion criteria. More surgical centres need to be trained and equipped adequately to perform cisternostomy and more data needs to be collected to analyze the outcomes on a global scale.

ETHICAL CLEARANCE

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CONFLICT OF INTEREST

None declared

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AUTHOR CONTRIBUTION

Authors were equally contributed in manuscript preparation, literature search, manuscript editing and final manuscript. All of the content in the manuscript have been approved by all authors.

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