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Basal Cisternostomy Proper for Acute External Brain Herniation during Craniotomy: A Case Report

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ABSTRACT

BACKGROUND: Traumatic brain injury (TBI) is a major cause of mortality and morbidity worldwide. Cisternostomyis a novel microsurgical technique that opens the cisterns to atmospheric pressure. The use of cisternostomy as an adjunct or a stand-alone treatment in TBI-affected patients is not well studied. **Case description:** A three-year-old girl presented to the emergency department following a fall from a six-meter level. The patient's GCS score was 10/15. An urgent brain CT scan showed an open, depressed skull fracture with an underlying acute subdural hematoma along with significant mass effect. The patient underwent surgical evacuation of the hematoma. Towards the end of the surgery, significant brain herniation occurred. After failure of decompressive craniotomy, cisternostomy was performed and this successfully controlled the swelling. There were no surgical complications and the patient remained well. **Conclusion:** Basal cisternostomy proper holds a promise in reducing ICP in patients with moderate-to-severe TBIs.

Abbreviations: TBI; Traumatic brain injury, ICP; Intra-cranial pressure, CSF; Cerebrospinal fluid, SDH; Subdural hematoma. CCP: Cerebral perfusion pressure. GCS: Glashow coma scale. EMV: Eye, movement, vision. 3D: Three-dimensional. PaO2: Partial arterial pressure of Oxygen. PaCO2: Partial arterial pressure of carbon dioxide. CT: Computed tomography.

INTRODUCTION

Traumatic brain injury (TBI) remains a major cause of morbidity and mortality globally (1). In terms of their underlying mechanisms, TBIs are classified as either primary or secondary (2). Primary TBI refers to the irreversible brain damage sustained at the time of initial insult, such as cerebral contusions and intracranial hemorrhage (2). Secondary TBI refers to the cascade of focal and systemic insults that induce further brain damage hours-to-days following the original trauma (3). The ultimate result of these pathophysiological mechanisms is a variable set of alterations in cerebral dynamics resulting in decreased cerebral perfusion pressure and increased intracranial pressure (4). A more clinically-relevant classification of TBIs is based on the patient's GCS scores at the time of admission and includes three categories: mild (14-15), moderate (9-13), and severe (3-8) TBIs.

Surgical indications following TBI include 1) elevation of a depressed skull fracture, 2) hematoma evacuation 3) treatment of skull base fractures 4) treatment of elevated ICP that is refractory to medical management (5). Medical management of elevated ICP involves several measures including head elevation (15-30 degrees) to promote jugular venous drainage, oxygenation and ventilation to keep PaO2 >100, PaCO2 30-35, and the use of osmotic diuretics such as Mannitol (6,7). A surgical decompressive craniotomy is recommended when all the above-mentioned measures fail (8).

However, decompressive craniotomy only subjects the intracranial pressure to the atmospheric pressure without influencing the intracerebral pressure which is the primary cause of brain swelling and herniation (9).On the other hand, cisternostomy, which involves microsurgical fenestration of the basal cisterns, serves to equalize the cisternal pressure with the atmospheric pressure, thus allowing the CSF to shift back from the brain parenchyma to the basal cisterns and relax the brain (10).

Cisternostomy is a well-established procedure microsurgical practice. The use of cisternostomy in TBIs as an adjunct or a stand-alone treatment is not well studied, however.

Herein, we report a case of a moderate TBI where basal cisternostomy proper proved valuable in controlling the intra-operative brain swelling.

Case scenario:

A three-year-old girl presented to the emergency department following a fall from a six-meter level. The patient's Glasgow Coma Scale (GCS) score was 10/15 (E2M5V3). Initial resuscitation, intravenous lines, isotonic intravenous fluids, basic blood investigations, and a rapid history and examination were done simultaneously. On examination, the patient had a right-sided, irregular, 8-cm frontoparietal scalp wound with an underlying skull fracture suspected through palpation. An urgent brain computed tomography (CT) scan showed an open, depressed fracture with an underlying acute subdural hematoma (SDH) with significant mass effect (Figure 1,2).

Craniotomy for the evacuation of the acute frontal SDH and elevation of the temporal depressed fracture was done. Towards the end of the surgery, the brain had swollen significantly and herniated at the frontoparietal lobes from the craniotomy site. Initial steps for brain relaxation were undertaken but failed to subdue the herniation. At this juncture, a decision made to do a decompressive craniectomy, but this also failed to relax the swollen brain, which was now precluding scalp closure. Further, a ventricular tap was not possible because the ventricles were already compressed, leaving cisternostomy as our only option. A surgical loupe of magnification and illumination (Zeiss x 4.3) was used during the cisternostomy procedure. First, the olfactory cistern was laid open using the sub-frontal corridor, and guided by the sphenoid ridge. Next, the carotid, inter-optic, and chiasmatic cisterns were opened until the anterior communicating artery was identified. Cisternal opening resulted in significant CSF egress that served to relax the swollen brain. Then, the bone flap was repositioned and the skin closure was achieved effortlessly. There were no anesthetic or surgical complications. A postoperative CT scan showed no edema, contusions, or midline shift (Figures 3,4). The patient had an uneventful recovery, was discharged three days post-operatively, and remained well as per her last, six-month, follow-up visit.

DISCUSSION

Currently, the management of TBI is mainly based on ICP assessment and control measures (10). Meanwhile, decompressive craniectomy is the recommended treatment modality for patients with significant TBI. However, complications associated with decompressive

craniectomy are not uncommon, including bleeding at the time of bone decompression, expansion of existing brain contusions, external brain herniation, and CSF flow disruption (11). Hence, an immense work is underway to introduce novel techniques that could be used as adjuncts or alternatives to decompressive craniectomy (11). One of these novel techniques is cisternostomy which has been suggested as an effective tool to attain brain relaxation through the evacuation of the cisternal blood and CSF (7). Cisternostomy avails of the Glymphatic system to achieve brain relaxation, while preserving the cerebral parenchyma, unlike in decompressive craniectomy where the brain increases in volume (swell) due to cortical stretching or topographic distortion in compensation ICP elevation (12).

Recently, Hoz et al have proposed a classification system for cisternostomy, pertaining to its mechanism of action and indications. In terms of its mechanisms of action, cisternostomy may serve as either an outflow-one way- or inflow-two way- corridor, the so-called cisternostomy proper which is further subcategorized into convexity and basal cisternostomy. As for its indications, cisternostomy can be either planned or unplanned procedure. A planned cisternostomy is often applied in skull base and microvascular surgeries whereas unplanned cisternostomy is used to control intra-operative brain swelling (13). The patient in the present case needed an unplanned basal cisternostomy proper and had an outcome comparable to that reported for patients with similar indications.

This case has illustrated the potential role of cisternostomy in the management of patients with moderate -to- severe TBIs. However, controlled, multi-center studies are needed before the role of cisternostomy can be embedded in routine neurotrauma practice (14).

CONCLUSION

Basal cisternostomy proper is a novel technique that alleviates both the intraoperative brain swelling and intracranial pressure effectively in most instances. The technique has a promising potential in managing TBIs, either as an adjunct or a substitute to decompressive craniectomy. However, as compared to the well-studied decompressive craniectomy, cisternostomy has a long way to go before it can become ingrained into the standard, TBI-management protocols.

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