Technical Notes

Application of the subdural evacuating port system for the drainage of postoperative tension pneumocephalus: A technical note

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ABSTRACT

Background: Tension pneumocephalus is a neurosurgical emergency requiring prompt intervention. A variety of either temporizing or definitive methods was previously described as part of its management. Here, we report on an off-label use of a bed-side device and the subdural evacuating port system (SEPS)™ for the treatment of tension pneumocephalus.

Methods: The SEPS™ (Medtronic Dublin, Ireland) is a minimally invasive tool that is indicated for the removal of chronic or subacute subdural hematomas and at the patient's bedside. We describe the use of this system to evacuate tension pneumocephalus.

Results: A 44-year-old patient operated in our institution was presented with sudden obtundation 4 days post resection of esthesioneuroblastoma. Imaging confirmed a significant tension pneumocephalus. Immediate bedside decompression using a SEPS bolt placed frontally was performed, achieving rapid evacuation and patient regained consciousness. A definitive skull base reconstruction was done at the operating room at a later stage.

Conclusion: The SEPS™, well-known for evacuation of CSDH, can be potentially used as a bed-side tool to effectively treat mass effect created by tension pneumocephalus. As a readily-available and commercially used device, it can provide a simple and standard toolkit suitable for an emergent temporizing procedure.

Keywords: Brain compression, Burr hole, Craniotomy, Subdural evacuating port system, Tension pneumocephalus

INTRODUCTION

Tension pneumocephalus is a treatable neurosurgical emergency that occurs when air enters through a dural defect and becomes trapped, creating a mass effect.[11,12] The clinical presentation is variable and can include severe restlessness, deteriorating consciousness, focal neurological deficits, cardiac arrest, headache, nausea, vomiting, and seizures.[12,14]

There are two postulated mechanisms leading to the development of pneumocephalus: the “ball- valve” and the “inverted bottle” mechanisms. The former suggests that positive pressure (e.g., sneezing, coughing, Valsalva maneuvers) pulls air intracranially through a cranial defect, and resists outflow leading to tension pneumocephalus.[2,10,16] The latter indicates that drainage of cerebrospinal fluid (CSF) leads to negative intracranial pressure (ICP) that is relieved by the influx
In cases of pneumocephalus, normobaric oxygenation reduces the volume of intracranial air through accelerated clearance of nitrogen.\[^{8}\]\n
CT is the gold standard for the diagnosis of both pneumocephalus and tension pneumocephalus, requiring only 0.55 mL of air for detection.\[^{8}\]\n
The leading causes of pneumocephalus include trauma, infection, and postoperative (usually after cranial, spinal, or ENT procedures).\[^{9,14}\]\n
While the etiologies are variable, the pathophysiology is convergent with intracranial air producing mass effect on the brain with elevation of ICPs.\[^{10,11}\]\n
It has also been posited that direct exposure to high pressure air may be toxic to neurons leading to cerebral edema and other deleterious effects.\[^{15}\]\n
Therefore, tension pneumocephalus is considered an emergency, requiring immediate neurosurgical intervention.\[^{1,4,10,12}\]\n
**MATERIALS AND METHODS**

The subdural evacuating port system (SEPS)™ (Medtronic Dublin, Ireland) is a minimally invasive tool that is indicated for the removal of chronic or subacute subdural hematomas and hygromas.\[^{6}\]\n
Due to its minimally invasive nature, the SEPS enables the neurosurgeon to utilize the device at the patient's bedside using local anesthesia and hand-powered drill to make burr hole. The closed system does not require irrigation, aspiration, or a catheter, and the procedure can be completed within a few minutes with a relatively low complication rate.\[^{13}\]\n
We report on a case where an off-label use of this system, taking advantage of its rapid and simple bed-side instrumentation, was performed as a temporizing measure for treating an acutely decompensating patient suffering a postoperative tension pneumocephalus.

**RESULTS AND CASE PRESENTATION**

A 44-year-old man underwent a resection of a large esthesioneuroblastoma in our institution, using a cranial open approach. Four days postoperatively, he was found obtunded, with a sudden impairment in level of consciousness. The patient then undergone an emergent head computed tomography (CT) in the ICU showing a significant bifrontal extradural pneumocephalus compressing the frontal lobes [Figure 1].

A diagnosis of tension pneumocephalus was made and it was decided by the attending neurosurgeon to utilize the SEPS for rapid decompression as the right frontal side was chosen as the insertion point. The patient was immediately prepared and using local anesthetic; a stab incision was made in his right forehead down to the bone. A twist drill burr hole was placed and the SEPS bolt was screwed in. The SEPS JP drain was then attached and placed at self-suction. The entire procedure time took approximately 5 min. Following air drainage into the bag, the patient immediately improved and regained full consciousness. Follow-up CT imaging performed several hours later confirmed excellent brain decompression [Figure 2].

The patient subsequently underwent elective skull base reconstruction to seal the postoperative defect in his anterior cranial base [Figure 3]. He made an excellent recovery and was discharged home.
DISCUSSION

Although rarely under tension, pneumocephalus is a common occurrence after neurosurgical procedures.2,16 There is no established treatment of pneumocephalus after skull base surgery in the literature; however, the association of pneumocephalus with a skull base defect is similar to that of postoperative CSF leaks and may benefit from similar management.11 Most collections are small, benign, and respond to conservative therapy (i.e., bed rest and supplemental oxygen); however, space-occupying tension pneumocephalus requires prompt diagnosis and treatment.

This case, to the best of our knowledge, is the first to report on the utilization of the SEPS at the bedside as an emergent temporizing treatment of tension pneumocephalus.

Several temporizing measures for tension pneumocephalus have been described. Bed rest, raising the bed head, hyperosmolar therapy, and abstaining from valsalva-like maneuvers comprise the conservative approaches. Normobaric hyperoxia with 100% inspired oxygen facilitates faster resorption of pneumocephalus and has been described in the literature.3,7 Due to pulmonary toxicity, this therapy can be offered for a maximal duration of 24–48 h. In an acute ongoing deteriorating patient, therapy has to resort to surgical temporizing measures. These provide rapid decompression of the pneumocephalus and include burr holes, craniotomy, needle aspiration, and an external ventricular drain.10 These measures either require an operating theater setup or it may take time to assemble the required gear in a bed-side setup. An external ventricular drain may be more invasive in nature and relies on a catheter that has a long shaft compared to a bolt.

The SEPS is indicated for subacute and chronic subdural hematomas and hygromas and has been shown to be effective, safe, and durable for the indicated uses.13 Compared to the traditional burr hole management, there is no significant difference in mortality or other adverse outcomes.

The kit is composed of a bolt connected to a drain with a closed self-suction system and can be inserted through a 5-mm incision after twist-drilling the skull [Figure 4]. Designed to access and evacuate subdural fluid accumulations into an external suction reservoir, it is also intended to drain air and fluids from the subdural space immediately following craniotomy procedures removing chronic and subacute subdural hematomas.

Therefore, the system is capable of decompressing tension pneumocephalus in a similar manner to evacuating a subdural hematoma through a minimally invasive and quick procedure conducted at the bedside, rather than the operating room.

We believe that a potential advantage of this technique lies both in the rapid, bedside nature of this device, as well as the fact, it is an already assembled kit, which does not require gathering of different instruments, which could be challenging in an emergent ward setup. Importantly, the bolt can be left in place for a few days, allowing ample time for evacuation of air, which can accumulate in significant amounts particularly after skull base surgery.16 As it lies in the skull and is rigid, it potentially offers better patency over time compared to drains. The capability of the port to remain unclogged along with a high safety profile as a bolt contributes to it being a suitable candidate for use in such cases.

CONCLUSION

The SEPS™, known for its use in evacuation of CSDH, can be potentially used as a bed-side tool to effectively treat mass effect created by air trapped within the cranium. As a readily-available and off-the shelf device, it can provide a simple and standard toolkit suitable for an emergent temporizing procedure for the treatment of tension pneumocephalus.

Declaration of patient consent

Patient’s consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

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