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Technical Note

Use of frameless neuronavigation for bedside placement of external ventricular catheters

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ABSTRACT

Neuronavigation for placement of ventricular catheters has been described. At our institution, electromagnetic neuronavigation is frequently utilized for difficult ventricular catheter placement. In patients who develop a trapped ventricle as a result of an intraparenchymal or intraventricular mass lesion, successful catheter placement may be difficult, as the location and trajectory are unfamiliar. The authors report their experience using electromagnetic neuronavigation for bedside placement of external ventricular catheters in patients with trapped ventricles. The technique for bedside placement of external ventricular catheters utilizing electromagnetic neuronavigation is reviewed. The benefits of this technique and those patients in whom it may be most useful are discussed. Utilization of bedside electromagnetic neuronavigation for placement of difficult external ventricular catheters into trapped ventricles is an option for accurate navigated catheter placement. Bedside electromagnetic neuronavigation offers accurate catheter placement in awake patients. This technique may be utilized in patients with high perioperative risk factors as it does not require general anesthesia. The procedure is well tolerated as it does not require rigid head fixation.

1. Introduction

Intraoperative neuronavigation builds an anatomic map that has proven useful in cranial procedures. In some instances, and particularly for brain tumors, preoperative thin-slice cranial imaging is obtained so that a three-dimensional map may be generated for intraoperative use. At our institution, electromagnetic neuronavigation is frequently utilized for ventricular catheter placement in the setting of shunt procedures or for ventricular catheter placement into atypical locations. The practice of stereotactic-guided ventricular catheter placement has been previously described [1–3].

Patients with intraparenchymal or intraventricular mass pathologies such as tumor, abscess, or hemorrhage may develop an isolated entrapment of a portion of their ventricular system, such that the "trapped" part does not allow cerebrospinal fluid (CSF) to communicate with the remainder of the ventricular system (Fig. 1). The trapped ventricle may enlarge and the intraventricular pressure rise as CSF is produced, resulting in symptomatic mass effect. When this occurs, especially in the setting of periventricular cerebral edema, it is often beneficial to place a ventricular catheter into the trapped ventricle to divert CSF and allay the symptoms of mass effect and pressure (Fig. 2).

Electromagnetic neuronavigation, such as the StealthStation S7 AxiEM navigation system (Medtronic, Minneapolis, MN, USA), allows for reliable navigation without the need for rigid head fixation [1]. This characteristic makes its use appealing in patients who are awake [4]. In this note, the authors describe a technique for bedside ventricular catheter placement using electromagnetic neuronavigation. An illustrative patient is presented.

2. Methods

Intravenous analgesic and anxiolytic medications along with local anesthetic and appropriate cardiopulmonary monitoring are utilized for all patients who require bedside external ventricular drain placement. After obtaining thin-slice CT imaging, the mobile StealthStation S7 AxiEM navigation system is brought into the patient's room. The system requires placement of a non-invasive tracker which is frequently attached to the patient's forehead on the side opposite to catheter placement. The tracker is quite small

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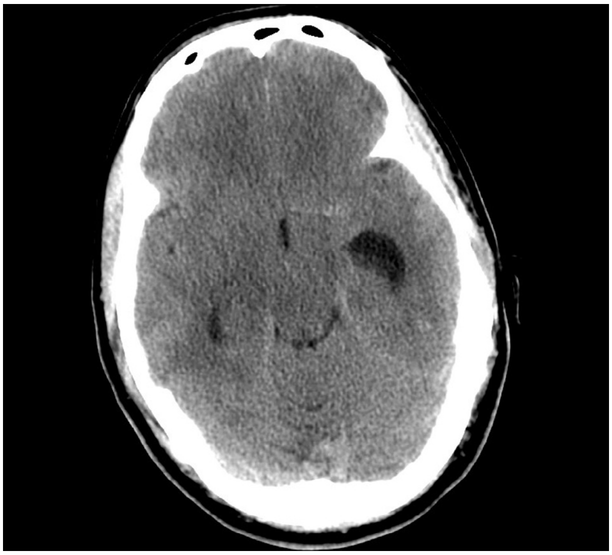

Fig. 1. Axial unenhanced CT scan of the head demonstrating asymmetric enlargement of the temporal horn of the left lateral ventricle.

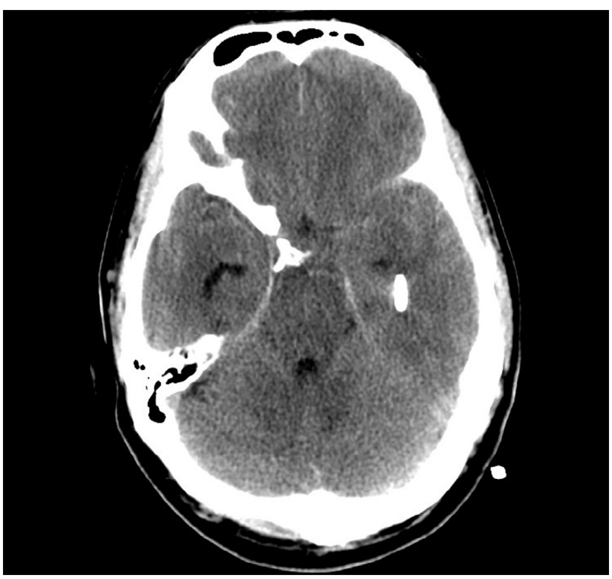

Fig. 2. Axial unenhanced CT scan of the same patient in Figure 1 after placement of a bedside external ventricular catheter utilizing electromagnetic neuronavigation.

and may be secured with tape if necessary. Registration requires tracing of the patient's face and scalp after affixing the controller arm and emitter to the patient's bed. Accuracy is confirmed by testing easily visualized facial landmarks.

Prior to catheter placement, a preselected target end point for the ventricular catheter tip is noted. From this target end point, an optimal entry point and trajectory are planned to minimize the risk of injury to critical neurovascular structures. After selecting an entry point on the scalp and a target end point in the ventricle or desired catheter tip location, the depth of catheter placement may be calculated with the navigation software. Upon passing the ventricular catheter, the surgeon may make real time trajectory adjustments and have a visual aid in determining the catheter tip's current location in relation to the desired final location.

3. Discussion

Accurate catheter placement may be obtained with the use of electromagnetic neuronavigation. Unfortunately, trapping or isolation of part of the ventricular system typically occurs in patients harboring mass lesions that result in distortion of the normal ventricular alignment making catheter placement utilizing standard landmarks more difficult. In addition, treating the trapped component often requires the surgeon to place the catheter tip into an unfamiliar location. In the setting of a mass lesion, the surgeon may also be required to take an unfamiliar trajectory in order to avoid critical neurovascular structures. When the area in question is near eloquent cortex, repeated attempts to place the catheter into the desired space may increase the risk of iatrogenic injury, resulting in neurologic sequelae.

A previous retrospective report on follow-up CT imaging after stereotactic placement noted poor placement in 1.4% of cases [2]. Though not perfect, catheter placement without neuronavigation, especially placement into unfamiliar locations or with unfamiliar trajectories, is likely to fare much worse. In patients who have already suffered injury related to cerebral edema from tumor, hemorrhage, or an infectious process, additional iatrogenic injury from attempted catheter placement into difficult locations along atypical trajectories may worsen the prognosis. Thus, minimizing the number of attempts at placing the catheter is an important strategy.

In order to minimize the risk of iatrogenic injury and catheter misplacement, we use electromagnetic neuronavigation for placement of difficult bedside external ventricular catheters. See Figure 3 for a brief illustrative case. Bedside catheter placement circumvents the risks of general anesthesia in patients who are systemically ill. Also, because cranial pin fixation is not used in this method of neuronavigation, the procedure is generally well tolerated. In the setting of ventriculitis, repeated sampling of CSF may be performed. Aspiration of catheters located partially within or entirely outside of the ventricular system may result in traumatic damage to the surrounding neurovascular structures. In addition, infusion of pharmacologic agents into improperly placed catheters may result in toxicity to the surrounding parenchyma.

Lastly, it is important to note that in patients who are unable or unwilling to cooperate, sudden vigorous head movements may result in catastrophic consequences and thus caution should be used. However, the risk of such an event is unlikely to be different than that associated with the routine placement of frontal approach external ventricular drains. In both instances, adequacy of sedation should be insured.

4. Conclusions

Use of electromagnetic neuronavigation for placement of bedside external ventricular catheters minimizes risk of iatrogenic injury for placement of catheters into unfamiliar locations and at unfamiliar trajectories and offers an alternative to performing the procedure under general anesthesia or with a rigid cranial frame. In patients who are suffering systemic illnesses that may increase their perioperative anesthetic risk, this technique may be performed without the need for general anesthesia. The procedure is generally well tolerated as it does not require rigid pin fixation.

Conflicts of Interest/Disclosures

The authors declare that they have no financial or other conflicts of interest in relation to this research and its publication.