Surface anatomy for implantation of external ventricular drainage: Some surgical remarks

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Abstract

Background: External ventricular drainage (EVD) is an emergency process intended to reduce intracranial hypertension resulting from the obstruction of cerebrospinal fluid (CSF) flow. This creates a temporary situation to extract CSF that cannot pass through normally. Knowing the surface anatomy for EVD implantation is important to prevent its inadvertent complications. The external landmarks have been designed in this anatomic study to review the classical landmarks and come up with new landmarks to improve this simple but lifesaving procedure.

Methods: From November 1998 to October 2012, we implanted 439 EVDs.

Results: In the first years, we employed usual landmarks to implant 97 EVDs. Since 2002, we used modified anatomical landmarks to implant 342 EVDs directly in the third ventricle.

Conclusion: Using effective landmarks for EVD implementation allows the catheter to be inserted in the third ventricle. In addition, it permits more precise accuracy to ensure a safer procedure with fewer complications.

Key Words: Acute hydrocephalus, cerebrospinal fluid, external ventricular derivation, lateral ventricle, third ventricle

INTRODUCTION

External ventricular drainage (EVD) is an emergency procedure aimed at reducing intracranial hypertension resulting from the obstruction of cerebrospinal fluid (CSF) flow. It is a relatively simple but lifesaving process. This process creates a temporary situation to extract CSF that cannot pass through normally.

The procedure consists of implementing a shunt in the right frontal horn of the lateral ventricle. It is usually done without any image guidance, which may be life-threatening.

The surgery is decided according to patient’s clinical condition, his (her) clinical exam, and his (her) imaging [computed tomography (CT) scan or magnetic resonance imaging (MRI)]. Being considered a simple procedure, EVD implementation is made using surface anatomy. It is generally the first surgery carried out by young resident or neurosurgeons.

Although in a majority of instances lateral ventricle is dilated, the neurosurgeon is sometimes confronted by...
cases in which the frontal horn is normal even narrow. Therefore, knowledge of the cranium projections of brain structures is essential for the success of the surgery and reduces the surgical complications and misplaced catheter. With experience and by the logic and nature of diseases requiring the implementation of EVD, on one hand, and reflecting brain anatomy and the physiopathology of CSF circulation and absorption, on the other hand, we believe that the implementation of EVD in the third ventricle is the best way to have a situation as close to reality as possible.

This paper presents our experience, our knowledge acquired over the years, our remarks, and our conclusion about EVD implantation in the context of the literature.

**MATERIALS AND METHODS**

From November 1998 to October 2012, we implanted 439 EVDs. Pediatric cases were excluded from study. In the first years, we employed usual landmarks to implant 97 EVDs. Since 2002, we used modified anatomical landmarks to implant 342 directly in third ventricle.

According to usual landmarks, the patient is positioned in a dorsal decubitus, the head is slightly flexed with a 0 degree of rotation. The trepanation hole is made 2–3 cm lateral to the midline and 1–2 cm anterior to the coronal suture. The ventricular catheter is passed perpendicular to the brain. The surgeon enters the lateral ventricle at 5–6 cm from the calvarium.\(^{[1,3,5,11,13-16]}\)

Since 2002, we employed the following technique and landmarks; for burr hole spacing, we choose a point 11.5 cm posterior to Nasion (measured by a flexible rule) at the midline. At this point, we choose a point 2.5 cm lateral to the midline and perpendicular to the latter. The burr hole is placed more or less at this point. The 3 cm curved incision is placed central to this point with its concave side facing anteriorly. We use a three-dimensional trajectory to first enter the lateral ventricle and then the third ventricle. For this purpose, we employ three references point in space. The first one is the inner canthus of the ipsilateral eye in the coronal plane. First, this point is targeted by the catheter. The second one is tragus in the sagittal plane. The trajectory is adjusted the second time to be parallel to tragus. And the third and last point in the space is the midpapillary point of the eye in axial plane. This point determines the exact placement of the burr hole that will be adjusted and referenced to the starting point (2.5 cm to midline). The burr hole is performed by twist drill. Dura is open by electric bistoury. The catheter is passed according to landmarks, point references, and abovementioned imaginary lines.

Once a slight resistance was felt, there will be immediately a popping as the ependymal layer is punctured. The catheter is pushed at 8.5–9.5 cm from calvarium to be placed gently in the third ventricle.

**RESULTS**

Table 1 shows the baseline of patients who have undergone the EVD implementation.

All the patients had a postoperative imaging (MRI or CT scan) at the latest 24 hours after surgery. If the patients did not improve or their neurological condition deteriorated, they had an imaging immediately after EVD implantation.

Table 2 demonstrates diseases requiring EVD implantation. Table 3 shows mechanical complication resulting from EVD implementation technique (misplaced catheter).

**DISCUSSION**

Over time, we modified our landmarks for EVD implantation. These modifications were carried out on the basis of the experience of EVD implementation but also, in particular, the experience of ventriculozysternostomy that need device introduction in the third ventricle. We noted that, with stringent compliance of landmarks and trajectories, we can enter the catheter in the third ventricle in the vast majority of cases without any difficulty. The interest of EVD implantation in the third ventricle is multiple; well-balanced extraction of CSF; non-unilateral evacuation, in particular, in the case of unilateral intracranial pressure due to tumor mass or other possible causes; and valve obstruction avoidance in case of lateral ventricular collapse. Obviously, there may be cases where EVD in the third ventricle is impossible. However, there have only been a handful of cases in our series.

Our three-dimensional landmarks provide the most precise accuracy against usual two-dimensional landmarks, and even more because this surgery is generally carried out as an emergency and would not always be possible to use neuronavigation and stereotaxic frame. Despite its reputation as a relatively simple procedure, this surgery is not an innocuous act and several complications have been identified in the medical literature. In addition to the general complications of EVD implantation as hemorrhage and obstruction, the most common misplaced catheters are basal ganglion, thalamus, internal capsule, corpus callosum, and frontal lobe.\(^{[1,5,6,8,20]}\)

In our series of 342 patients using three-dimensional landmarks, we had only 3 (0.88%) misplaced catheters [Table 3] against 4 misplaced catheter (4.12%) for the usual technique.

Using usual technique, we were led to try a second even a third time to correctly place the catheter and see CSF...
Table 1: Baseline of patients

| Patients operated by the usual technique |
|----------------------------------------|
| No of patients (%) | A.1 | A.2 | A.3 | LV |
|---------------------|-----|-----|-----|----|
| 97 (100)            | 86 (88.66) | 5 (5.15) | 6 (6.18) | 97 (100) |

Table 2: Diseases requiring external ventricular drainage implantation

| Diseases                              | No. of patients (%) |
|---------------------------------------|---------------------|
| Subarachnoid hemorrhage               | 342                 |
| Hydrocephalus shunt malfunction      | 97 (100)            |
| Shunt infection                       | 6 (6.18)            |
| Trauma                                | 97 (100)            |
| Intracranial hematoma                 | 331 (96.78)         |
| Subdural hematoma                     | 2 (0.58)            |
| Extradural hematoma                   | 18 (5.26)           |
| Tumor                                 | 324 (94.74)         |
| Postoperative hydrocephalus           |                     |

Table 3: Misplaced catheter resulting from external ventricular drainage implantation technique

| Patients operated by the usual technique |
|----------------------------------------|
| No. of patients | Complications |
|----------------|---------------|
| 1              | Catheter entered in the internal capsula |
| 2              | Catheter entered in the corpus callosum |
| 1              | Catheter entered in the basal ganglion |
| Total (%)      | 4 (4.12)      |

| Patients operated by the modified anatomical landmarks technique |
|---------------------------------------------------------------|
| No. of patients | Complications |
|----------------|---------------|
| 1              | Catheter entered in the corpus callosum |
| 1              | Catheter entered in the basal ganglion |
| 1              | Catheter entered in the frontal lobe   |
| Total (%)      | 3 (0.88)      |

Using effective landmarks for EVD implementation allows the catheter to be inserted in the third ventricle. In addition, it permits more precise accuracy to ensure a safer procedure with less complications.

**CONCLUSION**

Using effective landmarks for EVD implementation allows the catheter to be inserted in the third ventricle. In addition, it permits more precise accuracy to ensure a safer procedure with less complications.

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**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Bhargava D, Alalade A, Ellamushi H, Yeh J, Hunter R. Mitigating effects of external ventricular drain usage in the management of severe head injury. Acta Neurochir 2013;155:2129-32.
2. Chai FY, Farizal F, Jegan T. Coma due to misplaced external ventricular drain. Turk Neurosurg 2013;23:56-7.
3. Choo YS, Chung J, Joo JY, Kim YB, Hong CK. Borderline basal ganglia hemorrhage volume: Patient selection for good clinical outcome after stereotactic catheter drainage. J Neurosurg 2016;115:1-7 [Epub ahead of print].
4. Cinibulk Z, Aschoff A, Apedjinou A, Kaminisky J, Trost HA, Krauss J. Current practice of external ventricular drainage: A survey among neurosurgical departments in Germany. Acta Neurochir 2016;158:847-53.
5. Hsieh CT, Chen CJ, Ma HI, Chang CF, Cheng CM, Su YH, et al. The misplacement of external ventricular drain by freehand method in Emergent Neurosurgery. Acta Neurochir Belg 2011;111:22-8.
6. Kosty J, Pukenas B, Smith M, Storm PB, Zager E, Stiefel M, et al. Iatrogenic vascular complications associated with external ventricular drain placement: A report of 8 cases and review of the literature. Neurosurgery 2013;72(2 Suppl Operative):S208-13.
7. Meyer FB. Atlas of Neurosurgery: Basic Approaches to Cranial and Vascular Procedures. Philadelphia: Churchill Livingstone; 1999.
8. Murrhead WR, Busi S. Trajectories for frontal external ventricular drain placement: Virtual cannulation of adults with acute hydrocephalus. Br J Neurosurg 2012;26:710-6.
9. Muruliwishan R. External ventricular drains: Management and complications. Surg Neurol Int 2015;6(Suppl 6):S271-4.
10. Patil V, Lacson R, Vosburgh KG, Wong JM, Prevedello L, Andriole K, et al. Factors associated with external ventricular drain placement accuracy: Data from an electronic health record repository. Acta Neurochir 2013;155:1773-9.
11. Phillips SB, Delly F, Nelson C, Krishnamurthy S. Bedside external ventricular drain placement: Can multiple passes be predicted on the computed tomography scan before the procedure? World Neurosurg 2014;82:739-44.

12. Prabhakar H, Ali Z, Rath GP, Bithal PK. Tension pneumocephalus following external ventricular drain insertion. J Anesth 2008;22:326-7.

13. Roitberg BZ, Khan N, Alp MS, Hersonskey T, Charbel FT, Ausman JI. Bedside external ventricular drain placement for the treatment of acute hydrocephalus. Br J Neurosurg 2001;15:324-7.

14. Rosenbaum BP, Wheeler AM, Krishnaney AA. External ventricular drain placement causing upgaze palsy: Case report. Clin Neurol Neurosurg 2013;115:1514-6.

15. Sarrafzadeh A, Smoll N, Schaller K. Guided (VENTRI-GUIDE) versus freehand ventriculostomy: Study protocol for a randomized controlled trial. Trials 2014;15:478.

16. Toma AKJ, Camp S, Watkins LD, Grieve J, Kitchen ND. External ventricular drain insertion accuracy: Is there a need for change in practice? Neurosurgery 2009;65:1197-200.

17. Walker CT, Stone JJ, Jacobson M, Phillips V, Silberstein HJ. Indications for pediatric external ventricular drain placement and risk factors for conversion to a ventriculoperitoneal shunt. Pediatr Neurosurg 2012;48:342-7.

18. Wong FW. Cerebrospinal fluid collection: A comparison of different collection sites on the external ventricular drain. Dynamics 2011;22:19-24.

19. Weisenberg SH, TerMaath SC, Seaver CE, Killeffer JA. Ventricular catheter development: Past, present, and future. J Neurosurg 2016 4:1-9 [Epub ahead of print].

20. Zhao B, Tan X, Yang H, Zheng K, Li Z, Xiong Y. Stent-assisted coiling versus coiling alone of poor-grade ruptured intracranial aneurysms: A multicenter study. J Neurointerv Surg 2016 pii: neurintsurg-2016-012259.