

External ventricular drains: Management and complications

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Abstract

Background: Insertion of an External Ventricular Drain (EVD) is arguably one of the most common and important lifesaving procedures in neurologic intensive care unit. Various forms of acute brain injury benefit from the continuous intracranial pressure (ICP) monitoring and cerebrospinal fluid (CSF) diversion provided by an EVD. After insertion, EVD monitoring, maintenance and troubleshooting essentially become a nursing responsibility.

Methods: Articles pertaining to EVD placement, management, and complications were identified from PubMed electronic database.

Results: Typically placed at the bedside by a neurosurgeon or neurointensivist using surface landmarks under emergent conditions, this procedure has the ability to drain blood and CSF to mitigate intracranial hypertension, continuously monitor intracranial pressure, and instill medications. Nursing should ensure proper zeroing, placement, sterility, and integrity of the EVD collecting system. ICP waveform analysis and close monitoring of CSF drainage are extremely important and can affect clinical outcomes of patients. In some institutions, nursing may also be responsible for CSF sampling and catheter irrigation.

Conclusion: Maintenance, troubleshooting, and monitoring for EVD associated complications has essentially become a nursing responsibility. Accurate and accountable nursing care may have the ability to portend better outcomes in patients requiring CSF drainage.

Key Words: External ventricular drain, hydrocephalus, intraventricular hemorrhage, ventriculostomy

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INTRODUCTION

Insertion of an external ventricular drain (EVD) is arguably one of the most common and most important lifesaving procedures encountered in the neurologic intensive care unit.^[5] Various types of acquired brain injury, such as intracranial hemorrhage with intraventricular extension, subarachnoid hemorrhage, traumatic brain injury, and bacterial meningitis, may

benefit from EVD insertion. Many of these conditions are associated with intracranial hypertension or raised intracranial pressure (ICP) above 20 mmHg due to obstruction of cerebrospinal fluid (CSF) outflow.^[5]

CSF production approximates 0.2–0.4 mL/min or 500–600 mL a day.^[1,3] CSF is circulated along the ventricular system into the subarachnoid space and then absorbed into the venous system within the arachnoid granulations that line the convexity of the brain. An

equilibrium normally exists between its production and absorption. Disruption of this equilibrium, that is, caused by intraventricular blood, leads to intracranial hypertension with acute noncommunicating hydrocephalus, the condition wherein there is an excess of fluid in all or part of the CSF space in the brain.^[13] Insertion of an EVD in this scenario would aid in the reduction of intracranial hypertension by diverting CSF and intraventricular blood, allow instillation of medications, and allow continuous intracranial pressure monitoring to help guide brain targeted resuscitation in these critically ill patients.

EVD insertion

A freehand pass technique using surface landmarks is commonly used by surgeons to place an EVD.^[7] The right frontal cerebral hemisphere is the preferred site of entry given its nondominance for language function in >90% of patients.^[7,10] The patient is maintained with head of bed elevated at 45 degrees in the supine position. Hair is removed using clippers and the scalp is prepared in a sterile fashion.^[10] A burr hole is placed at Kocher's point to avoid the superior sagittal sinus and frontal cortex motor strip.^[7] This point is located by drawing one line in the midline from the nasion to a point 10 cm back and another from the previous point to a site 3 cm lateral to it, along the ipsilateral midpupillary line. After instillation of local anesthesia, a linear skin incision is made down to the bone and the periosteum is scraped. A twist drill is used to penetrate the cranium in the trajectory determined for ventricular cannulation, and the pia and dura are pierced with a scalpel. The ventricular catheter is primed and passed no more than 7 cm, aiming in a coronal plane toward the medial canthus of the ipsilateral eye and in the anteroposterior plane toward a point 1.5 cm anterior to the ipsilateral tragus, toward the ipsilateral Foramen of Monro. Once CSF flow is visualized after removal of catheter stylet, it can be transduced to obtain an opening intracranial pressure. It is then tunneled through the skin away from the point of entry through a separate incision, sutured securely in place, and then connected to an external drainage system.^[10] Complications such as hemorrhage and inadvertent placement into brain tissue is reported in 10–40% of cases.^[11] As a result, technical advances using computed tomography (CT), ultrasound, endoscopy, and stereotactic neuronavigation have been developed to improve the accuracy and efficiency of ventriculostomy placement.^[7,11]

Management of EVD

Immediately obtained after insertion of an EVD, the mean opening pressure has significant prognostic implications and it influences the strategy and desired height of the collection system. The underlying pathology of the patient is also taken to consideration when determining the height of the collecting system. In the setting of an

unsecured aneurysmal subarachnoid hemorrhage, the initial height of the collecting system is set "high" such that CSF is not drained too quickly in order to avoid rapid change in the transmural pressure across the aneurysm wall, which may predispose to rebleeding.^[5] Negative level of drainage may be encountered in patients with negative pressure hydrocephalus^[6] or massive intraventricular hemorrhage.

After a desired height (cmH₂O) of the collection system is determined, management of the EVD essentially becomes a nursing responsibility. Drainage can be continuous at a set level, fixed volume per desired time (i.e., every hour), or as needed according to ICP elevations.^[5] When positioning an EVD, the nurse adjusts the height of the EVD such that its pressure transducer is in line with the Foramen of Monro, which falls at the level of the external auditory meatus of the ear in the supine position and at the mid sagittal line (between the eyebrows) in the lateral position.^[2] Tools such as a Carpenter's level or laser leveling device is used to zero the drain at this level and assure accuracy of placement, as leveling based on visual checks alone are often inaccurate.^[2] Next the drip chamber is adjusted to the desired height level, before unclamping the chamber. At this prescribed height, CSF will drain whenever the interventricular pressure exceeds that set by the height of the collection system. Flow ceases once the pressure equalizes between the CSF compartments in the brain and collection system. As a result, the collection system must be re-leveled whenever the patient changes position to avoid erroneous ICP reading and/or over or under drainage.^[2] For example, if the transducer is above the Foramen of Monro, falsely low ICP and insufficient drainage of CSF may occur, in which case intracranial hypertension would go undetected and untreated. In addition, drain should also be clamped during transfer and transport.

Intracranial pressure tracing should be inspected after the collecting system is appropriately leveled. If an EVD is open with continuous drainage, the stopcock at the level of the transducer should be turned "off" to the drain and "open" to the transducer in order to obtain an ICP reading.^[12] The ICP waveform generally takes 30 s or so to stabilize, and should appear pulsatile. An ICP wave is comprised of three separate peaks, decreasing in height under normal conditions to correlate with the arterial pressure waveform occurring with each cardiac cycle.^[12,4] In patients with intracranial hypertension or failing intracranial compliance, the amplitude of all three peaks may increase, followed by elevation of the second peak over the first, with possible complete disappearance of the first peak within the wave.^[12,8]

If clinically indicated, the EVD collection system may be accessed by physicians, and in some institutions by nurses, to withdraw CSF for the purposes of cultures and/or

obtaining malignant cells, or to instill medications.^[5,8,15] Spinal fluid samples are generally obtained through the proximal port (closest to the head) of the EVD collecting system and is performed using strict sterile technique due to risk of infection.^[5] Samples should not be collected from the collection bag due to rapid degradation of cellular components. Though samples can be drawn from the distal port, white cell counts and cultures are often not accurate.^[15] When drawing the sample, aspiration should be very slow (no more than 1 ml/min) and if any resistance is met, the procedure should be aborted and a physician should be notified immediately. When medications are introduced into the EVD, such as tissue plasminogen activator for intraventricular hemorrhage^[5] or antibiotics for ventriculitis,^[9] the EVD should be clamped for 1 h after administration.

Other important aspects of nursing management include monitoring for signs and symptoms of intracranial hypertension and inspecting the entire EVD system and insertion site for CSF leak, which is known to predispose to infection.^[12] Noting the quantity, color, and clarity of CSF is also important. Clinically relevant scenarios can be detected by noting each of these factors such as an increase in the hourly output may signal intracranial hypertension, bright red bloody CSF may indicate aneurysm re-rupture and cloudiness of CSF may indicate the presence of an infection, respectively.^[12,16]

Trouble shooting and complications

Despite appropriate maintenance and surveillance of an EVD, complications such as obstruction and infection may arise given the invasive nature of the device.

Obstruction of a ventriculostomy catheter is often due to cellular debris, such as blood clots and/or tissue fragments. Mechanical EVD failure such as kinking of tubing, failure of any part of the system such as a wet filter (which can occur with horizontal positioning of an unemptied or unclamped drip chamber) and/or migration of EVD catheter, and physiologic factors such as over drainage or tight ventricles and/or CSF leak, may also result in obstruction.^[8,16] The entire drainage system can be lowered briefly to see if CSF flow ensues, which would argue against a fixed obstruction.

Dampening of the ICP waveform, reduction or absence of CSF flow and lack of pulsation of the CSF meniscus in drain tubing with respiration, insinuate catheter obstruction.^[8] If mechanical failure is suspected, the EVD collection system may need to be changed.^[8,16] If cellular debris is suspected, catheter irrigation using a small volume (less than 2 ml) of sterile isotonic normal saline is used to restore flow and is typically performed by physicians under strict sterile conditions. Often the distal port away from the patient is flushed first, particularly if debris or air is visualized in distal tubing. However, this will not alleviate a proximal obstruction, such as one

located at the tip of the ventriculostomy catheter. In this situation, the proximal port of the collection system may need to be flushed but this could potentially result in increased intracranial pressure in patients with preexisting intracranial hypertension and/or poor intracranial compliance according to the Monroe–Kellie hypothesis.^[8] Therefore, the importance of using the smallest volume of fluid cannot be overemphasized.

EVD associated meningitis or ventriculitis is a common complication with an incidence of 0–22%.^[5,12] Risk factors that have been associated with EVD infections include systemic infection, depressed skull fracture, lack of tunneling of EVD catheter, site leak, catheter irrigation, frequency of CSF sampling and possibly duration of EVD placement.^[5,12,16] A common practice aimed at reducing this is to administer intravenous antibiotics to cover common skin flora for the duration of EVD placement. Though this appears to carry some benefit, it may contribute to the development of resistant organisms.^[5,12] Antibiotic-impregnated and ionized silver particle coated EVD catheters offer a similar level of protection compared with prophylactic intravenous antibiotics but come at a cost.^[5,14] Other strategies include sampling an EVD only when infection is suspected, monitoring EVD dressing site for drainage suggestive of CSF leak, maintaining collection system in the upright position, and not routinely changing drain tubing.^[12] In the setting of infection, it is common consensus that the colonized EVD catheter be removed and replaced with a new catheter, preferentially at a new site.^[5]

CONCLUSION

Maintenance, troubleshooting, and monitoring for EVD associated complications has essentially become a nursing responsibility. Accurate and accountable nursing care may have the ability to portend better outcomes in patients requiring CSF drainage.

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