

Supplementary Digital Content 4
External Ventricular Drain Insertion and Maintenance Policy and Procedure
The Harborview Medical Center Policy Development Guide

Hospital name	Policy Name: External ventricular drain insertion and maintenance	Filed under: Policy and procedure	
Issuing Department Neurocritical care Nursing	Policy endorsement: Policy and procedure committee critical care leadership	Revision date mm/yyyy, mm/yyyy	Policy effective date: mm/yyyy
Original Policy Date: mm/yyyy		Page 1 of 13	Approved by: Name and title Designation

Applicability:(check all that may apply) Population served <input type="checkbox"/> Adults <input type="checkbox"/> Children	Care Setting: <input type="checkbox"/> Critical Care, including PACU <input type="checkbox"/> Emergency Department <input type="checkbox"/> Operating room <input type="checkbox"/> Inpatient non-critical care
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External ventricular drain (EVD) insertion

1. If the procedure is performed electively, obtain consent for ventriculostomy from the patient and/or family. In the case of an emergency, an attending must document the inability to reach the family and the emergent need for the procedure.
2. EVDs may be inserted in the emergency department, operating room, post-anesthesia care unit, or in the intensive care unit.
3. Practitioners planning to place EVDs follow formal institutional protocols for training, mentoring, and quality assurance. Neurosurgeons participate in the development of the institutional protocol and credentialing, and that neurosurgical backup availability is assured.
4. Anatomical landmarks (Kocher's point) or image-guided navigational assistance may be used while inserting EVDs.
5. Prior to insertion, verify that complete blood count and coagulation profile has been reviewed by the proceduralist. Prompt diagnosis and reversal of coagulopathy and attention to any antiplatelet or anticoagulants must be the standard.

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6. Anticoagulation management should be performed according to institutional protocols before the insertion of an EVD.
7. Antibiotics (typically in form of a first-generation cephalosporin such as Cefazolin) should only be administered before the placement of an EVD.
8. Use antimicrobial-impregnated catheters as part of a comprehensive management protocol to reduce the rate of EVD-associated infection.
9. If the physician will be inserting an antibiotic-impregnated catheter (Bactiseal™), check for a known allergy to Rifampicin, Clindamycin, or Minocycline (contraindication). If unknown, observe for an allergic response after insertion.
10. Bedside insertion of a ventricular drain should be treated the same as a surgical procedure in the OR with the surgeon wearing a sterile gown, surgical cap, mask, and sterile gloves. The (nurse) surgical assistant should wear a surgical cap, mask, and clean or sterile gloves as needed during the procedure. The nurse assists the surgeon in maintaining a strict sterile technique. The head and body of the patient are to be covered with sterile drapes
11. Assess the patient's neurologic status pre-procedure.
12. Gather supplies including cranial access kit, external ventricular drainage system flush less transducer and tubing, sterile normal saline flush (preservative-free), ventricular catheter, sterile gloves, gown, mask, cap, sterile drapes, transducer cable, disposable clipper or electric razor.
13. Performed time out to verify the correct patient, correct procedure, and correct site.
14. Perform hand hygiene. Don mask, cap, sterile gown, and sterile gloves.
15. After equipment and supplies assembled, ensure that all staff present during procedure wears masks and hair covers.
16. Assess patient need for and response to analgesia and sedation during the procedure.
17. Always tunnel the EVD catheter to decrease the risk of EVD-associated infection.
18. Verify that the EVD catheter is secured by the physician and, using sterile technique, apply a sterile transparent adhesive dressing to the insertion site
19. Assess the patient's neurologic status post-procedure.
20. Obtain a post-procedure Head CT to verify EVD placement.

EVD system set up

1. May be performed prior to EVD insertion.
2. Obtain IV pole and pre-assembled CSF drainage system, string or laser level, Sterile 10 mL syringe, Luer-activated vial adapter, 10 mL vial of preservative-free normal saline or prefilled 10 mL preservative-free, 3 sterile airtight non-injectable caps, flush less transducer, transducer cable, masks, and sterile gloves.
3. Attach the CSF drainage system to the IV pole using at least 2 methods.
 - a. Clamp drainage system to the IV pole by pressing the white clamp that protrudes out from the white panel of the drainage system.
 - b. Secure the drainage system from the IV pole using the cord and cord lock.

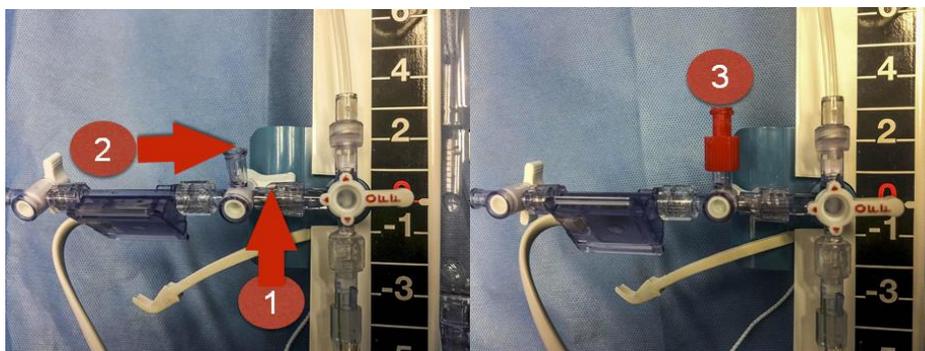
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4. Prime the transducer and drainage system prior to attaching the tubing to the ventricular catheter
 - a. Don mask
 - b. Open required supplies onto the sterile field: flush less transducer, 3 sterile airtight non-injectable caps, Sterile 10 mL syringe, Luer-activated vial adapter (if prefer to use prefilled preservative-free normal saline, do not place prefilled preservative-free sterile normal saline syringes on the sterile field)
 - c. Draw up 10 mL of preservative-free saline in a sterile syringe.
 - i. 1 person method: Don sterile glove on 1 hand; use another hand to hold vial. With a sterile hand, insert vial adapter into the vial and use a sterile syringe to draw up saline.
 - ii. Alternative method #1: Using aseptic technique, insert vial adapter into vial and attach vial securely to IV pole using tape. Don sterile glove, hold the sterile syringe and withdraw preservative saline from the vial.
 - iii. Alternative method #2: Use pre-filled 10 mL sterile preservative-free normal saline syringe. Hub and contents of the prefilled syringes are sterile. Outside of the syringe is clean.
 - d. Don sterile gloves.
 - e. Twist the hub of the Luer lock connection on the flushless transducer a full 360 degrees to loosen.
 - f. Attach syringe on to the distal end of the transducer. Attach transducer on the distal end of panel mount stopcock and tighten luerlock by turning luerlock connection towards you (clockwise).
 - g. Turn the burette stopcock upright (off to the drainage bag).
 - h. Turn both stopcocks on transducer open to prime system; prime transducer including a port on the 3-way stopcock. Replace the yellow cap on 3-way stopcock with sterile airtight noninjectable cap.
 - i. Turn panel mount stopcock off to the patient end of the drainage system and prime from distal end of the transducer to burette allowing the collection of normal saline into the burette. Once all air is eliminated in the tubing, turn panel mount stopcock off to the burette and open to the patient tubing and prime to the end of the tubing. Replace sterile cap at end of patient tubing with sterile airtight non-injectable cap. Remove syringe on distal end of flushless transducer and replace it with sterile airtight non-injectable cap.
 - j. Level transducer and zero of drainage system at external auditory meatus using string level (included in drainage system box) or laser level (as figure).

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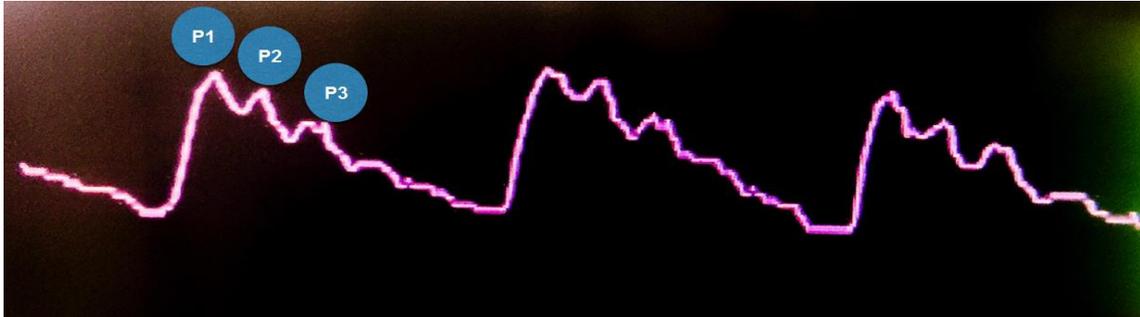


- k. Slide the graduated burette to the desired level by squeezing the white Squeeze Lok® tabs at the top of the burette and sliding the burette up and down. Verify drainage height with the Physician/NP/PA (either mm Hg or cmH20).
 - l. Turn the patient line stopcock off to the distal end of the patient line to prevent overdrainage upon attachment.
5. Don new sterile gloves and face mask if removed.
 6. Using sterile technique, attach the patient tubing of the drainage system to the ventricular catheter.
 7. Open patient line stopcock and note drainage into the burette
 8. Zero the EVD system. Attach pressure cable to the transducer and label the ICP parameter. Turn the stopcock off to the patient by turning it to a “3 o’clock” position (1). Open system to air (2) by removing the red cap. Press “zero” on the monitor. When the monitor indicates “0” return stopcock upright. Replace injection cap with a new sterile airtight non-injectable cap (3).



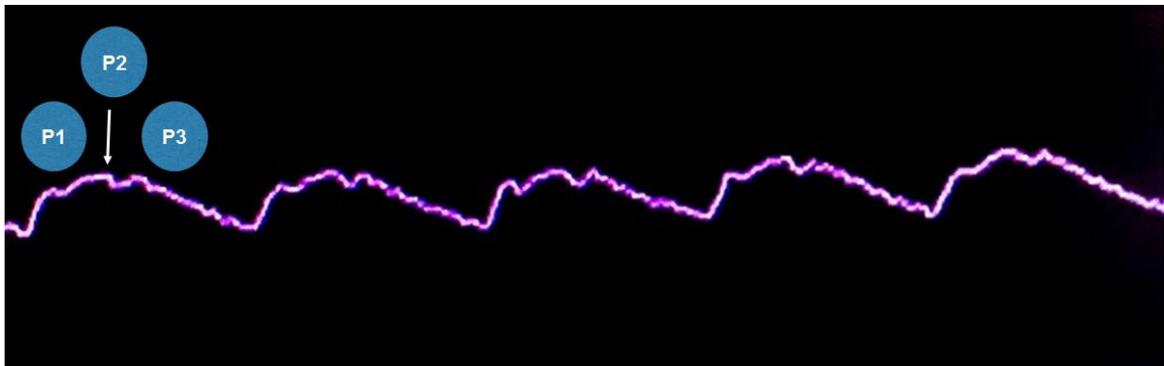
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- Note and document initial ICP reading. Open drainage system as ordered; observe for ICP waveform (P1, P2, P3) and numerical values. Set high and low ICP alarms and adjust the scale for optimal viewing. Normal and abnormal ICP waveforms are presented in the figure below.



Normal ICP waveform

P1 percussion wave reflections off choroid plexus. P2 tidal wave indicates brain compliance. P3 diastolic wave correlates to the closure of the aortic valve. P1 wave is the tallest, sharpest wave. P2 wave is no greater than 80% of the P1 wave.



Abnormal ICP waveform: reduced cerebral compliance

P2 wave is taller than P1, which may indicate reduced cerebral compliance.

- Label setup with the date and CSF/No Injection labels.

EVD maintenance

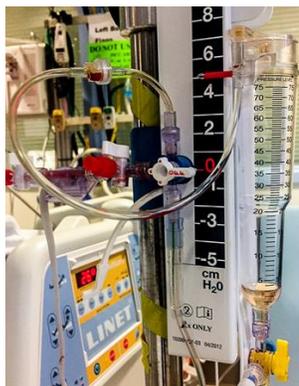
- Monitoring for signs and symptoms associated with changing ICP. Increases in ICP may be characterized by decreased level of consciousness, nausea, vomiting, headache, lethargy, or agitation. Neurological assessments should be performed and documented hourly by the registered nurse, or more frequently as the clinical situation warrants.
- Hourly assessment includes CSF drainage, color, and clarity.

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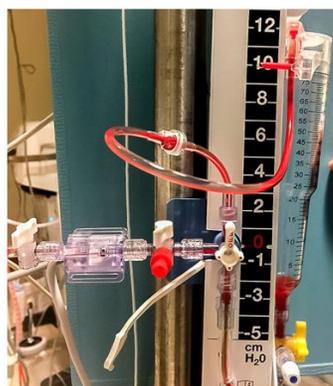
3. Measure ICP every hour. Notify the physician immediately if ICP exceeds established parameters. If no parameter is specified, notify the physician if ICP is >20 mmHg. To obtain accurate ICP monitoring, the stopcock should be at 12 o'clock as shown below.



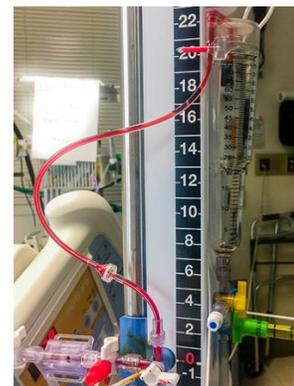
4. Keep HOB elevated 30° unless otherwise ordered by Physician/NP/PA.
5. Check the patient's position to ensure the transducer is at the ordered reference level. If the patient is very active and moving around in bed, it is imperative to frequently assess that the drain is leveled appropriately to prevent over- or under-drainage.
6. Verify neurocritical care primary team orders for drain height every shift and drainage parameters if indicated (mL/hour).
7. Verify the correct placement of the drainage chamber every 1- 2 hours and with every position change. Maintain cylinder in an upright position at all times. Examples of the setting of EVD are shown below.



+ 5 cm H2O



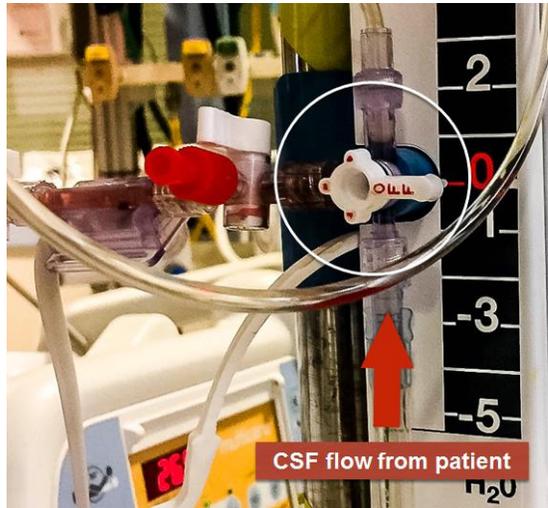
+ 10 cm H2O



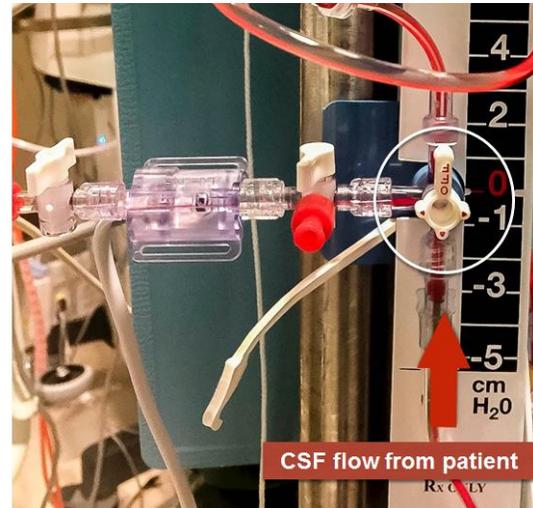
+ 20 cm H2O

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8. Ensure the system is appropriately clamped or open depending on patient situation and physician order.



Open to drain CSF



Closed to drain CSF

9. Assessment of the drainage system should be done a minimum of every 4 hours, which includes inspecting the EVD from the insertion site along with the entire drainage system, checking for cracks in the system or fluid leaking from the insertion site.
10. Check EVD for patency as needed by lowering the entire system for a brief moment to assess drip-rate into the graduated burette.
11. Waveform assessment should be ongoing with special attention noted to P1, P2, and P3 components. Be aware of changes in waveform and troubleshoot when warranted.
12. Document ICP waveform assessment once a shift and as waveform changes occur. Perform waveform analysis upon initial assessment of patient and system, establishing a baseline to use for comparison throughout the shift.
13. Observe ICP in relation to other hemodynamic parameters such as MAP, which will give an indicator of CPP.
14. If the ventricular drain is used for continuous drainage, clamp momentarily for changes in position, and suction.
15. After the patient activity that required clamping is completed, verify that the clamp is open at the pre-ordered level and HOB is returned to the previous position.
16. The transducer is rezeroed after a shift (minimally every 12 hours), as a troubleshooting technique, or when interface with the monitor has been interrupted.
17. Use of mechanical VTE prophylaxis (sequential compression device or intermittent pneumatic compression) in all patients with contraindications to pharmacological prophylaxis (UFH or LMWH) and without contraindications to mechanical devices.

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18. In patients with additional risk factors for VTE (including, but not limited to concurrent malignancy, trauma, spinal cord injury, critical illness, and immobilization), suggest pharmacological prophylaxis after an intracranial hemorrhage has been ruled out or is stable.
19. Avoid routinely changing catheter sites.

Dressing change

1. The initial dressing is removed every 48 hours or if soiled per institutional policy.
2. Perform hand hygiene. Don mask.
3. The nurse removes this initial dressing with sterile gloves. Remove old dressing carefully to avoid dislodgement and cutting of drainage tubing.
4. If the hair grows out (keep length 1/8 in. or less), the nurse clips it again so that the gauze dressing adheres.
5. The site is inspected for CSF leaks, infection, bleeding, signs of loose suture, and displacement of catheters.
6. The nurse then removes the first pair of gloves.
7. Hand hygiene is then performed for a second time before applying a new, second set of sterile gloves.
8. A new sterile gauze dressing is applied to the site, and benzoin is used to hold the tape. The dressing is tight and occlusive.

Flushing external ventricular catheter

1. Only a neurosurgeon may flush the EVD
2. Routine flushing of the EVD catheter should not be performed.
3. If any occluding material is present, the tubing can be flushed away from the patient to remove the debris.
4. The occlusion of the proximal catheter can sometimes be resolved by flushing the catheter toward the patient. This may increase ICP, as the irrigation solution adds to the intracranial volume. In patients with poor intracranial compliance, irrigation with even small volumes can create disproportionately large and dangerous increases of ICP, possibly causing brain herniation. Proximal flushing should only be attempted after discussion with the neurosurgeon.
5. Non-draining ventricular catheters may be flushed once by skill validated critical care nurses or advanced practice nurses on the order of a physician.
6. Gather 3 mL syringe, sterile 2x2 gauze, povidone-iodine swab, sterile gloves, mask, sterile syringe and vial of preservative-free normal saline or prefilled 10-mL preservative-free sterile normal saline syringe.
7. Scrub needleless sample port closest to the patient's head with povidone-iodine. Wipe off excessive povidone-iodine using 2x2 gauze.
8. Close clamp on catheter tubing above the sample port.

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9. Using strict aseptic technique, draw up 1 mL preservative-free normal saline into the syringe.
10. Slowly flush the catheter with 0.5–1 mL of preservative-free sterile normal saline. Do not attempt to aspirate obstruction. Notify physician if drainage is not re-established.
11. Record procedure, volume used to flush catheter and results.
12. If flushing to clear obstruction between the sample port and the collection chamber, turn stopcock between the sample port and patient off to the ventricular drain. Subtract the volume of flush from hourly drainage total.
13. The drainage system should be relevelled and re zeroed after manipulation.

Changing the CSF drainage system or drainage bag

1. Only change the bag when it is nearly full or when it is $\frac{3}{4}$ full.
2. May be performed by a neurosurgeon or an approved RN
3. Explain the procedure to the patient.
4. Don mask. Perform hand hygiene.
5. Prepare sterile field: Open a pair of gloves, chlorhexidine swab and replacement drainage bag maintaining sterility. Anyone in the room while changing the drainage bag must wear a mask. Close all doors to the room.
6. Clamp the drain proximal to the chamber.
7. Verify that the stopcock between the chamber and the drainage bag is in the upright (OFF) position.
8. Don sterile gloves.
9. Thoroughly clean the connection between the stopcock and the drainage bag with chlorhexidine swab. Allow to completely dry. Discard used chlorhexidine.
10. Twist open the clean connection to disconnect the drainage bag holding one 4x4 gauze in each hand to maintain sterility.
11. Detach the drainage bag from the panel and discard it.
12. Remove the red cap from new replacement bags using an aseptic technique.
13. Attach a new drainage bag turning the connector with the same twisting motion until fit is secured.
14. Hook the drainage bag to the system panel.
15. Cap used a drainage bag.
16. For continuously draining EVD: unclamp proximal stopcock to the chamber to allow CSF drainage.

CSF sampling

1. Avoid routine CSF sampling and obtaining CSF analysis only when there is clinical suspicion of meningitis/ventriculitis.
2. CSF specimens may be drawn by skill validated critical care nurses, advanced practice nurses, physician assistants, or physicians.

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3. Gather a 3 mL syringe, povidone-iodine swab, sterile 2x2 gauze, sterile gloves, and mask.
4. Use strict aseptic techniques to obtain samples.
5. Clamp tubing 5-10 minutes before drawing samples.
6. Don mask. Apply sterile gloves.
7. Scrub needleless sample port closest to the patient's head with povidone-iodine. Leave a thin coat of povidone-iodine on the port and allow it to dry.
8. Withdraw CSF slowly from the port using a 3 mL syringe. Cap syringe and sample port with sterile airtight non-injectable cap.

Administration of intraventricular medication

1. Only the physician administers intrathecal medications.
2. Ensure that the medication is labeled appropriately. The pharmacy should label the medication "For Intrathecal Administration".
3. Physician orders will include the amount of time the ventriculostomy catheter will remain clamped after medication administration (one hour is recommended).

Intrahospital transportation (IHT)

1. Consider conducting an EVD clamp trial prior to transport.
2. Review the hourly CSF output, baseline ICP, as well as EVD, draining vs. clamp status prior to initiation of IHT.
3. If a patient has an intolerance to clamp trial, the patient may be transported with EVD open to CSF drainage, and attention paid to CSF output.
4. If a patient tolerates a clamp trial, the patient may be transported with EVD clamped and ICP monitored during IHT.
5. Monitor and document vital signs, end-tidal carbon dioxide, and ICP during IHT.
6. Mounting EVD on a dedicated IV pole, leveling and transducing ICP and waveform on transport monitor.
7. Measure the drainage, then empty the collection chamber and record before leaving the unit.
8. If the EVD is clamped during transport: The ICP is to be continuously monitored. ICP values should not be outside ordered parameters and if ICP above 20 mmHg for 5 minutes requires staff to notify the attending physician.
9. If the EVD is opened during IHT, intermittent clamping of EVD for accurate ICP monitoring should be performed. The nurse must continuously observe the drain to avoid overdrainage. Clamp the tubing temporarily when transferring the patient on and off a stretcher or in/out of bed, reposition the patient, and changing the patient's HOB or bed height and then turn the system stopcock to open position immediately after finishing all previously described events and relevel of EVD system.

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10. Transport personnel should be prepared to treat intracranial hypertension in patients with indwelling EVDs during IHT especially when EVD is clamped during transport.
11. The collection system should be maintained in an upright position. If for some reason the collection chamber has to be laid down (for example, there is no MRI-compatible holder), the CSF should be drained into the lower collection bag. This will decrease the transfer of any bacteria in the collection chambers to the drainage tubing.
12. Hand hygiene, gloves, and a new sterile dead-end cap should be used to zero the transducer when necessary after transport. To clear air off the transducer again, wash hands before gloves then drain CSF off into sterile gauze and re-zero the transducer.

EVD Removal

1. EVD weaning should be accomplished as quickly as is clinically feasible so as to minimize the total duration of EVD monitoring and ventricular related infection risk.
2. EVD should be removed as early as the clinical situation allows.
3. Anticoagulation management should be performed according to institutional protocols before the removal of an EVD.
4. Obtain order to raise EVD and ICP parameters.
5. Monitor the patient's neurological status and elevations in ICP when EVD is clamped.
6. Notify Physician/NP/PA for any changes in neurological exam, vital signs or reports of pain.
7. The neurosurgeon removes the catheter using sterile technique.
8. Monitor patients when EVD is removed.
9. Anticipate post-procedure head CT as ordered.
10. Anticipate serial head CT during the weaning process.
11. Monitor for CSF leak at EVD site during clamp trial and after removal.
12. Notify the neurosurgeon with any redness/swelling/drainage from the site.

Management of special situations and complications

Complications	Actions
Cylinder "pressure level" mark slips below the ordered height	<ul style="list-style-type: none"> ● Clamp drain ● Notify Physician/NP/PA ● Perform neurological and vital sign assessment and compare to baseline ● Reposition drain as per ordered Physician/NP/PA orders
Lost or damped waveform	<ul style="list-style-type: none"> ● Verify drain is unclamped ● Ensure that the drain is leveled at the appropriate landmark and the system is zeroed. ● Perform a systematic assessment of the system to rule out the presence of air or debris in the tubing and remove

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	<p>if possible</p> <ul style="list-style-type: none"> ● Check for loose connection and system occlusion ● Assess dressing for dampness (indicating leak) ● Notify Physician/NP/PA ● Perform neurological and vital sign assessment and compare to baseline
CSF leak	<ul style="list-style-type: none"> ● Perform neurological and vital sign assessment and compare to baseline ● Notify Physician/ NP/PA immediately
Disconnect or accidental removal	<ul style="list-style-type: none"> ● Clamp the catheter ● Cover catheter tip and or EVD site with a sterile dressing ● Perform neurological and vital sign assessment and compare to baseline ● Notify Physician/ NP/PA immediately ● Anticipate for prophylactic antibiotics ● Anticipate STAT CT scan
Overdrainage (CSF output >20 mL/hr. in adult, >15 mL/hr. in children, and >5 mL/hr. in infants)	<ul style="list-style-type: none"> ● Clamp EVD to drainage ● Notify Physician/ NP/PA immediately
No CSF drainage	<ul style="list-style-type: none"> ● Verify drain is unclamped ● Verify that all stopcocks are opened to drain ● Assess for a blockage in a system, CSF leak ● Lower the system 6 inches below the auditory meatus for 2-5 seconds and observe for drainage ● If not draining, notify Physician/ NP/PA immediately
Suspected Aneurysmal rebleeding (sudden bloody CSF drainage)	<ul style="list-style-type: none"> ● Notify physician/NP/PA emergently. ● Perform neurological and vital sign assessment and compare to baseline ● Anticipate resuscitation measures.

Patient and family education

1. Assess the patient and family knowledge base of the external ventricular drain and their barriers to learning.
2. Using teach-back instruct the patient and family about the importance of maintaining the head of the bed at the ordered match level, the prohibition of any manipulation or touching of the drain system or insertion site, and activity or positional restrictions.

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3. Using teach-back instruct the patient and family to report acute changes in the level of consciousness, headache, stiff neck, nausea, new-onset weakness, or photophobia.
4. Using teach-back instruct the patient and family about the availability of prescribed analgesic medication and other pain relief measures.

Documentation related to EVD

1. Universal Protocol/ Time out procedure.
2. Document patient response to insertion of EVD.
3. During EVD maintenance, all of the following should be documented in the medical record
 - Vital signs
 - Drainage height (level of the burette or drainage chamber)
 - CSF characteristics including color, clarity
 - CSF drainage output per hour
 - Intracranial pressure (ICP), Cerebral perfusion pressure (CPP)
 - ICP waveform
 - Alarms set ex. The lower and upper limit of ICP, CPP
 - ICP drain open vs close, continuous or intermittent drainage
 - Degree of the height of bed elevation
 - Patient neurological status
 - Patency of EVD system
 - The appearance of ventricular drain site
 - Dressing change date and time
 - Patient/family education and comprehension
 - Any complications or quality improvement (QI) ex. EVD infection, over drainage, under drainage and immediate action

References

1. Slazinski T, Anderson TA, Cattell E, et al. American Association of Neuroscience Nurses. Care of the patient undergoing intracranial pressure monitoring/external ventricular drainage or lumbar drainage. *Glenview (IL): American Association of Neuroscience Nurses*. 2011:1-38.
2. Fried H, Nathan B, Rowe A, et al. The Insertion and Management of External Ventricular Drains: An Evidence-Based Consensus Statement: A Statement for Healthcare Professionals from the Neurocritical Care Society. *Neurocritical care*. 2016;24(1):61-81.
3. Lele AV, Hoefnagel AL, Schloemerker N, et al. Perioperative Management of Adult Patients with External Ventricular and Lumbar Drains: Guidelines from the Society for Neuroscience in Anesthesiology and Critical Care. *J Neurosurg Anesthesiol*. 2017;29(3):191-210.

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