External Ventricular Device Guideline (EVD)

Royal Hospital for Sick Children
PICU – Neurosurgery
1. Introduction

Definition
External Ventricular Drains (EVDs) are a temporary system which allow drainage of cerebrospinal fluid (CSF) from the lateral ventricles of the brain. EVDs are commonly used within neurosurgery for the management of patients who require drainage of CSF. The EVD system is a closed system; breakage of the system would increase risk of contamination. Strict asepsis must be maintained.

Indications
Common indications include raised intracranial pressure (ICP) associated with:
- Head injury
- Subarachnoid haemorrhage
- Acute hydrocephalus
- Posterior fossa tumours
- Meningitis

Ventricular System Anatomy
There are four ventricles which comprise the ventricular system within the brain. The two lateral ventricles are the largest of the four, and are situated deep within the subcortical tissue, one each side of the midline. Each lateral ventricle communicates with the third ventricle through intra-ventricular foramina (Foramen of Monro). This third ventricle communicates with the fourth ventricle (located in the medulla) through the aqueduct of Sylvius (see Fig 1). There are two lateral foramina and one median foramina located in the roof of the fourth ventricle which communicate with the subarachnoid space beneath the arachnoid membrane. The floor of the fourth ventricle is continuous with the central spinal canal.
Flow of CSF

The function of CSF is to provide buoyancy and support for the brain and spinal cord. It is a modified form of plasma consisting of water, glucose, protein, minerals and a few lymphocytes.
CSF is continuously secreted by the choroids plexus of the two lateral ventricles at a rate of approx. 20-25ml/hr in an adult (or 500ml/day).
At any one time, approx. 100-150ml of CSF are contained within the cerebral ventricles and the spinal cord. Once produced, it flows through the intraventricular foramen of Monro into the third ventricle and then through the single aqueduct of Sylvius into the fourth ventricle.
Once in the fourth ventricle, the CSF then flows into the subarachnoid space to flow around and over the brain, and into the spinal canal to flow around the spinal cord.
CSF is reabsorbed into the vascular circulation through the arachnoid villi at the sagittal sinus. In health, the rate of reabsorption equals the rate of secretion.
An obstruction at any point in the flow of CSF will result in dilation of the cerebral ventricles and create a condition known as obstructive hydrocephalus. See Fig 2.
Failure of absorption of CSF at the sagittal sinus will have the same effect on the ventricles but is known as communicating hydrocephalus.
Effects of CSF on Intracranial Pressure (ICP)

The Monro-Kellie hypothesis states that the skull is a rigid compartment filled to capacity with essentially incompressible substances (brain matter, blood and CSF). As such, an increase in one or more of the components will result in an increase in the overall pressure within the skull unless another component decreases in volume reciprocally. ICP is thus affected directly by any changes in the volume of CSF within the brain. These changes in volume may be a result of –
- Change in the rate of secretion of CSF.
- Obstruction to the CSF flow within the ventricular system.
- Change in the rate of absorption of CSF.

Problems associated with the production, flow or absorption of CSF can cause a rise in ICP and therefore would be an indication for insertion of an EVD.

The above graph describes the relationship between pressure and volume within the skull. As can be seen a reasonable increase in volume (irrespective of whether this is oedema, mass, blood or CSF) will be tolerated prior to ICP rising. The key is to intervene prior to reaching the critical point. Clinically this is associated with bradycardia, hypertension and pupil changes. This is a pre-terminal event.

Symptoms and Signs of Raised Intracranial Pressure (ICP)

**Infants:**
- Irritability
- Vomiting
- Full, bulging fontanelle
- Neurological symptoms – decrease in GCS, cranial nerve palsy, sun-setting eyes (eyes unable to look up)
- Irregular respirations & apnoeic periods
- Splaying of cranial sutures, a big head – measure head circumference regularly
- Tachycardia /Hypertension /Bradycardia
- Pupil changes (fixed pupils, irregularly shaped pupils or dilated pupils all worrying)
Older children:
- Headache
- Nausea, vomiting
- Lethargy
- Irritability
- Worsening concentration
- Decreased GCS
- 6th nerve palsy
- Other abnormalities – seen at neurologic exam
- Tachycardia /Hypertension/ Bradycardia
- Pupil changes (fixed pupils, irregularly shaped pupils or dilated pupils all worrying)

The combination of bradycardia, hypertension and irregular respiration in a neurological patient is a pre-terminal event. Inform medical staff immediately.

2. Scope

This guideline is intended for all healthcare professionals caring for patients with an EVD in the Paediatric Intensive Care Unit at the Royal Hospital for Sick Children, Glasgow.

3. Roles & Responsibilities

All medical, nursing and allied professionals caring for patients who have an EVD should be familiar with the protocol.

4. Evidence

The guidelines have been constructed after consultation with standard textbooks, device literature, benchmarking and local expert neurosurgical opinion.

5. Insertion of an EVD

EVDs are inserted by a Neurosurgeon in the Operating Theatre under sterile conditions. The catheter is then connected to the drainage system and the incision site on the scalp either sutured or stapled. Staples also secure the catheter to the scalp. Mark as an event on CIS when return from theatre.
6. Drainage System

Once the EVD has been inserted, the surgeon attaches a Becker External Drainage and Monitoring system (Fig 3). This is a complete closed system for draining CSF from the lateral ventricles in the brain. The Becker EVD system does not have a pressure valve, so the drainage of CSF is gravity-dependent.

The drainage system is attached to an IV stand at the head of the bed. The system comprises of a measuring chamber which is connected to a drainage bag, with a sampling port and stopcock between them. All the connections are “Luer Lock” for safety.

A drainage pressure scale (in 1cm increments) is adjacent to the drainage chamber. The chamber should be zero referenced to the patient, aligned to the patient's external auditory meatus (this corresponds with the Foramen of Monro). A Medtronic levelling clamp is used for accuracy if available. A Neurosurgeon will document the prescribed drain level, and be responsible for all subsequent alterations. Fig 4. The drain height will be displayed on a sign above the drain.

![Becker EVD](image-url)
Fig 4: Zero level and Sampling Port

3 way-tap: Drain is clamped and un-clamped here by turning tap.

Roller clamp: Closed for changing EVD drainage bag

Fig 5: Zeroing an EVD

Zero level

Manual zero using EVD catheter tubing

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Q-Pulse Ref: YOR-PICU-035
### 7. Nursing Care of an EVD

#### Positioning, zeroing and securing

<table>
<thead>
<tr>
<th>PROCEDURE</th>
<th>RATIONALE</th>
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<tbody>
<tr>
<td>Maintain patient’s head elevation if requested by medical staff (usually at 30°C)</td>
<td>To assist venous drainage of the head</td>
</tr>
<tr>
<td>Maintain drainage system in vertical position</td>
<td>Ensure CSF drainage and avoid the air filter becoming wet which will lead to non-drainage. This can only be resolved by replacing the whole system. See transfer section below.</td>
</tr>
<tr>
<td>The zero reference point must be adhered to (in the supine patient, the external auditory meatus, using the infra-red Medtronic levelling clamp if available or manually). See Fig 4 and 5</td>
<td>The external auditory meatus should be taken as the reference point, as this is at the level of the foramen of Monro</td>
</tr>
<tr>
<td>Slide chamber up the gauge until the arrow at the top of the chamber is at the height/level prescribed by neurosurgical staff, eg. 5cm</td>
<td>This means that the EVD is at 5cm above the foramen of Monro, and for CSF to drain, the CSF pressure within the ventricles must be at least 5cmH2O. This level will determine the amount of CSF drainage; for example, if the drain is set at 15cm and the ICP is less than 15cm H2O then there will be no drainage. If however the level/height is 15cm and the ICP is greater than 15cm H2O the system will drain to maintain the pressure ordered. Therefore if the drain is yielding 5-10ml/hr, the pressure inside the ventricles can be said to be 10-20cmH2O, this is then a reflection of the ICP Monitor for clinical signs of high ICP as monitored by the ICP monitor.</td>
</tr>
<tr>
<td>The height/level should be displayed on the EVD sign which hangs above the drain. Ensure the height/level of the drain is also documented on CIS.</td>
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Before moving the child for any reason (i.e sitting up or lying down) the drain must be clamped. Following the procedure, re-establish the zero point and **unclamp** the drain.

The 3 –way tap is used to clamp and unclamp. See Fig 4.

Re-positioning could cause an over drainage of CSF. This may lead to the ventricles collapsing, leading to low pressure headache or to subdural collection.

Ensure **unclamp drain** post procedure – otherwise ICP could climb quickly.

The drainage system is positioned at the head of the bed. If impossible to stretch beyond cot sides – the EVD must be put through the cot sides and not over the top.

This will affect the level at which CSF is drained.

The EVD system must be secured to a drip stand at the head of the bed, facing the foot of the bed.

To ensure that accidental removal is avoided.

The EVD system must be clearly labelled with the pink EVD stickers, preferably near the 3 way tap.

To avoid confusion with other lines.

Change the collection bag (using Universal Precautions) when ¾ full. See appendix A.

### Hourly observations

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<td>Observe the tubing for patency/kinked obstruction.</td>
<td>If obstructed the patient may redevelop hydrocephalus.</td>
</tr>
</tbody>
</table>

Ensure the CSF oscillates with respiration. Ensure the CSF drips into the chamber.

If there is no drainage, but the drain is patent, the meniscus of the CSF should be seen to oscillate (swing) because of pulsatile pressure.

If the drainage is zero, and the CSF is not seen to oscillate, this could mean the drain is blocked. Inform medical team.
<table>
<thead>
<tr>
<th>Ensure that the tubing has not been clamped and that all the taps are in the open position.</th>
<th>To allow CSF to drain and prevent hydrocephalus and raised ICP.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record CSF drainage hourly and empty the amount of CSF drained.</td>
<td>The amount of CSF drainage is an indication of the ICP. An increase could indicate mounting intracranial pressure. An overfilled chamber will lead to a wet air filter. The EVD drainage system will need replaced.</td>
</tr>
<tr>
<td>Report excessive drainage the amount of drainage exceeds 10ml more than previous hour or more than 20ml/hr, or cessation of drainage, to the consultant intensivist immediately. (sometimes higher drainage is expected - discuss with neurosurgery on return from theatre)</td>
<td>Average drainage for an adult is 10-15ml/hr excessive drainage can collapse the ventricles, pulling brain from dura. This may lead to a subdural haematoma.</td>
</tr>
<tr>
<td>Be vigilant with fluid balance and electrolytes, particularly if there are large losses or prolonged need for EVD.</td>
<td>Particularly important in small babies (&lt;5kg). May need to replace volume.</td>
</tr>
<tr>
<td>Observe CSF for colour and consistency. Normal CSF is clear and colourless. Report if cloudy, milky, or turbid, yellow or newly red.</td>
<td>Cloudy, milky or turbid CSF may equal infection. Yellow/orange CSF (xanthochromic) contains partially broken-down red blood cells from previous haemorrhage. Red – fresh blood, may indicate cerebral haemorrhage or recent surgery.</td>
</tr>
</tbody>
</table>

### PROCEDURE

Monitor the patient’s neurological responses and pupillary response. Report any significant changes to the consultant intensivist. Tentorial herniation can occur with over or under drainage – as well as deteriorating GCS, the patient may be irritable, have vital signs changes, and respiratory compromise if this occurs. Neuroobservations should be performed more frequently if the drain has been raised or lowered recently or if clamped for intrathecal (IT) antibiotics or transfer – this is patient dependent. 15 min neuro obs may be appropriate.

### RATIONALE

To detect any deterioration in the patient’s condition, which may be a result of ICP.
<table>
<thead>
<tr>
<th>Record the fontanelle if present - Tense/Normal/Sunken</th>
<th>Another marker of ICP. Alert medic if changes.</th>
</tr>
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<tbody>
<tr>
<td>Observe the insertion site for signs of infection. Report pyrexia to medical staff.</td>
<td>As the catheter has direct passage into the brain, there is an increased risk of meningitis. There is a reported risk of infection of 1-27% with EVD's.</td>
</tr>
<tr>
<td>Report any CSF leakage from the insertion site to a Neurosurgeon.</td>
<td>If the dressing appears wet at the entry site this could indicate CSF leak or may present as a halo stain on pillow.</td>
</tr>
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### Infection

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<tr>
<td>A strict aseptic technique must be used during any sampling or maintenance procedures.</td>
<td>As the catheter has direct passage into the brain, there is an increased risk of meningitis. There is an infection risk of 1-27% with EVD’s.</td>
</tr>
<tr>
<td>Many of the EVD’s inserted will be impregnated with antibiotic. Eg. Bactiseal (rifampicin and clindamycin)</td>
<td>To reduce levels of infection.</td>
</tr>
<tr>
<td>In the presence of intracerebral infection, intraventricular antibiotics may be instilled (under strict aseptic technique) by the Neurosurgeon. After instillation, the drain will be clamped for one hour, to allow the antibiotic to circulate with the CSF. Increase neuro observations to every 30 mins during this time.</td>
<td>Strict asepsis to reduce introduction of infection. Occassionally antibiotics are required to be instilled directly into CSF to ensure penetration. <strong>Ensure drain unclamped 1 hour post procedure.</strong> If patient changes clinically at any point during this time inform doctor immediately.</td>
</tr>
<tr>
<td>CSF samples should be sent routinely daily at 8am to Bacteriology (MC&amp;S) and Biochemistry (protein &amp; glucose) See photograph below.</td>
<td>Could indicate that an infection is occurring whether that be meningitis or ventriculitis. Ceftriaxone is first line antibiotic. <strong>Normal &lt;5WBC. WBC:RBC &lt;1:500-1000</strong></td>
</tr>
</tbody>
</table>
See page 14 for sampling procedure.

Transfer
A checklist is available on CIS and intranet for transfer of the child with an EVD.

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<td>Before moving the child for any reason (i.e. sitting up or lying down) the drain must be clamped. Following the procedure, re-establish the zero point and unclamp the drain. See Fig 4.</td>
<td>Re-positioning could cause an over drainage of CSF. This may lead to the ventricles collapsing, leading to low pressure headache or to subdural collection. Ensure unclamp drain post procedure – otherwise ICP could climb quickly.</td>
</tr>
<tr>
<td>Eg. If moving a patient from bed to trolley or onto CT scan this process should be followed.</td>
<td></td>
</tr>
<tr>
<td>When in transit: eg. in ambulance/ going to CT. Aim to maintain CSF drainage during transfer. Once the patient is settled on the bed/trolley and the zero-point is re-established. The drain should be unclamped. The patient must be closely monitored to prevent accidental disconnection or any alteration in position, which may affect CSF drainage.</td>
<td>To ensure adequate CSF drainage and prevent rises in ICP. To avoid accidental disconnection, ensure adequate CSF drainage.</td>
</tr>
<tr>
<td>The transfer trolley has a pole at the head of the bed which can be used to secure the drain. A pole must be attached securely to the hospital bed to maintain EVD upright.</td>
<td></td>
</tr>
</tbody>
</table>
A decision to clamp the EVD must be made following assessment of the patient’s clinical condition and neurological status; it must be clamped for the briefest time possible.

Suggest re-open drain as soon as possible – during CT scan or once in transit, or any clinical concern.

Clamping an EVD may result in inadequate CSF drainage and subsequent rise in ICP, however there are occasions when it may be necessary to clamp the system for short periods.

**Golden Rules**

- EVD tubing must not be irrigated, changed or manipulated in any way other than by Neurosurgeon or trained delegate.

- If any concerns report to medical staff quickly. A decrease in pulse rate and an increase in BP or an alteration in consciousness may indicate a rise in ICP. An awake child may also complain of headaches if their ICP changes.

Any changes must be reported immediately to medical staff

8. Sampling of CSF from an EVD

As with any invasive device, an EVD may become a source of infection. Sampling of CSF allows for early detection of infection. There are two "schools of thought" on this issue –

- Sampling daily affords early detection.
- Sampling only when there are other signs of infection minimises the interruption of the closed circuit.

Currently there is no “best practice” recommendations to substantiate either point of view.

The procedure is:

- Assemble a clean dressing trolley with a dressing pack, sterile gloves, 10ml syringe, orange needle, and two white-topped, universal containers and a grey top (Sodium Fluoride) bottle. See Fig 6.
- Don sterile gloves, and, using the needle and syringe, withdraw specimen of CSF (2-3ml to each Lab as an ideal, but 0.5ml is the minimum required).
- Clean the sampling port beneath the collection chamber with a Chloraprep wipe for 30 seconds, and allow to dry for at least 30 seconds.
- Remove and safely discard needle, before decanting the CSF equally between the containers.
- Send one universal to Microbiology (for culture, sensitivity and cell count), and one to Biochemistry for protein analysis. The grey topped bottle also goes to biochemistry for glucose analysis. See Fig 6.
9. Removal of Drain

The drain is removed (when no longer required) by a Neurosurgeon (or delegate), under strict aseptic technique. Often, removal is preceded by a period where the height of the drain has been increased, or the drain has been clamped (to see if the patient can regulate their own CSF again). The surgeon will require a clean dressing trolley (Neuro trolley), set up with –

- Dressing pack
- Betadine or Chloraprep (surgeon dependent)
- Sterile gloves
- Staple removers
- Stitch cutter
- Hand-held suture
- Sterile scissors
- White-topped universal container
- Mepore dressing

It may be appropriate to increase neuroobservations after removal of drain. Clarify with neurosurgeon removing drain. The catheter tip should be sent to microbiology for culture.

10. Measuring ICP from an EVD

It is possible; although not routine to monitor intracranial pressure through the ventricular catheter using a continuous closed monitoring system with a non-flush transducer device. See separate guideline: Measuring ICP form an EVD.
11. Changing an EVD drainage bag

The collection bag must be changed:
   a) When ¾ full
   b) Under strict aseptic technique
   c) Only by a trained member of staff

The procedure:
- Put on apron
- Wash hands and trolley
- Prepare equipment.
- Check roller clamp above drainage clamp is closed.
- Turn 3 way clamp off to patient. Consider goggles.
- Wash hands, sterile towel to dry hands. Don sterile gloves.
- Using a strict aseptic technique clean bag connector/tubing with chloraprep allow to dry for 30 seconds.
- Remove bag and attach bung to seal contents.
- Reattach new bag.
- Reopen 3 way tap.
- Check that fluid is pulsating within tubing.
- Clear away and wash hands.

12. Accidental disconnection /splitting of tubing or total dislodgement.

If at any time accidental disconnection should occur, the ventricular catheter should immediately be clamped and the patient nursed in a supine position until the catheter is reconnected using aseptic technique. If it is thought that the ventricular catheter or the EVD system has become contaminated, or indeed it cannot be guaranteed that they have not, then a neurosurgeon must be contacted immediately as it may be necessary to change the entire system.

Accidental cutting or splitting of tubing will lead to a free flow of CSF. The catheter should be clamped immediately with atraumatic forceps (blue forceps) and the neurosurgeon informed.

Despite best nursing care, EVD’s may be dislodged completely particularly in the awake and active child. Cover site with sterile dressing. Inform neurosurgeon

13. Lumbar Drain

The management of a lumbar drain is fairly similar to that of an EVD- seek specific guidance from neurosurgery.
The zero-point is level with the top of the mattress. Patient lying flat on back.
The level is often set at 0 or 5cm H2O.
Sampling is the same process as for an EVD – see above.
The indications for insertion include; assist healing of CSF leak, evaluate the effect of reducing CSF pressure and as a temporary external shunt.
14. Review
This guideline should be reviewed every 2 years from date of approval

15. Monitoring
An audit of EVD care is planned and surveillance of critical incidents.

16. Implementation plan
1. Education and training for nursing staff
2. Education for PICU trainees
3. Guideline to be put on electronic clinical information system and intranet.
4. CIS documentation adjusted to be consistent with guideline.

References
EVD Guideline – Neuroinstitute Glasgow -2011
Benchmarking Best Practice for External Ventricular Drainage
S Woodward. Br J of Nursing 2002
EVD Guideline Alder Hey 2010.
EVD Guideline Birmingham 2009.