External Ventricular Drains and Intracranial Pressure Monitoring: Self Learning Guide

Developed for the Neurosciences Nursing Department

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Introduction

The External Ventricular Drain (EVD) and Intracranial Pressure (ICP) Monitoring Learning package is designed to increase the nurse’s awareness of the policies and procedures regarding care of the patient with an EVD and/or ICP monitoring device.

EVDs and ICP monitoring are considered specialized nursing skills and are currently only done in the ICU and on 3R at BC Children’s Hospital. EVD care is considered an advanced skill and is only practiced by nurses who have the required advanced neuroscience education and whose learning has been validated at the bedside with the appropriate clinical support person. Patients who require an EVD should be closely monitored by nurses trained and competent in assessment and management of both the drain and the neuroscience patient population.

The process to qualify to provide safe, competent care of these systems, will be achieved by successfully completing the following:

1. EVD & ICP Self Learning Module
2. Neurovital sign Assessment Self-learning module
3. Review of all policies and procedures pertaining to the skills
4. Clinical Skill Validation with CRN initially and annually thereafter

It is the joint responsibility of each individual nurse to assess one’s own competency and ensure competency is maintained. Unit Leadership will track and provide opportunities to obtain annual competency requirements. Staff requiring up-dating in the educational program may independently refer to the learning guide, or repeat the education program in collaboration with the CNE.
Learning Objectives

At completion of this module, the nurse will:

1. Understand the ventricular system and cerebral spinal fluid (CSF) dynamics:
   a. List the four ventricles of the brain
   b. Identify circulation, production and reabsorption of CSF
   c. Describe the functions of CSF
   d. Identify the characteristics of CSF
   e. Identify the amount of CSF produced daily and amount present within the central nervous system (CNS)

2. Understand intracranial pressure (ICP):
   a. Define intracranial pressure
   b. State the normal ICP for children
   c. Describe the Monro-Kellie hypothesis
   d. Identify the compensatory mechanisms to maintain ICP
   e. Describe intracranial compliance
   f. List two examples of clinical conditions that can result in increased ICP

3. Understand Cerebral Blood Flow (CBF):
   a. Define cerebral blood flow
   b. Identify factors that affect cerebral blood flow
   c. Describe the metabolic requirements of cerebral tissue

4. Understand Cerebral Perfusion Pressure (CPP):
   a. Define cerebral perfusion pressure
   b. State normal CPP for children

5. Understand the principles of External Ventricular Drainage (EVDs):
   a. List the indications for the use of an EVD
   b. Label the components of an EVD and describe the purpose of each component
   c. Describe the nursing care of a patient with an EVD
   d. Describe potential complications and corrective measurements for an EVD
   e. Document appropriate information regarding the EVD

6. Understand ICP Monitoring
   a. List reasons for ICP monitoring
   b. List methods of ICP monitoring
   c. Describe the advantages and disadvantages of each ICP monitoring technique
   d. Accurately identify ICP waveforms
   e. Describe two potential monitoring problems and how to troubleshoot each problem
The Ventricular System

There are four ventricles in the brain. They are interconnected chambers in which CSF circulates.

Two Lateral Ventricles
The lateral ventricles are the primary site of CSF production (70% of CSF is produced here) and the largest intracranial reservoir of CSF. CSF is produced, in part, by the ependymal cells which line the ventricles and the choroid plexus. The two lateral ventricles drain (communicate) with the third ventricle through the Foramen of Monro.

Third Ventricle
The third ventricle is located deep inside the brain in the diencephalon (the part of the brain directly above the brain stem that contains the thalamus and hypothalamus). The third ventricle drains into the fourth ventricle through the aqueduct of Sylvius (cerebral aqueduct).

Fourth Ventricle
The fourth ventricle is located in the posterior fossa of the brain, between the brainstem and the cerebellum. The fourth ventricle drains through three foramina (2 lateral Foramina of Luschka and 1 midline Foramen of Magendie) into the subarachnoid space around the brain and spinal cord.

http://static.howstuffworks.com/gif/brain-ventricles.gif
**Subarachnoid Space**
The subarachnoid space surrounds the brain and spinal cord between the pial and arachnoid membranes. When the CSF exits the 4th ventricle, it circulates in this subarachnoid space; some circulating around the spinal cord and some around the brain. The fluid that goes around the spinal cord eventually is pumped back to the subarachnoid space around the brain. When the CSF reaches the top of the brain, arachnoid villi, which are finger-like projections of vascular dura extending from the superior sagittal sinus, reabsorb the CSF into the bloodstream. The CSF is absorbed across a pressure gradient from the subarachnoid space to the venous system.

See below for a diagram of the CSF flow:

![Cerebrospinal Fluid Flow](image)

**Cerebrospinal Fluid (CSF)**
CSF is the protective cushioning fluid which surrounds the brain and spinal cord. CSF is produced at a rate of approximately 0.35cc/min or 21cc/hr or 500cc/day. Production rates can be affected by a number of conditions. CSF is produced in part by the choroid plexus (lateral 3rd & 4th ventricle) and, in some cases, the choroid plexus may produce too much CSF, resulting in communicating hydrocephalus. Infections, such as ventriculitis, will also cause an increase in CSF production.
The composition of CSF is similar to plasma, containing water, oxygen, electrolytes, glucose, a small amount of protein, and the occasional white blood cell. It is normally a clear, colorless and odourless fluid. Review the table below for characteristics of CSF:

<table>
<thead>
<tr>
<th>TEST</th>
<th>NORMAL</th>
<th>ABNORMAL</th>
<th>IMPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Clear, colourless</td>
<td>Cloudy</td>
<td>Infection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pink, red or bloody</td>
<td>Subarachnoid hemorrhage, intracerebral, Intraventricular hemorrhage, or traumatic tap</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brown, orange or yellow (xanthrochromic)</td>
<td>RBC breakdown (blood present at least 3 days), acute purulent bacterial infection, subdural hematoma.</td>
</tr>
<tr>
<td>Protein</td>
<td>15-45 mg/100mL (lumbar puncture)</td>
<td>Marked</td>
<td>Tumours, trauma, hemorrhage, bacteria or fungal meningitis</td>
</tr>
<tr>
<td></td>
<td>5-15 mg/100mL (ventricular)</td>
<td>Marked</td>
<td>Rapid CSF production</td>
</tr>
<tr>
<td>Glucose</td>
<td>40-80 mg/100mL (-50% of serum glucose)</td>
<td>Marked</td>
<td>Systemic hyperglycemia</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Systemic hypoglycemia, bacterial infection</td>
</tr>
<tr>
<td>Cell Count</td>
<td>0-5 WBC</td>
<td>RBC’s present</td>
<td>Active disease: meningitis, acute infection, onset of chronic illness, tumor, abscess, infarction</td>
</tr>
<tr>
<td></td>
<td>No RBC’s</td>
<td></td>
<td>Hemorrhage or traumatic tap</td>
</tr>
<tr>
<td>Gram stain</td>
<td>No organisms</td>
<td>Gram + or Gram – organisms</td>
<td>Meningitis</td>
</tr>
</tbody>
</table>

**Functions of CSF Include:**
- Protection of the brain and spinal cord
- Assists in maintaining the acid-base balance of cerebral tissues (oxygen and carbon dioxide balance)
- Provides nourishment to nervous system tissue as well as maintains the chemical composition for CNS metabolic activity
- Provides a medium for removal of end products of metabolism
- Transports neurotransmitters and hormonal messengers

**Cerebral Flood Flow (CBF)**

Cerebral blood flow (CBF) is the blood supply to the brain at any given time and is measured in mL/min. Cerebral blood volume (CBV) is the total amount of blood in the intracranial space at any one time (both arterial and venous) and it is approximately 100cc.
There are a number of factors that affect CBF and CBV which, in turn, affect ICP:

a. **Impaired Cerebral Venous Return**
   If cerebral arterial flow is maintained when venous return is obstructed, there will be an increase in CBV and ICP may, in turn, rise. ICP also rises because increased venous pressure limits absorption of CSF across the arachnoid villi. There are a number of conditions that can affect cerebral venous return:
   - Compression or thrombosis of the internal jugular vein
   - Obstruction of the superior vena cava, preventing blood from returning to the heart
   - Compression of cerebral veins related to cerebral edema or other blockage
   - Increased abdominal or thoracic pressure, preventing blood from draining back to the heart.

b. **Increased Cerebral Metabolic Needs**
   Some of the conditions that can cause cerebral blood flow to exceed normal limits include head injuries, encephalopathy, anemia, vasodilators, hyperthyroidism, seizures and hypoglycemia. This is related to increasing cerebral metabolic needs.

c. **Increased ICP**
   Cerebral blood flow will usually be compromised if there is an increase in ICP. The compensatory mechanism of auto regulation will cause vasoconstriction and limit the amount of blood entering the cranium to accommodate excessive CSF pressure. Cerebral auto regulation is the process by which CBF is maintained at a constant level. It can be defined as the constant adjustment of the tone and resistance in the cerebral arteries in response to local tissue biochemical changes. For example, if the systemic blood pressure rises, cerebral arterial vasoconstriction will occur in an attempt to prevent a rise in the cerebral arterial pressure. Auto regulation may be compromised by acute traumatic or anoxic brain injuries.

d. **Acid Base Balance**
   Acid-base balance has a direct effect on cerebral blood flow. Depending on the serum level of CO2, vasodilation (increased CO2) or vasoconstriction (decreased CO2) will occur. Adequate ventilation is extremely important in controlling cerebral blood flow. It is essential that CBF is adequate to ensure that the oxygen and metabolic needs of the cerebral tissue are met. The brain consumes about 20% of the body’s oxygen supply due to its high metabolic activity. Cerebral tissues are unable to store oxygen or engage in anaerobic metabolism if there is a shortage of oxygen. This is why, in a state of hypoxia, the brain cells will only function for approximately 10 seconds and die within 4-6 minutes. In order to ensure there is a source of energy for the brain cells, glucose must be available on an on-going basis. It is important to realize that the brain has no glycogen stores and that
glucose is its only source of energy. If CBF is reduced, the brain will also become starved for energy.

Cerebral Perfusion Pressure (CPP)

CPP helps to maintain normal cerebral blood flow and metabolism. It can be defined as the difference between the arterial blood entering the brain and the venous blood leaving the brain (Barker, 2002).

The normal CPP required to adequately perfuse brain tissue ranges from 60-100 mmHg in adults. CPP values greater than 100 mm Hg represent hyperperfusion. Hyperperfusion can cause disruption of the blood-brain barrier and increase edema or hemorrhage. If CPP drops between 40-60 mm Hg, the brain will sustain irreversible ischemia. CPP of 0-40 mm HG represents death.

**NOTE** In children normal CPP values are lower than in adults and the child’s brain will tolerate lower CPPs than adults without developing irreversible ischemic damage.

Calculation of CPP is often used in the assessment and management of patients with severe head injuries. Although patients on 3R will be stable, it is important to understand the concept of CPP in relation to the perfusion of brain tissue. CPP can be determined indirectly by subtracting the patient’s ICP from their mean arterial blood pressure (MAP). Although the most accurate way to get MAP is from an arterial line (ICU only), on 3R the MAP from a peripheral BP can also be used.

To calculate CPP use the following calculation:

\[
\text{MAP-ICP}=\text{CPP}
\]

Increasing ICP or declining arterial blood pressure will reduce CPP resulting in ischemia of brain tissue.

Actions to stabilize CPP:
- Maintain systolic BP within normal ranges
- Prevent shock (third spacing results in hypovolemia and hypotension)
- Maintain sodium balance (sodium regulates fluid balance)
- Prevent systemic hypertension

Intracranial Pressure

**Monro-Kellie Hypothesis**
Intracranial pressure is the pressure exerted by the contents within the skull. The contents are made up of brain (80%), blood (10%) and CSF (10%). The Monro-Kellie hypothesis suggests that in a rigid skull a change in the proportional volume of any of these three components must be accompanied by a
compensatory change in another. If this compensation does not occur, there will be an increase in the intracranial pressure. Therefore:

**Intracranial Volume = brain volume + blood volume + CSF volume**

In adults normal ICP ranges from 0-15mmHg.
In children <5 years normal ICP ranges from 0-5 mm Hg
In children >5 years normal ICP ranges from 0-10 mm Hg

*NOTE* it is ALWAYS good to have the physician order acceptable ICP limits when doing ICP monitoring

**Keeping it all Balanced... Our Compensatory Mechanisms**

Adjustments to changes in volume in a normal, uninjured brain occur because of intracranial compensation. Compensation is the ability to tolerate an increase in intracranial volume without a corresponding increase in ICP. Injury or disease will alter the brain’s ability to maintain normal compensation. This may be as the result of either acute injuries such as massive bleeds or swelling, or because of a slow growing tumour that has exceeded the brains compliance abilities; this is when we need to monitor for signs of increased ICP and provide clinical interventions to lower ICP.

The body uses the following compensatory mechanisms to maintain a relatively constant ICP under ‘normal’ circumstances.

- **Skull Sutures** – Children’s skulls are less rigid than adults and the sutures remain open until 18 months of age. In infants with an open fontanelle and open cranial suture, the skull is not rigid and is able to expand. Thus, an increase in CSF (e.g. in hydrocephalus) may be accommodated to some extent by expansion of the skull, thus ameliorating the ICP rise that would have occurred in a rigid skull.

- **CSF Regulation** - CSF production increases or decreases depending on intracranial pressure. CSF also moves to areas of lower pressure (spinal column) and to the subarachnoid space where it can be re-absorbed

- **Auto regulation** – When systemic pressure rises, cerebral arterioles constrict to keep the pressure of the blood entering the brain at a steady pressure. Infants do not have auto regulation, therefore will have concurrent rise in Cerebral Perfusion Pressure (CPP) as BP rises

- **Metabolic Regulation** - Low O2 levels and high CO2 levels trigger vasodilation, causing more oxygenated blood to circulate to the cerebral tissues.

It is important to note that these mechanisms of compensation are limited and **eventually will fail** to manage ICP if it continues to increase.
How do you know if the compensatory mechanisms are failing?
You know when your compensatory mechanisms are failing when small changes in volume start to produce greater increases in pressure and more clinical signs & symptoms of increased ICP. This is represented by the volume pressure curve.

**Volume-pressure curve.** Volume-pressure response (VPR), also referred to as the pressure-volume index (PVI), provides a method of estimating the compensatory capacity of the intracranial cavity. Note that the intracranial pressure (ICP) remains within the normal limit of 0-15 mm Hg as long as compliance is normal and fluid can be displaced by the additional volume (A). Once the compensatory system is exhausted, a small additional volume causes a greater increase in pressure (B). This increase in pressure and may lead to serious and sometimes fatal neurological deterioration.

![Volume-pressure curve](image)

**Signs & Symptoms of Increased ICP**

Because small changes in pressure can have a big impact on the patient, we need to pay close attention to the clinical signs & symptoms of increasing ICP.
Early Signs and Symptoms of Increased ICP

- Changes in LOC: restlessness, irritability, personality changes, mild confusion, agitation, lower Glasgow Coma Score (GCS)
- Pupils: ptosis, avoid pupil, delayed or sluggish reaction, unilateral change in pupil size
- Vision: blurred, diplopia, decreased visual acuity
- Motor: pronator drift, decreased grasp, paresis
- Sensory: decreased response to touch or pinprick
- Headache: early morning headache with nausea/vomiting
- Speech: slow or slurred
- Memory: slightly impaired
- Appearance of cranial incision: postoperative bulging or swelling
- Vital signs: no change
- Cranial nerves: may or may not show changes initially
- Seizure activity: may or may not occur depending on cause

Late Signs and Symptoms of Increased ICP

- LOC: difficult to arouse, require more stimulus, any decrease in Glasgow Coma Score (GCS), coma
- Pupils: unilateral enlarging pupil, progressing to fixed, dilated “blown pupil,” papilledema; later bilateral fixed, dilated
- Motor: dense weakness, decorticate or decerebrate posturing, flaccid muscles
- Sensory: may only posture to painful stimulus
- Headache: worsening with projectile vomiting
- Speech: may only groan/moan to painful stimuli
- Respiratory: irregular respirations, Cheyne-Stokes progressing to central neurogenic hyperventilation, ataxia, and respiratory arrest
- Vital signs: rising systolic BP with widening pulse pressure, bradycardia followed by tachycardia, temperature changes as hypothalamus is compressed, Cushing’s response
- Cardiac: Q-waves with ST depression, elevated T waves, supraventricular tachycardia, sinus bradycardia, A-V block, PVCs, and an agonal rhythm leading to cardiac arrest
- Cranial nerves: related to supratentorial or infratentorial lesion and edema with brainstem reflexes (corneal, gag)
- Abnormal reflexes: Babinski sign

**NOTE**

ICP may be elevated for some time with little or no outward clinical signs, however, on ocular examination, papilledema may be present. Papilledema is the swelling of the optic nerve and is a definitive clinical finding of increased ICP. The optic nerve is surrounded by a continuation of the arachnoid membrane. Because the retinal veins travel a short distance into the subarachnoid space, when ICP is elevated, venous drainage from the optic nerve is blocked or impaired. This results in venous engorgement. Papilledema may take some time to resolve once ICP has been normalized.

In infants – other symptoms and signs of increase ICP: include a full or bulging fontanel and a head circumference that is expanding too rapidly.

**Nursing Interventionsto Decrease ICP:**

- **Ensure adequate oxygen saturation.** Elevated CO2 levels cause cerebral vasodilation (causing increased blood flow to the brain). Assess the rate, depth and quality of respirations to ensure the patient is ventilating adequately. Briefly pre-oxygenate prior to suctioning. NEVER apply supplemental oxygen to a patient who is suspected of having increase ICP as it can potentiate a build-up of CO2. A child with emergent increased ICP requires assisted ventilation and ABG monitoring in the ICU.
- **Elevate the head of the bed 30-45 degrees** (or use reverse Trendelenburg if spinal precautions are required) to promote adequate venous drainage.
• **Maintain the patient’s head in the midline position.** Extreme flexion or extension of the head can impede drainage from the jugular veins.

• **Group nursing care** to avoid excessive stimulation. Stimulation will increase cerebral metabolism.

• **Maintain normothermia** in the patient. Shivering can cause an increase in oxygen consumption.

**Medical (Physician ordered) Interventions to Decrease ICP:**

• Mannitol, an osmotic diuretic used to decrease cerebral blood volume and cerebral metabolic rate.

• Sedatives and analgesics to decrease pain and anxiety which cause an increase in the cerebral metabolic rate.

• Pharmacologically induced paralysis (ICU) to decrease the cerebral metabolic rate and induce cerebral vasoconstriction.

• Fluid restriction to decrease extracellular fluid

• Mechanical hyperventilation (ICU) to decrease CO2 levels in cerebral tissue.

• Corticosteroids such as Decadron to decrease swelling (may also mask infection)
External Ventricular Drainage (EVD)

EVD systems drain CSF from the lateral ventricles of the brain to a collection system outside of the body. This procedure requires an external ventricular catheter to be inserted through a ventriculostomy (opening) into the frontal portion of the lateral ventricle, preferably on the non-dominant side of the brain. This procedure is performed by a neurosurgeon in the OR or in the ICU setting using STRICT aseptic technique.

Once an intraventricular catheter is inserted, it is attached to a collection reservoir to allow for drainage of CSF. Adjusting the height of the collection chamber regulates the flow by increasing or decreasing the amount of pressure required for the CSF to drain. CSF drainage is dependent on the balance between ICP and the height of the reservoir. Ventricular drainage can be used to assist with controlling increased ICP by providing a temporary exit for the CSF flow.

The Indications for EVD Placement are:

- **To divert** CSF during acute periods of hydrocephalus related to illness of injury such as in subarachnoid hemorrhage or meningitis.

- **Shunt Infections.** The CSF is temporarily diverted until treatment with antibiotics is complete or the shunt hardware may be removed and an EVD placed until the infection is cleared. The EVD will remain in place until CSF samples are negative for organisms x3 days.

- **Intracranial Pressure Monitoring.** The EVD can be connected to a transducer that converts fluid pressure into an electronic signal that is
displayed on a monitor providing a pressure reading in mmHg. The EVD can also be used to determine ICP through a visual method.

- **Peritonitis/Perforated Bowel when VP shunt in situ.** The VP shunt can be externalized from the abdomen when there is the presence of an infection in the abdomen. This is to prevent micro-organisms from migrating into the CNS. The shunt remains externalized until the infection is cleared. An EVD from the abdomen is cared for in the same manner as when externalized from the head. The physician is responsible for clarifying how the device should be leveled which may vary depending whether the shunt valve is functioning or not.

**Nursing Care of an EVD**

Upon receiving a patient with an EVD, place an EVD sign (see appendix) above the patient’s bed, at the foot of the patient’s bed and outside of the patient’s room. Inform family members about the importance of maintaining the patient’s position in bed and monitoring the system. **It is the expectation that all nurses review the EVD Policies and routine care requirements annually and as needed to maintain competency.**

**A) Setup and Leveling**

The drainage system will be attached to the patient in the OR or ICU. The unit nurse will be responsible for setting the device up using an IV pole and leveling the device at the level specified in the physician’s orders.

**B) Wound Care**

The exit site of an EVD may have a dressing, or it may be left open with application of antiseptic ointment to the site. If the site is covered with a dressing, the dressing should be changed according to policy. The frequency of dressing changes are as needed such as when wet, soiled or have come loose. If the site is left open, the nurse should ensure that the exit site is covered with antiseptic ointment at all times, reapplying the ointment as needed or as ordered by the physician.

**C) Clamping an EVD**

The EVD should remain open to drainage unless ordered by the physician to clamp or in the following situations:
- When repositioning the patient
- When transporting the patient
- When testing the patient’s tolerance (need physician order)
- When obtaining a CSF sample (clamp x 15 minutes prior to taking the sample then only open the proximal port to the patient to obtain sample)
- When changing any part of the system
- When emptying the buretrol into the bag.
• If the line has broken, use Kelly clamps to stop the CSF from leaking out.

**Note** When clamping the EVD use only the stopcocks located inline on the tubing. The use of other clamps can damage and crack the tubing. Always turn TWO stopcocks OFF to the patient when clamping the line.

D) Monitoring

In addition to monitoring the patient as outlined in the policy, the nurse is responsible for:

• Ensuring the patients head is elevated a minimum of 30 degrees and is supported in the midline position.
• Assessing for signs of infection such as redness, swelling or discharge at the exit site or an increased temperature.

E) Documentation

The nurse is responsible for documenting hourly CSF output on the Intake and Output record. Also, any additional information regarding the patency of the device, clamping, repositioning and confirmation of the level of the device must be clearly documented in the Nurse’s Notes.

F) CSFSampling

CSF samples are only taken when specifically ordered by the physician. If ordered daily, CSF samples are to be sent to the lab by 0600 so that the results are back by midmorning. CSF sampling must be done using aseptic technique. The CSF sample should be taken from the buretrol only. Ensure that the CSF in the buretrol has drained within the last hour of collection time so that the sample is ‘fresh’.

G) Transporting the Patient

Any time a patient is required to be clamped and taken off the unit when tolerance to clamping has not been determined, an RN must remain with the patient to assess for tolerance and to be able to communicate to others how to appropriately manage the system.

**NOTE** A complete neurological assessment should be completed prior to the patient leaving the unit. Kelly clamps and sterile gauze must go with the patient in the event the EVD tubing breaks.
H) Capping the Line and Changing the EVD Drainage System:

Capping or changing an EVD system is to be done only with a direct physician’s order. The line may be capped on children who have tolerated clamping and are being prepared to have the drain removed. Capping the line enables the child to move around more freely in the interim. The RN is responsible for ensuring a replacement EVD system is available on the unit in the event that drainage must be re-established. NEVER reapply a disconnected EVD system.

In the event that the EVD system fails to drain, the RN is responsible for troubleshooting the system by checking that all stopcocks are in the open position and lowering the bag below the exit site then watching for CSF drainage. If CSF fails to drain the RN is to call the physician. The physician may request that the system be changed. This is an aseptic technique and it is advisable that an RN elicit the assistance of a second RN for this procedure.

I) Changing the Drainage Bag

The CSF collection bag must be changed when the bag is approximately ¾ full. We do not empty the bags, we replace them. This is required to prevent the bag from overfilling and not being able to drain from the buretrol appropriately. This is an aseptic technique and a new drainage bag will need to be placed on the drainage port after each time.

J) Monitoring CSF Drainage

The collection chamber must be emptied into the collection bag no less frequently than q4h, although the output must be recorded q1h. The amount of drainage per hour varies with each individual, therefore, the nurse must establish a baseline for each patient and assess for variations from that baseline along with neurological changes.

If the drainage suddenly increases, the position of the drainage system must be double checked to ensure it is in the appropriate position. To do this, the device must first be clamped, leveled at the Foramen of Monro, and then the bag must be elevated to the ordered height. If this does not correct the problem, the physician should be notified. Rapid drainage from the ventricles must be prevented as it can lead to subdural hematomas, hemorrhage, slit ventricle syndrome (collapsed ventricles), rostral herniation and, in extreme cases, death.

If the amount of drainage suddenly decreases or stops and the level of the device has been confirmed as above, the system may be blocked. This is considered an EMERGENT SITUATION because, if not corrected, may lead to increased ICP. The physician must be notified at once.
**Physician Responsibilities**

The following procedures are considered physician responsibilities and at no time are to be done by an RN:

- Irrigation or aspiration of a blockage
- Installation of medication into the drain or ventricles
- Removal of the EVD (RN may assist)

Review the Standard Physician’s Order form for Post-op EVD and Lumbar Drain Insertion.

**Intracranial Pressure (ICP) Monitoring**

Increased ICP is a symptom of an uncompensated rise in intracranial volume. This increase can lead to decreased cerebral perfusion and if untreated, brainstem herniation (‘coning’) and death. ICP monitoring assists us in early recognition and intervention in cases of increased ICP, thereby preventing or limiting adverse effects for the patient. In the ICU, ICP monitoring is especially valuable when usual neurological assessment parameters are not available due to paralyzing agents or barbiturates. However, on 3R, ICP monitoring will only be used in stable patients which may be admitted to determine if a VP shunt is still required, the efficacy of a 3rd ventriculostomy, and for those with unexplained headaches.

There are several methods of monitoring ICP, however at BC Children’s Hospital, the two methods that are most commonly used are intraventricular and intraparenchymal.

![Diagram of Intraventricular and Intraparenchymal Monitoring](image-url)
The **intraventricular** catheter is felt to be one of the more reliable methods. The catheter is inserted through the skull, meningeal layers, brain tissue and into the lateral ventricle. The advantage of this type of catheter, due to it’s placement in the ventricles, is that it can be used for sampling and draining CSF as well. However, because this catheter is more invasive it is also associated with the highest complication rate. Complications may be infection, hemorrhage, cerebral edema, CSF leakage and ventricular air entry.

The second method of ICP monitoring is **intraparenchymal** monitoring. This method is considered to give an accurate reading of ICP, however, because the catheter is not in the ventricle, CSF sampling and drainage are not possible. This catheter is considered less invasive andposes less of an infection risk than the intraventricular catheter.

The ICP monitors used at BC Children’s Hospital are the Codman monitor, Phillips monitor, and the DASH 4000 monitor. The Phillips and the Dash monitors are both able to provide a numerical ICP, CPP, and waveform readout. The Codman monitor displays only a numerical ICP readout. On 3R, in order to get a full waveform reading for each patient, we will be connecting the Codman monitor to the DASH 4000 monitor.

As a side note, instead of a waveform readout, the Codman provides a Systolic and Diastolic ICP pressure. This reading is a numerical equivalent of a waveform. For example, a normal wave form has peaks and valleys that are representative of the pulsing of CSF (related to respirations, and heart rate). The systolic and diastolic numbers, therefore, should fluctuate within the normal ICP range. Periodic increases in ICP levels can be the normal response to stimuli such as coughing or straining, however, if the pressure elevates above normal limits and remains elevated, this must be reported.

**NOTE** It is important to recognize that ICP monitoring is not an infallible means of assessing the neurological status of a patient and clinical signs must not be ignored.

**ICP Monitoring using the DASH 4000 & Codman Monitors**

The **DASH 4000 monitor** uses an external transducer that is connected via a luer lock connection to one of the in-line EVD stopcocks (usually the proximal stopcock). The transducer must always be leveled at the level of the patient’s tragus. This means that the transducer can be attached to the blue EVD leveling device (at level zero) and then raised or lowered to correspond to the patient’s tragus, or the transducer can be secured to the patient’s head at the level of the tragus with a cling gauze dressing. If the transducer is leveled on the EVD leveling device, it must be re-leveled each time the patient moves (as you would an EVD). If the transducer is secured to the patient’s head, the patient may move about and re-leveling is not necessary until EVD drainage is re-established.
When using the DASH 4000, the most reliable way to obtain an ICP reading is to turn the EVD drainage ‘off’. In most cases, on 3R, children will not require drainage at the same time as ICP monitoring. The physician must specify the duration of ICP monitoring and when drainage is to be turned off and on. To turn EVD drainage off and the transducer on, the “off” arm on the stopcock should be facing the drainage system.

The machine will require calibrating (‘zeroing’) to atmospheric pressure at the start of each shift. This is required as atmospheric pressure changes frequently. Zeroing will also be required if the system is bumped or jarred, opened or if you must trouble shoot a dampened ICP wave.

**The Codman monitor** is used to monitor ICP via a Codman intraparenchymal probe which is inserted through a burr-hole into the brain parenchyma. The end of the probe houses a transducer which is zeroed by the neurosurgeon prior to insertion and therefore does not require ongoing zeroing. When the Codman monitor is initially set up, the machine is calibrated to atmospheric pressure and a numerical code is displayed. This number is recorded on the ventricular catheter and in the chart, most likely on the OR record. If the patient is accidentally disconnected from the machine, when reattaching, the nurse must ensure that the number displayed on the machine screen and on the patient’s catheter or chart match. If they do not, the RN is responsible for appropriately adjusting the calibration number by using the up and down arrows. **This machine does not require zeroing each shift** as zeroing is only done if trouble shooting a dampened ICP wave.

The Codman monitor will be connected to the intraparenchymal probe in the OR, but it will need to be interfaced to the DASH 4000 by a special cord and subsequently set-up with the DASH 4000 monitor by the nurses on 3R. See Appendix B for these instructions. Instructions for managing the monitors are to be clearly recorded in the patient’s kardex and careplan and a visual handover **MUST BE DONE** with the oncoming staff.

**Additional Nursing Responsibilities for ICP monitoring:**

- Record in the Nurse’s Notes any patient behaviours or interventions such as suctioning or turning that could cause fluctuations in ICP. This is to help correlate the changes in ICP to noxious stimulation.

- If a patient is being monitored with an intraparenchymal probe for headaches, the time, location, duration, severity and ICP must be recorded with each headache.

- ICP readings should be recorded q1h or as otherwise instructed. These can be entered on the flowsheet and additional information provided in the Nurse’s Notes.

- Care of the exit site and dressing should be done as per EVD policy.
• Ensure that all connections are tight as this will decrease the chance of a recording malfunction (dampened wave), infection or CSF leak. If the pressure line has been broken, it will need to be replaced and the transducer zeroed to atmospheric pressure again.

• Prevent tubes from getting caught in bedrails, snagged or pulled.

• Complete a visual bedside handover between shifts. Record all instructions clearly in the kardex and nursing care plan.
Appendix A: Setting up The Dash 4000 Monitor for a patient who has an EVD system

When the patient arrives on the unit they will have a clamped EVD system attached to them. You will need to set up the traditional EVD drainage system as well as level the transducer at the level of the tragus. The transducer will be set up with the system while the patient is in the OR.

Initiating ICP Monitoring using the DASH 4000:

1. Turn machine on
2. Admit patient
   a. Check if the previous patient has been discharged, if not go to:
      Admit menu discharge patient press knob to select (machine will power down)
   b. Then admit patient when machine turns on again
3. Select profile for patient
   a. Menu monitor set up monitor defaults recall defaults select age group
4. Set Parameters
   a. Menu monitor set up parameters on/off turn off ECG (automatically defaults to off)
   b. Highlight ART on main screen Select change name ART scroll through and select ICP
5. Select Graphing trends/parameters
   a. Menu Patient Data Graphic Trends Select parameters
      Select HR, ICP1 and SPO2-R (this will ensure that you can go back and view the graphic trend/ICP waveform for the last 24 hours)
6. Zero Machine
   a. Turn transducer OFF to the patient(turn OFF arm towards patient) and also clamp the stopcock closest to the patient (OFF toward patient)
   b. Open the transducer cap on the stopcock to air
   c. Wait for machine to read zero and then press zero on machine
   d. Replace cap
   e. Turn stopcock OFF arm towards the cap
   f. Machine will re-start monitoring
7. Printing History
   a. Select More menu patient data vital signs view older
   b. At any time you can print a reading by pressing the graph button
8. Printing Waveform (Q12 hourly)
   a. Menu Patient Data Graphic Trends Time period 12 hours press graph go/stop button to print (then attach this strip @ 0400 & 1600 to the patient flowsheet)
9. Stopping monitoring
   a. Discharge patient
Appendix B: Interfacing the Codman machine with the DASH 4000 for a patient who has an Intraparenchymal probe

When the patient arrives on the unit you will see:
- The patient will have a white transducer present that may or may not be already attached to the codman monitor
- There will be a # written on the white transducer as well as on the OR record; this # is referred to as the reference #. **NOTE: You will need this number to program the codman monitor**

If the patient is not connected to the Codman monitor, or the monitor is turned off, please follow these steps:
1. Turn Codman monitor on
2. Connect transducer to the Codman monitor cord
3. A reference # will appear on the screen, if it matches the one on the transducer then press ENTER
4. If the reference # does not match, use the arrows to scroll down to ADJUST and then press ENTER and put in the correct code using the arrows, once finished, press ENTER
5. Now the Codman monitor should start reading an ICP number

Once the patient is connected to the Codman monitor, or if they arrive connected, you need to connect the Codman monitor to the DASH 4000 monitor. To do this, please follow these steps:

1. Plug in the DASH interface cable with the red end in the plug labeled BP1 on the DASH monitor and the black end connected at the back of the Codman monitor
2. Turn Dash Monitor **ON and follow steps 2-5 in Appendix A**
3. Now the Codman monitor will start to communicate with the DASH
4. The Codman monitor will now prompt you to “**PROCEED TO ZERO PATIENT MONITOR**”, the machine is referring to zeroing the DASH monitor now. To do this, you must wait for the DASH monitor to read 0 and then press “**ZERO ALL**” on the DASH
5. Once the DASH monitor is zeroed, you need to send a calibration test from the Codman to the DASH to do this you:
   a. Press 20 on the Codman monitor
   b. Wait for the DASH monitor to read 20
   c. Then press ENTER on the Codman monitor and the two machines should now start reading the same number
6. Now proceed with to monitor the patient using the numbers on the DASH monitor
7. Printing History
   a. Select **More** menu patient data vital signs view older
   b. At any time you can print a reading by pressing the graph button
8. Printing Waveform (Q12 hourly)
   a. Menu Patient Data Graphic Trends Time period 12 hours
   press graph go/stop button to print (then attach this strip @ 0400 & 1600 to the patient flowsheet)