

## Intracranial Pressure Monitoring: Performing in the Adult Patient

### What is Intracranial Pressure Monitoring?

- › Intracranial pressure (ICP) monitoring is the measurement of pressure within the skull using an implanted device
  - *What:* This invasive procedure involves the placement of an intraventricular, epidural, or subdural catheter; a subarachnoid bolt; or a fiber-optic intraparenchymal sensor. A transducer provides a continuous pressure reading, in waveform, on a monitoring screen. Catheters placed into the ventricle can also be used to drain cerebrospinal fluid (CSF) when pressure increases become dangerous
  - *How:* The ICP monitoring device is implanted under sterile conditions. The equipment required for insertion includes a monitoring catheter, transducer, tubing, and monitor. Once the device is inserted nursing responsibilities include monitoring the insertion site for signs of infection, monitoring clinical status and pressure reading for indications of deterioration, controlling environmental and care-related factors that can contribute to increased ICP, and distinguishing between mechanical malfunction and signs of danger
  - *Where:* Monitoring of ICP is performed in the inpatient critical care environment
  - *Who:* Insertion of an ICP monitoring device is typically performed by a neurosurgeon, who can be assisted by other clinicians and nurses. Following device insertion, the bedside nurse is typically responsible for monitoring ICP and reporting any abnormalities to the treating clinician. While it is not appropriate for family members to be present during insertion of the device, they can be present during the monitoring period, as permitted by the clinician and by facility policy regarding visitation

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### What is the Desired Outcome of Intracranial Pressure Monitoring?

- › The desired outcome of ICP monitoring is to maintain a safe ICP through detection and prompt management of subtle pressure changes that might not be clinically apparent

### Why Is Intracranial Pressure Monitoring Important?

- › ICP monitoring is used to identify and quantify increased ICP, to evaluate the effectiveness of the therapeutic plan once in place, and to allow access to CSF for draining and sampling purposes
  - Prompt intervention in a patient with increasing ICP can be life-saving. ICP monitoring provides a continuous pressure reading, which can alert the healthcare team to changes in ICP before they become clinically evident

### Facts and Figures

- › Although ICP monitoring in patients with traumatic brain injury (TBI) is a standard of care, its effect on mortality has remained controversial due to conflicting study results. More recent evidence favors its use. In 2007, the Brain Trauma Foundation published new guidelines suggesting indications for ICP monitoring in TBI. The authors of a recent meta-analysis reported that ICP monitoring was associated with a survival benefit in patients with severe TBI in studies conducted after the guideline was issued (Shen et al., 2016)

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- Researchers in an observational study not included in the meta-analysis, reported that ICP monitoring was associated with significantly decreased 6-month mortality risk in patients with severe TBI (Yuan et al., 2016)
- › In a meta-analysis of studies on the accuracy of ICP monitoring systems, researchers concluded that the average error between ICP measures was clinically negligible; however, the error exceeds  $\pm 6$  mm Hg in 30% of readings, which could have clinical implications related to daily patient care and future comparisons studies (Zacchetti et al., 2015)

## What You Need to Know Before Monitoring Intracranial Pressure

- › ICP monitoring is ordered in a patient whose clinical presentation and physiologic parameters suggest increased ICP. Indications for ICP monitoring include TBI, intracranial hemorrhage, brain tumor, hepatic encephalopathy, and cerebral edema
  - Increased ICP can cause shifting and eventual herniation of brain tissue through the dura. As blood supply is interrupted in areas of high pressure, ischemia and cell death can result
  - Other, less serious complications of increased ICP include diabetes insipidus (DI) and syndrome of inappropriate antidiuretic hormone secretion (SIADH), both which occur because of the brain's failure under high pressure to maintain controlled release of antidiuretic hormone
- › Normal ICP is 0–15 mm Hg; increased ICP is indicated by a pressure greater than 15 mm Hg
  - Cerebral perfusion pressure (CPP) is considered the most important predictor of patient outcomes. CPP = mean arterial pressure (MAP) minus ICP
    - Normal CPP is 60–100 mm Hg. When CPP falls below 60 mm Hg, irreversible brain damage occurs. When CPP equals ICP, brain perfusion ceases altogether
- › Clinical signs of increased ICP include Cushing's triad of concurrent bradycardia, bradypnea, and hypertension (see *Red Flags* below), headache, lethargy, seizures, vomiting, and decreased level of consciousness
- › Placement of the ICP measuring device is performed under sterile conditions by a neurosurgeon
  - The intraventricular catheter is inserted into a lateral ventricle within the brain
  - The subarachnoid bolt is inserted through the skull wall to rest between the skull, and the dura that surrounds the brain
  - The epidural or subdural sensor is also inserted through the skull wall into the space between the skull and dura
  - The parenchymal device is inserted through the skull into the patient's brain tissue
- › MAP should be measured simultaneously in patients with continuous ICP monitoring
- › Some routine nursing care activities, including chest percussion and suctioning, can trigger potentially devastating increases in ICP. An important aspect of care for patients on ICP monitoring is to prioritize and individualize nursing care activities, eliminating those that are not absolutely necessary
- › Guidelines issued in 2011 by the American Association of Neuroscience Nurses (AANN) recommend the following in the care of patients undergoing ICP monitoring:
  - The surgical site should be cleansed in a circular motion using an antiseptic solution. NOTE: Chlorhexidine 2% should NOT be used in procedures involving risk for contact with the meninges
  - During catheter insertion, the nurse should monitor the patient's neurological status every 15 minutes to identify any changes and facilitate early treatment
  - During ICP monitoring the nurse should notify the treating clinician immediately for an ICP  $> 20$  mm Hg, in the absence of individualized, physician-established parameters
  - Neurological assessments should be performed at least every hour
  - Assessment of the drainage system should be performed at least every four hours
  - For more information access the full text of AANN guidelines for ICP monitoring at <http://www.aann.org/pubs/content/guidelines.html>
- › Preliminary steps that should be performed before ICP monitoring include the following:
  - Review the facility/unit-specific protocol for ICP monitoring, if one is available
  - Review the treating clinician's orders related to ICP monitoring. Note
    - prescribed laboratory tests
    - ICP and CPP pressure parameters
    - the indication for insertion of the intraventricular catheter and whether it will be used for collection/drainage of CSF
  - Review the manufacturer's instructions for all equipment to be used and verify that the equipment is in good working order
  - Verify completion of facility informed consent documents
  - Review the patient's medical history/medical record for any allergies (e.g., to latex, medications, iodine, or other substances); use alternative materials, as appropriate

- › Gather supplies necessary for the procedure, which typically include the following:
  - Sterile/nonsterile gloves and additional personal protective equipment (PPE; e.g., gown, face mask, eye protection) if exposure to body fluids is anticipated
  - Facility-approved pain assessment tool
  - Prescribed analgesic/anesthetic and supplies for its administration
  - Equipment for taking vital signs, including pulse oximetry
  - Preassembled ICP monitoring unit. These come in many types and should be specifically described in the facility protocol or specialist's orders
  - Sterile procedure pack for inserting the ICP measuring device
  - Written information, if available, to reinforce verbal education

## How to Monitor Intracranial Pressure

- › Perform hand hygiene and don PPE as appropriate
- › Identify the patient according to facility protocol
- › Establish privacy by closing the door to the patient's room and/or drawing the curtain surrounding the patient's bed
- › Introduce yourself to the patient and family member(s), if present; explain your clinical role in ICP monitoring; assess the coping ability of the patient/family and for knowledge deficits and anxiety regarding ICP monitoring
  - Determine if the patient/family requires special considerations regarding communication (e.g., due to illiteracy, language barriers, or deafness); make arrangements to meet these needs if they are present
    - Use professional certified medical interpreters, either in person or via phone, when a language barrier exists
  - Explain the procedure to the patient and/or legally responsible family member; answer any questions and provide emotional support as needed
- › Assess the patient's general health status, including his/her level of pain using a facility-approved pain assessment tool
- › Administer preprocedure analgesic/anesthetic, as prescribed, to minimize patient discomfort and provide sedation
- › Assist as necessary with the assembly of equipment and preparation of the patient for insertion of the ICP device
  - Obtain the preassembled ICP monitoring unit
  - Set up the ICP monitoring system according to facility protocol and/or clinician's orders. Adhere to sterile technique and maintain a sterile field throughout the preparatory phase of the insertion procedure. The nurse might be responsible for the following components:
    - Establishing the sterile field and arranging supplies
    - Filling the tubing and the manometer that are part of the measuring system with sterile normal saline. Take meticulous care to ensure that there are no air bubbles, however small, within the tubing or the manometer
    - Attaching separate components of the system, e.g., the transducer to the monitor, the manometer tubing to the catheter
    - Calibrating the monitoring equipment per manufacturer's guidelines
    - Discarding or disinfecting used supplies according to facility protocol
    - Positioning the patient as requested by the neurosurgeon
- › Assist the neurosurgeon as requested during placement of the ICP monitoring unit
  - Elevate the patient's head to at least a 30° angle
  - During placement, monitor neurological status, heart rate and rhythm, respiratory rate, pulse oximetry, and blood pressure
- › Once the unit has been placed, monitor the patient according per facility/unit protocol and/or clinician's orders
  - Assess the insertion site at least every 4 hours for swelling, redness, or drainage
  - Cleanse the insertion site using scrupulous sterile technique, per facility protocol
  - Assess waveform on the monitor frequently to ensure that "damping" has not occurred due to impingement of the catheter tip inside the skull, and that the catheter tip has not migrated from its intended position
    - Calibrate the monitoring equipment according to the manufacturer's guidelines and facility protocol
  - Assess clinical status, ICP measurement, CPP calculation, ICP waveform, and vital signs. Perform neurologic assessments hourly or as ordered by the treating clinician
    - Waveforms are classified as A, B, and C waves
      - A waves are also called *plateau waves*; elevations in A waves, which can range in amplitude from 50 mm Hg to 100 mm Hg over 5–20 minutes, indicate vascular changes that are dangerous to cerebral perfusion. Increases in amplitude and frequency should alert the healthcare team to impending cerebral ischemia and cell death
  - Notify the treating clinician if the ICP or CPP is outside the desired parameters, or if there are other abnormal assessment findings, including abnormally high ICP, abnormally low CPP, or a deterioration in level of consciousness (LOC)

- Check the patient's vital signs frequently, per facility protocol
  - Monitor the patient's level of pain using a facility-approved pain assessment tool, through interpretation of verbal and/or nonverbal cues; maintain comfort with analgesic medication, as ordered by the treating clinician
  - Complete a post-procedural neurological examination
  - Set the ICP alarm for high ICP, per facility protocol and the treating clinician's orders
  - Provide supportive care by doing the following:
    - Positioning the patient to avoid compression of the jugular vein
    - Controlling the environment to maintain calm (i.e., by limiting noise, dimming lights, and instructing family to speak softly and avoid overstimulating the patient)
    - Administering prescribed I.V. medications to reduce inflammation and cerebral edema (e.g., corticosteroids to reduce inflammation, mannitol to decrease cerebral edema)
    - Restricting fluids, as prescribed
    - Draining CSF through intraventricular catheter, as prescribed by the treating clinician
    - Prioritizing and individualizing nursing interventions that can induce marked increases in ICP
    - Identifying nursing interventions that have the potential to induce marked increases in ICP and monitoring closely during individualized delivery of each intervention
  - Cleanse insertion site using sterile technique
  - Assess catheter insertion site per the treating clinician's orders or facility protocol (e.g., every 4 hours), for discoloration, swelling, or discharge
- › Dispose of used materials in proper receptacles and perform hand hygiene
- › Update the patient's plan of care, as appropriate, and document ICP monitoring in the patient's medical record, including the following information:
- Date and time of the procedure
  - Description of the procedure, including site of the ICP device placement and ICP alarm parameters. Document that the alarm has been turned on
  - Clinical assessment information, including neurological status, vital signs, ICP readings, pain level, and a description of the CSF, if observed
  - Patient's response to insertion of the ICP device and to sedation
  - Any unexpected patient events or outcomes, interventions performed, and whether or not the treating clinician was notified
  - Patient/family member education, including topics presented, response to education provided/discussed, plan for follow-up education, and details regarding any barriers to communication and/or techniques that promoted successful communication

## **Other Tests, Treatments, or Procedures That May be Necessary Before or After Intracranial Pressure Monitoring**

- › Prior to insertion of an ICP monitoring device, a physical examination and imaging studies will be conducted
- › Following insertion of the device, measures to reduce ICP can be indicated, including the following:
- Urinary catheterization, which prevents bladder distention and allows for measurement of urine output
  - Administration of I.V. mannitol, an osmotic diuretic that reduces cerebral edema
  - Administration of I.V. corticosteroids to reduce inflammation
  - Fluid restriction
  - Withdrawal of CSF from the intraventricular catheter, if one is used
- › Cultures of blood and/or CSF can be necessary due to the risk of infection from ICP monitoring
- › Administer medication, as prescribed, to block shivering in a patient who is in a state of medically induced hypothermia, as shivering can increase ICP

## **What to Expect After Intracranial Pressure Monitoring**

- › The ICP monitor will be inserted and maintained without complications or mechanical malfunction
- › ICP monitoring will detect fluctuations and elevations in pressure, and rapid therapeutic interventions will be taken
- › After several days or more of continuous monitoring, the patient will be successfully withdrawn from the monitor without rebound pressure spikes

## **Red Flags**

- › Position the patient to prevent jugular compression, which can inhibit venous blood return and further increase ICP

- › Cushing’s triad of bradycardia, bradypnea, and hypertension indicate impending herniation of brain tissue. A marked alteration in level of consciousness can precede this ominous sign
- › Fever can indicate the onset of a potentially devastating central nervous system (CNS) infection. Monitor clinical presentation and vital signs carefully, and notify the clinician immediately for abnormal findings
- › Use sterile gauze and contact the treating clinician immediately should the ICP device become dislodged

## What Do I Need to Tell the Patient/Patient’s Family?

- › Reinforce the treating clinician’s explanation of the purpose of ICP monitoring; communicate with empathy, bearing in mind that the family members could be experiencing significant anxiety related to the invasive and risky nature of ICP monitoring placement
- › Educate the patient/family about what to expect during ICP monitoring, including the desired outcome and the potential for complications. Encourage questions
- › Explain the importance of all infection-control measures taken
- › Explain the need to maintain a calm environment for the patient, as stimulation can increase ICP
- › If laboratory tests or other diagnostic/monitoring procedures are ordered, explain how these tests and/or procedures are performed and when the results will likely become available

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## References

1. American Association of Neuroscience Nurses. (2011). Care of the patient undergoing intracranial pressure monitoring/external ventricular drainage or lumbar drainage. *AACN Clinical Practice Guideline Series*. Retrieved May 15, 2017, from <http://www.aann.org/pubs/content/guidelines.html> **(G)**
2. Carney, N., Totten, A. M., O’Reilly, C., Ullman, J. S., Hayryluk, G. W., Bell, M. J., ... Ghajar, J. (2017). Guidelines for the management of severe traumatic brain injury, fourth edition. *Neurosurgery*, *80*(1), 6-15. doi:10.1227/NEU.0000000000001432 **(GI)**
3. Cox, S. (2017). Intracranial catheter with external transducer for cerebrospinal fluid drainage and intracranial pressure monitoring. In D. L. Wiegand (Ed.), *AACN procedure manual for high acuity, progressive, and critical care* (7th ed., pp. 842-855). St. Louis, MO: Elsevier. **(PP)**
4. Gupta, G., & Nosko, M. G. (2015, September 17). Intracranial pressure monitoring. *Medscape*. Retrieved May 15, 2017, from <http://emedicine.medscape.com/article/1829950-overview> **(RV)**
5. Intracranial pressure monitoring. (2016, November 11). *Lippincott Procedures*. Retrieved May 15, 2017, from <http://procedures.lww.com/Inp/view.do?pld=792366> **(PP)**
6. Shen, L., Wang, Z., Su, Z., Qiu, S., Xu, J., Zhou, Y., ... Yan, R. (2016). Effects of intracranial pressure monitoring on mortality in patients with severe traumatic brain injury: A meta-analysis. *PLoS One*, *11*(12), e0168901. doi:10.1371/journal.pone.0168901 **(M)**
7. Yuan, Q., Qu, X., Cheng, H., Yang, C., Wang, Y., Wang, E., ... Hu, J. (2016). Is intracranial pressure monitoring of patients with diffuse traumatic brain injury valuable? An observational multicenter study. *Neurosurgery*, *78*(3), 361-368. doi:10.1227/NEU.0000000000001050 **(R)**
8. Zacchetti, L., Magnoni, S., Di Corte, F., Zanier, E. R., & Stocchetti, N. (2015). Accuracy of intracranial pressure monitoring: Systematic review and meta-analysis. *Critical Care*, *19*, 420. doi:10.1186/s13054-015-1137-9 **(M)**