PROCEDURE

92 Intracranial Bolt and Fiberoptic Catheter Insertion (Assist), Intracranial Pressure Monitoring, Care, Troubleshooting, and Removal

Tess Slazinski

PURPOSE: The fiberoptic catheter is a device utilized for continuous measurement of intracranial pressure (ICP). The fiberoptic catheter is placed in the brain parenchyma and reflects pressure exerted by the intracranial contents, brain tissue, blood, and cerebrospinal fluid (CSF) within the skull. The fiberoptic catheter is inserted through a bolt. Unlike a ventricular catheter, which is attached to an external transducer and drainage system, the fiberoptic catheter does not allow for CSF drainage.

PREREQUISITE NURSING KNOWLEDGE

- A fundamental understanding of neuroanatomy and physiology is needed.
- Knowledge of aseptic and sterile technique is necessary.
- Proper equipment assembly and setup specific to the fiberoptic ICP monitoring device must be understood.
- ICP is the pressure exerted by the intracranial contents, brain tissue, blood, and CSF. Increased ICP occurs when the intracranial volume exceeds the brain's ability to compensate for increased volume.[15]
- Normal ICP ranges from 0 to 15 mm Hg; sustained ICPs of greater than 20 mm Hg are generally considered neurological emergencies.[5,6,12]
- ICP is measured via a catheter inserted into the brain parenchyma. The catheter is inserted through an intracranial bolt (Fig. 92-1).
- The normal ICP waveform has three or four peaks with P_1 of greater amplitude than P_2 and P_3. P_1 is thought to reflect arterial pressure; P_2, P_3, and P_4 (when present) have been described as choroid plexus or venous in origin (Fig. 92-2).[15] The amplitude of P_2 may exceed P_1 with increased ICP or decreased intracranial compliance (Fig. 92-3).
- ICP waveform trends include *a*, *b*, and *c* waves. The *a* waves, also referred to as plateau waves, are associated with ICP values of 50 to 100 mm Hg and last 5 to 20 minutes. The *a* waves (Fig. 92-4) are associated with abrupt neurological deterioration and herniation. The *b* waves (Fig. 92-5), with ICP values of 20 to 50 mm Hg and lasting 30 seconds to 2 minutes, may become *a* waves. The *c* waves (Fig. 92-6) may coincide with ICPs as high as 20 mm Hg but are short lasting and without clinical significance.[1–3,7]
- Cerebral perfusion pressure (CPP) is the pressure at which the brain is perfused. CPP is calculated by subtracting the ICP from the mean arterial pressure. Normal CPP is thought to be approximately 80 mm Hg.[13] In severe traumatic brain injury, the CPP for adults should range between 50 and 70 mm Hg.[4] Patients with other neurological injuries may require individualized CPP parameters reflective of the neuropathology and brain perfusion needs. Research continues regarding the relationship between cerebral blood flow and CPP.
- ICP and CPP must be considered together in management of the patient. Cerebral autoregulation is the intrinsic ability of the cerebral vessels to constrict and dilate as needed to maintain adequate cerebral perfusion. Cerebral autoregulation is impaired with brain injury and the cerebral blood flow becomes passively dependent on the systemic blood pressure. The cerebral blood vessels are no longer able to react to maintain CPP in response to a change in blood pressure.[5,8]
- Sustained ICP elevations of 20 mm Hg or greater necessitate immediate reporting and intervention. ICP waveform changes that indicate loss of cerebral compliance or cerebral autoregulation should be reported immediately.[5,10,12,15]
- ICP monitoring is indicated for the following:
  - Traumatic brain injury with a Glasgow Coma Scale score of less than or equal to 8 and abnormal computed tomography (CT) scan results or normal CT scan results with two of the following: hypotension, greater than 40 years of age, and motor posturing[4]

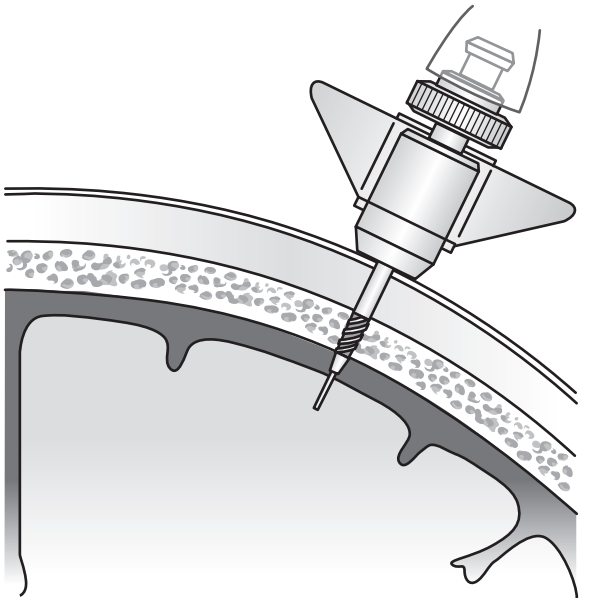

Figure 92-1 Intracranial bolt inserted into the parenchyma. *(From Littlejohns L, Bader MK:* AACN-AANN protocols for practice: Monitoring technologies in critically ill neuroscience patients. *Sudbury, MA, 2009, Jones and Bartlett, p. 35.)*

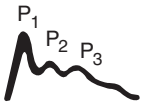

Figure 92-2 Components of the intracranial pressure waveform: P_1, P_2, and P3.

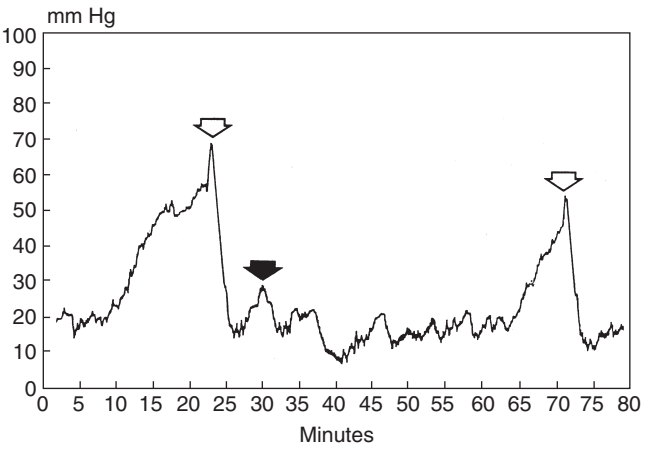

Figure 92-4 *a* or plateau waves. *Open arrows* indicate plateau elevations in intracranial pressure. Note that when intracranial pressure falls, it does not return to baseline preceding the first wave (*closed arrow*). *(From Marshall SB, et al:* Neuroscience critical care: Pathophysiology and patient management. *Philadelphia, 1990, Saunders.)*

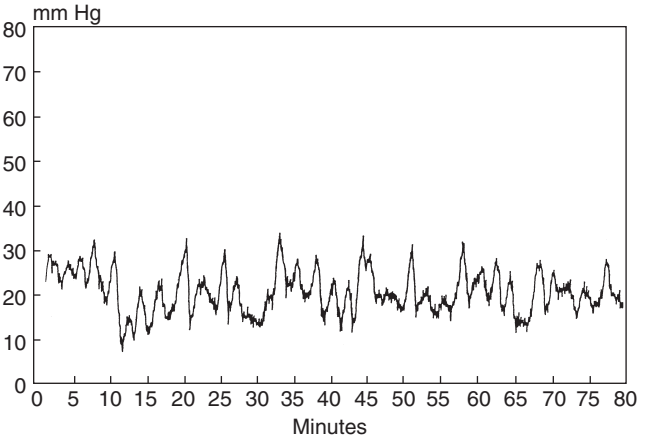

Figure 92-5 Elevations in intracranial pressure represent *b* waves. The intracranial pressure rise is steep and rapid but to heights less than those observed with *a* waves and is also much briefer. *(From Marshall SB, et al:* Neuroscience critical care: Pathophysiology and patient management. *Philadelphia, 1990, Saunders.)*

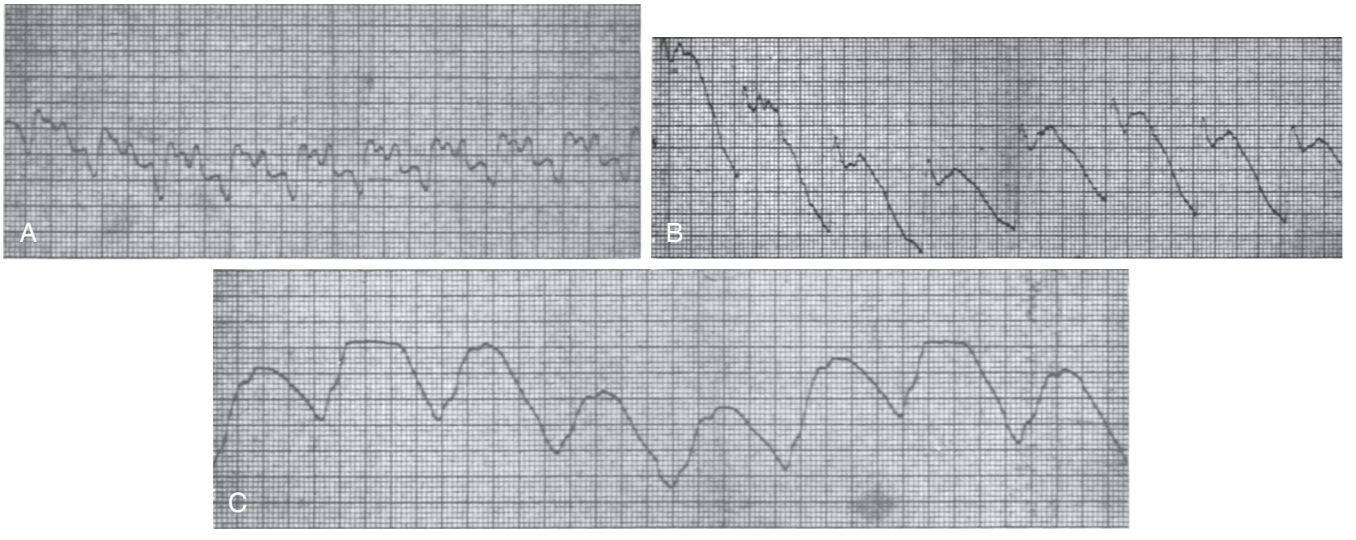

Figure 92-3 Example of intracranial pressure waveforms with P_2 elevation indicating decreased cerebral compliance.

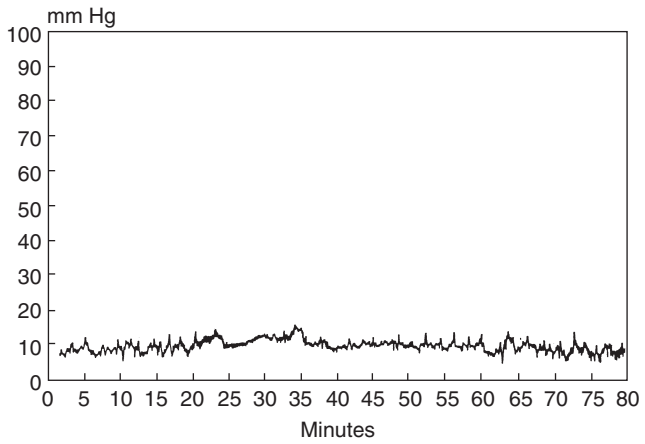

Figure 92-6 *c* waves. The intracranial pressure changes are much less impressive than those in *a* or *b* waves and reflect changes in arterial blood pressure. *(From Marshall SB, et al:* Neuroscience critical care: Pathophysiology and patient management. *Philadelphia, 1990, Saunders.)*

- Intracranial hemorrhage[15]
- Subarachnoid hemorrhage[15]
- Hydrocephalus[15]
- Fulminant hepatic failure with encephalopathy[15]
- Ischemic stroke with massive edema[15]
- Meningitis[15]
- Cysts[15]

- Contraindications for inserting ICP monitoring devices include infection and coagulopathies.[17]
- Concerns with accuracy of ICP monitoring values primarily relate to displacement, misplacement, or breakage of the catheter and drift (especially after 5 days).[13,15]
- Management of the patient with increased ICP and decreased CPP is a multitiered approach that includes positioning, maintaining normothermia and normocarbia, administration of pharmacological agents, and surgical procedures.[2,8,11]

EQUIPMENT

- Antiseptic solution
- Sterile gloves, surgical caps, masks, goggles or face shields, and sterile surgical gowns
- Sterile towels, half-sheets, and drapes
- Local anesthetic (lidocaine 1% or 2% without epinephrine), 5-mL or 10-mL Luer-Lok syringe with 18-gauge needle (for drawing up lidocaine), and 23-gauge or 25-gauge needle (for administration of lidocaine)
- Shave preparation kit
- Cranial access tray
  - Scalpel
  - Scalpel retractor
  - Forceps
  - Needles/needle holders
- Monitoring equipment
  - Pressure box (bedside monitor)
  - Pressure cable
  - Stand-alone monitor (for interpretation of fiberoptic data)
  - Preamp fiberoptic catheter connector cable
  - Monitoring cable to connect to bedside monitor
- Sterile dressing supplies

PATIENT AND FAMILY EDUCATION

- Assess patient and family understanding of fiberoptic catheters and management of elevated ICP. ***Rationale:*** Explanations to patient and family concerning their specific needs may allay fears.
- Explain the fiberoptic catheter–insertion procedure. Review normal parameters and patient care after insertion. Review the family's role in maintenance of an optimal ICP with limitation of patient stimulation. ***Rationale:*** Explanation of expected interventions may allay patient and family anxieties, encourage questions, and promote therapeutic family interaction.

PATIENT ASSESSMENT AND PREPARATION

Patient Assessment

- Assess the patient's neurological status and vital signs. ***Rationale:*** Performing a baseline neurological assessment enables the nurse to identify changes that may occur during or as a result of the fiberoptic catheter placement.
- Assess the patient's current laboratory profile, including complete blood count or platelet count, prothrombin time, international normalized ratio, and partial thromboplastin time. ***Rationale:*** Baseline coagulation study results determine the risk for bleeding during intracranial bolt and catheter insertion.
- Assess for allergies. ***Rationale:*** Assessment minimizes the risk of allergic reaction.

Patient Preparation

- Verify that the patient is the correct patient using two identifiers. ***Rationale:*** Before performing a procedure, the nurse should ensure the correct identification of the patient for the intended intervention.
- Perform a preprocedure verification and time out, if nonemergent. ***Rationale:*** Ensures patient safety.
- Ensure that informed consent has been obtained. ***Rationale:*** Informed consent protects the rights of the patient and makes a competent decision possible for the patient; however, in emergency circumstances, time may not allow for the consent form to be signed.
- Administer preprocedural analgesia or sedation as prescribed. ***Rationale:*** The patient needs to remain still during fiberoptic catheter insertion. In an emergency situation, the patient may already be receiving continuous analgesia and sedation.
- Assist the patient to a supine position with the head of the bed at 30 to 45 degrees and the neck in a midline, neutral position. ***Rationale:*** This position provides access for fiberoptic catheter insertion and enhances jugular venous outflow, contributing to possible reduction in intracranial pressure.

Procedure for Intracranial Bolt and Fiberoptic Catheter Insertion (Assist), Intracranial Pressure Monitoring, Care, Troubleshooting, and Removal

Steps	Rationale	Special Considerations
1. HH		
2. Apply goggles or masks with face shields, caps, gowns, and sterile gloves.	Prepares for sterile procedure.	
3. Assist as needed with identifying the optimal area for placement of the catheter.	Facilitates catheter placement. Catheters placed adjacent to the intracranial pathology are more likely to identify increased ICP earlier.[15,18,19,21]	
4. Assist as needed with shaving and cleansing the insertion site with an antiseptic solution.	Reduces transmission of microorganisms and minimizes the risk of infection.	The choice of povidone-iodine or chlorhexidine as an antiseptic agent is an unresolved issue.[16] Both should be allowed to dry completely.
5. Assist as needed with covering the patient's head and upper thorax with a sterile half-sheet and drape.	Protects the insertion site from contamination.	
6. Preparation of the fiberoptic system: A. Ensure that the preamp cable connects from the catheter to the stand-alone monitor. B. Follow manufacturer's instructions for zeroing the catheter before insertion. **(Level M*)**	The catheter is zeroed before insertion and never rezeroed.[15]	
7. Assist as needed with insertion of the intracranial bolt and fiberoptic catheter.	Facilitates the insertion process.	Manually assisting in maintaining head positioning may be required during cranial drilling while maintaining the sterile field.
8. Assist as needed with applying a sterile occlusive dressing.	Reduces the transmission of microorganisms.	
9. Secure the catheter and preamp cable to the patient in such a way as to prevent accidental removal.	Lessens the likelihood of dislodgment and breakage of the catheter.	
10. After fiberoptic catheter placement, follow the manufacturer's instructions for the "synchronize to monitor" interface. **(Level M)**	Ensures accurate fiberoptic data at the bedside monitor and allows printing of ICP tracing.	
11. Set the appropriate ICP scale for the measured pressure.	Necessary for visualization of the complete ICP waveform and to obtain readings.	
12. Set the monitor alarms.	Goals for ICP management are individualized for each patient based on pathology.	
13. Discard used supplies in an appropriate receptacle.	Removes and safely discards used supplies; safely removes sharp objects.	
14. HH		

*Level M: Manufacturer's recommendations only.

Procedure for Intracranial Bolt and Fiberoptic Catheter Insertion (Assist), Intracranial Pressure Monitoring, Care, Troubleshooting, and Removal—*Continued*

Steps	Rationale	Special Considerations
Troubleshooting		
1. HH		
2. PE		
3. Assess the integrity of the fiberoptic device. Note the location and presence of any markers on the fiberoptic catheter system that identify location (depth of the catheter).	Occlusion or dislocation may require manipulation or replacement.	Intracranial device manipulation is not a nursing responsibility in most institutions. Notify the physician if the device is occluded or dislocated.
4. Observe for messages or numeric values that indicate a broken catheter.	Breakage requires replacement.	
5. Correct the ICP monitoring device malfunction.	Fiberoptic catheters may become damaged or dislodged, requiring catheter replacement.	Follow manufacturer's instructions and troubleshooting manuals for identifying and correcting common problems.
6. Change the monitoring system, if needed.	Replaces a malfunctioning system.	
7. Discard used supplies.		
8. HH		
Fiberoptic Catheter Removal		
1. HH		
2. Ensure physicians, advanced practice nurses, and other healthcare professionals who are assisting with catheter removal apply sterile gloves and mask with face shield or goggles.	Minimizes the risk of infection; maintains aseptic and sterile precautions.	
3. Assist with the removal of the fiberoptic catheter.	Facilitates the removal process.	
4. Assist as needed with applying a sterile occlusive dressing.	Minimizes contamination by microorganisms.	Observe for any CSF drainage or blood from insertion site.
5. Discard used supplies in an appropriate receptacle.	Removes and safely discards used supplies.	
6. HH		

Expected Outcomes

- Accurate and reliable ICP monitoring, CPP calculation, and assessment of cerebral compliance[9,12]
- Maintenance of ICP within the range of 0 to 15 mm Hg or as prescribed[9,12,15]
- Early detection of elevated ICP trends[9,12,15]
- Management of increased ICP and decreased CPP[9,12,15]
- Protection of cerebral perfusion with maintenance of CPP within prescribed parameters[9,12]

Unexpected Outcomes

- CSF infection[14,16,17]
- CSF leakage[15]
- Dislodgment or damage of the fiberoptic catheter[15]
- Dislodgment of the bolt[15]
- Pneumocephalus (rare)[15]
- Cerebral hemorrhage (rare)[4,15]
- Sequelae of sustained increased intracranial pressure and decreased cerebral perfusion pressure: cerebral infarction, herniation, and brain death[8,9,13]

Patient Monitoring and Care

Steps	Rationale	Reportable Conditions
		These conditions should be reported if they persist despite nursing interventions.
1. Assess the patient's neurological status and vital signs during the procedure.	Evaluates the patient's response to the procedure.	• Changes in neurological status • Abnormal vital signs

Procedure continues on following page

Patient Monitoring and Care —*Continued*

Steps	Rationale	Reportable Conditions
2. Note the ICP waveform and numeric values during the insertion procedure.	Provides baseline data.	• P_2 of greater amplitude than P_1
3. Assess the patient's neurological status hourly or more often as indicated.[15]	Provides clinical confirmation of and correlation with the monitored ICP data.	• Changes in neurological status
4. Assess the ICP hourly.	Determines the neurological status.	• Increased ICP • ICP waveform abnormalities • Immediately report sustained ICP elevations of 20 mm Hg or greater[15]
5. Calculate the CPP hourly (or more often as indicated).	A CPP of 50–70 mm Hg should be maintained for adult patients with traumatic brain injury. CPP parameters should be individualized to meet patient perfusion needs.	• Changes in CPP • CPP less than the lowest prescribed parameter may put the patient at risk for cerebral ischemia.[4,6]
6. Set the bedside alarm limits based on the parameter goals.	The ICP limit is usually set to sound an alarm when the ICP is >20 mm Hg; however, this needs to be individualized for each patient.	• Abnormal ICP • Abnormal waveforms
7. Assess the catheter system hourly.	Ensures accuracy and safety of monitoring.	
8. Change the insertion site dressing as needed or based on institutional standards.	Provides an opportunity to assess catheter insertion site and observe for signs and symptoms of infection.[16]	• Significant drainage on ICP insertion site dressing or head dressing • Signs and symptoms of infection
9. Provide a safe environment, preventing inadvertent dislodgment of the fiberoptic catheter through appropriate catheter positioning, sedation, and analgesia as needed and as prescribed.	Catheter dislodgment results in the inability to effectively monitor ICP and may require reinsertion. If intrahospital transportation is required, ICP should be monitored.[20]	• Dislodged device • Abnormal ICP • Abnormal ICP waveform • Increased ICP may occur when patient is lying flat for diagnostic study
10. Follow institutional standard for assessing pain. Administer analgesia as prescribed.	Identifies need for pain interventions.	• Continued pain despite pain interventions

Documentation

Documentation should include the following:

- Insertion time and patient response to procedure
- Completion of informed consent
- Preprocedure verifications and time out
- Procedural and sedation monitoring
- Initial and hourly ICP[1,12,15]
- Initial and hourly CPP calculation[1,12,15]
- Insertion site assessment
- Patient and family education
- Initial ICP tracing (include ICP waveform morphology) and any changes in the waveform[12,15]
- Nursing interventions used to treat ICP or CPP deviations and expected or unexpected outcomes[12,15]
- Pain assessment, interventions, and effectiveness

References and Additional Readings

For a complete list of references and additional readings for this procedure, scan this QR code with any freely available smartphone code reader app, or visit http://booksite.elsevier.com/9780323376624.