

VIDEOS IN CLINICAL MEDICINE  
SUMMARY POINTS

## Insertion of an Intracranial-Pressure Monitor

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*The following text summarizes information provided in the video.***OVERVIEW**

Invasive intracranial-pressure monitoring, or ICP monitoring, is often used in patients in whom elevated intracranial pressure is suspected, particularly those with traumatic brain injury. The two most common tools used for invasive ICP monitoring are intraparenchymal ICP monitors and external ventricular drains.<sup>1</sup> Each has its own benefits and drawbacks.

This review describes the insertion of an intraparenchymal ICP monitor. Although such monitors do not allow for therapeutic drainage of cerebrospinal fluid (CSF), placement is more straightforward, particularly if there is ventricular effacement or displacement (both of which are common in patients with traumatic brain injury).<sup>2,3</sup> Intraparenchymal monitors are also associated with fewer complications (e.g., hemorrhage and ventriculitis) than are external ventricular drains.<sup>2,3</sup>

**INDICATIONS**

Guidelines on the use of invasive ICP monitors vary, but the Brain Trauma Foundation recommends their insertion in patients with severe traumatic brain injury and abnormalities on computed tomography (CT) and in selected patients with a normal CT scan (e.g., those who are older than 40 years of age and have abnormal motor posturing or hypotension).<sup>4,5</sup> Invasive ICP monitors can also be used in patients with other conditions associated with elevated intracranial pressure.

**CONTRAINDICATIONS**

The insertion of an intracranial monitor should be avoided in patients with coagulopathy (e.g., those with a platelet count less than 100,000 per cubic millimeter, platelet dysfunction, or an international normalized ratio greater than 1.3). ICP monitors should not be inserted at or near a site of local infection.

**EQUIPMENT**

Several types of intraparenchymal ICP monitors are available, including piezoelectric strain gauges, fiberoptic monitors, and pneumatic monitors (Fig. 1). These monitors can be inserted through a skull bolt or tunneled under the skin. Here we describe the insertion of a piezoelectric strain gauge through a skull bolt, but the principles of insertion are similar for all types of intraparenchymal ICP monitors.

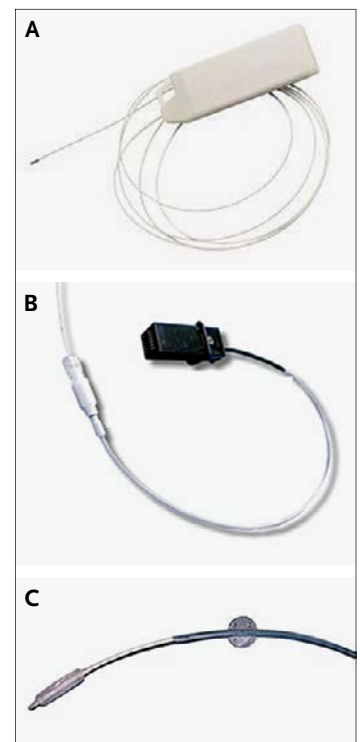
Begin by gathering the necessary equipment. For the initial preparation, you will need nonsterile gloves, a water-absorbent underpad, water, soap, a washcloth or brush, a hand towel, a razor, and a marker pen. For the procedure itself, you will need a face mask, a sterile gown and sterile gloves, an antiseptic solution such as chlorhexidine, a sterile fenestrated drape, a local anesthetic agent such as 2% lidocaine with 1:200,000 adrenaline, a 5-ml syringe, a 21-gauge needle for drawing up

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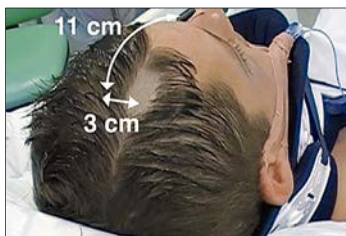
**Figure 1. Types of Intraparenchymal ICP Monitors.**

Several types of intraparenchymal monitors are available, including the piezoelectric strain gauge (Panel A), the fiberoptic monitor (Panel B), and the pneumatic monitor (Panel C).

the anesthetic, a 27-gauge needle for administering the anesthetic, a scalpel with a number 11 blade, and an ICP-monitoring kit. The kit should contain a twist drill with drill bit, an ICP bolt, an ICP sensor, and a transducer. Finally, you will need suture material, such as a 3-0 nylon suture, and a sterile dressing.

#### PREPARATION

Put on nonsterile gloves. Place the patient in the supine position, and put the water-absorbent underpad beneath the patient's head, with the plastic side down. Wash the patient's scalp with soap and clean water using the washcloth or brush. Dry the skin with a hand towel and shave as necessary. Identify the anatomical landmarks and mark the incision site. Generally, ICP monitors are inserted on the side of the nondominant hemisphere, which is usually the right side. The incision is made along the midpupillary line, 3 cm lateral to the midline to avoid the sagittal sinus, approximately 11 cm posterior to the nasion, and at least 1 cm anterior to the coronal suture to avoid the motor strip (Fig. 2).



**Figure 2.** Location of ICP Monitor Insertion.

The ICP monitor should be inserted on the side of the nondominant hemisphere, which is usually the right side, 3 cm lateral to the midline and approximately 11 cm posterior to the nasion.

Put on a face shield, wash and disinfect your hands, and put on a sterile gown and sterile gloves. If you are using a drill guide, loosen the guide with the hex wrench, place it at a suitable depth (typically, approximately 20 mm), and then retighten it. Thick hematomas of the skull and scalp may obviate the need for the drill guide. Prepare the autoclaved twist drill by placing the bit into the chuck, holding the drill handle in place, and then turning the chuck clockwise. Prepare the bolt by placing the stylet in the lumen, with the tip exposed. In most adult patients, the spacing washer is unnecessary and may be discarded.

#### PROCEDURE

Wipe the right frontal area with an antiseptic solution from the center to the periphery three times. Then place a sterile fenestrated drape over the head. Larger sterile drapes may also be used, but follow the guidelines at your institution. Raise a bleb with a local anesthetic. Make a short (5-mm) linear stab incision. The use of a retractor is usually unnecessary. Ask an assistant to secure the patient's head. Place the drill perpendicular to the skull and turn the handle clockwise; do not lean on the drill. You will usually be able to feel the drill bit penetrate the hard outer cortex, the soft central medulla, and the hard inner cortex. Place the bolt in position perpendicular to the skull, and turn it clockwise — usually nine half-turns — until it is secure. Loosen the cap of the bolt by turning the adapter counterclockwise, and make a puncture in the dura using the dural puncture stylet. CSF may be visible at this point.

Turn on the ICP transducer. Place the ICP sensor in sterile water, and ask an assistant to connect the sensor to the transducer. Ask the assistant to calibrate the transducer and to record the reference number. Insert the ICP sensor through the bolt to the desired depth, which is often approximately 15 mm into the cranium, and then secure the sensor in the bolt by turning the adapter clockwise. When using a strain gauge, you may bend the sensor at a point that indicates the desired depth, but other types of sensors should not be kinked.

Dress the wound site using antiseptic-soaked gauze. You may place a purse-string suture, which can aid in wound closure after the bolt is removed.

#### COMPLICATIONS

Hemorrhage can occur at any stage of the procedure but is seldom clinically significant.<sup>2</sup> Before the procedure, identify and correct any coagulopathy. Hemorrhage of the scalp or skull usually ceases once the bolt is placed, but skin sutures and

bone wax may be applied if bleeding persists. Intracranial hemorrhage is rare, but unenhanced CT of the head may be performed after the procedure if hemorrhage is suspected. Infection is a rare but serious late complication.<sup>2</sup> Make sure that you adequately prepare the skin and use meticulous aseptic technique. Avoid handling the tip of the ICP sensor. The use of perioperative antibiotic agents may be considered, but if you decide to administer such drugs, follow the guidelines at your institution.<sup>2</sup> CT of the head, with and without the administration of contrast material, may be requested, and a CSF sample may be obtained if intracranial abscess or ventriculitis is suspected.

#### INTERPRETATION

The normal intracranial pressure is 7 to 15 mm Hg. The upper limit of the normal range is 20 mm Hg.<sup>3,5</sup> Gentle pressure over the jugular veins should cause a rise in intracranial pressure. The rate at which the intracranial pressure rises may indicate the degree of compliance of the brain. If there is no increase in intracranial pressure, then check the waveform. An ICP waveform consists of several peaks (P1, P2, and P3) that may be considered to be a combination of the arterial and other waveforms (Fig. 3). For cases in which the ICP waveform is not present, check the ICP sensor and transducer. Technical malfunction or loss of calibration of the ICP sensor can lead to inaccurate readings. For cases in which the intracranial pressure is no longer consistent with clinical and radiologic findings, the ICP sensor may need to be replaced.

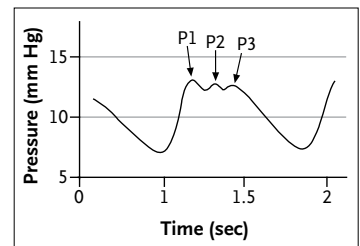
#### SUMMARY

Intraparenchymal ICP monitoring is often useful for patients in whom elevated intracranial pressure is suspected, particularly in those with traumatic brain injury. Meticulous technique is important to reduce the risk of complications, such as hemorrhage and infection.

No potential conflict of interest relevant to this article was reported.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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**Figure 3. ICP Waveform.**

The peaks shown (P1, P2, and P3) may be considered to be a combination of the arterial and other waveforms.

#### REFERENCES

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