BIS monitoring: From the OR to the ICU

Find out how bispectral index monitoring can give you an objective measure of your patient’s level of sedation.

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Caring for critically ill patients in the ICU can present multiple challenges. Because of the physiologic dynamics of critical illness, predicting the patient’s need for analgesia and sedation is difficult. Until recently, the only physiologic measures we had to ensure appropriate medication use were indirectly tied to patient comfort. This method often resulted in oversedation for patients, increasing ICU stays, and overall morbidity.

Bispectral index (BIS) monitoring, an objective measure of the patient’s response to sedation, has been used in anesthesia for over a decade. This technology is finding its way into the ICU to provide a means of assessing the adequacy of sedation and preventing oversedation of critically ill patients.

In addition, because the BIS monitor reflects electroencephalographic data, it adds to the objective information regarding brain activity.

BIS is also used to monitor sedation in patients with neurologic disorders, and clinical trials use BIS monitoring to improve sedation protocols in endoscopy and interventional endoscopy.

What BIS reveals

BIS monitoring measures cerebral electrical activity derived from an electroencephalogram (EEG). The BIS device reads the electrical activity from a sensor placed on the patient’s forehead and converts several parameters into a single numeric value that correlates to sedation level. The digital BIS value ranges from 0 (isoelectric EEG) to 100 (fully conscious).

The BIS monitoring system consists of a sensor and a display monitor. The sensor is an electrode strip. Three of the electrodes, when properly placed, pick up EEG activity. A fourth electrode is used to measure artifact and electromyographic (EMG) resistance, which sends signals that contaminate EEG readings. The sensor is connected to the monitor that displays a single-channel EEG tracing and the BIS score.

The monitor also provides information that can confirm the reliability of the data. A high signal quality index (SQI) indicates a reliable BIS value. The suppression ratio (SR), noted as a numeric value, indicates the percentage of isoelectric EEG. The suppression ratio values are inverse to the BIS values. A tracing without any iso-
electric periods would have an SR of 0, whereas a fully isoelectric tracing would have an SR of 100. The value of the EMG indicator, which reflects muscle stimulation, will rise with any occurrence that increases muscle tone or movement. As the EMG value rises, the BIS value becomes less reliable.

**Monitoring how-to**

Beginners to BIS monitoring can use the following technique.

**Placing the sensor:** You can place the electrode strip on either side of the patient's forehead. First, gently clean and dry the patient's forehead to remove oils. The sensor strip, which doesn't require any additional skin preparation, has three circles to ensure placement to record EEG activity. Circle one is centered 2 inches above the nose. Circle four is placed above the eyebrow in a parallel fashion. Circle three is centered on the temple between the corner of the eye and the hairline. (Circle two doesn't have a specific placement.)

Once the strip is placed, secure it by pressing around the edges of each circle, then press and hold each circle for at least 5 seconds to secure contact to the skin.

**Monitoring:** Use the interface cable to connect the sensor to the monitor. The BIS monitor will display the raw EEG tracing, and within several minutes the BIS numeric value will stabilize. Check the SQI for reliability of signal. Document the baseline value; use the BIS value to titrate sedative medication. (See **BIS sedation scale**.)

**Care and troubleshooting**

The BIS monitor requires little in the way of troubleshooting. The sensor should be changed every 24 hours. The monitor will alert you when the 24-hour period is over.

If the SQI decreases, check that the sensor is still in good contact with the patient's forehead. Remember, if the EMG activity increases, the accuracy of your BIS value decreases. Because EMG resistance reflects muscle activity, search for and treat the cause of the EMG activity. If it's pain, your interventions will include administering analgesics. If it's seizure, administer antiepileptics. If the patient needs to be immobile for medical treatment (such as an imaging study), you may need to obtain an order to add muscle relaxants or paralytics to the patient's medication.

**BIS in action**

Let's look at some scenarios in which BIS monitoring can be used.

Marisol Jiminez, 44, arrives at the ED after the sudden onset of what she describes as the worst headache of her life. She had no focal neurologic deficits. Mild nuchal rigidity and headache were present on admission. A computed tomography (CT) scan of the head demonstrated a subarachnoid hemorrhage suspicious for a middle cerebral artery aneurysm. A CT angiogram confirmed the presence of a left middle cerebral artery aneurysm. Ms. Jiminez was taken to the OR for clip obliteration of the aneurysm. She was given propofol for sedation because of its short half-life; a neurologic exam can be performed quickly after the infusion is stopped.

She remained intubated and sedated postoperatively, and the BIS monitor provided objective information about her level of sedation. A postoperative CT scan completed the morning after surgery showed no new hemorrhage, good clip position, and no indication of cerebral edema. During the morning exam, with the propofol infusion off for 20 minutes, Ms. Jiminez was sleepy and commands with both upper extremities; however, her response was quicker on the left side than the right.

Early on the second postoperative day, her BIS values were trending lower than the desired range. The CT scan was repeated and showed no change from her im-
mediate postoperative scan. She had a transcranial Doppler study, which demonstrated high velocities suggestive of vasospasm. At the same time, propofol was titrated down with no change in BIS values. After the transcranial Doppler sonography, she was taken immediately to the interventional radiology suite for a cerebral arteriogram, which confirmed the vasospasm. She was treated with intra-arterial papaverine. After 20 minutes, a repeat arteriogram demonstrated no further vasospasm, so she was maintained on triple-H therapy (hypertension, hypervolemia, and hemodilution, designed to increase cerebral perfusion and reduce the risk of vasospasm). Her BIS values at this time were 40 to 50.

Twenty-four hours after the intra-arterial papaverine was administered and while Ms. Jimenez was still on triple-H therapy, her BIS values dropped again. A CT scan of the head showed no change, but her intracranial pressure (ICP) values were trending upward from 15 to 18 mm Hg and transcranial Doppler values showed increased velocities. Triple-H therapy was maximized. Throughout this period, she remained sleepy with some weakness of her right arm and would follow commands only intermittently. Her BIS values continued to trend downward as her ICP values trended up, despite treatment with cerebrospinal fluid drainage and mannitol. A repeat CT scan 12 hours later (3.5 days postoperatively) demonstrated the development of a left middle cerebral artery infarction. Sedation was titrated off as BIS values continued to trend low. Her ICP numbers remained in the 20 to 25 mm Hg range, refractory to treatment. Her neurologic status during this time period worsened. She no longer responded to verbal stimulation, she was decerebrate to deep pain, her pupils were 5 mm, and she was sluggish to reaction.

By the end of the third postoperative day, her neurologic exam had worsened despite treatment for vasospasm and increased ICP. Her BIS values had dropped to 0. Her neurologic exam was consistent with cerebral death, and a cerebral blood flow scan was consistent with no flow. Her family, following her wishes, requested an evaluation for organ donation. Twelve hours later, her neurologic exam remained consistent with brain death and she was pronounced dead and taken to the OR for organ harvest.

Now let's consider another case. Tom Cameron, 25, is admitted to the trauma center following a motorcycle crash. His Glasgow Coma Score on admission was 6 (normal is 15). A CT scan of the head showed a large subdural hematoma with underlying contusions. He was urgently taken to the OR for evacuation of the hematoma and placement of a ventriculostomy for ICP monitoring. Upon arrival in the ICU, he was restless and agitated, refusing to follow commands and fighting the ventilator. His ICP values were 18 to 20 mm Hg. He was sedated with fentanyl and lorazepam.

Mr. Cameron was placed on BIS monitoring with the goal of maintaining a BIS value of 50 to 60. On the second postoperative day, however, his BIS value increased to 80, and he was restless, agitated, not following commands, and attempting to pull out his endotracheal tube. The lorazepam and fentanyl infusions were increased, and within 45 minutes the BIS values returned to the desired range. Over the course of the next 48 hours, the sedation was gradually titrated down and the BIS values increased. Mr. Cameron's ICP values remained normal, and he was extubated on the fifth postoperative day.

A measure of success

In both of these cases, the BIS monitor was helpful in providing an objective measure of the patient's response to sedation and to limiting the amount of sedation used. In Ms. Jimenez's case, because the neurologic decline was suggested by the falling BIS numbers despite the reduction in sedation, successful organ recovery was facilitated.

In Mr. Cameron's case, as he recovered from surgery, BIS values increased, indicating that his sedation could be increased without oversedating him. This system allowed for easier, more prompt extubation and a decreased stay in the ICU.

Overall, BIS monitoring is an easy-to-use adjunct to monitoring sedation in the critically ill patient that may reduce costs, morbidity, and mortality related to sedation in the ICU.