

USE OF THE BILATERAL BIS MONITOR AS AN INDICATOR OF CEREBRAL VASOSPASM IN ICU PATIENTS

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Abstract

Earlier diagnosis of cerebral vasospasm and delayed cerebral ischemia (DCI) and treatment has the potential to decrease post-bleed morbidity after subarachnoid hemorrhage (SAH). Previous studies have shown that electroencephalogram (EEG) can detect blood flow changes associated with DCI sooner than other modalities potentially leading to earlier diagnosis. However, continual monitoring with raw EEG requires significant expertise and effort, and may be difficult due to the intermittent need for MRI studies in these patients. Here we describe a series of patients with subarachnoid hemorrhage in the Neurosurgical ICU who underwent monitoring with the Bilateral Bispectral Index (BIS) monitor.

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Introduction

Subarachnoid hemorrhage (SAH) affects 30,000 Americans each year¹. It is initially fatal in 33- 50% of cases^{2,3}, with a large percentage of remaining patients suffering from late complications due to rebleeding or cerebral vasospasm. Twenty to 40 percent of patients who survive the initial hemorrhage will develop cerebral vasospasm which results in delayed cerebral ischemia (DCI). Early diagnosis and treatment of is critical in preventing infarction⁴. Recognition of clinical neurologic deterioration in the absence of hydrocephalus or rebleeding is often the first clinical sign leading to a diagnosis of vasospasm¹.

Current modalities used to diagnose cerebral vasospasm include transcranial Doppler (TCDs), angiography, and several Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) techniques¹. These diagnostic tools are invasive, require specially trained personnel to administer,

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and are not continual. There is electroencephalographic (EEG) evidence that blood flow related changes associated with vasospasm precede clinical deterioration by as much as two days⁵. However, the use of continuous standard EEG is difficult because it requires trained personnel, must be removed for follow up MRI, etc...

We thought that processed EEG with BIS had the potential to be very useful because uses a single sensor on the forehead which can be removed and reapplied, and the interpretation is simple. To this end we performed a small case series utilizing bedside monitoring with bilateral Bispectral Index (BIS) (Aspect Medical Systems Inc., Newton, MA) as a means to follow real time changes in processed EEG patterns in SAH patients.

Methods

After IRB approval, written informed consent was obtained from each subject or a legal surrogate. All patients received standard intensive care unit (ICU) monitoring with the addition of a bilateral BIS probe applied within 48 hours of SAH. Left and right BIS values were recorded every 12 hours until discharge from the Neurosurgical ICU. Additionally, Glasgow Coma Scale (GCS) scores and focal

neurologic deficits were recorded every 12 hours. Modalities used to diagnose vasospasm included TCD, angiography, MRI and CT. The formal diagnosis was made by a neurointensivist using a combination of modalities and clinical criteria. Bilateral BIS data was analyzed for trends and correlated with clinical and radiographic evidence of vasospasm as determined by the neurointensivist.

Results

15 patients completed the protocol. The number of days in the ICU ranged from 2 to 15. Five patients had vasospasm diagnosed by a neurointensivist. In two of these individuals there was significant divergence between right and left BIS scores at the time of vasospasm. During angiography in these patients, selective injection of calcium channel blockers was associated with a resolution of the discrepancy in right and left BIS scores (Figure 1). Divergent BIS scores also correlated with elevated unilateral TCDs and cerebral infarction even when vasospasm was not diagnosed. However, similar discrepancy between left and right signals were episodically present at times when patients did not have vasospasm, elevated TCDs, or cerebral infarction (Figure 2).

Fig. 1
Divergent bilateral BIS scores in a patient with right-sided cerebral vasospasm after SAH and aneurysm clipping. The BIS scores converge after intraarterial injection of verapamil during angiography

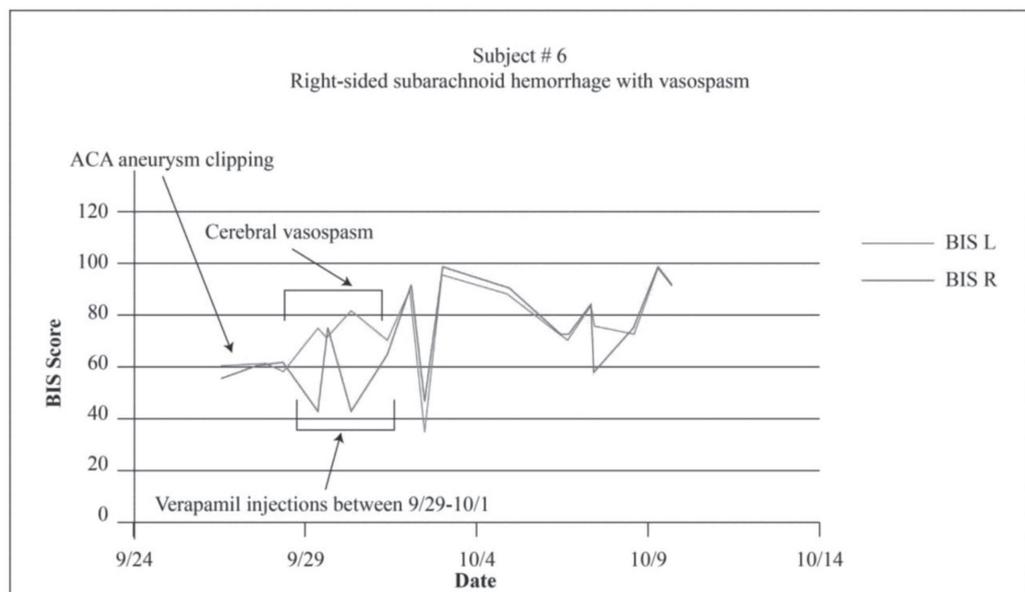
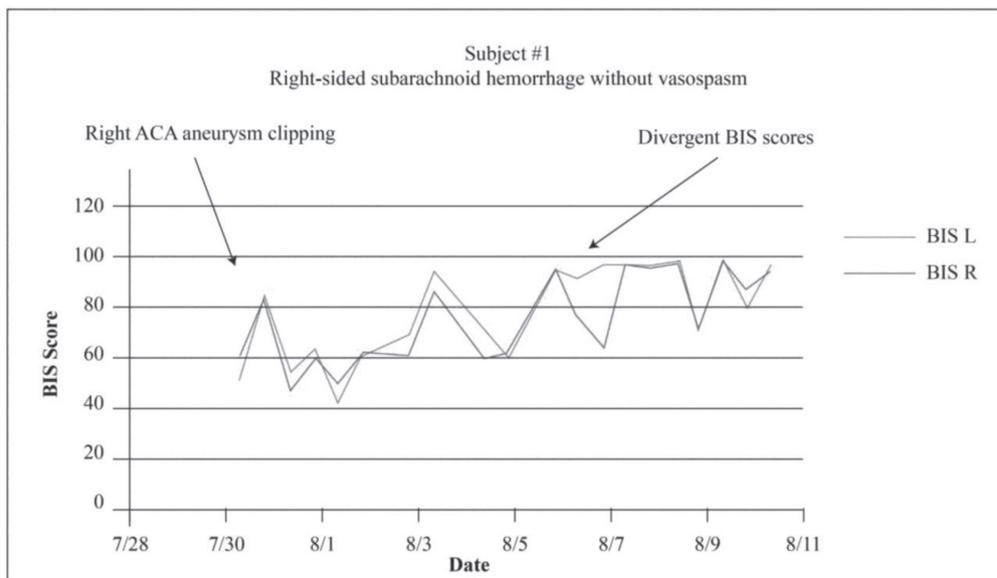


Fig. 2
Divergent bilateral BIS scores in a patient without cerebral vasospasm. The BIS scores converge and diverge in the absence of vasospasm



Conclusions

Divergent BIS values between left and right side of the brain seems to be a nonspecific and insensitive indicator of cerebral vasospasm. Reasons for the mixed results include: depressed level of consciousness from the underlying condition or sedation may mask left and right sided differences in EEG, spontaneous muscle activity, electrical interference and patient movement.

In some cases it was likely that the spastic vessels did not supply the frontal lobes thus making it unlikely to detect a divergent BIS score.

The condition of DCI is more complex than just vasospasm or decreased cerebral blood flow; cerebral infarction correlates with the territory of angiographic vasospasm in only 25% to 81% of SAH patients. However, DCI correlates more closely with clinical outcomes than the presence of vasospasm⁶. Interestingly even in the absence of significant vasospasm, one sided BIS score discordance may develop with infarction and increasing pulsatility indices on TCDs. This suggests

that EEG is a sensitive indicator for blood flow but may not capture the complexity of this more inclusive definition of vasospasm for the reasons above.

There were some limitations in our observation of the patients; BIS scores can fluctuate significantly in a small time period, but for the purposes of this study we recorded the value at a single time point and not as error bars over a period of time. While it seems a minor issue, many patients had significant headache associated with their condition and did not wish to wear the probe for a significant period of time.

Bilateral BIS may be a good indicator of hemispheric changes in blood flow to the frontal lobes and may be better suited for situations or procedures where the frontal lobes are most likely to be affected e.g. carotid endarterectomy. Use of the BIS monitor in an ICU setting on awake patients is complicated by discomfort, muscle activity, and movement. The diagnosis of cerebral vasospasm after SAH continues to be made via clinical signs, bedside Doppler, and radiographic testing.

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