CASE REPORT

Changes in bilateral bispectral index VISTA monitoring system during Wada test

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Abstract The Wada test is a procedure used in the preoperative assessment before epilepsy surgery in order to determine language lateralization, to assess the post-operative risk of an amnesia syndrome, and to evaluate the risk of material-specific memory deficits, in particular verbal memory deficits. This test involves inserting a cannula into the internal carotid artery via the femoral artery, and then to inject amobarbital to shut down brain function, usually in one of the brain hemispheres. The bilateral bispectral index (BIS) VISTA™ monitoring system (BVMS) was used to detect changes in EEG, and in the power spectrum distribution using the density spectral array (DSA) of both hemispheres. We describe a patient with an agenesis of the A1 segment of the right anterior cerebral artery, scheduled for a Wada test, in whom the BVMS demonstrated its potential value.

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PALABRAS CLAVE
Test Wada; Epilepsia; Índice Biespectral Bilateral VISTA; Matriz de Densidades Espectrales

Cambios en el sistema de monitorización índice Biespectral Bilateral VISTA durante la prueba de Wada

Resumen El test de Wada es un procedimiento usado en la valoración preoperatoria antes de la cirugía de epilepsia para determinar la lateralización del lenguaje, evaluar los riesgos de síndrome amnésico en el postoperatorio, y de déficits de memoria, particularmente déficit de memoria verbal. Esta prueba se realiza mediante cateterización de la carótida interna a través de la arteria femoral, administrando amobarbital para anestesiar la función cerebral de todo un hemisferio. El índice Biespectral Bilateral (BIS) VISTATM MonitoringSystem (BVMS) se utilizó para detectar cambios en el EEG y en espectro de fuerza mediante la Matriz de Densidades Espectrales (MDE) en ambos hemisferios. Describimos el caso de un paciente con una agenesia del segmento A1 de la arteria cerebral anterior derecha, programado para realizar el test de Wada, en el que el BVMS demostró su utilidad.

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Introduction

The Wada test is used in the preoperative evaluation of patients with epilepsy\(^1\) to determine which side of the brain controls language,\(^2\) to predict post-surgical memory changes,\(^3\) and to localize seizure focus.\(^4\) This test has been the "gold standard" for locating language function for several decades, but it has been performed in fewer patients since the development of non-invasive alternatives, in particular functional magnetic resonance imaging (fMRI). Several studies have shown fairly good agreement between the fMRI and Wada test findings for language lateralization. The test has not been replaced by fMRI or any other method to date,\(^5,6\) and it may still have value in assessing epilepsy surgery candidates with atypical or bilateral language representation.

The Wada test involves injecting a sufficient amount of a short-acting anesthetic (traditionally, sodium amobarbital) into the internal carotid artery to anesthetize the injected hemisphere and assess the impact on motor and speech function.\(^7\) The presence of seizures is confirmed in real-time by continuous electroencephalographic (EEG) monitoring. Anesthesia, which usually lasts between 4 and 8 min, causes contralateral hemiparesis and hemianopsia. When the language-dominant hemisphere is anesthetized, aphasia occurs; language is assessed by testing fluency, naming, comprehension, reading, and repetition. The procedure is usually completed within 10–15 min on one hemisphere, and is repeated on the other side after waiting at least 30 min after the initial injection.\(^7\)

The bispectral index (BIS) VISTA\(^\text{TM}\) monitoring system (BVMS) (Aspect Medical Systems Inc., Norwood, MA) consists of the BIS VISTA Monitor, the BIS × 4, the PIC-4 and a BIS bilateral sensor. The single-use sensor uses an electrode montage designed to capture high-quality EEG signals from both cerebral hemispheres of the patient. The BVMS was designed to enable the user to record and display four EEG channels, two from each side of the brain. This monitor also shows changes in the power spectrum distribution through the density spectral array (DSA). Asymmetry (ASYM) is a processed variable indicating the percentage of EEG power present in the left or right hemispheres with respect to the total (left and right) EEG power.\(^8\) Asymmetry data may be plotted on a graph as part of the DSA display. The ASYM scale begins at 20% at the center line and runs left or right to 100%. In a situation of clear hemispheric difference, the asymmetry indicator points to the hemisphere that measures greater power.

We describe a patient in whom the BVMS was used to detect changes in EEG during the Wada test. This case report shows the potential value of this monitor. The patient gave written permission for the authors to publish the report.

Case description

A 48-year-old man, left-handed, 50 kg, 174 cm, Glasgow Coma Score 15, ASA grade III, with drug resistant epilepsy was scheduled for a Wada test. He was taking: Levetiracetam (2000 mg/12 h), Lacosamide (150 mg/12 h), Retigabine (200 mg/8 h) and Estilcarbazepine (1200 mg/24 h). He had bradypsychia, dysarthria, and a right hemiparesis. Ictal SPECT showed a hyperperfusion in the left temporal lobe that correlated with a hyperperfusion in the same area during the interictal evaluation. The patient gave written consent for the procedure. The patient was awake during the procedure and not sedated in order to perform an accurate functional assessment.

On arrival in the Radiology Department for the preoperative assessment, standard recommended monitoring was performed. A BVMS electrode strip was placed on the frontotemporal head bilaterally, according to the international 10–20 system of electrode placement, and a BIS Vista was used to record BIS values. Baseline DSA values showed a right ASYM reaching 66% (Fig. 1). A simultaneous EEG was performed to record functional changes in the ipsi- and contralateral hemisphere.

A catheter was inserted into the femoral artery under local anesthesia, and then advanced over a guide wire into the left internal carotid artery. A digital subtraction angiography with the injection of contrast agent (2–3 ml) was performed to observe the blood vessels supplied by the internal carotid artery, checking for correct placement of the catheter, to designate the affected area and the morphology of the circle of Willis. The Neuroradiologist observed an agenesis of the A1 segment of right anterior cerebral artery and that the flow was conducted from the A1 segment of left anterior cerebral artery to the right A2 segment of anterior cerebral artery, through the anterior communicating artery. The left hemisphere, thought to have the epileptogenic focus, was injected first followed by the opposite hemisphere. The purpose of this injection was to temporarily put one side of the brain "to sleep" in order to test the awake side. A 175 mg dose of amobarbital was required to observe a complete hemiplegia. At this point, BIS values decreased around 65 on both sides, the EEG showed more frequent delta and theta waves, and the ASYM decreased to 40% (Fig. 2A). At this time the patient was able to speak; thus language dominance, and the memory of the contralateral (non-injected) hemisphere could be evaluated. The amobarbital effect lasted approximately 9 min; with the beginning of the recovery, the right ASYM reached 70%. Thirty minutes later, the catheter was moved to the main blood vessels on the right side of the brain, and amobarbital (85 mg) was again injected to temporarily put this side of the brain to sleep. At this point, the neurological function was affected, there was an apnea that lasted 5 s, and when the patient regained his breathing, he was unable to speak. The right BIS value (65) decreased more than the left, showing an ASYM that ranged between 30% and 56% (Fig. 2B), and the EEG became slower. Ten minutes later during recovery, there was a further decrease in BIS values in each hemisphere, and ASYM (42–72%) on the right side appeared. The presence of ASYM was related to an increase of power in the delta and alpha bands of right hemisphere. At the end of the procedure the patient was awake and was able to be transferred to the hospital ward on the same day.

Discussion

The Wada test involves an injection of an anesthetic agent, usually amobarbital, into the internal carotid artery. This invasive procedure is not free of risk. A retrospective
study by Loddenkemper et al. reported a significant rate of complications associated with the test, citing major or minor complications occurring in up to 10.9% of cases. Complications included encephalopathy (7.2%), seizures (1.2%), strokes (0.6%), transient ischemic attack (0.6%), and localized hemorrhage at the site of catheter insertion (0.8%).

On the other hand, an anomaly of the circle of Willis represents a challenge when differences between both hemispheres have to be analyzed. In our case, a double dose of barbiturate in the left internal carotid was necessary to reach a right hemiplegia, probably because the drug was partially distributed to the contralateral hemisphere.

Heller et al., by placing two BIS sensors during Wada test, did not find differences between left and right hemispheres after barbiturate injections, and BIS descended to values around 91, indicating that the BIS monitor was unable to distinguish significant hemispheric EEG changes. In our case, the injection of amobarbital in the affected side induced a decrease in BIS values of around 65 in both hemispheres, with the drug effect being shown on the EEG. The lack of differences between both sides can be explained by the anomaly of the circle of Willis. In addition, BVMS also demonstrated differences between hemispheres when amobarbital was administered in the healthy side. Thus, BVMS was able to detect EEG changes induced by the barbiturate.

ASYM also revealed changes of power in frequency bands when the barbiturate was injected into each side; however the ASYM, but not the BIS trend, detected differences at baseline, and coincided with recovery times. DSA shows a spectral range between 0.5 and 30 Hz; above this frequency changes of drug effect are not evaluated, and is likely to include noise from muscle activity, and electrical interference. BIS is influenced by electromyographic (EMG) signals which are conventionally believed to be in the 30–300 Hz band. An EMG activity over 40 dB present in our patient during the performance of Wada test could elevate and prevent BIS trends showing differences between both hemispheres during the awake state.

The BIS VISTA bilateral monitoring system, by incorporating processed DSA and asymmetry indicator, improves the
**Figure 2** (A) Trend of BIS showing the decrease of values of both hemispheres when amobarbital was injected into LIC. (B) Right BIS values decreased more than in the left when the amobarbital was injected into the RIC. BIS L (left); BIS R (right); LIC: left internal carotid I; RIC: right internal carotid.

Information provided by BIS trend, and it allows us to better observe the baseline state of the brain and the EEG responses to anesthetic procedures.

**Conflict of interest**

The authors declare no conflicts of interest.

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**References**