Balloon Test Occlusion of the Internal Carotid Artery with Monitoring of Compressed Spectral Arrays (CSAs) of Electroencephalogram

T. Morioka¹, T. Matsushima¹, K. Fujii¹, M. Fukui¹, K. Hasuo², and K. Hisashi³

¹Department of Neurosurgery, Neurological Institute, and Departments of ²Radiology and ³Otolaryngology, Faculty of Medicine, Kyushu University, Fukuoka, Japan

Summary

We used the compressed spectral arrays (CSAs) of the electroencephalogram (EEG) to monitor cerebral blood flow related events in balloon test occlusion of the internal carotid artery (balloon Matas test). Reliability of the CSAs was examined in 22 patients subjected to the test. Of 9 patients who underwent subsequent permanent carotid occlusion, in 6 there was no change on CSAs and/or in neurological conditions. In 2 patients, there was a slowing on CSAs prior to the appearance of neurological deterioration during clinical testing. CSAs transformed these EEG changes into a succinct graphic display. In 1 of the 2, for whom the Matas test was repeated 1 year later, there was a change from positive to negative and delayed cerebral infarction occurred after carotid occlusion. In the other patient, an ischaemic insult occurred during the balloon occlusive procedures. The third patient had a fatal delayed ischaemic complication 3 days after surgical ligation of the cervical carotid artery, despite the negative balloon Matas test. Complications in these 3 patients were presumably related to thromboembolic mechanisms.

The balloon Matas test monitored by CSAs is useful for detecting change in brain functions attributed to an inadequate blood flow. However, this test is unreliable for predicting thromboembolic complications.

Keywords: Balloon test occlusion; internal carotid artery; compressed spectral arrays (CSAs); electroencephalography (EEG); Matas test.

Introduction

Prior to the therapeutic occlusion of the carotid artery, tolerance to the temporary test occlusion has to be estimated (Matas test)²¹. A simple but unreliable method involves use of percutaneous brief manual compression of the cervical carotid artery. Recent advances in neuroradiology have led to a reversible and authentic occlusion of the common, external or internal carotid arteries (CCA, ECA or ICA) with an inflatable balloon catheter (balloon Matas test)³, ⁸, ¹¹, ¹⁴, ²⁵. During these procedures, the subsequently occurring neurological deficits cannot be correctly predicted by clinical observation alone¹², ¹³, ²⁵. Therefore, objective data on changes in a patient's brain function should be monitored. The on-line recording of the electroencephalogram (EEG) is widely used as a neurophysiological parameter¹⁴, ²⁰, ²³.

The conventional EEG is impractical for continuous monitoring⁶, ⁷, and the introduction of compressed spectral arrays (CSAs) by Brickford et al.⁴ has made feasible this monitoring. CSAs automatically convert the EEG into a graphic output, and the changes in brain activity are displayed. In other reports of interventional neuroradiology¹², ¹³ CSAs were used, but only one patient was examined. We report here the usefulness of CSAs for monitoring cerebral events related to the use of the balloon Matas test.

Clinical Materials

Between 1985–1988, 25 procedures of the balloon Matas test monitored with CSAs were performed on 22 patients. All were scheduled for elective surgery for either carotid occlusion for the treatment of giant or inaccessible ICA aneurysm and carotid-cavernous fistula (CCF), or radical neck or skull base surgery in which the carotid artery was considered to be at risk. Nine patients who finally underwent the permanent carotid occlusion surgically or with a detachable balloon were the subjects of the present study (Table 1). There were 6 with unclippable ICA aneurysm, 2 with cervical tumour and 1 with CCF. The ages ranged from 47 to 69 years, with a mean of 56 years.

Methods

All tests were performed under local anaesthesia. Temporary occlusion of the carotid artery was performed with 5-French Swan-Ganz double lumen catheter or Debrun’s detachable balloon catheter, introduced using transfemoral Seldinger’s techniques. All patients were given 3000 units of Heparin as a bolus prior to inflation.
Table 1. Relationship Between CSAs Change and Clinical Outcome

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Age</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Cross flow</th>
<th>EC-IC bypass</th>
<th>CSAs change</th>
<th>Carotid sacrificed</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47</td>
<td>F</td>
<td>Cavernous aneurysm</td>
<td>+</td>
<td>Yes</td>
<td>None</td>
<td>(S) C4</td>
<td>No deficit</td>
</tr>
<tr>
<td>2</td>
<td>53</td>
<td>F</td>
<td>IC-Oph aneurysm</td>
<td>+</td>
<td>Yes</td>
<td>None</td>
<td>(S) C2</td>
<td>No deficit</td>
</tr>
<tr>
<td>3</td>
<td>57</td>
<td>F</td>
<td>Cavernous aneurysm</td>
<td>+</td>
<td>No</td>
<td>None</td>
<td>(B) C4, 5</td>
<td>No deficit*</td>
</tr>
<tr>
<td>4</td>
<td>60</td>
<td>M</td>
<td>Cavernous aneurysm</td>
<td>+</td>
<td>No</td>
<td>None</td>
<td>(B) C4, 5</td>
<td>No deficit</td>
</tr>
<tr>
<td>5</td>
<td>60</td>
<td>M</td>
<td>Cervical tumour</td>
<td>+</td>
<td>No</td>
<td>None</td>
<td>(B) CCA</td>
<td>No deficit</td>
</tr>
<tr>
<td>6</td>
<td>50</td>
<td>F</td>
<td>CCF</td>
<td>+</td>
<td>No</td>
<td>Slowing</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>57</td>
<td>F</td>
<td>Cavernous aneurysm</td>
<td>+</td>
<td>Yes</td>
<td>Slowing</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>69</td>
<td>F</td>
<td>Cervical aneurysm</td>
<td>+</td>
<td>Yes</td>
<td>Slowing</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>48</td>
<td>M</td>
<td>Cervical tumour</td>
<td>+</td>
<td>Yes</td>
<td>No</td>
<td>(B) C5</td>
<td>MCA infarction</td>
</tr>
</tbody>
</table>

EC-IC external carotid-internal carotid arteries, CSAs compressed spectral arrays, IC-Oph internal carotid-ophthalmic arteries, CCF carotid-cavernous fistula, (S) by surgery, (B) with detachable balloon, CCA Common carotid artery, Bif Cervical carotid bifurcation, * transient IVth nerve palsy, MCA middle cerebral artery.

of the balloon. The electrophysiological tolerance to the occlusion was assessed for 20 minutes after the balloon had been inflated. During the procedure, frequent clinical examinations of motor and sensory functions were also made. The recording electrodes were placed on the C3, C4, A1, A2 and Fz, according to the international 10-20 system. These electrodes were applied with collodion and filled with conductive jelly to maintain the interelectrode impedance at below 3 kohm. Continuous presentation of the EEG spectra was monitored on the oscilloscope as an alternative to the EEG signal using OEE-7102 (Nihon Kohden.) A printer (WX-701 B) plotted out immediately the mean spectra related for 30 or 60 sec, in a pseudo-three-dimensional display. The spontaneous frequency analysis of leads C3 to A1 or Fz and of leads C4 to A2 or Fz was compared with changes occurring after carotid occlusion with the balloon catheter.

Results

For all 9 patients, satisfactory CSAs recordings were obtained. However, with the Fz reference various artifacts produced by eye movement made interpretation difficult, therefore, the A1 A2 reference was preferable. The relationship between the CSAs change and clinical outcome is summarized in Table 1.

Seven patients showed no definite change in CSAs during the procedures, and 6 of 7 had no neurological deficits after permanent carotid occlusion (surgery in 3 and with detachable balloon in 3). The remaining 1 (Case 9) had a fatal embolic complication 3 days after ligating of the cervical carotid artery, although he had awakened from the anaesthesia without neurological deterioration.

There were two patients (Case 7 and 8) with marked or mild slow changes on CSAs during the balloon Matas test and an ischaemic complication developed during and after balloon occlusion of the ICA. In these 2, CSAs change always preceded the clinical deterioration.

Findings in three patients (Case 7, 8, and 9) who had complications are described below, in detail.

Case Presentation

Case 7: A 57-year-old woman presented with a large aneurysm of the cavernous portion of the left ICA. On right carotid angiography there was enough flow across the midline. About 7 or 8 minutes after test occlusion of the left ICA, dominant rhythm of 9 Hz became obscure and slower CSAs activities were observed (Fig. 1). However, neurological changes did not develop. Twenty minutes after deflating the balloon, CSAs reverted to the dominant rhythm (Fig. 1).

Since we thought that the patient would be unable to tolerate occlusion of the left ICA without surgical augmentation of the collaterals, a left superficial temporal artery—middle cerebral artery (STA-MCA) anastomosis was done. The next day, after confirming the patency of the bypass angiographically, a second test occlusion of the left ICA was done. Just after the occlusion delta peak of 2.5 Hz appeared bilaterally (Fig. 2), and in 15 minutes aphasia and right hemiparesis occurred. The balloon was deflated and alpha dominant rhythm on CSAs gradually recovered (Fig. 2). She was neurologically normal within several minutes.

On the 23rd day after the STA-MCA anastomosis, a 3rd temporary occlusion of left ICA for 30 minutes led to no change in the CSAs (Fig. 3) and as the clinical tests were normal, permanent occlusion was performed. During the procedure, the monitored CSAs were normal (Fig. 3). The patient was taken back to the ward neurologically normal. Systemic anti-coagulation was not prescribed. The next day, right hemiparesis and aphasia suddenly occurred. The CT scan revealed cerebral infarction in the left MCA territory. Embolic complication from the occluded