Correlation of transient neurological deficit and somatosensory evoked potentials after intracranial aneurysm surgery

Case report

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A patient is reported in whom intraoperative somatosensory evoked potential (SEP) changes occurred in response to temporary clipping of the right middle cerebral artery. A period of 10 minutes elapsed before changes in SEPs in response to contralateral nerve stimulation were noted and, during the following 2 minutes, the waves decreased in amplitude and then were unrecordable. Waves of SEP, with amplitude similar to those recorded before clipping but with abnormal latency, returned within 45 seconds of removal of the clip, and the latency abnormalities persisted until the end of the operation. The patient awakened promptly at the end of the procedure with a dense left hemiparesis which resolved over 24 hours. At the end of 24 hours, the SEPs in response to median nerve stimulation were symmetrical in both latency and amplitude. This report demonstrates the accuracy of intraoperative evoked potential monitoring in demonstrating alterations of cerebral perfusion during aneurysm surgery. It also suggests that a prolonged period of observation may be necessary to assess the effects of temporary vessel occlusion during surgery on aneurysms or arteriovenous malformations.

KEY WORDS □ somatosensory evoked potentials □ intraoperative monitoring □ intracranial aneurysm

PATIENTS who have suffered subarachnoid hemorrhage (SAH) from an intracranial aneurysm have been shown to have abnormalities of cerebral blood flow and autoregulation in the involved hemisphere.6,10,13 The degree of flow abnormality appears to correlate with the neurological deficit.13 It has been further demonstrated that hypertension may be necessary to insure adequate perfusion to all areas of the brain.5 The perioperative management of these patients requires maintenance of blood pressure high enough for adequate perfusion of the brain without undue stress on the aneurysm. Following the induction of anesthesia, the inability to assess changes in neurological function makes this particularly difficult.

The short-latency components of evoked potentials have been shown to be useful in monitoring neurological function intraoperatively. Anatomical as well as physiological abnormalities have been shown by such monitors,16,20 and intraoperative manipulation, such as moving a retractor, based on these data has been thought to decrease neurological injury.7,18 Recent studies have shown that changes in somatosensory evoked potential (SEP) waveforms parallel changes in function in patients with SAH from intracranial aneurysm.19 This observation, coupled with a recent demonstration of lack of cerebral autoregulation in patients undergoing clipping of intracranial aneurysms during induced hypotension,8 suggests that intraoperative SEP monitoring offers dynamic assessment of changes in neurological function. Such monitoring might be expected to demonstrate alterations in neurological functions prior to permanent neurological damage. An advantage of short latency SEP recording is its resistance to anesthetic effects.

Spontaneous scalp electroencephalography (EEG) has been shown to be an unreliable predictor of neu-
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rological injury during induced hypotension and during aneurysm surgery. One difficulty with this method of neurological monitoring is its sensitivity to anesthetic agents. The following patient is presented to demonstrate the accuracy and timely nature of the SEP recording in reflecting neurological dysfunction intraoperatively.

Case Report

This 58-year-old right-handed white woman suffered a severe headache and a grand mal seizure 1 week prior to admission. Evaluation of the patient at another hospital, including angiography and computerized tomography scanning, demonstrated a 10-mm aneurysm at the trifurcation of the right middle cerebral artery (MCA). At the time of presentation for aneurysm clipping, the patient was classified as neurological Grade I according to Hunt and Hess.

Preoperative Protocol. Prior to induction of anesthesia, an arterial line and central venous catheter were placed. Gold cup electrodes were placed at C3', C4' over the left and right scalp region (according to the international 10-20 system), the C-2 vertebra, and Erb's point bilaterally, utilizing dermal abrasion. Stimulating needle electrodes were placed percutaneously over each median nerve, and SEP's were obtained prior to the induction of anesthesia. The SEP's were developed with a Nicolet Med 80 physiological monitor.* Electrode impedances were maintained at less than 2 kohm except for sterile needle electrodes which were about 3 kohms. Band-pass filters were 5 to 1500 Hz. A time period of 2 to 82 msec after stimulus was observed and 128 stimuli at a rate of 5.9/sec were accumulated and averaged. Anesthesia was induced with fentanyl, 25 µg/kg, followed by 0.15 mg/kg pancuronium. Throughout surgery, the mean arterial blood pressure (MABP) was maintained within 10% of control, and the PaCO2 maintained between 25 and 30 mm Hg.

Intraoperative Monitoring. The waveforms obtained by median nerve stimulation are shown in Fig. 1. Reproducible SEP's were obtained subsequently during positioning and initiation of surgery. The amplitude of the SEP over the right hemisphere was slightly but consistently less than that over the left hemisphere, with symmetrical wave latencies. After the surgical preparation the C4' (right hemisphere) electrode was replaced with a sterile needle electrode. During the initial parts of surgery, SEP's were obtained approximately every 5 minutes.

During the dissection of the aneurysm, which had an ill defined neck, bleeding developed in the area of the aneurysm and a temporary clip was applied to the MCA. A period of approximately 10 minutes elapsed in which no detectable changes were noted in the SEP (wave developed at 1053 hours as shown in Fig. 1). During that time, the SEP wave over the right hemisphere was developed approximately every 45 seconds. At the end of 10 minutes, the SEP over the right hemisphere deteriorated over approximately 2 minutes and became unrecordable (wave developed at 1056 hours, Fig. 1). The evoked response recorded at the level of the C-2 vertebra at that time in response to stimulation of the left nerve was unchanged in both amplitude and latency, indicating a failure of the right hemisphere along with integrity of the upper spinal region and suggesting a block between the brain stem and cortex. No change from the preclip recordings was noted in SEP's in response to stimulation of a right median nerve. The clip was quickly removed from the MCA and the SEP wave reappeared over the right hemisphere within approximately 45 seconds. The waveform demonstrated an amplitude similar to that prior to clipping, with an increase in the latency of the waves (waves developed at 1058 hours, Fig. 1). The conduction time from the C-2 vertebra to the right cortex was increased by approximately 20%, whereas the conduction time from the C-2 vertebra to the left cortex was unchanged. This asymmetry of the SEP's continued until the end of the procedure. Approximately 45 minutes after removal of the temporary clip from the MCA, a clip was applied to the aneurysm. At the time of clip application it was thought that a small perforating artery was included in the clip. No changes in SEP wave over either left or right hemisphere were

noted with aneurysm clipping. It should be noted that no changes in MABP or heart rate were observed during the period when the MCA was clamped or subsequent to removal.

Postoperative Course. The patient awakened promptly at the end of the procedure with a dense left hemiparesis. The only movement of the left side was weak hip flexion. Over the following 24 hours, the hemiparesis resolved almost completely, and SEP's obtained by transcutaneous stimulation of the median nerves showed symmetry of the SEP in both amplitude and latency, although the amplitude was decreased below the control level. Central conduction time was equal (C-2 vertebra to the right cortex, and C-2 vertebra to the left cortex). Over the following few days weakness in the left side completely resolved, and, at the time of this report, the patient's neurological examination is normal.

Discussion

This case is reported to demonstrate the association of changes in the SEP's and neurological function during aneurysm clipping. This technique represents a reversible ischemic event that is best explained by clipping of the MCA. Although this group of patients is at risk of ischemia due to arterial spasm and failure of autoregulation both prior to and during surgery as well as hypoperfusion during induced hypotension, these events seem less likely in this situation. Attempts to correlate EEG changes with neurological deficits during aneurysm surgery have been unsuccessful.14 This may be due either to diagnostic difficulties caused by anesthetic effects on EEG or to a subcortical site of injury. An increased conduction time of the SEP through the brain stem has been shown to correlate with brain stem dysfunction.9,19 Hence, the SEP might be useful in assessing such subcortical sites of injury. Although a clearly definable event precipitated the SEP changes, the literature suggests that diffuse physiological changes may cause similar changes in the SEP waveform.8

The prolonged time course before failure of the SEP occurred is longer than might be expected from results of experimental MCA clipping in animals.9 This is perhaps due to the moderately low temperature (35.5°C) of the patient as well as the reduced cerebral metabolic requirement for oxygen secondary to anesthesia. The correlation of return of SEP waveform to normal with improvement of neurological function is consistent with the findings in animal studies8,14 and in clinical studies performed shortly after head injury.11 It also suggests that if SEP monitoring is used to assess the effect of vessel occlusion during arteriovenous malformation surgery, as has been suggested,17 a prolonged period following temporary clipping may be necessary to demonstrate physiological alteration due to surgical intervention.

Recognition of exact time of SEP changes indicating neurological dysfunction resulted from the following: 1) direct communication between the surgical and anesthetia team; 2) a monitoring technique that allows rapid assessment of integrity of the stimulating system (Erb's point and the C-2 vertebra); and 3) waveform development over a short period of time (approximately 30 seconds).

Transient neurological dysfunction occurred in this patient despite reperfusion of the affected area within 2 minutes of the loss of evoked electrical activity. Technical limitations cause this minimum time in which abnormal waveforms can be developed, evaluated, and verified intraoperatively. Movement artifact or electrocautery could easily have slowed or prolonged the averaging processing, and prolonged the time to recognition of SEP abnormality.

Although it is unclear how long areas of the brain can survive lack of oxygen during anesthesia and mild hypothermia, the transient nature of this patient's neurological deficit suggests that impairment of oxygen delivery was significant. Animal studies have shown that the degree of ischemia necessary for disappearance of the evoked potential is less than that necessary for permanent neurological damage.1 This suggests that recognition of SEP changes may allow restoration of flow prior to onset of permanent neurological deficit.

The rapid disappearance of all recognizable waves (the N20-P23 complex) with preservation of the evoked potential in the upper spinal cord suggests that the block was probably in the area of the thalamus, which is considered to be the origin of the N20 wave.15 The prolongation of conduction time from the C-2 vertebra to the right cortex following clip removal, which persisted until the end of the operation, also supports a subcortical site of injury.

This observation has importance in several clinical situations. It demonstrates that ischemic events can be identified in the absence of hemodynamic changes. This patient also demonstrates that in anesthetized patients, functional changes associated with surgical intervention may take a longer period to develop than is suggested by animal studies.

References

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