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Somatosensory Evoked Potential Monitoring During Intracranial Surgery

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Summary

In the neurosurgical approach to intracranial aneurysms which are often accompanied by arterial spasm and cortical ischaemia, monitoring procedures aim to obtain useful information on cerebral function.

SEPs evoked by stimulation of the median nerve at the wrist and of the tibial nerve at the medial malleolus were registered in 45 patients with intracranial aneurysms during neurosurgical procedures.

Our results show SEP abnormalities during different stages of neurosurgical procedures in 36 patients out of the monitored 45. Significant abnormalities of SEPs with respect to the control group were decrease of the amplitude of N 20-P 25 complex, lengthening of the absolute latency of the waves N 20-and P 25 and lengthening of the central conduction time (CCT) (N 13-N 20).

The greatest SEP abnormalities were registered during the neurosurgical apporach to aneurysm and during the clipping procedure. However, the changes were reversible in the majority of the patients. The aim of this paper was to focus on early detection of some cerebral function disturbances during the neurosurgical procedure as well as the prevention of possible brain damage.

Keywords: Intracranial aneurysm; intra-operative monitoring; somatosensory evoked potentials; central conduction time.

Introduction

The development of brain ischaemia during surgery on an intracranial aneurysm may be a serious complication with unpredictable consequences. Any method which increase the safety of surgery is, therefore, of importance. One of such methods which enables us to assess function is the intra-operative monitoring of evoked potentials with different modalities.

Several investigators have applied the intra-operative monitoring of somatosensory evoked potentials (SEPs) as a method in the detection of function of cortical and subcortical structures of the brain[6, 8, 10, 11, 12, 19, 20, 21].

There are several factors (anaesthetics, blood pressure, body temperature, partial pressure of CO_2) that can significantly change neuro-electric signals primarily in EEG activities[13, 18]. Somatosensory evoked potentials are less sensitive to anaesthetics and other factors and they can be reliably applied in anaesthetized patients[5].

The intra-operative monitoring of SEPs markes it possible to control dysfunction of the sensory system from periphery up to the sensory cortex and corresponding structures. This dysfunction can be reversible, but if one does not correct it in time it will result in irreversible damage of the brain with severe neurological deficits[12]. For that reason this method can be useful in operative procedures.

We will present our experience with the intra-operative monitoring of SEPs dring intracranial aneurysm surgery.

Patients and Methods

Our group consisted of 45 patients who ranged from 35 to 68 years (mean 56 years). These patients underwent operation for clipping of 45 aneurysms. The most common location of aneurysms were on the middle cerebral artery (MCA-18) and the anterior communicating artery (ACoA-10) (Table 1). The pre-operative clinical grades were determined by Hunt/Hess classification. Ten patients were operated on in the first week after the initial bleeding, the rest of them later on. There were two deaths. One patient died on the second postoperative day after severe bleeding on the contralateral side of the aneurysm during the operation; the second one, with a giant internal carotid bifurcation aneurysm, died due to severe respiratory complications on the 30 th postoperative day. This patient had no new postoperative neurological deficit after temporary clipping of the main vessels during the operation. We also had a poor outcome in a patient with a giant (more than 6 cm long in size) internal carotid artery aneurysm who suffered long-lasting compressive effects with signs and symptoms of "the frontal lobe" and who improved slightly postoperatively but continued to be apathetic and indifferent with dulling of mental faculties.

Table 1. *The Classification of Patients According the Grading System of Hunt and Hess, Location of Aneurysms and Outcome of Patients*

N	Aneurysm cite	Grade at admission		Outcome	
				good	15
18	MCA	I-II	12	fair	2
		III	6	expired	1
10	ACoA	I-II	8	good	8
		III	2	fair	2
7	ICA	I-II	4	good	4
		III	3	poor	1
				expired	1
				fair	1
5	PCoA	I-II	5	good	4
				fair	1
3	Aophth.	I-II	3	good	3
1	PerA	I	1	good	1
1	BA	II	1	good	1

There were 34 patients in gr-I-II and 11 in grade III.

Good: means a normal patient or a patient with a minor neurological deficit which resolved completely after 3 months.

Fair: indicates a patient, who is ambulatory but has mild to moderate neurological deficit.

Poor: implies a patient with a permanent moderate to severe neurological deficit and poor mental faculties.

Abbreviations: MCA: middle cerebral artery; ACoA anterior communicating artery; ICA internal carotid artery; PCoA posterior comunicatiing artery; Aophth ophthalmic artery; Per.A pericallosal artery; BA basilar artery.

SEPs were registered simultaneously by stimulation of the median nerve at the wrist and of the tibial nerve at the medial malleolus. In every patient the registration of SEPs was done before induction anaesthesia, during anaesthesia itself and during the operation by surface silver electrodes. The stimulation intensity of 20 mA square waves of 0.2 msec duration were applied with filters of 30 and 3 000 Hz. The times of analysis were 50 and 100 msec after simulation. There were 256 responses on the average. Recording electrodes were placed over the surface of the spine at C 7 and at the appropriate position of the scalp (C 3/C 4) which corresponds to the right and left somatosensory regions. The reference electrode was at Fz point according to International 10 – 20 system.

During the intra-operative monitoring the poststimulus latencies of N 13, N 20 and P 25 waves were analysed as well as the central conduction time (CCT) and the amplitude of the cortical evoked response N 20-P 25. Decrease in the amplitude of more than 50% in relation to the standard value was taken as abnormal.

Results

The majority of our patients were in grades II and III[34] (Table 1): most of them had MCA and ACoA aneurysms: good outcomes were achieved in 36 patients, fair in 6, poor in one, and 2 patients died.

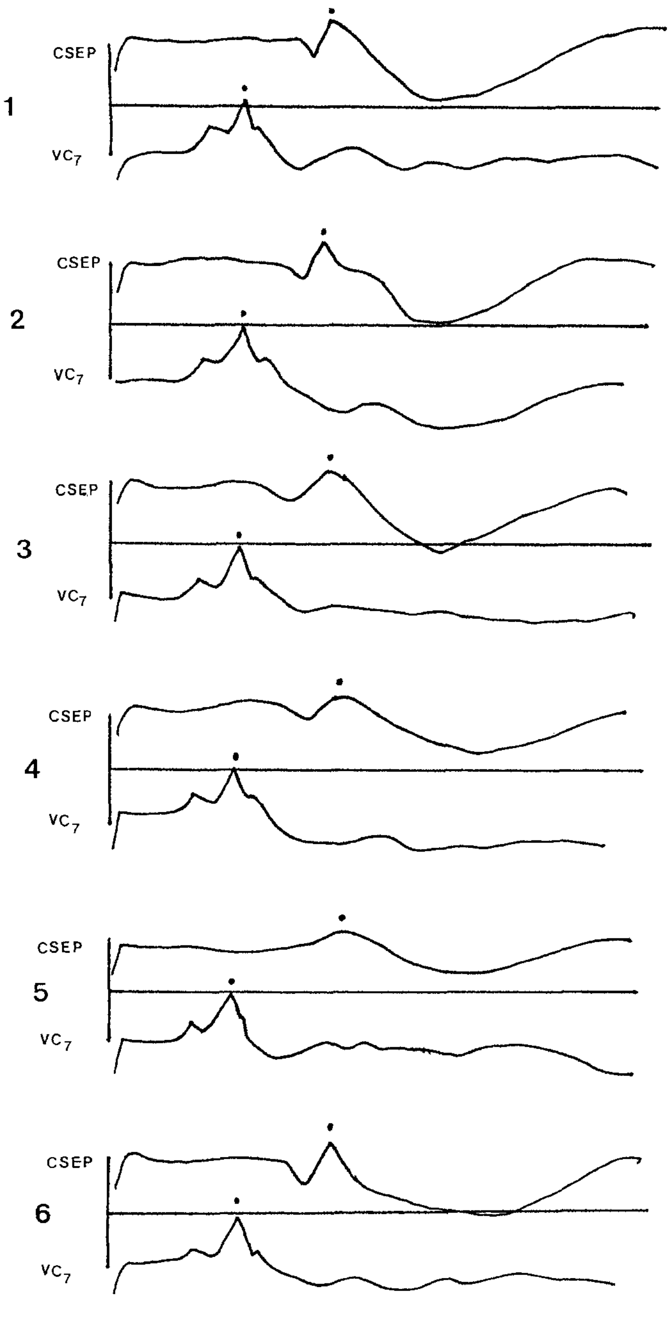


Fig. 1. Cortical and the spinal SEP with stimulation of the median nerve during operation of the ICA aneurysm. 1) Cortical (above) and spinal (below) SEP before the operation. BR-130/70 mmHg. CCT-5.9 ms. 2) Cortical and spinal SEP during anaesthesia. BP 120/80 mmHg. CCT-5.9 ms. 3) Cortical and spinal SEP during brain retraction. BP 120/80 mmHG; CCT-7.9 ms. Further decrease in the amplitude of wave N 20 and increase of its latency. 4) Cortical and spinal SEP before clipping the aneurysm. CCT-7.9 ms. The lowering of N 20 wave and the further increase of latency. 5) Cortical and spinal SEP after clipping of the aneurysm BP-110/70 mmHG. CCT-8.5 ms. Almost unmeasurable N 20 wave. 6) Cortical and the spinal SEP at the end of operation. BP-120 /80. CCT-6.4 ms. The recovery of the amplitude and the reduction of the latency of the cortical N 20 wave. The time of registration (for all parameter) was 50 ms, the amplification was 20 microV. Abbreviations: BP-blood pressure; CCT- central conduction time

There was increase of the poststimulus latency of N 20-P 25 waves, decreased amplitude of the complex N 20-P 25 and prolongation of the CCT during opening, brain retraction, the clipping of the aneurysm and during the periodic drop of blood pressure (Fig. 1). Statistically significant changes in SEPs were monitored especially during brain retraction and the clipping of the aneurysm (Table 2). No changes were registered in 8 patients (in 3 with an ACoA aneurysm and in one patient each with basilar, ophthalmic and pericallosal artery aneurysm). Technical difficulties were encountered, in a patient with a giant internal carotid bifurcation aneurysm who died on the 30 th postoperative day. We were not able to monitor SEP satisfactorily in this case.

In all patients with SEP changes drop in amplitude of waves fell below the standard value. In patients with poor and fair outcomes as well as in patient who died the greatest drop in amplitude (50 – 80%) was registered (Gr. 1). On the other hand, the drop in amplitude was reversible and without postoperative sequelae in patients with good outcome.

Prolongation of CCT of 0.2 – 2.4 msec was registered in 19 patients. Irreversible prolongation of CCT of 2.4 msec was found in the patient who had a poor outcome and in the second patient who died on the 2 nd postoperative day. Transient changes of CCT were registered in 17 patients with good or fair outcomes: 6 patients with fair outcome and prolongation of CCT between 1.3 – 2.2 ms, and 11 patients with good outcome and prolongation of CCT between 0.2 – 1.2 ms (Gr. 2).

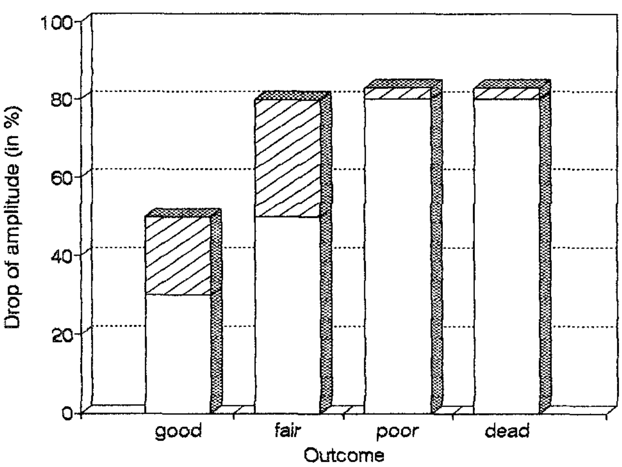
The greatest drop in amplitude and the longest prolongation of CCT of 2.4 ms were registered in patients who died and in the patiens who had a poor outcome. On the other hand the least drop in amplitude and prolongation of CCT between 0.2 – 1.2 ms were registered in patients with good outcome (Gr. 3).

Prolongation of poststimulus latency of N 20 and P 25 waves was registered in 31 out of 36 patients.

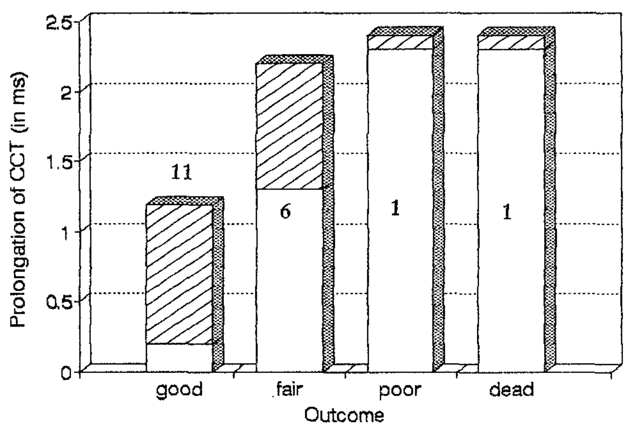
Table 2. *The Findings of SEPs Before and After Clipping of the Aneurysm*

SEP parameters	Before clipping	After clipping	P
N 13	14.3 ± 1.66	14.08 ± 1.58	P < 0.01
N 20	21.54 ± 2.40	22.84 ± 2.70	P < 0.02
P 25	25.86 ± 3.06	27.16 ± 3.22	P < 0.01
CCT	5.9 ± 0.70	8.3 ± 0.98	P < 0.01
N 20-P 25	2.07 ± 1.82	1.61 ± 1.74	P < 0.01

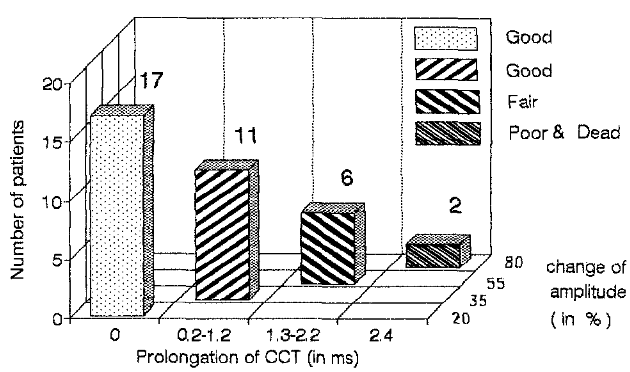
(Mean ± 2 SD in msec. "Peak-to peak" amplitude N 20-P 25 in mV).



Gr. 1. Outcome against amplitude change



Gr. 2. Outcome against prolongation of CCT (in ms)



Gr. 3. Outcome against amplitude change and the prolongation of CCT

Changes were most evident during brain retraction and after the clipping of aneurysms in 7 out of 31 patients, who belonged to all three groups.

Transient occlusion of the main vessel was used in 10 patients. In the majority of them (8) the duration of the occlusion was short, lasting for 2–5 min, with no obvious SEPs changes. In one patient (mentioned above) we had technical difficulties. In the other one, with a giant internal carotid aneurysm, the temporary occlusion lasted for more than 15 min and the drop in amplitude and the prolongation in CCT was evident after 5 min of the application of the temporary clip and disappeared 30 min after the clip release.

Gradual loss of the cortical evoked response in the opposite hemisphere was recorded in one patient who died 48 hours after the operation. The autopsy revealed a large intracerebral haemorrhage on the contralateral side from the bleeding aneurysm (Fig. 2).

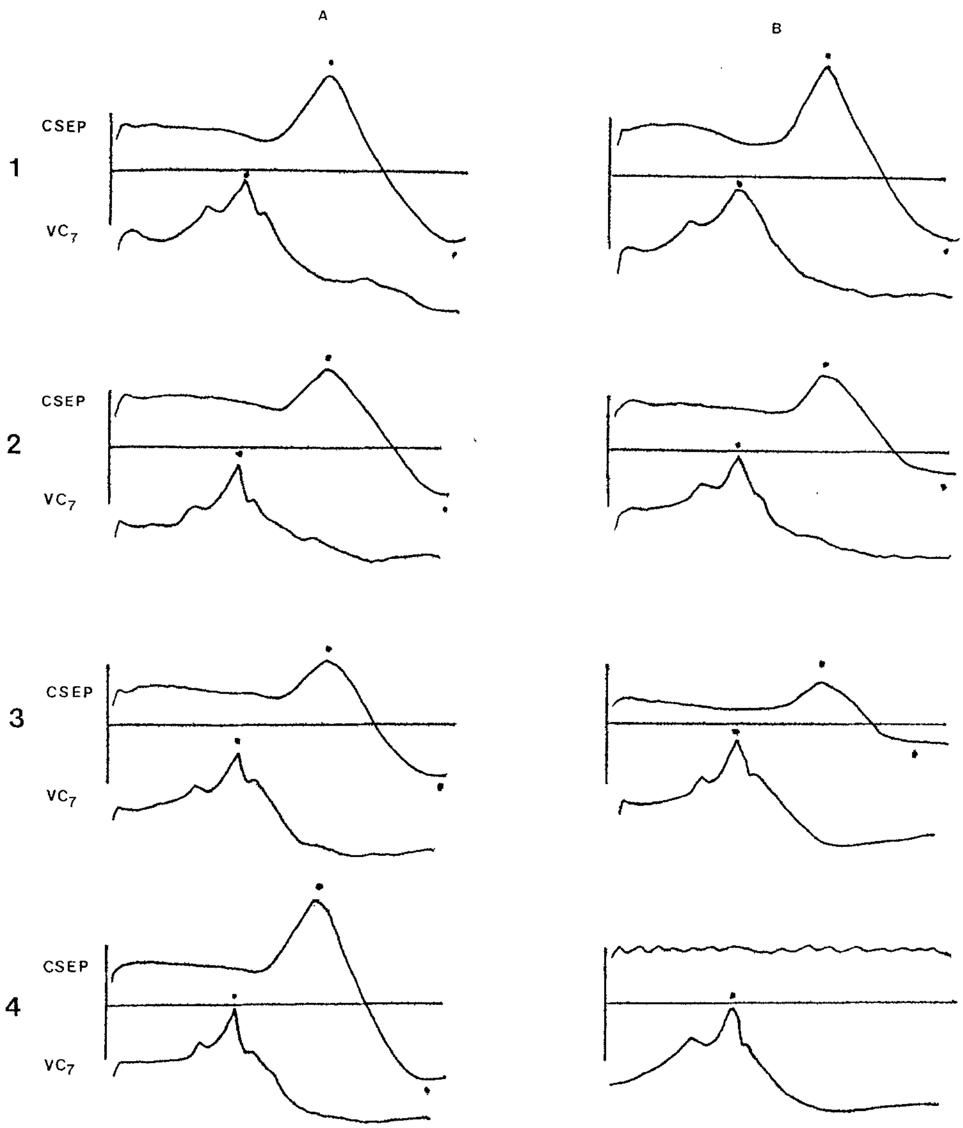


Fig. 2. Cortical and spinal SEP during stimulation of both sides during a left ICA aneurysm operation. A) SEP during stimulation of the right median nerve. B) SEP during the stimulation of the left median nerve. 1) Cortical (above) and spinal (below) SEP with CCT A-5.9 ms; B-5.4 ms. 2) Decrease of the amplitude of the cortical N 20-P 25 waves and increase of CCT. A-6.5 ms; B-6.1 ms. 3) Further drop in amplitude and prolongation of CCT, more obvious at the left median nerve. CCT A-6.8 ms; B-6.4 ms. 4) Increasing of amplitude of N 20-P 25 waves during stimulation of the right median nerve. A-CCT 6.0 ms. Complete loss of the cortical response during left median nerve stimulation. B.

Discussion

The introduction of intra-operative monitoring of some modalities of evoked potentials especially SEPs has significantly reduced the incidence of neurological complications in neurosurgery in the last few years.

Our experience with intra-operative monitoring of SEPs in aneurysmal surgery has shown that SEP changes have appeared in different stages of neurosurgical procedures especially during brain retraction and immediately after the clipping of the aneurysm, in agreement with others[4, 8, 19, 20, 21].

There have been several studies clearly showing that SEPs are signficant indicators of central nervous system (CNS) function in cerebral ischaemia[7, 8, 9, 20]. The routine use of temporary vessel occlusion in aneurysmal surgery unequivocally demands intra-operative monitoring of cerebral function, especially in transient occlusion of the internal and middle cerebral arteries. In such cases the "far-field" potential of SEPs represents a very important control over the function of cortical and subcortical structures of the brain.

According to studies by Russ *et al.* (1985) and Grundy *et al.* (1985) irreversible changes of SEPs during cerebrovascular surgery were always followed by severe postoperative deficits. In one case we had a complete loss of SEPs signal on the contralateral side which was confirmed by the CT to be due to a large intracerebral haematoma on the opposite side from the aneurysm. In one patient with poor outcome and death there were no SEPs changes which can be explained by the postoperative course. Technical difficulties were encountered in a patient with a giant internal carotid bifurcation aneurysm and so we were not able to record SEP changes properly on the right hemisphere where the aneurysm was.

On the basis of our findings we would say that the amplitude is the most sensitive parameter and was found to change in 36 out of 45 cases. Drops in amplitude of the cortical evoked response of N 20-P 25 were 30 − 80% in relation to the standard value especially during brain retraction and after aneurysmal clipping. Fava *et al.* (1988) found similar changes, but Symon *et al.* (1989) stressed that amplitude changes were of less reliability and they preferred to use latency changes of CCT as their specific monitor. On the other hand, in our material the CCT changes were less sensitive (they were found in 19 out of 36 patients). Our suggestion would be that the amplitude of the cortical response is a more reliable indicator in relation to CCT in newly developed ischaemia of cortical and subcortical brain structures.

The loss of cortical evoked response was not recorded on the aneurysmal side in any of our cases but was found in the opposite hemisphere in a patient who died due to unexpected cerebral haemorrhage involving the opposite hemisphere. This finding stresses the sensitivity of the method and the need for monitoring of both hemispheres.

Conclusions

1. Changes of SEPs were monitored during the different stages of operation, especially during brain retraction and after the clipping of aneurysms.
2. All parameters of SEPs did not show the same grade of sensititivy. The most sensitive parameters were the amplitude and CCT.
3. There is a good correlation between the SEPs changes, the postoperative clinical findings and outcome.
4. The intra-operative monitoring of SEPs is a very sensitive, highly specific and safe method.
5. Thanks to the procedure and its influence on the operation, the possibility of undetected brain damage is much reduced.

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