MONITORING OF BRAINSTEM AUDITORY EVOKED POTENTIALS DURING BASILAR ARTERY OCCLUSION IN MAN

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Since posterior fossa operations in the vicinity of the brainstem may be complicated by compression and ischaemia of the brainstem (Drake, 1981), the intraoperative monitoring of brainstem function is desirable. Although cardiovascular and respiratory signs have been used as indicators of the functional state of the brainstem during surgery, these reflect medullary activity alone and are modified by anaesthetic agents. Likewise, monitoring EEG activity is inadequate; it is influenced by anaesthetic agents and provides information on cortical rather than brainstem function.

Brainstem auditory evoked potentials (BAEP) are electrophysiological responses generated from stimulation of the auditory nerve. They provide information on the functional integrity of the auditory nerve pathway through the brainstem (Grundy et al., 1982; Raudzens, 1982; Grundy, 1983). With vascular decompression procedures such as the Jannetta Procedure for hemifacial spasm, Raudzens (1982) and Grundy and colleagues (1982) have demonstrated a good correlation between intraoperative changes in BAEP and postoperative VIIIth nerve function. During global brainstem ischaemia, which may occur during vascular occlusion of the vertebrobasilar system, or during extreme induced hypotension, monitoring of changes in BAEP may reasonably reflect, not just the integrity of the VIIIth nerve, but the well-being of the brainstem. We report on our experience with intraoperative monitoring of BAEP for this purpose in three patients who underwent craniotomy for aneurysms of the posterior circulation.

**SUMMARY**

Brainstem auditory evoked potentials (BAEP) were recorded during surgery as a monitor of brainstem function in three patients undergoing posterior fossa surgery for clipping of basilar aneurysms. In two patients, ligation of the basilar artery, and of a vertebral artery, was associated with deterioration in BAEP and resulted in postoperative brainstem dysfunction. In the third patient, postoperative transient neurological dysfunction occurred following temporary occlusion of the basilar artery and this correlated with intra- and postoperative changes in BAEP. BAEP monitoring is recommended where temporary or permanent occlusion of the vertebrobasilar system is planned.

**PATIENTS AND METHODS**

**Methods of recording BAEP**

BAEP was recorded from vertex (Cz) in reference to the right or left ear lobes (A1 or A2) using silver-silver chloride disc electrodes anchored with collodion. To avoid cross contamination, disposable plastic ear inserts connected to transducers were used to deliver the auditory stimuli. Whenever possible, BAEP was recorded before the induction of anaesthesia and then continuously during the surgical procedure. The evoked potentials were recorded with a Nicolet CA 1000 averager and all tracings were replicated.

Electrode impedances were maintained at less than
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3 kΩ and at least 1000 sweeps were averaged. Monaural alternating clicks were delivered to the ear ipsilateral to the surgical site at an intensity of 60 dB above the patient’s hearing threshold with contralateral masking of 30 dB above threshold at a rate of 21.1 Hz. Bandpass filters were set at 150–1500 Hz. In all three patients, anaesthesia was induced with thiopentone, fentanyl and nitrous oxide (in oxygen), and maintained with isoflurane and nitrous oxide in oxygen. Hypotension was achieved with an infusion of sodium nitroprusside in two patients and with increasing concentrations of isoflurane in the third patient (Lam and Gelb, 1983). Throughout the operative procedure, body temperature was maintained between 35 and 36°C using a thermal blanket and the end-tidal carbon dioxide tension between 30 and 34 mm Hg as monitored by an infra-red analyser.

Reproducible BAEP were obtained in all instances. Contralateral recordings were obtained whenever changes were seen on the side ipsilateral to the surgical wound. All patients had normal hearing thresholds before the operation. For reason of clarity, most tracings in the figures are not shown in duplicate.

CASE REPORTS

Patient 1

A 33-year-old female of Jehovah’s Witness faith presented with a history of coma producing subarachnoid haemorrhage as a result of a mid-basilar artery aneurysm. She had no neurological deficits before operation. Normal BAEP were obtained following the induction of anaesthesia. Spontaneous ventilation was allowed during the procedure and utilized as an additional monitor of brainstem function (Sellery, Aitken and Drake, 1973). To facilitate dissection of the aneurysm, mean arterial pressure (MAP) was decreased from 85 to 35 mm Hg with an infusion of sodium nitroprusside. The decrease in arterial pressure was immediately accompanied by a distortion of the BAEP waveforms with loss of IV–V complex, indicating possible brainstem ischaemia (fig. 1). MAP was then increased and the waveforms returned towards a normal configuration. A temporary clip was placed across the basilar artery and this caused a similar deterioration in the BAEP. The clip was removed and further dissection caused bleeding from the aneurysmal sac. The decision was then made permanently to occlude the basilar artery, since the patient was unwilling to accept blood transfusion. With application of the permanent clip, the BAEP again deteriorated with complete loss of IV–V complex and the patient’s respiratory rate increased from 24 to 35 b.p.m. Gradual improvement in the waveforms occurred over the next 5 min, but at the end of the procedure the latency of the IV–V complex remained prolonged. Upon emergence from anaesthesia, the patient was alert and orientated, but had a mild right hemiparesis, bilateral VIth nerve palsy and a mild right VIIth paresis. The bilateral VIth nerve palsy was felt to be secondary to a pontine infarct.

Patient 2

A 45-year-old right-handed male suffered numerous transient cerebral ischaemic attacks as a result of a giant aneurysm at the vertebral–basilar junction. Although he had no preoperative neurological deficit, the BAEP waveforms showed...
an increase in latency of all peaks, indicating delayed brainstem conduction. (Peak V occurred at 7.72 ms; the upper limit of normal during isoflurane anaesthesia is 7.0 ms in our institution.)

As in the first patient, brainstem function during surgery was additionally monitored by the assessment of the pattern of spontaneous respiration. Following lumbar drainage of cerebrospinal fluid and the positioning of retractors the waveforms deteriorated, with a decrease in amplitude and an increase in latency of all peaks (fig. 2). Within 1 min of basilar artery occlusion with a clip, the patient became apnoeic, although no further deterioration in evoked potentials was seen. The clip was removed and then placed across the right vertebral artery. The BAEP remained abnormal at the end of the procedure (fig. 2). In the postoperative period the patient required airway and ventilatory support and was dysphagic with complete absence of laryngeal reflexes. Subsequently, he was discharged with a permanent tracheostomy, the gag reflexes remaining absent.

**Patient 3**

A 50-year-old female presented with an aneurysm at the bifurcation of the basilar artery. Before clipping of the aneurysm, she had mild confusion with no localizing signs. Satisfactory BAEP were recorded before and following the induction of anaesthesia. Application of the retractors caused an increase in latency of all peaks. MAP was decreased from 75 to 40 mm Hg by increasing the inspired isoflurane concentration to approximately 2.5% (Lam and Gelb, 1983). Immediately there was gross distortion and flattening of the BAEP waveforms (fig. 3A). MAP was then increased to 65 mm Hg and the BAEP reappeared within 1 min. Five minutes later, hypotension was again induced. Further dissection was difficult and again the BAEP became unrecordable for a period of 5–6 min. Utilizing temporary occlusion of the basilar artery, the neck of the aneurysm was clipped successfully. MAP was increased to 70 mm Hg, retractors were withdrawn from the surgical field and the BAEP waveforms started to return towards a normal configuration. However, at the end of the procedure, they remained abnormal with the latency of the IV–V complex very much prolonged from its awake control value (fig. 3B).

Recovery from anaesthesia was extremely slow; the patient was drowsy and demonstrated a mild quadriplegia and bilateral IIIrd nerve palsy. Her condition was remarkably improved at 36 h when she became lucid and orientated. At this time a repeat recording of BAEP was shown to be normal and similar to that obtained while the patient was awake before the operation.

**DISCUSSION**

Previous reports have demonstrated the potential use of intraoperative BAEP monitoring during posterior fossa surgery (Hashimoto et al., 1980; Little et al., 1983). These three patients further demonstrate the utility of intraoperative BAEP monitoring to predict and, possibly, to prevent brainstem dysfunction in complicated neurovascular procedures when temporary or permanent occlusion of the vertebrobasilar system may be necessary. In the first two patients, spontaneous breathing was also allowed and utilized as an additional means of monitoring brainstem function. In both patients, changes in respiratory pattern were preceded by changes in BAEP waveforms. Thus, it appears that BAEP may be a more sensitive monitor of brainstem function. More interestingly, in the second patient, although changes in BAEP preceded changes in respiratory activity, the onset of complete apnoea was not accompanied by
further deterioration in BAEP. This is not entirely surprising, since the auditory nerve enters the brainstem at the pontomedullary junction and the pathway is more diffuse in nature compared with the respiratory centre which is situated lower in the medulla. Observations in these two patients suggest that, although BAEP monitoring may be more sensitive, the additional monitoring of respiratory activity may be valuable when deterioration in the former occurs.

In the first two patients, although changes in BAEP were clearly observed, there was no appropriate intervention therapy because of the nature of the lesion. The resultant postoperative neurological deficits confirmed the predictive value of the intraoperative changes in BAEP. Although the neurological deficits were not prevented, the changes at least warned the anaesthetist of potential problems in the immediate recovery period, and indicated that extra supportive care might be required.

In the third patient, changes in BAEP were evident simply with a decrease in systemic arterial pressure, suggesting that the lower threshold of autoregulation had been exceeded. This is not surprising, considering the presence of the retractor in the proximity of the brainstem, the pressure under which can be considerable but not monitored. Because of the changes in BAEP, attempts were made to increase the arterial pressure to a higher value and the retractors were immediately withdrawn upon application of the clip across the aneurysm. Despite these efforts, the BAEP remained abnormal at the end of the procedure and this again correlated with postoperative neurological dysfunction. Thirty-six hours later the clinical status improved, as did the BAEP. Thus there was an excellent correlation between the electrophysiological monitoring and the clinical condition. It further suggested that the changes observed during the procedure were ischaemic in nature and that, had the arterial pressure been allowed to remain at the lower value for a longer period of time, the patient may have suffered permanent rather than transient neurological dysfunction. One may argue that the changes observed during isoflurane-induced hypotension may be artefacts resulting from the effect of isoflurane. However, previous work in our laboratory in human volunteers has demonstrated that the effect of isoflurane on BAEP is self-limiting, and that the waveforms can be recorded clearly even at an end-tidal concentration of 2% (Manninen, Nicholas and Lam, 1984).

Thus, we have demonstrated the utility of intraoperative monitoring of BAEP as a monitor of brainstem function during high-risk neurovascular procedures in the posterior fossa. In order to interpret the changes occurring during surgery, the body temperature and the end-tidal carbon
dioxide tension should be maintained within as narrow a range as possible. Other factors such as age and sex, which may influence the latency of the peaks, are not important factors for this purpose, as each subject acts as his own control (Stockard, Stockard and Sharbrough, 1978). When deterioration in BAEP is observed, depending on the nature of the surgical procedure, either interventional therapy in the form of increasing the arterial pressure or alternative surgical therapy can be planned. Such monitoring may help to improve patient safety during high-risk procedures in the posterior fossa.

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REFERENCES