THE AUDITORY EVOKED RESPONSE AS AN INDICATOR OF AWARENESS


Previous studies using the auditory evoked response (AER) to investigate depth of anaesthesia [1,2] demonstrated changes in the early cortical AER with increasing concentrations of anaesthetic agents. These studies began with a background anaesthetic of 70% nitrous oxide in oxygen. Immediately after induction of anaesthesia and tracheal intubation, a period which is associated with a risk of awareness, the AER displayed a characteristic pattern. This consisted of three positive waves occurring between latencies of 15 and 100 ms. These correspond with the waves Pa to Pc [3]. Adding the test anaesthetic increased the latencies of the waves to the extent that only two were recorded in the same time window. Deepening the anaesthetic further reduced amplitudes and increased latencies.

Using discriminant function analysis on the various latencies and amplitudes in 36 patients studied previously, the latency of the early cortical wave Nb emerged as the best feature distinguishing the “three wave” AER pattern (Nb latency less than 44.5 ms) from the “two wave” pattern (Nb latency greater than 44.5 ms). In these previous studies, no attempt had been made to elicit a response, as the patients were paralysed and subsequently anaesthetized deeply, and had no recall afterwards. This does not preclude the possibility that the patients were aware or very lightly anaesthetized when the three high amplitude waves were seen.

In the present study, we used Tunstall’s isolated forearm technique [4], together with the AER, to test the hypothesis that Nb latencies of less than 44.5 ms are associated with very light anaesthesia and awareness.

METHODS AND RESULTS

The study had Hospital Ethics Committee approval. Seven elective surgical patients agreed to be studied in a period after induction of anaesthesia and before surgery. The aims of the study and the use of the isolated forearm method to detect awareness were explained fully.

Premedication with morphine and atropine was given 1 h before anaesthesia, which was induced with sodium thiopentone i.v. and maintained by
70% nitrous oxide in oxygen. A pneumatic tourniquet on the dominant arm was inflated to a value greater than systolic arterial pressure and pancuronium or vecuronium was given via the other arm, for tracheal intubation [4]. At 2–3 min intervals the patient was asked to squeeze and release the investigator’s fingers (an unequivocal response).

Corresponding AER recordings were made in response to clicks (Telephonics TDH 39P Headphones, 6 Hz, 70 dB above the average hearing threshold) using silver–silver chloride electrodes (mastoid with vertex as a reference). The signals were amplified by 100 dB at a frequency response of 25–3600 Hz using purpose-built amplifiers. The EEG signals were recorded on FM tape for subsequent analysis using a Datalab DL 4000 averager.

The concentration of nitrous oxide was reduced gradually to 50% (inspired) or until there was a response, whichever happened first. At that point 1–2% inspired enflurane was given. Readings were continued until the start of surgery.

In patients Nos 1–4 there was an initial period in which no patient movement occurred, followed by a positive movement on command. This constituted an unambiguous end-point (fig. 1). Responses were seen in patients only when Nb latency was 44.5 ms or shorter. After a volatile agent was added to the anaesthetic, patients no longer responded and the Nb latencies increased above the 44.5-ms threshold.

Patients Nos 5–7 gave equivocal responses. For example, patient No. 5 developed hand clenching approximately 7 min after induction of anaesthesia (previously giving no response to command). The Nb latency at the time was less than 44.5 ms, and when the inhalation agent was added it increased above this value and the clenching ceased. Hand movements occurred immediately following induction of anaesthesia in patients Nos 6 and 7. In these two, most of the Nb latencies recorded were less than 44.5 ms. In patient No. 6 the inhalation agent did not change Nb latency. Although patient No. 7 responded only once, clinically his anaesthesia became progressively lighter, and both arms moved at the point indicated in the figure by an asterisk, at which point the inhalation agent was given. On recovery, none of the patients remembered any event following induction of anaesthesia.

**COMMENT**

The data of patients Nos 1–4 demonstrated an association between short Nb latency and awareness. Patients Nos 5–7 demonstrated signs of light anaesthesia (some arm movements did occur) also at Nb latencies less than 44.5 ms. Considering the limitations of the clinical situation and the
problems with the isolated forearm technique described below, the results lead us to conclude that there are characteristic patterns in the AER which indicate potential awareness.

When applying this technique to monitor patients during elective Caesarean section, the authors (who had no control over the anaesthetic) found few positive responses using the isolated arm technique. Following delivery, Nb latencies of less than 44.5 ms, suggesting awareness, were seen almost always in patients anaesthetized with nitrous oxide, oxygen and morphine. In others who received enflurane, Nb latencies invariably exceeded 44.5 ms.

Our findings are in line with those of Russell [5] who showed that 44% of patients anaesthetized with nitrous oxide and fentanyl alone showed positive or equivocal responses during isolated arm testing, compared with only 7% in patients receiving an infusion of etomidate. He has also suggested [6] that the isolated forearm technique may underestimate the incidence of awareness because, even when electrical nerve stimulation showed that a response should be possible, some patients wished to respond but were unable to.

A characteristic AER pattern identified by Nb latencies less than 44.5 ms was associated with both a high incidence of responses of the isolated arm to verbal command, and with very light anaesthesia. Further studies are necessary to develop the technique of AER pattern recognition and to allow on-line analysis if it is to provide a clinical indicator of awareness.

REFERENCES