DEPRESSION OF CORTICAL SOMATOSENSORY EVOKED POTENTIALS BY NITROUS OXIDE

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Sensory evoked potentials are used in some centres to monitor patients whose major nerve tracts are at risk during surgery. Such monitoring may be valuable during central nervous system surgery or the operative correction of scoliosis. Many of these operations are conducted with a narcotic-based anaesthetic, which includes the use of nitrous oxide. Nitrous oxide depresses midbrain and cerebral evoked responses to dental pulp stimulation (Haugen and Melzack, 1957; Benedetti et al., 1982) and cortical responses to auditory stimulation (Lader and Norris, 1968, 1969; Fenwick et al., 1979; Harkins et al., 1982). It is possible that the effects of nitrous oxide and narcotics combine to decrease the somatosensory evoked responses (SSEP).

This study measured SSEP during skin closure, when nitrous oxide was added to the inhaled gases of patients undergoing central nervous system or spinal surgery under a narcotic-based anaesthetic.

PATIENTS AND METHODS

Intraoperative SSEP monitoring was used in the care of 90 consecutive patients (ASA class II–III) during spinal cord, posterior fossa, or supratentorial surgical procedures. The records of these patients were evaluated and 44 were chosen for study by the exclusion of those in whom nitrous oxide was not used, or in whom other factors could have altered the SSEP (technical problems were encountered, there were changes in ventilation, temperature or arterial pressure, or other anaesthetics were administered). The study was conducted with approval from the Northwestern Memorial Hospital Institutional Review Board.

Patients and anaesthesia

All patients were anaesthetized similarly, using a narcotic-based, relaxant technique. Premedication was with atropine or hyoscine 0.4 mg i.m. sometimes supplemented with morphine 0.05–0.15 mg kg\(^{-1}\) by mouth 45–60 min before surgery. After pretreatment with pancuronium 0.02 mg kg\(^{-1}\), anaesthesia was induced with thiopentone 3–5 mg kg\(^{-1}\) and a loading dose of fentanyl 10–20 \(\mu\)g kg\(^{-1}\). Sterile subdermal needle electrodes were inserted over the posterior tibial nerve (PTN) at the ankle, or the median nerve (MN) at the wrist and the constant current necessary to produce a motor response established.
(motor threshold). Additional pancuronium (to a total of 0.1 mg kg\(^{-1}\)) was given and the trachea intubated. The patients were ventilated with 100% oxygen in a low flow (0.7–1.0 litre min\(^{-1}\)) semi-closed circle system. Additional fentanyl (to a total of 20–50 \(\mu\)g kg\(^{-1}\)) and pancuronium were administered as required. Usually, an inhalation agent (halothane, enflurane or isoflurane) was administered at an inspired concentration of 0.25 MAC during surgical manipulation. Nitrous oxide, at an inspired concentration of 50%, was commenced during skin closure and at least 30 min after cessation of the inhalation agent. The fresh gas flow rate was increased to 2–4 litre min\(^{-1}\). The SSEP chosen for analysis were recorded before the introduction of nitrous oxide and after the establishment of a new steady state during the 7–10th min of exposure to 50% nitrous oxide. Neither deep body temperature nor end-tidal carbon dioxide concentration altered during the study period.

**Recording of evoked potentials**

Stimulation of the median or posterior tibial nerves was with a 300-ms square wave at 5.4 Hz using a constant current at least 2 mA above the predetermined motor threshold. The cortical evoked potentials were recorded using sterile subdermal needle electrodes. The active recording electrode was placed over the contralateral hand area (2 cm posterior to \(C_a\) or \(C_4\) of the international 10–20 system) or foot area (midline 2 cm posterior to \(C_z\)) for MN and PTN, respectively. Both types used a reference subdermal electrode placed in the midline on the forehead (\(F_r\)) and a silver–silver chloride ground electrode on the shoulder. The resulting electrical response from 250–500 stimulations for 50 ms (MN) or 100 ms (PTN) following the stimulus were amplified, filtered and digitized using a Nicolet CA 1000 signal averager. Bandpass filtration was set between 5 and 1500 Hz (PTN) or 5 and 3000 Hz (MN). Data were plotted so that a relative positivity at the active electrode caused an upward deflection.

The latency of the major cortical peak (recorded as negativities at about 25 ms for MN and 45 ms for PTN) was derived as the time (ms) from stimulus to maximal amplitude of the peak. Peak amplitude was measured as the difference (\(\mu\)V) between this peak and the preceding peak of opposite polarity. The latency and amplitude information were determined once the peaks were stable before and after nitrous oxide administration. The data were analysed using least squares linear regression. The null hypothesis was rejected when \(P < 0.05\) using the paired t test.

**RESULTS**

Nitrous oxide produced a consistent decrease in the amplitude of the cortical SSEP. Figure 1 shows serial recordings taken from single limb stimulation of the posterior tibial nerve. In this patient, as in the others, nitrous oxide produced a marked decrease in amplitude of the SSEP recording, which recovered with discontinuation of the nitrous oxide. Except for transient alterations in latency during skin closure, the latency of the negative peak remained essentially unchanged.

The steady state cortical amplitudes before and after nitrous oxide administration.
after the inhalation of nitrous oxide in all 44 patients are shown in figure 2. Using data for all the patients, linear regression analysis (table I) gave the equation \( y = 0.56x - 0.04 \) \((r = 0.88)\) where \( y \) is the amplitude of the SSEP after inhalation of nitrous oxide and \( x \) represents the amplitude before the inhalation. Comparison of values before and after nitrous oxide using the paired \( t \) test revealed a significant decrease in amplitude \((P < 0.01)\).

Latencies before nitrous oxide were 45.9 ms ± 2.7 ms (SD) (PTN, range 41.0-49.5) and 22.3 ms ± 2.0 ms (SD) (MN, range 20.0-26.2). During nitrous oxide administration latency increased in 17 patients, decreased in 18 and was unchanged in nine. There was no statistically significant difference in latency before and after the administration of nitrous oxide.

**Discussion**

A significant decrease in the amplitude of SSEP occurred when 50% nitrous oxide was administered during a narcotic-oxygen-relaxant-based anaesthetic for surgery of the central nervous system. The steady response data (fig. 2) suggest that 50% nitrous oxide decreased the amplitude of the measured waves by approximately half, whatever the control voltage. If other known causes of changes in evoked potential occurred during the study period, data from that patient were excluded. Thus end-tidal carbon dioxide concentration, rectal temperature and arterial pressure were unchanged. No narcotic had been administered in the previous hour and volatile inhalation agents had been discontinued for at least 30 min. The concentration of these agents would be expected to be declining slowly and to be associated with a slow increase in amplitude rather than the decrease seen coincident with the administration of nitrous oxide. Other causes of alteration include the effects of surgical stimulation. Skin closure has not been reported to cause a decrease in amplitude and it is unlikely that such an acute deterioration would occur as a consequence of surgical manipulation. Thus the change seen in this study coincident with the administration of nitrous oxide is unlikely to be the result of physiological, other anaesthetic or surgical factors.

These results are similar to those of studies which examined the effect of the inhalation of nitrous oxide on cortical evoked responses and demonstrated a dose-related, linear decrease in amplitude. Lader and Norris (1968, 1969) found nitrous oxide-related decreases in amplitude of cortically (50-130 ms) derived evoked potentials from auditory responses. Jarvis and Lader (1971) and Fenwick and colleagues (1979) found similar decreases in the amplitudes of cortical responses (100-300 ms) attributable to nitrous oxide. Other studies using electrical stimulation of the dental pulp and recording of cortical responses (100-250 ms) also showed a reduction in amplitude. As in this study, previous studies (Fenwick et al., 1979; Benedetti et al., 1982), have demonstrated a reduction in amplitude of approximately 50% when concentrations of nitrous oxide approached 50%.

These data suggest that nitrous oxide and narcotics are additive in depressing intraoperative SSEP during nitrous oxide-narcotic-relaxant anaesthesia. In this study, acute alterations in the
nitrous oxide concentration in the absence of major changes in the narcotic delivery altered the SSEP. Previous studies have indicated that the effect of nitrous oxide is dose related. Pathak, Brown and Cascorbi (1982) and Pathak and others (1983) have shown that SSEP amplitudes varied coincidentally with the bolus administration of narcotics during a nitrous oxide–narcotic anaesthetic when the inspired concentration of nitrous oxide was held constant. This suggests that the maintenance of constant inspired concentrations of nitrous oxide as well as of narcotic concentration may be necessary to minimize changes in SSEP amplitude during a nitrous oxide–narcotic anaesthetic.

This decrease in amplitude results in a deterioration in signal quality and may produce an unmeasurable signal in patients with very small signals. This may prevent monitoring or reduce its usefulness by requiring more extensive signal acquisition methods (e.g. a longer period of signal averaging). The use of a narcotic–oxygen anaesthetic may, therefore, be valuable in patients with very small signals where the attenuation resulting from nitrous oxide is unacceptable.

REFERENCES


