Paradoxical changes in bispectral index during nitrous oxide administration

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I report two patients undergoing open heart surgery, with nitrous oxide and isoflurane anaesthesia, for whom bispectral index (BIS) monitoring showed high BIS values with nitrous oxide and isoflurane anaesthesia. The BIS decreased immediately after nitrous oxide was stopped and increased again after nitrous oxide was restarted.

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The bispectral index (BIS) is a variable, derived from the EEG, that has been reported to have the ability to measure the hypnotic component of the anaesthetic state and has been shown to correlate well with the degree of sedation using several general anaesthetics.1 2 I have been using BIS monitoring (Aspect A-1000 EEG monitor; Aspect Medical System Inc., MA, USA) to titrate anaesthesia in cardiac surgery patients for the last 3 years. During this period, I found two patients (out of more than 300) in whom increasing the concentration of potent inhalational anaesthetic was associated with no change in BIS. Instead, the BIS decreased upon discontinuation of nitrous oxide and increased again after the reintroduction of nitrous oxide.

Case reports

Case 1

A 35 yr old woman was scheduled for mitral valve replacement for mitral regurgitation. Anaesthesia was induced with morphine 0.2 mg kg⁻¹ and midazolam 0.1 mg kg⁻¹ and a titrated sleep dose of thiopental. The BIS was monitored using silver chloride electrodes applied to the
forehead, with one on each malar bone, one at the centre of the forehead and a ground electrode on one side of the centre electrode. Tracheal intubation was facilitated with the use of vecuronium 0.1 mg kg⁻¹ and the lungs were mechanically ventilated. Anaesthesia was maintained with 66% nitrous oxide in oxygen and with isoflurane. Ten minutes after tracheal intubation, the BIS increased to >90. It did not decrease even with increasing doses of isoflurane (inspired concentrations of ≤3% isoflurane). At this point the patient’s arterial pressure began to decrease. Nitrous oxide and isoflurane were stopped and the patient was given 100% oxygen. Two minutes after the nitrous oxide was discontinued, the BIS started to decrease; it fell to <30 after another 5 min. After a further 5 min, the systemic arterial pressure had improved. Nitrous oxide was then reintroduced, whereupon the BIS increased; the BIS fell again after the nitrous oxide was stopped. BIS monitoring was abandoned and anaesthesia controlled using clinical judgement.

Case 2

A 60 yr old man was scheduled for coronary revascularization. Anaesthesia was induced and maintained as in case 1. In spite of adequate concentrations of isoflurane (2–3% inspired concentrations), the BIS remained at >90. Nitrous oxide was stopped and the BIS decreased to <50 within 5 min. Reintroduction of nitrous oxide again increased the BIS.

Discussion

The ability of nitrous oxide to reduce the requirement for other anaesthetic agents has been well described.²³⁴ Yamamura and colleagues⁵ studied the effect of nitrous oxide on the EEG of healthy volunteers and showed an increase in high β-range activity after nitrous oxide administration. Rampill and colleagues⁶ found that inhalation of nitrous oxide was associated with an increase in high-frequency and θ-range activity of the EEG but this did not alter BIS. A reduction in nitrous oxide concentration was associated with a sudden increase in high-amplitude δ activity of the EEG along with a decrease in BIS.⁷ Nitrous oxide in combination with more potent anaesthetics has been studied previously. Porkkala and colleagues⁸ have shown that nitrous oxide antagonizes the depressant effects of isoflurane on the EEG. Sebel and colleagues⁹ found that the BIS was higher when isoflurane was used in combination with nitrous oxide than when it was used without nitrous oxide. Analogous effects were observed in a study by Glass and colleagues, who showed that the addition of nitrous oxide to propofol increased the BIS at which patients failed to respond to verbal commands.¹² Barr and colleagues found no effect of nitrous oxide on the BIS when given alone or added to isoflurane.¹⁰ These conflicting reports of the effect of nitrous oxide on the BIS show that the effects of nitrous oxide are not consistent, reflecting a potential inadequacy of the algorithm used for calculating the BIS from the EEG.

The algorithm that computes the BIS evaluates predominantly three features of the EEG: the ratio of very high β-range activity to high α plus low β activity (relative β ratio), very high β-range phase relationships and burst suppression phenomena. These features are used sequentially by the algorithm as sedation and anaesthesia increases, with relative β ratio being the most influential feature during light sedation. As no single pattern of EEG reflects depth of anaesthesia correctly, a number of features are used to calculate the BIS. The paradoxical changes in the BIS of our patients may have resulted from an alteration in the relative β ratio with nitrous oxide or withdrawal of nitrous oxide. These findings question the utility of monitoring BIS in controlling the depth of anaesthesia in patients receiving nitrous oxide in addition to other anaesthetic agents. Other neurophysiological measures of depth of anaesthesia may be prone to similar problems with nitrous oxide.¹⁰¹¹

References

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