EEG Effects Produced By Nitrous Oxide And Remifentanil; BIS Vs Chaos

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Remifentanil and nitrous oxide are commonly used in combination, together with other anesthetics, for routine surgical anesthesia, yet the electroencephalogram (EEG) effects of the two agents are poorly described. The present study examined effects of these two agents on EEG signals recorded from 40 randomly chosen surgical patients using a BIS monitor, following patient consent, under an Stanford University approved protocol. Remifentanil concentrations were varied on a steady background of nitrous oxide and cortical responses to a train of four (TOF) stimulus were compared at these different concentrations. At surgical planes of anesthesia high amplitude slow waves (1 to 2 Hz) dominated the EEG, similar to effects seen with most anesthetics, but these slow waves were interspersed with rhythmic theta activity from 4 to 10 Hz that lasted a few seconds to several minutes before reverting to slow wave activity, that could also last several minutes. Changes in remifentanil concentrations had little effect on background activity, marginally increasing slow waves, and did not change the alternating pattern of delta and theta activity. BIS values remained high (>75) in patients, even though they were surgically anesthetized, but occasionally dipped down to 40 following prolonged runs of lower frequency activity. The BIS was somewhat responsive to increased remifentanil doses, regardless of whether the increased dose was on a background of delta or theta activity. Chaos analysis of the same EEG signals showed a typical flatting of attractors that is seen with thiopental, propofol, ketamine as well as with volatile anesthetics. Attractor flattening was seen for both the delta and theta dominant EEG patterns, with little apparent difference, at surgical planes of nitrous oxide/remifentanil anesthesia. TOF stimulation produced cortical activation, seen as a marked decrease in signal amplitude and increase in higher frequency content, which was diminished by higher concentrations of remifentanil. Chaotic attractors were predictive of whether a TOF response would be seen, or not, with a flatter attractor being associated with loss of response. We conclude that remifentanil/nitrous oxide anesthesia is associated with a unique oscillating pattern of delta/theta frequency activity that the BIS failed to correlate to anesthetic depth. Chaos analysis, in contrast, consistently provided a good measure of anesthetic depth in these patients.

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