A Case of Paradoxical Increase in the Bispectral Index with Higher Concentrations of Desflurane: Paradox Unveiled?

Cite this article as: Ajayan N, Lionel KR, Hrishi AP. A Case of Paradoxical Increase in the Bispectral Index with Higher Concentrations of Desflurane: Paradox Unveiled? Turk J Anaesthesiol Reanim 2018; 46(6): 482-3.

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A 49-year-old female diagnosed with lumbar intervertebral disc prolapse presented for lumbar laminectomy in the prone position and underwent standard anaesthesia induction μcg kg^{-1}, thiopentone sodium 5 mg kg^{-1} and vecuronium 0.1 mg kg^{-1} injections. Intraoperative monitoring included electrocardiography (ECG), pulse oximetry (SpO_2), non-invasive blood pressure, end-tidal carbon dioxide ($EtCO_2$), anaesthesia gas and bispectral index (BIS). BIS electrodes were attached in the standard forehead position as per the manufacturer's instructions (2 Channel BISTM; Medtronic, MN, USA). The trachea was intubated when the BIS was 40, and post intubation, ventilation was provided with air:oxygen (50:50) mixture and anaesthesia was maintained at a minimum alveolar concentration (MAC) of 0.8 with end-tidal desflurane (EtDes) of 5.3%. Over a period of 5 min, the BIS sequentially increased to 70 and the anaesthesiologist lowered the depth of the anaesthetic plane by increasing the MAC to 1.4 with a EtDes of 8%, which increased the BIS to 87. The patient was haemodynamically stable with a train-of-four count of 0, and no noxious stimuli were present because surgery had not commenced. The frontal electroencephalogram (EEG) waveform had a delta waveform pattern, which signified a deep anaesthetic plane. Further evaluation of BIS monitoring revealed a high signal quality index (SQI) (which showed that the values were reliable), suppression ratio (SR) of 12 and no electromyography (EMG) activity, thus ruling out any artefacts caused by pain, seizures, eye movements and muscle activity. Suspecting the high BIS value as an artefact, the anaesthesiologist reduced the concentration of desflurane to EtDes of 3.8% (0.5 MAC) and noticed that the BIS decreased to 45. As the concentration of desflurane was increased to an EtDes of 6% to maintain a depth of 1.0 MAC, the same phenomenon occurred, with the BIS reaching up to 77 and decreasing to 40 when the concentration of desflurane was maintained below EtDes of 4.4% (0.7 MAC), thereby confirming our diagnosis of an erroneous high BIS. Following this episode, surgery commenced with an uneventful intraoperative period and the patient had a smooth recovery with no recall of intraoperative events.

The BIS is computed from multiple EEG-derived variables, i.e. the frequency domain (consisting of bispectrum and power spectrum) and the EEG time domain for the burst suppression analysis. Both of these variables are combined to a process a single index of hypnotic level, displayed as a dimensionless number on a continuous scale of 0–100 in the BIS monitor. A BIS of 100 represents an awake subject with normal cortical electrical activity, whereas a BIS of 0 indicates cortical electrical silence. Other indices derived include the SQI, which measures the reliability of the signal, i.e. higher the SQI, the more reliable is the BIS value. SR is the percentage of time during which EEG is suppressed over the previous 63 seconds. The BIS is subject to artefact and interference, particularly like any EEG signal, mostly from EMG activity, resulting in elevated BIS values. The BIS in general is found to decrease with increasing concentrations of anaesthetics, with a characteristic pattern of EEG slowing until burst suppression.

Significant increases in BIS values are noted in up to 40% of patients receiving isoflurane anaesthesia when the end-tidal concentration of isoflurane is increased from 0.8% to 1.6% (1). This pattern is termed as 'paradoxical BIS response' because with increasing anaesthetic concentration, the BIS value is expected to decrease (1, 2). These paradoxical increases in the BIS during isoflurane anaesthesia could be misleading at times and is commonly observed when nitrous oxide is used as an adjuvant to isoflurane (1-3). The underlying mechanisms of the paradoxical BIS response remain speculative as the BIS algorithm combines various parameters that are not published in detail (1, 4). This could be due to failure in the BIS algorithm, which includes complex variables such as the burst suppression ratio or 'QUAZI suppression index' (1). The other cause might be the presence of a pre-burst pattern induced by the anaesthetic agent in the EEG, resulting in a high BIS value (1). Increasing concentrations of isoflurane and desflurane in patients presenting with a baseline delta predominant EEG pattern has shown increased slow wave activity and decreased median frequency with similar pattern of burst suppression (4, 5). Patients with high baseline delta activity did not show any change in the EEG frequency spectrum with increasing anaesthetic dose but developed burst suppression at lower anaesthetic concentrations in comparison to patients with a lower baseline delta EEG pattern (5, 6). Because isoflurane and desflurane produce similar changes in the EEG patterns, they may produce similar paradoxical BIS patterns (1, 4).

In our case, we noted high SQI, indicating good signal reliability, SR of 12, which ruled out seizures, and absence of EMG activity, which ruled out artefacts. We observed erroneous high BIS values with increasing concentrations of desflurane, and this prompted us to arrive at the conclusion of a possible paradoxical increase in the BIS associated with desflurane anaesthesia. To the best of our knowledge, similar reports have not been found in our literature search. Further studies are warranted to investigate the correlation of BIS values in desflurane anaesthesia.

Informed Consent: Written informed consent was obtained from the patient who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – N.A., K.R.L., A.P.H.; Design – N.A., K.R.L., A.P.H.; Supervision – N.A., K.R.L., A.P.H.; Resources – N.A., K.R.L., A.P.H.; Materials – N.A., K.R.L., A.P.H.; Data Collection and/or Processing – N.A., K.R.L., A.P.H.; Analysis and/or Interpretation – N.A., K.R.L., A.P.H.; Literature Search – N.A., K.R.L., A.P.H.; Writing Manuscript – N.A., K.R.L., A.P.H.; Critical Review – N.A., K.R.L., A.P.H.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

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DOI: 10.5152/TJAR.2018.93467
Received: 04.06.2018
Accepted: 17.07.2018