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Survey on the adequacy of depth of anaesthesia with bispectral index and isolated forearm technique in elective Caesarean section under general anaesthesia with sevoflurane†

F. Zand, S. M. R. Hadavi*, A. Chohedri and P. Sabetian

Shiraz Anaesthesiology and Critical Care Research Center, Department of Anaesthesia, Shiraz University of Medical Sciences, Faghihi Hospital, Zand Blvd, Shiraz, Iran

* Corresponding author. E-mail: hadavimr@sums.ac.ir

Editor's key points

- Bispectral index (BIS) monitoring is commonly used to monitor depth of anaesthesia.
- The authors studied parturients in whom standard techniques were used for general anaesthesia for Caesarean section.
- The isolated forearm test was used to study the ability of the BIS to detect consciousness.
- BIS values below 60 were commonly associated with IFT responses, particularly before delivery.

Background. Awareness during general anaesthesia for Caesarean section (C/S), although uncommon, remains a concern for anaesthesiologists. We examined the relationship between the bispectral index (BIS) and responses to the isolated forearm technique (IFT) to evaluate the adequacy of general anaesthesia in C/S and determine a suitable cut-off point for BIS values based on IFT results.

Methods. In 61 parturients, a standardized anaesthetic technique was applied. It included sodium thiopental and succinylcholine for induction, and O_2, N_2O, and sevoflurane for maintenance of anaesthesia. BIS values and IFT response were recorded at 16 predetermined events during anaesthesia.

Results. Positive IFT responses were seen in 41%, 46%, and 23% of the parturients at laryngoscopy, intubation, and skin incision, respectively. BIS could not reliably differentiate between IFT responders and non-responders during these three stages. The receiver operating characteristic curve cut-off points for BIS to predict IFT responders with 100% sensitivity were 34, 37, and 27, respectively, for these stages. In all stages of the operation *after* skin incision, more than 90% of parturients had no IFT test response, and BIS values between 40 and 63 were associated with negative IFT results. During a structured interview within 12–24 h after the operation, no patient had evidence of explicit recall of intraoperative events.

Conclusions. The BIS is not reliable for monitoring anaesthesia depth in C/S. Lower than previously recommended values are needed to avoid IFT test responses during laryngoscopy, intubation, and skin incision.

Keywords: anaesthetics, sevoflurane; awareness; bispectral index; Caesarean section; general anaesthesia

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Awareness during general anaesthesia is a problem that has become increasingly recognized since the introduction of routine use of neuromuscular blocking agents.[1 2] It has long been recognized that this is a particular problem during Caesarean section (C/S), because a lack of sedative premedication, a low inspired concentration of nitrous oxide and volatile agent, and the withholding of opioids until after delivery, all contribute to the risk of awareness.[3 4]

The isolated forearm technique (IFT) is the gold standard test for detecting wakefulness during C/S.[5 6] It relies on isolation of the forearm from the effects of the neuromuscular blocking drug by occlusion of the circulation with a pneumatic tourniquet inflated before injection of neuromuscular blocking agent. Movement of the hand in response to a recorded command played to the patient is then monitored.

The bispectral index (BIS), a multivariate variable calculated from the processed electroencephalogram, is believed by some to be a useful aid to ensure adequate hypnosis during general anaesthesia,[7–9] but others would dispute its accuracy, and believe that the BIS is of value only in that it gives some idea as to memory function and absence of subsequent explicit recall and is not a guarantee of lack of wakefulness.[10 11]

We carried out an observational study to compare and correlate BIS values with IFT responses to find a cut-off point for

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BIS values associated with the absence of wakefulness during general anaesthesia for C/S.

Methods

The study protocol was approved by the ethics committee of the Shiraz University of Medical Sciences, Shiraz, Iran. Sixty-one ASA I or II patients undergoing elective C/S under general anaesthesia gave informed consent to participation in the study. Exclusion criteria were uncooperative patients, language barrier problems, $MgSO_4$ administration before the study, psychological disorders, history of awareness, opium addiction, and neuromuscular disorders.

All patients were monitored with ECG, non-invasive arterial pressure, pulse oximetry (Sp_{O_2}), end-tidal gas analyser, and BIS monitoring. Anaesthesia was administered by senior residents, under the supervision of one of the authors.

The researcher, who supervised the anaesthesia, explained the concept of the study to the patients and placed a sphygmomanometer cuff around the right forearm of the patients after placing a cotton bandage and inflated it to 200 mm Hg immediately before induction. This isolated the right hand from the effects of the neuromuscular blocking agent. The headphones of an MP3 player were placed over the patient's ears and the following command was presented: 'open and close your right hand'. This was repeated every 30 s throughout the period of the trial until the time of tracheal extubation. The cuff was deflated after 20 min to prevent ischaemic paralysis, but was re-inflated before any further boluses of neuromuscular blocking drugs were administered. Arm activity was scored as no movement (0), non-specific movement (e.g. fine movements of fingers) (1), or firm clenching/flexing movement (2).[12] Before induction of anaesthesia, the Bispectral Index monitor (Aspect Medical Systems Inc., USA) was connected to the Aspect BIS sensor, which had been placed on the forehead of the patient as recommended by the manufacturers.

After 3 min of preoxygenation, rapid sequence induction was performed with sodium thiopental 4–5 mg kg^{-1} and succinylcholine 1–2 mg kg^{-1}. Cricoid pressure was applied and tracheal intubation was performed. Anaesthesia was then maintained with 50% nitrous oxide in oxygen (7 litre min^{-1}) and sevoflurane. The inspired concentration of sevoflurane was set at 1.8–2.2% until delivery; thereafter, it was reduced to 1.2%. After delivery, i.v. morphine 0.15 mg kg^{-1}, midazolam 0.03 mg kg^{-1}, and fentanyl 100 μg were administered. After recovery of spontaneous respiration, 10 mg atracurium was administered. Sevoflurane administration was stopped at subcutaneous layer closure and nitrous oxide stopped at the start of skin closure.

The BIS value, IFT responses, and end-tidal sevoflurane concentrations were noted in association with the following events: baseline value, induction of anaesthesia (at the end of thiopental injection), laryngoscopy (at insertion of blade to hypopharynx), intubation (at the time of cuff inflation), at the end of skin incision, at the end of peritoneal incision, at the end of uterine incision, at the end of uterine retraction (widening the uterine incision by the surgeon), delivery (cord clamping), start of uterine closure, start of muscle closure, start of subcutaneous layer closure, start of skin closure, 2 min after the end of skin closure, eye opening, and extubation.

BIS was read off the machine. BIS and IFT values were noted by two independent observers. All patients were interviewed 12–24 h after surgery regarding the experience of dreaming or recall using the following questions:[13]

(1) What was the last thing you remembered before going to sleep?
(2) What was the first thing you remembered on waking?
(3) Do you remember anything between going to sleep and waking?
(4) Did you dream while you were sleeping during the operation?

Receiver operating characteristic (ROC) analysis was used for determining the best cut-off point for BIS, that is, the BIS value with best (nearest to 100%) sensitivity and specificity to prevent wakefulness. Also, the Mann–Whitney test was used to determine the relationship between BIS and IFT values, after combining the data at laryngoscopy, intubation, and skin incision events.

Results

All 61 enrolled parturients completed the study. All collected data are presented. The median (range) Apgar scores of newborns were 9 (4–9) at minute 1 and 10 (9–10) at minute 5. Table 1 shows the percentage of patients who showed IFT responses of grades 2, 1, and 0 at various stages of surgery with the mean, SD, and range of BIS in each group. The BIS values and the end-tidal sevoflurane concentrations recorded at predetermined intraoperative events are shown in Figures 1 and 2, respectively. The mean BIS values were 37, 45, and 46 at induction, laryngoscopy, and intubation, respectively (i.e. before the start of sevoflurane). For the time points when BIS was recorded during sevoflurane administration, the median BIS values were between 45 and 59, except for delivery time, when the median BIS was 39.

Unlike routine sensitivity analysis of diagnostic tests that try to find a cut-off point with the best sensitivity and specificity, we believe that the best cut-off for BIS is the cut-off point associated with 100% sensitivity (i.e. below that value no patients showed evidence of wakefulness defined as IFT=2). Table 2 shows the cut-off points for BIS values with 100% sensitivity for preventing wakefulness and the cut-off point with best overall sensitivity and specificity. As the results show that to be 100% certain that a patient will not regain consciousness (IFT response=2), the BIS value must be below 27 in the pre-delivery stages.

The BIS and IFT values for laryngoscopy, intubation, and skin incision stages were combined to give 183 data points (3 for each patient). The BIS data were analysed according to whether there was a clear IFT response (IFT=2) *vs* no clear IFT response (IFT=0 or 1). At these times, amalgamated BIS values were not normally distributed. The BIS values were