BIS Readings Of Aspect A 2000 Monitor Are Not Contaminated By Transmitted Oscillations Induced By Jet Ventilation

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Citation

G Schwarz, G Mausser, G Litscher, U Ohner, A Schoepfer, G Friedrich. *BIS Readings Of Aspect A 2000 Monitor Are Not Contaminated By Transmitted Oscillations Induced By Jet Ventilation*. The Internet Journal of Neuromonitoring. 2004 Volume 4 Number 1.

Abstract

The tubeless high-frequency jet ventilation during surgery of the upper respiratory tract is usually performed with total intravenous anesthesia (TIVA). Because TIVA is associated with an increased incidence of awareness, the bispectral index (BIS) is considered useful to monitor the depth of anesthesia. However, BIS values can be influenced by physiological, pharmacological and technical factors. Specific technical devices are described to compromise BIS-readings during anasthesia by transmitted oscillations. Jet ventilation causes rhythmic pulsations that are conducted to frontal structures. We studied whether oscillations caused by tubeless jet ventilation affect BIS readings of an Aspect 2000 BIS monitor. Nineteen patients (13 male, 6 female; ASA status 1 - 3; mean age 46.9 ± 15.7 years; range 21 - 70) undergoing ear, nose and throat (ENT) procedures were enrolled. TIVA was standardized (propofol 8 - 10 mg/kg/h; remifentanil 0.2 - 0.5 µg/kg/min) and paralysis obtained with rocuronium (0.5 mg/kg). BIS was recorded with an Aspect A2000 BIS monitor before induction and during anesthesia (M1 = spontaneous breathing; M2 = superimposed high-frequency jet ventilation, pulsating frequency 600/min; M3 = high-frequency jet ventilation, pulsating frequency 60/min). The median BIS recordings (range of mean BIS values 31 - 35) during anesthesia did not show significant changes ($p < 0.05$) during jet ventilation (M2, M3) in comparison to spontaneous breathing (M1). In conclusion, oscillations of tubeless jet ventilation do not appear to contaminate BIS readings obtained during anesthesia in adults.

INTRODUCTION

The bispectral index (BIS) is an adjunctive method to monitor depth of anesthesia [1,2,3]. However, BIS readings are subject to pharmacologic [4,5,6,7,8,9,10] and non pharmacologic [11,12,13,14,15,16] influences which can compromise the interpretation of BIS or cause paradoxical readings. Biologic oscillations such as the EMG [13] and technical oscillations due to equipment [16] can also influence BIS readings. Oscillations induced by jet ventilation can be conducted to the forehead and are recordable over these structures [17]. We studied whether such oscillations affect BIS readings obtained with the BIS Aspect A 2000 monitor under total intravenous anesthesia (TIVA).

METHODS

The protocol was approved by the institutional ethics committee and all patients gave written informed consent. We enrolled 19 patients (13 male, 6 female; ASA status 1 - 3, mean age 46.9 ± 15.7 years; range 21 - 70 years) in our study. Biometric data and the indications for ENT surgery of the upper airways are shown in Table 1. All patients received 7.5 mg midazolam PO 1 hour before anesthesia. Induction and maintenance of anesthesia were standardized. Anesthesia was induced intravenously with fentanyl (1.5 µg/kg) and propofol (2 - 2.5 mg/kg). Paralysis was obtained with rocuronium (0.5 mg/kg) IV. Anesthesia was maintained with propofol (8 - 10 mg/kg/h IV) and remifentanil (0.2 - 0.5 µg/kg/min). Jet ventilation and endoscopic surgical procedures (with the micromanipulator guided CO_2 laser, n = 14) were performed with a modified Kleinsasser laryngoscope (n = 18) or a special tracheoscope [18] (n = 1). Tubeless high-frequency jet ventilation was performed with a commercial jet respirator (BronchotronTM, Percussionaire Air Corp., Sandpoint, ID, USA) at the following settings: superimposed high-frequency jet ventilation (SHFJV) with a respiratory rate of 14/min superimposed with pulsating frequencies of 600/min and high-frequency jet ventilation

(HFJV) with a pulsation frequency of 60/min. Inspiration was set at 50 %, the driving pressure was < 2 mbar, FIO_2 0.4.

Figure 1

Table 1: Indications for surgical procedures under jet ventilation (n = 19)

Vocal cord polyps	5
Vocal cord carcinoma	4
Bilateral vocal cord paralysis	2
Carcinoma of the larynx	3
Subglottic stenosis	1
Granuloma after long-term intubation	1
Tracheal stenosis	1
Tumor of false vocal cord	2

BIS was recorded with an Aspect A 2000 monitor (Aspect Medical Systems, Natick, MA, USA). The monitor recorded the proportion of EMG inputs and the signal quality index (SQI). The surface electrodes (BIS, Aspect Medical Systems, Natick, MA, USA) were placed frontally according to the manufacturer's guidelines. The impedance was < 5 kOhm. The BIS trend depiction was digitally photodocumented for post hoc plausibility analysis. Standard monitoring included ECG, noninvasive blood pressure, peripheral oxygen saturation (SaO_2) and skin temperature (Solar 800, Marquette Medical Systems, Milwaukee, USA). Blood gasses were measured at the measuring points as described below.

BIS readings were obtained immediately before induction of anesthesia (A) and three phases during anesthesia (M1, M2, M3), with the ventilation settings described above. M1 was defined as 1.5, 2.5 und 4.0 min after the BIS decreased to < 50. M2 and M3 were measured after changing of the ventilation settings, including 1-min. equilibration intervals at 1.5, 2.5 und 4.0 min.

STATISTICS

The values obtained before anesthesia and at all 3 measuring points of the 3 measuring phases were tested with one way repeated measures analysis of variance using SigmaStat software (Jandel Scientific Corp., Erkrath, Germany). As post hoc analysis Dunnett's method was used. P values < 0.05 were considered statistically significant.

RESULTS

The median BIS just before induction of anesthesia was 95. Median BIS readings at M1, M2 and M3 were within the ranges of 31 - 32, 32 - 33 and 33 - 35, respectively. All BIS readings during anesthesia differed significantly from those before induction. BIS readings during anesthesia (M1, M2 and M3) did not differ from one another and were not affected by the patterns of jet ventilation (Fig. 1). The EMG proportion was 80 % before induction and 0 % between M1 and M3 (Fig. 2). The median SQI at M2 and M3 was > 90 % and 60 % before induction (Figs. 1, 2).

Figure 2

Figure 1: Box plot of bispectral index (BIS) before (A) and during (M1 - M3) jet ventilation in 19 patients (spontaneous breathing (M1); jet ventilation with pulsating frequencies of 600/min (M2) and 60/min (M3)). The ends of the boxes define the 25th and 75th percentiles, with a line at the median and error bars defining the 10th and 90th percentiles.

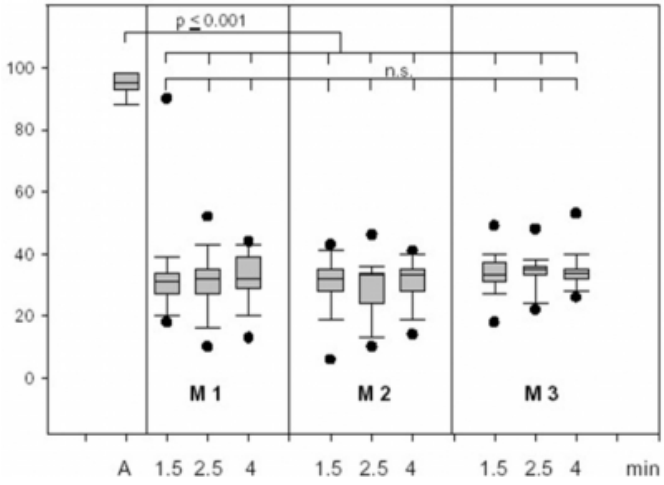
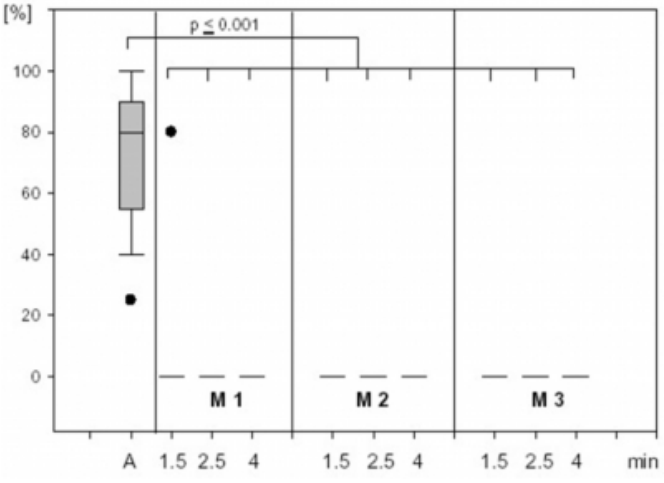


Figure 3

Figure 2: Electromyographic recordings (EMG) before (A) and during (M1 - M3) jet ventilation. Abbreviations explained in Fig. 1.



SaO_2 exceeded 90 % in all patients at all measuring points.

Body surface temperature ranged from 35.0 to 35.7 °C. NIBP and pCO_2 showed no associations with BIS readings.

DISCUSSION

Tubeless high-frequency jet ventilation increases diagnostic and therapeutic options during endoscopic surgery of the respiratory tract by providing sufficient ventilation without restricting the surgical field [18,19,20]. TIVA is preferred for procedures done under jet ventilation (18] but is associated with a higher incidence of awareness [21]. Accordingly electrophysiologic monitoring of the depth of anesthesia appears appropriate. But monitoring makes sense only if the recorded data are plausible and unaffected by the ventilation technique used, especially as increases and decreases of BIS are not always signs of inadequate anesthesia, and because BIS does not accurately indicate the depth of anesthesia in all patients (22,23,24].

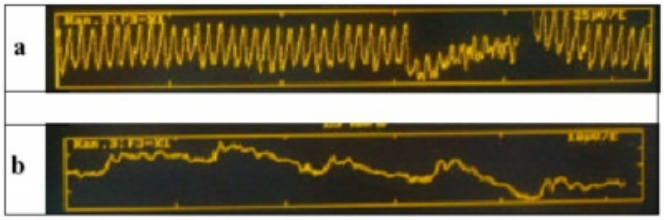
The A 2000 Bispectral IndexTM (BISTM) monitoring system we used in this study is the successor of the Aspect A 1000 (Aspect Medical Systems, Natick, MA, USA). Additional features of the Aspect A 2000 are bar readings of the EMG and signal quality, which help to interpret BIS values.

Current surgical navigation systems in otorhinolaryngology can create electromagnetic fields that cause changes in brain electric activity and inadequate BIS readings [15].

A further category of biomedical instruments affecting BIS readings during surgery are equipments generating mechanical oscillations. Devices for forced-air warming of the head have been reported to interfere with BIS readings [14]. Guignard and Chauvin [22] speculated that air circulation can generate vibration of the head wires. Hemmerling and Migneault [16] described an endoscopic shaver that induced falsely increased BIS values and hypothesized that shaver-induced oscillations at the shoulder joint are transmitted via bone to forehead and temporal area. In a pilot study we found transmission of oscillations from laryngeal and buccal localizations to the frontal region of the head [17]. These oscillations (Fig 3 a,b) were synchronous to the pulsation frequencies (60/min, 600/min) of jet ventilation and were probably caused by rhythmic pressure transmission of the jet ventilation from the pharyngolaryngeal region to the skull. However, our BIS readings presented here showed no significant changes at any point during anesthesia, neither during spontaneous breathing nor during SHFJV with a pulsating frequency of 600/min or HFJV with a pulsating frequency of 60/min. Data quality was adequate with absent artificial high frequency (EMG) contaminations and with a predominantly high signal quality index.

Figure 4

Figure 3: Oscillations of jet ventilation (digitally fotodocumentation) at pulsation frequencies of 600/min (a) and 60/min (b) recorded with a piezzo-electric sensor at the forehead (BIS Monitor Aspect A 1000).



The mean BIS readings in this study were slightly below the recommended lower target range of 40 [2,3] because anesthesia for surgery of laryngeal and tracheal structures was kept deeply enough to suppress autonomic responses to surgery-induced stimuli. Whether the deeper stages of anesthesia could have an influence on our results cannot be verified by the study design.

In summary, physically transmitted oscillations to the forehead generated by the pulsations of tubeless jet ventilation do not appear to compromise the BIS readings of Aspect A 2000.

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