Can Electrocardiogram Electrodes Replace Bispectral Index Electrodes for Monitoring Depth of Anesthesia?

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Background: *Bispectral index has been introduced to provide optimal level of anesthesia. However, Bispectral index monitoring may not be cost effective in a relatively short procedures due to the high costs of the electrode. The authors conducted the present study to compare the feasibility of commercially available electrocardiogram (ECG) electrodes instead of the Bispectral index (BIS) monitoring.*

Material and Method: *The authors evaluated the difference in signal quality index (SQI) and BIS values collected from two BIS monitors, using ECG electrodes and BIS electrodes on the same patients before anesthesia, during light anesthesia, deep anesthesia and the emergence period. Both sets of electrodes were placed at bifrontal areas throughout the procedure. Statistical analysis was evaluated by mean difference 95% confidence limits of agreement and visualized by Bland-Altman plot. A parametric analysis was analyzed using paired t-test.*

Results: *There were 390 parallel signal quality index and BIS values recorded in the present study. During anesthesia the mean BIS values were 58.63 18.77 in the ECG electrode group and 56.99 19.84 in the BIS electrode group, which were not statistically different. The mean SQI values were 79.2 24.8 and 82.8 21.6 using ECG electrodes and BIS electrodes, respectively. The mean difference between BIS values was 1.65 with 95% confidence limits of agreement between 0.91 and 2.38.*

Conclusion: *Commercial ECG electrodes could be used for monitoring depth of anesthesia with clinically acceptable mean bias and 95% confidencelimits of agreement of BIS value obtained from BIS electrode.*

Keywords: *Electroencephalogram, Signal quality index, Bispectral index Depth, Equipment, Electrodes*

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The quantitative assessment of consciousness during surgery has been a long-standing challenge for the anesthesiologists. Bispectral index, a non-invasive, simple to use measurement of anesthetic depth, has been used currently in the clinical setting[1-3]. Bispectral index monitoring may have a cost benefit over the anesthetic management as it can guide the anesthesiologists to provide optimal level of anesthesia for each patient individually. However, if only direct costs are calculated, Bispectral index monitoring is not cost effective in a relatively short procedure, due to the high cost of special adhesive electrode[4-6]. In Thailand, a BIS electrode (BIS sensor®, Aspect Medical System) costs over 1000-1200 Baht (13.30-15.96 GBP) each while three pieces of electrocardiogram electrode cost approximately 45-60 Baht (0.6-0.8 GBP) and can be used readily with the special connector.

The authors, therefore conducted a prospective randomized study to compare Bispectral index values derived from the original Bispectral index (BIS) electrode with those derived from commercially available electrocardiogram (ECG) electrodes during anesthesia to compare the signal quality index (SQI) and total value.

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Material and Method

After approval by the Departmental Committee of the Research Ethics and the director of Prasat Neurological Institute, Department of Medical Services,

Ministry of Public Health. Twenty two ASA physical status I-II patients aged 16-60 years scheduled for spinal surgery under general anesthesia were enrolled by random on computer selection daily during a 3 month period from the schedule list. Exclusion criteria were allergy or contraindication to the anesthesia plan, dementia and inability to communicate as well as the expected surgical duration greater than 3 hours.

All patients received midazolam 0.15 mg/kg orally approximately 3 hours before operation for premedication. On arrival in the operating theatre, hemodynamic, peripheral nerve stimulator, temperature and respiratory values, along with administered gases were monitored. After routine degreasing of the skin using alcohol swabs, ECG electrodes were applied on the following three points: 1) right temporal region; between lateral edge of the eye and upper edge of the ear 2) the middle of the frontal region as a referential electrode and 3) lateral to the midline as a ground electrode. On the left side a BIS electrode was applied at the same points. Each set of electrodes was connected to each BIS monitor as shown in Fig. 1.

Anesthesia was induced with fentanyl 1 mcg/kg and incremental dose of propofol intravenously until the BIS value from the BIS electrode reached 40-60. Rocuronium 0.6 mg/kg was intravenously given and the intubation of the trachea was done after the train of four (TOF) ratio read zero. Anesthesia was maintained with hourly intermittent intravenous boluses of fentanyl 0.5 mcg/kg, 67% of nitrous oxide in 33% oxygen with controlled ventilation, rocuronium 0.2 mg/kg intravenously according to the TOF ratio and continuous intravenous infusion of propofol titration to achieve 40-60 BIS value from the BIS electrode. At the end of surgery the propofol infusion was discontinued, residual neuromuscular blockade was reversed with prostigmin 0.04 mg/kg and atropine 0.02 mg/kg intravenously.

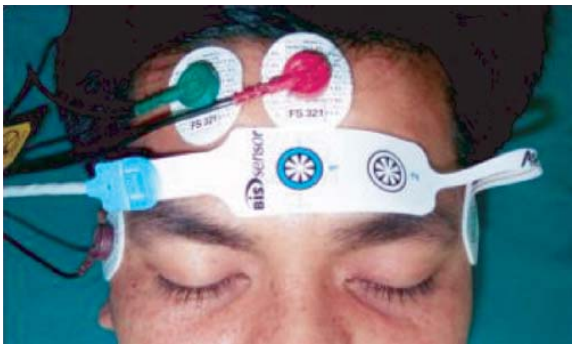

Fig. 1 The application of the Bispectral index electrode and the electrocardiogram electrodes on the forehead and the temporal area

The BIS monitoring and the signal quality index from both sets of electrodes were measured and recorded under similar conditions as follows: before induction, during intubation and every 10 minutes interval until the end of anesthesia.

Statistical analysis

Paired Student t-test was applied for the parametric variables. A p value < 0.05 was considered statistically significant. Differences in BIS values and signal quality index between BIS electrode and ECG electrodes were evaluated by mean difference with 95% confidence limits of agreement and visualized by Bland-Altman plot. Data are presented as mean +/- standard deviation.

Results

There were twenty-two patients, 16 male (72.7%) and 6 female (27.3%) with a mean age of 45.1 +/- 9.8 years, weight of 63.7 +/- 12.9 kg and categorized to ASA physical class I 40.9% and class II 59.0%. The mean time of anesthesia was 99.9 +/- 37.9 minutes.

The BIS values and the signal quality index were calculated from 390 values for each type of electrode. The mean values of BIS from ECG electrodes were 58.6 +/- 18.8 and 57.0 +/- 19.8 from BIS electrode, which were not statistically different. The mean difference in bias with 95% limits of agreement measured by two types of electrodes was 1.65 (0.91-2.38) and is shown as Bland-Altman plot in Fig. 2. There was no difference in the distribution of the Bispectral index difference plots from both groups and values were not within the clinically useful range.

The mean of signal quality index from ECG electrodes and BIS electrodes were 79.2 +/- 24.8 and 82.8 +/- 21.6 respectively which were not statistically different. The mean difference in bias measured with two types of electrodes with 95% limits of agreement was -3.62 (-5.15 - -2.09) and is shown as Bland-Altman plot in Fig. 3.

Discussion

Bispectral index has been investigated as an indicator of anesthetic depth. The set of equipment for the monitoring process consists of integrated special adhesive electrode, cable with the special pin connector and the BIS monitor (Model 90367, Spacelabs Medical). In the present study, beside the standard bispectran equipment, the authors applied 3 silver

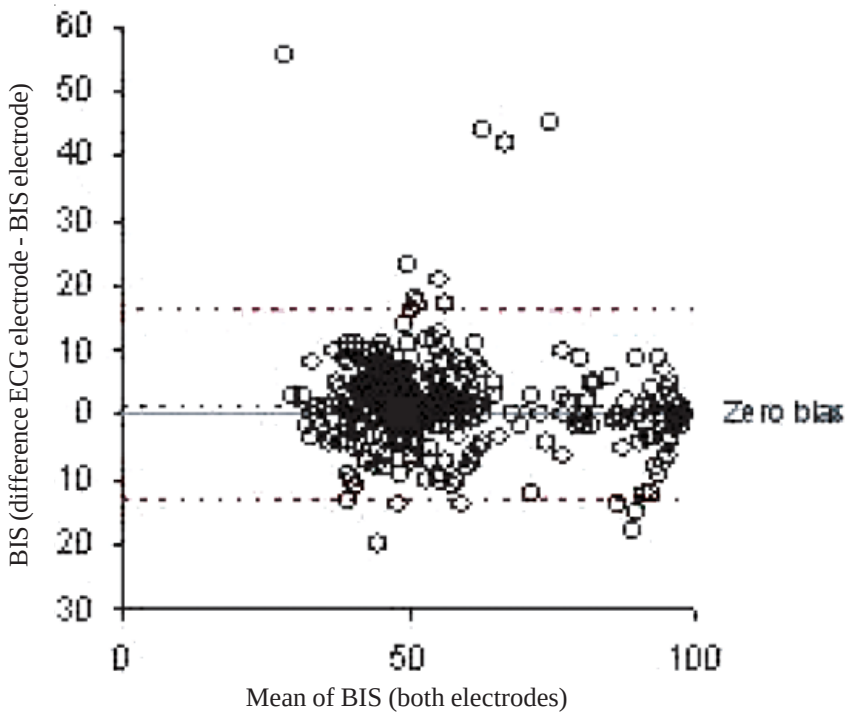

Fig. 2 Bland-Altman plot of agreement between Bispectral index values derived from limits of the electrocardiogram electrodes and the Bispectral index electrode. Mean difference of 1.65 and 95% confidenceagreement of -0.9 and 2.38

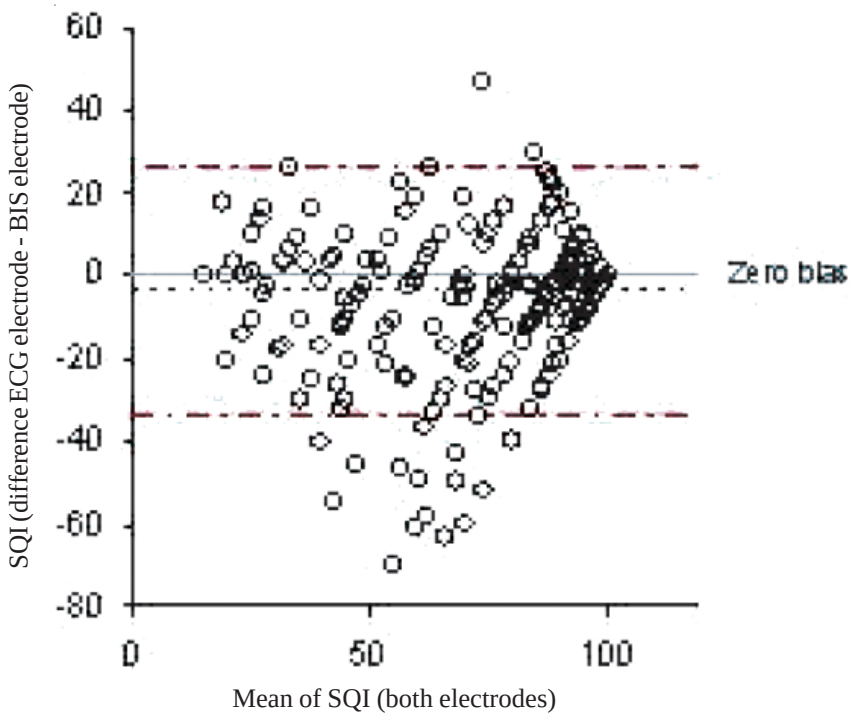

Fig. 3 Bland-Altman plot of agreement between signal quality index values derived from the electrocardiogram electrodes and the Bispectral index electrode. Mean diffence of –3.62 and 95% confidence limits of agreement of -5.15 and -2.09

Fig. 4 The connection of 3 small lead wires with buttons and the monitor cable of the Bispectral index

chloride ECG electrodes (Skintact AGFS 321), small lead wires with buttons connected to the BIS monitor as shown in Fig. 4.

Interface impedance between the contact of the electrode and the skin is of importance. One previous study of Seitsonen et al suggested that abrasive paste should be used as the pretreatment because the skin-electrode impedances below 10 kW are generally considered adequate[4]. In the present study, the skin preparation was done only with an alcohol swab before applying both types of electrodes similar to the study of Hammerling et al[7] even though it results in higher impedance for the ECG electrode but not exceeding 7.5 kW and moreover it was more convenient and easily applicable.

Alteration of skin impedance can be found in certain situations. Some studies have shown that dry skin affected from dehydration, desiccated electrode gel[4] and also the surgical stress can change skin impedance[8] which may be the cause of low signal quality index in the present study.

Analogous to previous studies using different types of electrodes such as needle electrode[9,10], dome electrode[3] and ECG electrode[4,6,7], they can be accepted clinically to monitor the Bispectral index. These suggestions were made by the determination of the skin-electrode impedance. Regardless of its capability as a monitor of anesthetic depth, the BIS monitor can measure the signal quality index and display in percent which is more reliable and convenient to interpret. In the present study, the inspection of individual scatter plots of the signal quality index difference support the hypothesis that they are equivalent between the ECG electrode group and the BIS electrode group.

In summary, the presented results suggest that the commercially available electrocardiogram electrodes can replace the Bispectral index electrode in the routine monitor of the Bispectral index intraoperatively but further study to ensure the reliability of signal quality index is required.

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การใช้ electrocardiogram electrode สามารถทดแทน bispectral index electrode ขณะทำการเฝ้าระวังระดับความลึกของการให้ยาระงับความรู้สึก ได้หรือไม่

ภูพิงค์ เอกะวิภาต, เกศินี ดำรงบุล, ปัทมา เนียมนาค

วัตถุประสงค์: เพื่อประเมินการใช้ electrocardiogram electrode (ECG electrode)ในการเฝ้าระวังระดับความลึกของการให้ยาระงับความรู้สึก ด้วยเครื่อง Bispectral index (BIS) เปรียบเทียบกับ bispectral index electrode (BIS electrode)

วัสดุและวิธีการ: ทำการประเมินค่าคุณภาพของสัญญาณ (signal quality index, SQI) และค่า BIS จากเครื่องเฝ้าระวังความลึกของการให้ยาระงับความรู้สึก 2 เครื่อง โดยใช้ electrode ที่ต่างกัน คือ ECG electrode และ BIS electrode ในผู้ป่วยรายเดียวกัน โดยการติด electrode ดังกล่าวที่บริเวณหน้าผากซ้ายและขวา ตั้งแต่ก่อนให้ยาระงับความรู้สึก ขณะให้ยาระงับความรู้สึก จนกระทั่งเสร็จสิ้นการให้ยาระงับความรู้สึก วิเคราะห์ข้อมูลทางสถิติด้วยค่า bias ที่ 95% limit of agreement แสดงผลด้วย Bland-Altman plot ข้อมูลกลุ่ม non parametric วิเคราะห์ด้วย paired t-test โดยที่ค่า p น้อยกว่า 0.05 ถือว่ามีนัยสำคัญทางสถิติ

ผลการศึกษา: จากการวิเคราะห์ข้อมูลทั้งหมด 390 ข้อมูลของค่า SQI และค่า BIS พบว่า ค่าเฉลี่ยของ BIS เท่ากับ 58.63 +/- 18.77 ในกลุ่ม ECG electrode และเท่ากับ 56.99 +/- 19.84 ในกลุ่ม BIS electrode ส่วนค่าเฉลี่ยของ SQI ในกลุ่ม ECG electrode เท่ากับ 79.20 +/- 24.77 และในกลุ่ม BIS electrode เท่ากับ 82.82 +/- 21.65 ซึ่งไม่แตกต่างกัน ค่า bias เฉลี่ยของค่า BIS เท่ากับ 1.65 และค่า 95% limit of agreement อยู่ระหว่าง 0.91 ถึง 2.38

สรุป: การใช้ ECG electrode ในการเฝ้าระวังระดับความลึกของการให้ยาระงับความรู้สึกด้วยเครื่อง bispectral index สามารถทำได้ โดยไม่แตกต่างกับการใช้ BIS electrode ในทางคลินิก