*Original Article*

# COMPARATIVE EVALUATION OF THE CEREBRAL STATE INDEX™ AND BISPECTRAL INDEX™ MONITORING DURING PROPOFOL -REMIFENTANIL ANESTHESIA FOR OPEN HEART SURGERY

*Shahrbanoo Shahbazi[1], Farid Zand[2], Jalal Saem[3]*

**ABSTRACT**

***Objective:*** The Cerebral State index (CSI) is a new index based on electroencephalogram to monitor depth of anesthesia. Transferring guidelines for titration of the Bispectral index (BIS) to the CSI depends on their compatibility. We compared the relationship between BIS and CSI values during propofol-remifentanil anesthesia.

***Methods*:** Forty one adult patients about to have open heart surgeries were enrolled. The skin was prepped and electrodes of both monitors were applied according to the manufacturers' recommendations. The anesthesia was induced by midazolam, propofol, remifentanil and pancuronium and maintained by propofol and remifentanil and 50% nitrous oxide in oxygen. The BIS and CSI values were recorded in 37 pre-determined milestones during the operation and the anesthetic drugs were adjusted according to clinical signs of light anesthesia regardless of the CSI or BIS values.

***Results:*** The BIS and CSI values decreased progressively from pre induction values of 93.15 (55-100) and 88.86 (52-100) to post induction values of 38.72(16-71) and 40.27(5-69), respectively. These values showed good linear correlation during laryngoscopy, before and after surgical incision and during CPB; R=0.695 with determination coefficient of 0.483.

***Conclusions:*** We found a good correlation between BIS and CSI values. Our results might serve as a blue print for a rational "translation" of BIS into CSI values.

**KEYWORDS:** Monitoring, Depth of anesthesia, Bispectral index, Monitoring, Cerebral state index.

**Pak J Med Sci July - September 2007 Vol. 23 No. 4 505-509**

## INTRODUCTION

The electroencephalogram (EEG) is an established method for indicating the level of consciousness during anesthesia.[1] The handling of the raw EEG varies in the various signal-processing algorithms, most of which create a numerical index between 0 and 100.

The introduction of Bispectral Index (BIS; Aspect Medical Systems, Newton, MA, USA) for the parameterization of the EEG was a milestone.[2] However; there is still no gold standard for defining anesthetic depth.[3] Until recently, there were three EEG monitors commercially available in clinical anesthesia including BIS™, processed EEG ™ to measure the 90% spectral edge frequency and Mid – latency auditory evoked potential (AEP), with many studies performed to evaluate the validity of each monitor. In this study one of the most recent commercial monitors of depth of anesthesia, the cerebral state index (CSI, Danmeter A/S; Odense, Denmark) was compared to the well established BIS™ during

1. Dr. Shahrbanoo Shahbazi
2. Dr. Farid Zand
3. Dr. Jalal Saem

1-3: Namazi Hospital,
Shiraz University of Medical Sciences, Shiraz – Iran.

Correspondences:

Dr. Farid Zand,
Department of Anesthesiology, Namazi Hospital,
Namazi Square, 71937-11351, Shiraz – Iran.
E-mail: zandf@sums.ac.ir

* Received for Publication: September 2, 2006
* Revision Received: December 27, 2006
* Revision Accepted: April 4, 2007

general anesthesia with propofol and remifentanil for open heart surgeries.

## METHODS AND MATERIALS

After approval by the local Ethics Committee and obtaining informed consent, forty one ASA class II and III patients referred for open heart surgeries (coronary artery bypass grafting, valvular and congenital heart disease repair) were enrolled in this cross sectional single blind study. Those patients with positive history of major tranquilizers and alcohol consumption and opium addiction were excluded. After arrival in the operation theatre, standard monitoring was placed and intra-arterial catheter was inserted in the radial artery. After preparation of the skin with water and soap, the electrodes of BIS and CSI were placed on the both sides of the patient's forehead according to the instruction of the manufacturers.

All patients received midazolam 0.15mg/kg, remifentanil 2 microgr/kg, propofol 1-2mg/kg for induction of anesthesia and pancuronium 0.1mg/kg for muscle relaxation. After tracheal intubation, CVP was inserted in right internal jugular vein. The anesthesia was maintained by intravenous propofol 50-100 microgr/kg/min and remifentanil 0.125-0.25 microgr/kg/min and 50 percent $N_2O$ in oxygen.

The BIS and CSI values were recorded by a technician in 37 pre-determined milestones during the operation and the anesthetic drugs were adjusted according to clinical signs of light anesthesia regardless of the CSI or BIS values. The anesthetist was blinded to the BIS and CSI data. Both these instruments were left unnoticed by the anesthetist and only a technician who was not involved in the patient care was aware of the data. The patients were interviewed for any recall during surgery about twenty four hours after arrival in the ICU.

The number of the required patients was determined according to a preliminary pilot study on five patients using Bland-Altman plot method. The correlation coefficient was 0.422, the power of the study was considered 80% and the confidence interval was defined as 95%. The data analysis was performed by SPSS 10.0 software.

## RESULTS

Forty one patient 32 male and 9 females with a mean age of 52.2(range 17-75) and mean weight of 66.2(range 44-86 kg) were enrolled in this study. The mean duration of surgery was 291 ± 57 minutes .No patient reported perioperative recall.

The BIS and CSI values decreased progressively from pre induction values of 93.15 (55-100) and 88.86 (52-100) to post induction values of 38.72(16-71) and 40.27(5-69), respectively. The data was analyzed by simple and multiple regression analysis. These values (Table-I) showed good linear correlation during laryngoscopy, before and after surgical incision and during CPB; R=0.695 with determination coefficient of 0.483. (Figures-1,2 and 3)

## DISCUSSION

The measurement of depth of anesthesia is still an unsolved problem because there is no definition of what "depth of anesthesia" means exactly. At present, there is no "gold standard" for the measurement of depth of anesthesia;[3] however, a depth – of –anesthesia monitor would be of enormous clinical interest to increase patient safety and to reduce costs by avoiding drug overdosing.[4-8] Recent studies show that there is a good correlation between BIS and sedation levels during propofol anesthesia.[1] In other studies there were good correlation between blood concentration of propofol and BIS index[1,4,5] and BIS was

Table-I: Bispectral and Cerebral State index values at ten selected milestones during anesthesia for open heart surgery.

| *Variables* | *BIS (mean±SD)* | *CSI (mean±SD)* |
|---|---|---|
| Pre induction | 93 ± 10 | 89 ± 14 |
| induction | 39 ± 14 | 40 ± 15 |
| 1min after laryngoscopy | 40 ± 14 | 41 ± 17 |
| before surgical incision | 44 ± 13 | 44 ± 12 |
| 1 min after sternotomy | 46 ± 13 | 50 ± 14 |
| before CPB | 41 ± 8 | 43 ± 9 |
| 30 min after start of CPB | 40 ± 11 | 43 ± 10 |
| before rewarming | 42± 8 | 40± 12 |
| 7 min after rewarming | 44 ± 12 | 44 ± 15 |
| after total pump off | 49± 12 | 43 ± 12 |

SD: Standard deviation, CPB: Cardiopulmonary bypass.

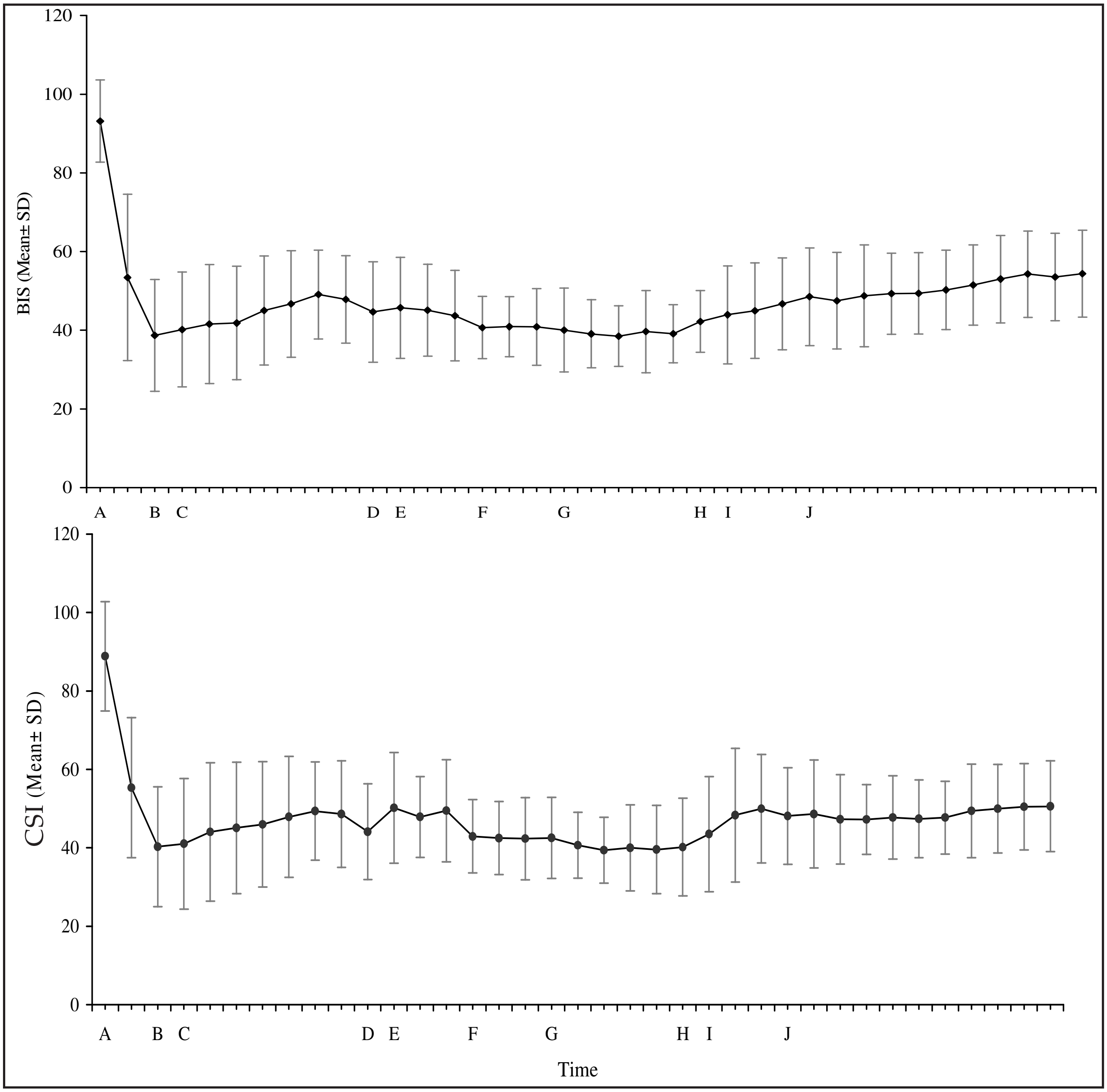


Figure-1: Changes of Bispectral index and Cerebral State index during anesthesia at 37 pre determined milestones. A = pre induction, B = post induction, C =1 min after laryngoscopy, D = before surgery, E = 1min after sternotomy, F = before cardiopulmonary bypass (CPB), G = 30 min after start of CPB, H = before rewarming, I = 7 min after rewarming, J = after total pomp off (Ten selected milestones)

considered a useful indicator of anesthetic adequacy.[1] According to a Medline analysis performed in June 2006, more than 880 publications were available for BIS. These covered a huge range of information e.g. titration guidelines for anesthetics in different procedures and different patient population. At the same time, there were only 5 studies available for the CSI, another monitor designed to assess the depth of anesthesia.[3,9-13] A comparison of these numbers clearly shows that transferring guidelines from BIS to CSI values would make it possible to extrapolate BIS data to CSI applications especially if a good correlation could be demonstrated in similar studies between the indexes showed by these monitors.

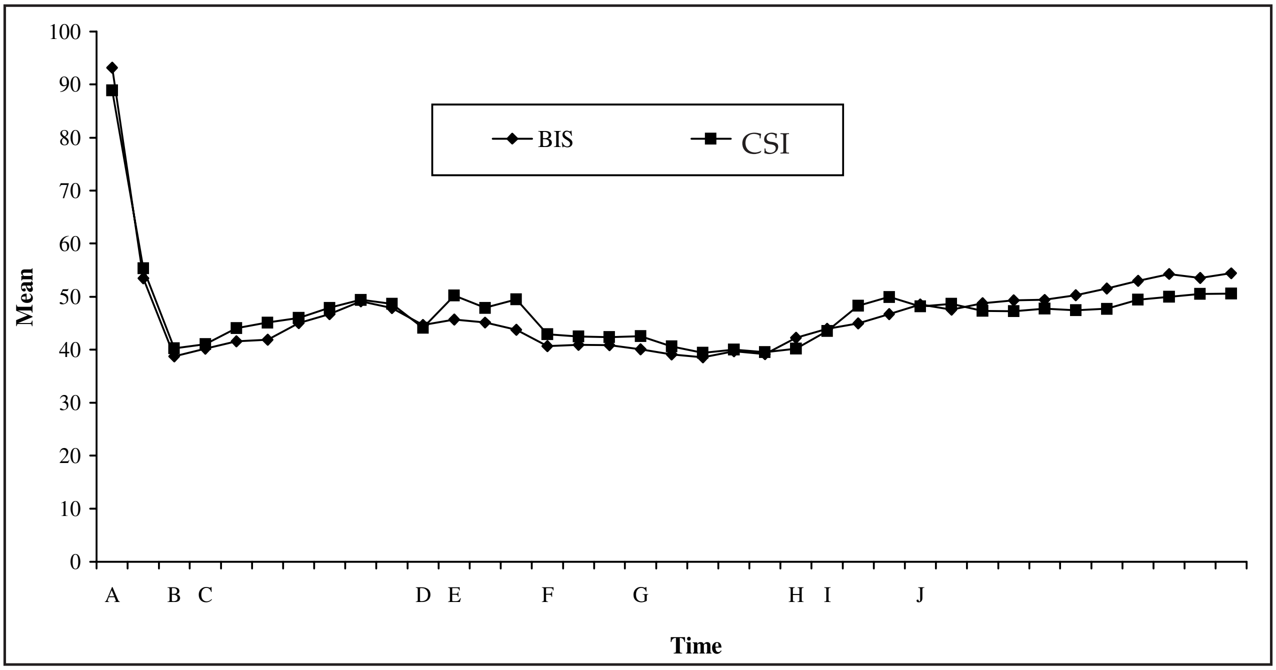


Figure-2: Comparison of changes in mean of Bispectral and Cerebral State indexes during anesthesia at 37 pre determined milestones. A = pre induction, B = post induction, C =1 min after laryngoscopy, D = before surgery, E = 1min after sternotomy, F = before cardiopulmonary bypass (CPB), G =30 min after start of CPB, H = before rewarming, I = 7 min after rewarming, J = after total pomp off (Ten selected milestones).

The present study was performed in a patient group undergoing a specific type of operation; open heart surgery, with relatively significant risk of awareness[14] and marked hemodynamic and temperature changes to examine clinical usefulness of CSI, a recently developed anesthesia depth monitor in comparison to BIS; a well known in these circumstances.

The CSI ™ resembles BIS by utilizing the spontaneous EEG for calculating a numerical index between 100 and 0.[3] The algorithm for calculation of the CSI utilizes a power analysis of the beta-, alpha- and beta-alpha ratios in conjunction with an estimation of burst suppression ratio.[3] While both monitors utilize the raw EEG signals for calculating the single index value presented to the clinicians, they use different algorithms and even different electrode placements for retrieval of signal processing of the index. The BIS employs a particular complex algorithm and referenced to 1500 patient anesthesias,[13] while the algorithm for the CSI is based on a more straight forward Fourier analysis of the EEG.

The main findings of this study are that the new CSI is as easy to use as BIS and that the CSI values recorded before and during general anesthesia with propofol and remifentanil are very similar.

Our results are well in agreement with Anderson and colleagues.[16] They found similar CSI and BIS patterns and numerical values during routine day-surgery anesthesia; however they reported large discrepancies between pair-wise readings. Although not completely explainable, these differences could be attributable to different study designs.

Some methodological limitations must be considered. For the comparison between BIS and CSI index values, we chose a non-steady – state approach with changing propofol and remifentanil concentrations. This is in contrast to possible study designs using either constant effect compartment concentrations of the anesthetic drugs e.g. via target –controlled infusion, or keeping one EEG parameter value constant and recording the parameter values of the second EEG parameter at that specific value of the first parameter .

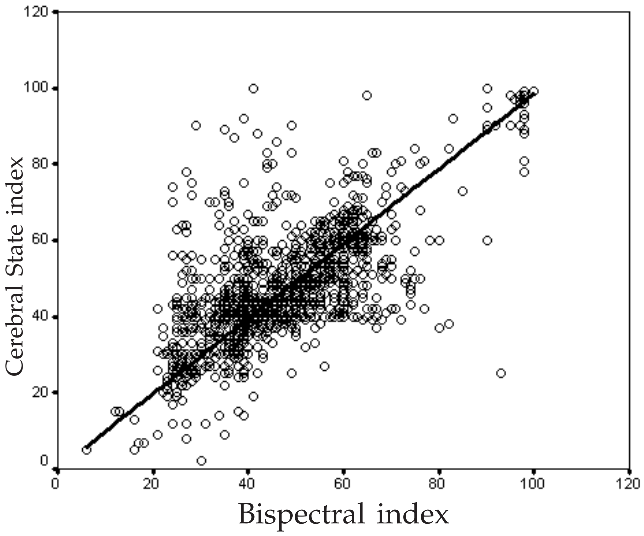


Figure-3: Relationship between Bispectral index and Cerebral State index during anesthesia for open heart surgeries.

The non-steady-state approach we chose has the advantage that a larger range of values are covered. In additional the non-steady-state approach is closer to daily clinical practice in anesthesia.

While it is not clinically relevant to have both monitors at the same time, this method is useful for determining the agreement between two similar techniques. However, this study design can not determine which monitor defines the depth of anesthesia most accurately.

This study was neither designed nor powered to determine whether depth of anesthesia monitoring provided any clinical benefit nor if there is any association between monitor values and potentially light anesthesia, awareness, recall or clinically inadequate anesthesia.

In conclusion, we found a sufficient correlation between BIS and CSI values. Our results might serve as a blue print for a rational "translation" of BIS into CSI values.

## ACKNOWLEDGEMENTS

The authors would like to thank the Persia Darman company; the local representative of Danmeter Company for providing the CSI monitor, S. Tabatabaee MS. for statistical advise and The Office of Vice Chancellor for Research of Shiraz University of Medical Sciences for financial support.

## REFERENCES

1. Nishiyama T, Matsukawa T, Hanaoka K. A comparison of the clinical usefulness of three different electroencephalogram monitors: Bispectral index, processed electroencephalogram, and Alaris auditory evoked potentials. Anesth Analg 2004;98:1341-5.
2. Sigl J, Chamoun N. An introduction to bispectral analysis for the electroencephalogram. J Clin Monit 1994;10:392-404.
3. Anderson RE, Jakobsson JG. Cerebral state monitor, a new small handheld EEG monitor for determining depth of anaesthesia: A clinical comparison with the bispectral index during day – surgery. Europ J Anaesth. 2006;23:208-12.
4. Gan TJ, Glass PS, Windsor A. Bispectral index monitoring allows faster emergence and improved recovery from propofol, alfentanil and nitrous oxide anesthesia. Anesthesiology 1997;87:808-15.
5. Song D, Joshi GP, White PF. Titration of volatile anesthetics using bispectral index facilitates recovery after ambulatory anesthesia. Anesthesiology 1997;87:842-8.
6. Yli-Hankala A, Vakkuri A, Annila P, Kortilla K. EEG bispectral monitoring in sevoflurane or propofol anesthesia: Analysis of direct costs and immediate recovery. Acta Anaesthesiol Scand 1999;43:545-9.
7. Bannister CF, Brosius KK, Sigl JC, Meyer BJ, Sebel PS. The effect of bispectral index monitoring on anesthetic use and recovery in children anesthetized with sevoflurane in nitrous oxide. Anesth Analg 2001;92:877-81.
8. Guignard B, Coste C, Menigaux C, Chauvin M. Reduced isoflurane consumption with bispectral index monitoring. Acta Anesthesiol Scand 2001;45:308-14.
9. Zhong T, Guo QL, Pang YD, Peng LF, Li CL. Comparative evaluation of the cerebral state index and the bispectral index during target-controlled infusion of propofol. Br J Anaesth 2005;95(6):798–802.
10. Bollen PJ, Saxtorph H. Cerebral state monitoring in Beagle dogs sedated with medetomidine. Vet Anaesth Analg 2006;33(4):237-40.
11. White PF. Use of cerebral monitoring during anaesthesia: effect on recovery profile. Best Pract Res Clin Anaesthesiol 2006; 20(1):181-9.
12. Pilge S, Zanner R, Schneider G, Blum J, Kreuzer M, Kochs EF. Time delay of index calculation: analysis of cerebral state, bispectral and narcotrend indices. Anesthesiology. 2006;104(3):488-94.
13. Anderson RE, Barr G, Jakobsson JG. Cerebral state index during anaesthetic induction: a comparative study with propofol or nitrous oxide. Acta Anaesthesiol Scand 2005;49(6):750-3.
14. Sebel PS. Central nervous system monitoring during open heart surgery: an update. J Cardiothorac Vasc Anesth 1998;12(2 Suppl 1):3-8.
15. Struys M, Jensen E, Smith W, Smith NT, Rampil I, Dumortier F, et al. Performance of the ARX-derived auditory evoked potential index as an indicator of anesthetic depth : A comparison with Bispectral index and Hemodynamic measures during propofol administration. Anesthesiology 2002;96(4):803-16.
16. Anderson RE, Barr G, Assareh H, Jakobsson J. The AAI™ index and end-tidal concentration during wash out of sevoflurane. Anaesthesia 2003;58:531-5.
17. Rampil IJ. A primer for EEG signals processing in anesthesia. Anesthesiology 1998;89:980-1002.