Original Article

Changes in BiSpecteral Index (BiS) Values During Cardiopulmonary Bypass (CPB)

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Abstract

Background: BiSpecteral Index (BiS) monitoring is standard monitoring regimen in anaesthesia practice. It has also been used in cardiac surgery. It is especially important due to the high incidence of neurological injury or dysfunction that occurs following CPB. This is a retrospective study of 33 cases that were monitored with BiS during the course of coronary artery or valvular surgery, including the period of CPB.
Methods: Thirty three cases monitored with BiS were studied retrospectively.
Result: From the recordings it was determined that the value of BiS which was ranging between 40 to 60 after induction, dropped below 25 at the onset of CPB. This change was statistically significant ($p<0.05$).
Conclusion: This decrease in the BiS value is probably a result of hypo-perfusion and due to clear, oxygen - poor priming fluid reaching the brain. Other periods of hypotension also correlated with the low values of BiS. This cerebral hypoxia which would occur at this time could be the cause of the incidence of neurological dysfunction that is known to occur following CPB.

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Key Words : Neurological dysfunction; Cardiac surgery; BiSpectral Index; Monitoring

Introduction

The BiSpectral Index (BiS) is a relatively new modality of neuromonitoring in cardiac surgical patients. BiS was introduced into clinical practice in 1998 [1]. Since then, it has gained wide acceptance. BiS is used in clinical practice with the aim of documenting depth of anaesthesia to ensure that awareness does not occur. In cardiac surgical patients undergoing cariopulmonary bypass (CPB), neurological damage and dysfunction are major concerns and the incidence of these has been reported to be in the order of 1 to 2% and 80% respectively [2]. Additionally, these patients are at higher risk for awareness [3].

BiS uses a proprietary alogorithm to analyse the electro encephalographic (EEG) signal and filter it from the myo-electric signal to give a dimensionless value between 0 to100. This value has been found to correlate to the depth of anaesthesia.

In this retrospective study we have attempted to utilize this newer monitoring modality to document the changes that occur during Cardio-Pulmonary Bypass (CPB) in the values of BiS, by studying 33 consecutive patients that were monitored with BiS.

Material and Methods

BiS being a standard monitoring tool, no consent was required for the study as the records of monitoring of cases already done were studied. Adult patients had been consecutively selected to undergo BiS monitoring, without any particular indication and bias. Inclusion criteria were adult patients who had undergone cardiac surgery on CPB with BiS monitoring. Paediatric cases were excluded from the study.

BiS monitor manufactured by Aspect Medical Systems ™ was used for the study. This displayed the values of BiS, signal quality and raw EEG. It recorded the BiS as trend in its internal memory. At the end of the operation a print of the BiS recording was taken from the integral thermal printer with the monitor.

The BiS electrode was applied to the forehead, aligning the marker line to the midline and the distal electrode over the temporalis muscle above the zygomatic arch. In application of the electrodes, if there was high impedance, a minute drop of strong KCl solution was applied to the electrode so that it passed the impedance test.

We practiced a standard institutional protocol for cardiac anaesthesia and all patients were managed according to this protocol. On the night before, the patients were given diazepam, 5 mg, orally. In the morning injection Morphine was given IV in the dose of 0.15 mg/ kg. After securing arterial access the patient anaesthesia was induced with a sleep dose of Thiopentone. Intubation was done with pancuronium.

After inserting central line and patient positioning the surgery commenced. Continuous recording of BiS was done during the period and the BiS value was also directly monitored and noted during this period.

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Our CPB protocol used clear crystalloid prime in all adult cases. No blood was added to any of the priming solution in all patients in this study. The BiS recording continued throughout including the period of CPB. At the end of surgery the patient was either electively ventilated or reversed and extubated. Prior to shifting the patient out of the OT the printout of the entire BiS recording for the patient was taken, covering the period from induction to the end of surgery and patient particulars endorsed on the recording, which was then kept for record.

Results

The distribution of cases by type of surgery is given in Table 1.

The mean age of the group was 58.63 (SD ± 13.08) years. There were 11 females and 22 males. Typical trend recordings of the BiS values is shown in Fig. 1. These are actual BiS recordings from four patients which are given to indicate the nature of the changes that occur in the BiS value. Table 2 shows the mean values of BiS at different times during the surgery.

From the BiS recordings of all the patients it was seen that before induction the BiS value was seen to be above 80. At induction there was a fall in BiS to the anaesthetic values as expected with a mean value of 58.06. The BiS value was seen to vary between 40 and 60 in the pre-CPB period. The BiS value frequently showed variation which was an artefact due to use of electrocautery. However, in the immediate period of CPB there were no confounding variables such as no electrocautery was being in this period and the recording was dependable and it accurately reflected the neurological state.

From the BiS recordings it was seen that there was marked dip in the BiS value immediately on going on CPB and lasting till application of the aortic cross clamp, a total duration 1.5 minutes approximately as seen from the BiS record. These observations were then analysed with the help of the Open Office Calc spreadsheet statistical formulae. This drop in the BiS was to a mean value of 25.35. The one tailed t test value for the fall of the BiS value from the post- induction to the CPB value is 0.0000000193 ($p < 0.05$), which is statistically significant. The test hypothesis being that no change in BiS value should occur during CPB i.e. a comparison of the data points post-induction and with the onset of CPB in each patient. The Pearson co-relation coefficient of these two sets of data is 0.32.

Following this the BiS value was seen to return to the pre-CPB values and this continued till the end of surgery. In case

Table 1

Distribution of cases by type of surgery

Diagnosis	No
Mitral valve replacement (MVR)	6
Coronary artery bypass grafting (CABG)	17
Aortic valve replacement (AVR)	4
Aortic and mitral valve replacement (DVR)	5
CABG + femoral artery aneurysm repair	1
Total	33

Table 2

Mean BiS values during surgery n=33

Time	Mean BiS Value	SD (±)
Induction	58.06	13.29
Onset of CPB	25.35	12.5
End of anaesthesia	74.76	13.58

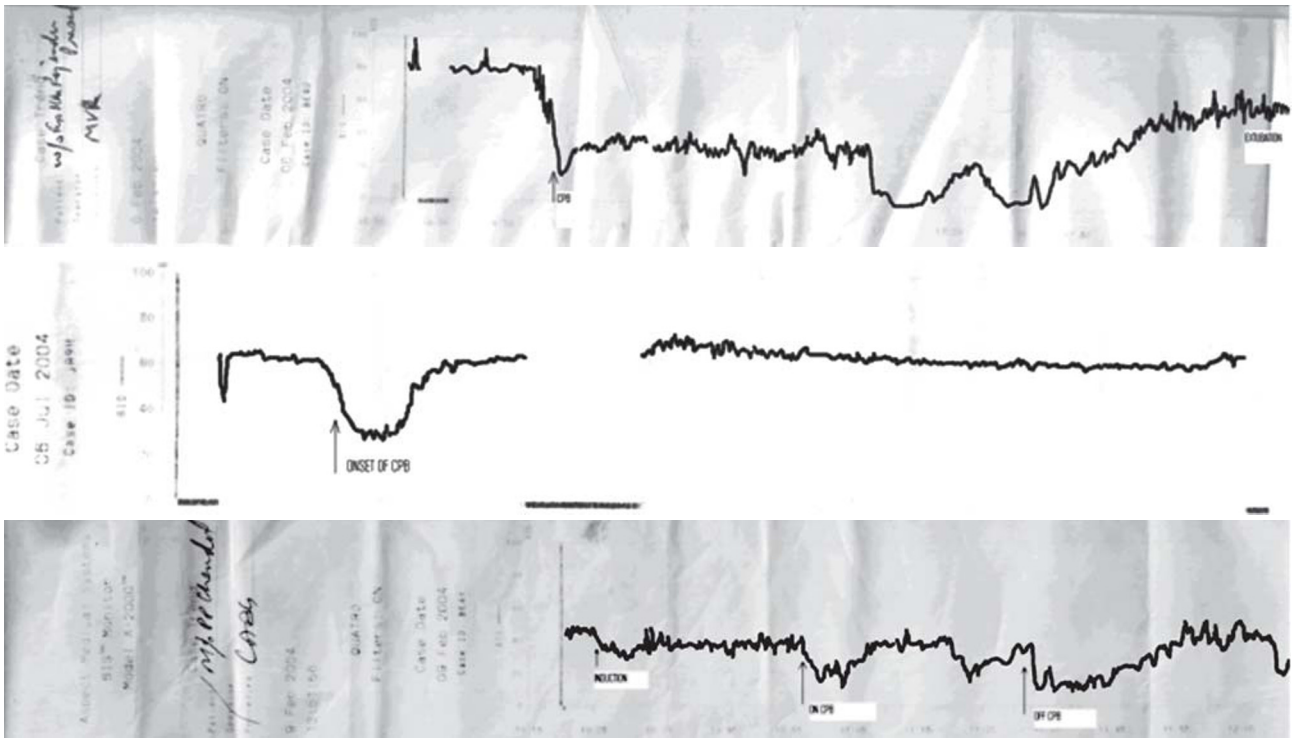

Fig. 1 : Actual BiS recordings.

the patient was reversed and extubated the BiS value was again seen to rise above 70 after the termination of general anaesthesia. Otherwise the patient was electively ventilated and extubated in the Intensive Care Unit. This did not affect the present study, which was concerned with BiS values at the time of CPB and during surgery. Fall in BiS was also noted with periods of intra-operative hypotension when correlated with the clinical charts.

Discussion

BiS is a well established monitoring modality intended to monitor the state of the brain by data acquisition of EEG signals in the intensive care unit, operating room and for clinical research. The Bispectral Index (BiS), a processed EEG variable, may be used as an aid in monitoring the effects of certain anesthetic agents. BiS value is an arbitrary number between 0 and 100, which is derived from the processing of the EEG signal by a proprietary algorithm. Zero corresponds to EEG electrical silence. The fully awake state corresponds to 100. Adequate level of anaesthesia which has been found to correlate with values of 40 to 60. The values correspond to Guedel's stages of anaesthesia. Narcotic based anaesthetic regimes do not correlate well. It has been used extensively in different types of cardiac surgery and also compared with different types of neuro-monitoring modalities. BiS recording of patients undergoing cardiac surgery has also been studied with the aim of studying awareness under anaesthesia [4]. There was no indication by the authors that any drop in BiS values occurred with the onset of CPB in this study.

A study done in children undergoing CPB documented the drop in BiS value at onset of CPB, though this study correlated all episodes of cerebral hypoperfusion and concluded that reduction in BiS value correlated with cerebral hypoperfusion [5]. Thomas et al [6] studied BiS in patients undergoing off pump coronary artery surgery (OPCAB) and found that the incidence of hypotension correlated with low values of BiS and proposed that BiS might be used as an indicator of cerebral hypoperfusion in OPCAB.

CNS dysfunction after CPB is known and has been studied [2,7]. Our study has attempted to demonstrate that real time processed EEG signal monitoring such as BiS shows a marked drop in electrical activity at the time of onset of CPB. Reduced EEG signal from the brain may result from increasing depth of anaesthesia but it may result from other causes of decreased neuronal activity such as hypoxia [8]. It is hypothesized that this could occur due to the transient hypoxia which occurs due to the clear crystalloid prime reaching the brain immediately on onset of CPB and the lower CPB flows which occur at the time of onset of CPB. By the time the aortic cross-clamp is applied by the surgeon sufficient time has elapsed for the prime with minimal oxygen content to reach the brain and reduced oxygen delivery to occur. Another reason for this would be the lower cardiac output due to the diversion of venous return to the CPB pump. The correlation of this period of lowered levels of BiS value would require further investigation to correlate it with cerebral hypoxia and with any neuro-behavorial changes. Further pre and post-operative neurocognitive assessment is required to establish the extent of dysfunction, if any [9].

In conclusion in this study we found that there is a rapid decline of the BiS value with the onset of CPB. This is likely to be on account of the hypoxia which would occur due to the decreased oxygenation of the brain due to transition of the circulation to CPB and the clear, oxygen-poor prime reaching the brain.

Conflicts of Interest

None identified

Intellectual Contribution of Authors

Study Concept : Col Ashok Sinha
Drafting & Manuscript Revision : Col Ashok Sinha, Brig GS Ramesh, Brig VP Singh
Statistical Analysis : Col Ashok Sinha
Study Supervision : Brig VP Singh

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