Use of the bispectral index to monitor anaesthesia

In October 1996, the Food and Drug Administration approved the use of the first anaesthesia effect monitor in the USA: the bispectral index (BIS) monitor (Aspect MS®, Newton, MA). The BIS is a computer-processed electroencephalography (EEG) variable, which results in a single number, ranging from 0 (isoelectric EEG) to 100 in the awake state. It is derived by combining several different EEG descriptors: the BetaRatio, the SynchFastSlow and a measure of burst suppression (Rampil, 1998).

The company collected EEG recordings from over 5000 subjects undergoing anaesthesia with multiple different anaesthetic regimens. Clinical information related to anaesthetic depth was collected, such as changes in heart rate and blood pressure with skin incision, response to commands or recall of information presented via headphones. These recordings were processed, and a database of the EEG predictors and the corresponding clinical states was created. The descriptors were then ranked by the ability to predict a particular clinical event, and a statistical analysis was performed to construct combinations of the descriptors that would best correlate with the clinical condition.

This statistically based and empirically derived combination of predictors, rather than a single predictor, forms the basis of the BIS (Rampil, 1998). A BIS value below 50–60 was associated with a low probability of response to a verbal command in volunteers. Loss of recall occurred at higher BIS, with the probability of recall being low when BIS values were below 70 (Glass et al, 1997).

CLINICAL USES

The main use of BIS monitoring is for titrating anaesthetics to optimum levels. A number of prospective randomized studies have demonstrated that monitoring the depth of sedation with BIS resulted in reduced drug dosage, more rapid recovery and an improved side effect profile.

In a large multicentre study, the BIS was used to titrate propofol infusions in a propofol–alfentanil–nitrous oxide anaesthetic to target optimum values of the BIS between 45 to 60. This was compared with controls in which a similar anaesthetic regimen was used and the drug infusion regimen was based on standard practice. It was found that the BIS group were given less propofol, were extubated sooner, were more orientated on arrival to the post-anaesthetic care unit, had better nursing care assessments and became eligible for discharge sooner.

There were significantly fewer patients (3% *vs* 15%) who took longer than 15 minutes to emerge from anaesthesia in the BIS group compared with the standard practice group (Gan et al, 1997). The use of BIS allows the practitioners to titrate the drug effect based on the pharmacodynamic endpoint, thus reducing the pharmacokinetic and pharmacodynamic variables between patients.

BIS is also useful in deciding whether to administer an antihypertensive agent or to further deepen anaesthesia in a patient who is apparently adequately anaesthetized but develops intraoperative hypertension. The presence of a BIS value compatible with an adequate depth of anaesthesia would avoid unnecessarily deepening the anaesthetic (Mavoungou et al, 2000). Zbinden et al (1994) have shown that, during isoflurane anaesthesia, haemodynamic responses alone were not reliable indicators of the depth of anaesthesia, showing a large interindividual and intraindividual variability.

BIS AND AWARENESS

Monitoring depth of anaesthesia is of particular interest to anaesthesiologists. There has been increased attention in the press to the problem of awareness during general anaesthesia. McCleane and Cooper (1990) reported that over 50% of patients undergoing general anaesthesia feared that they would not be asleep during the operation. Indeed, in a recent survey, patients reported they were willing to pay a median of US$34 for a monitor that would reduce the incidence of intraoperative awareness (Wright et al, 2001).

In the analysis of the America Society of Anesthesiologists' Closed Claims Project, factors identified as associated with recall were complete lack or inadequate dose of an anaesthetic agent in 83% of cases. This was either because of a planned nitrous–narcotic–relaxant technique (18%), discontinuation of anaesthetic agents to avoid hypotension (18%) or inadequate doses of drugs (47%). The reasons for inadequate doses included vaporizer leaks, failure to turn the vaporizer on, difficult tracheal intubation or failure to increase doses appropriately in obese patients. There was no obvious factor for claims in the remaining cases (Domino et al, 1999).

Based on these findings, it is conceivable that BIS monitoring may reduce the incidence of awareness by more accurately defining the patient's state of consciousness. Interestingly, claims for awareness more often involved women than men, and women were found to wake up faster than men from general anaesthesia using a similar anaesthetic regimen (Gan et al, 1999).

On the other hand, will the use of BIS actually prevent awareness in routine practice? Since the incidence of recall is very low (0.18%), it has been estimated that to conduct a prospective randomized trial capable of demonstrating a significant reduction in the incidence of recall, approximately

50 000 patients in each group would be required (Sandin et al, 2000). A multicentre trial of this size is currently underway.

It is also important to appreciate that the BIS value, as an average over the last 15–30 s, is an indicator of a patient's recent state of sedation but should not be regarded as a predictive index of future events. Therefore, a consideration of the anaesthetic regimen and clinical circumstances is important when evaluating a BIS number; an unstimulated patient with a low BIS may move and have exaggerated responses and possible awakening with a rise in BIS following a sudden skin incision.

Studies suggested that the auditory evoked potential index was better at detecting the transition from unconsciousness to consciousness (Gajraj et al, 1999). Iselin-Chaves et al (2000), however, demonstrated that BIS correlated better with the level of sedation than any of the mid-latency auditory evoked potential parameters. BIS values reflect cortical activity and the hypnotic component of anaesthesia but do not reliably predict motor response to noxious stimuli, which is primarily mediated at the spinal cord level. The correlation between BIS and response to skin incision also depends on the type of anaesthetic used, becoming less significant with an opioid-based anaesthetic (Sebel et al, 1997).

USE OF BIS IN INTENSIVE CARE AND IN CHILDREN

There are preliminary indications that BIS functions reliably in the intensive care unit setting and may be useful in guiding sedation and/or analgesia. Close correlation was found between BIS and both the sedation–agitation scale and the Ramsay sedation score. The use of BIS might be particularly useful in patients receiving neuromuscular blocking agents to facilitate mechanical ventilation and in avoiding the side effects of an overdose of sedative drugs in intensive care patients (Simmons et al, 1999).

BIS has also been used in the paediatric population, and a smaller paediatric sensor has recently been introduced in the USA. The BIS value is, however, based on adult EEG data and EEG changes have been noted with maturation from birth through puberty. Although some studies suggest that the BIS is useful in titrating anaesthetic requirements, especially in older children, the validity of the BIS monitor in children of different age groups has yet to be established (Bannister et al, 2001).

CONCLUSION

The BIS monitor is more widely used in the USA than in the UK, and its use is gaining popularity. BIS monitoring during general anaesthesia reduces anaesthetic drug usage and recovery times with potential cost savings. The use of BIS allows practitioners to more accurately titrate the administration of sedative drugs to achieve the desired pharmacodynamic endpoint, thereby reducing the variability of patient response when an average weight-based dose is administered.

The introduction of BIS monitoring has stimulated much research and improved the understanding of the hypnotic and analgesic components of general anaesthesia. HM

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KEY POINTS

- The bispectral index (BIS) is a computer-processed electroencephalography variable.
- A combination of predictors is used to derive the BIS value.
- The BIS is useful for titrating anaesthetics to optimum level.
- Reduced drug dosage and faster recovery have been shown with the use of BIS.
- The BIS does not predict movement or when the patient is at risk of arousal.
- The BIS has potential for use in the intensive care unit and in the paediatric population.