Editorial

Bispectral index in pediatrics: fashion or a new tool?

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The bispectral index (BIS™, Aspect Medical Systems, Inc. Newton, MA) is becoming the gold standard for assessing depth of anesthesia in adult patients. Indeed, BIS values are highly correlated with the concentration of hypnotic drugs such as propofol or sevoflurane (1–8). The BIS is derived from a large database of EEG traces obtained in adult patients under various conditions of anesthesia (9). This database is regularly updated and the corresponding software is changed accordingly. The calculation of BIS is kept secret, but the elements included into the algorithm are known. Basically, the value displayed takes into account the frequency of EEG signal (the proportion of rapid to slow waves decreases with increasing hypnotic concentration), the synchronization of the waveforms (from virtually no synchronization in awake patient to higher degree of synchronization with increasing depth of anesthesia), and the percentage of burst suppression (the latter being observed at very deep level of anesthesia). The BIS is displayed as a dimensionless number between 0 (deep anesthesia) and 100 (awake), with 40–60 being suitable for surgical anesthesia (10). The BIS has well-known limitations. First, the BIS is more or less insensitive to narcotics, thus it reflects the hypnotic state which is only one component of anesthesia. Therefore it is not surprising that the specificity of BIS for predicting the response to noxious stimuli (such as surgical incision or laryngoscopy) under balanced anesthesia is low. Second, the BIS algorithm was validated mainly against propofol or volatile agents currently in use (isoflurane, desflurane and sevoflurane). BIS values are not correlated with ketamine plasma concentrations and are much higher at a given MAC values of halothane compared with sevoflurane (11). The latter drawbacks are not surprising as EEG traces obtained with these agents are very different from those integrated in the database (i.e. propofol and more recent volatile agents) (12–14). The BIS monitor was developed to assess depth of anesthesia and to decrease the incidence of awareness. The latter objective is achieved (15). Indeed, the B-Aware randomized controlled trial demonstrated that BIS-guided anesthesia reduces the risk of awareness in at-risk adult surgical patients undergoing relaxant general anesthesia. Other potential benefits in adults include decreased drug consumption, decreased postoperative incidence of nausea and vomiting (16) and quicker recovery time compared with non BIS-guided anesthesia (17).

Having said that, one can understand easily that the BIS was conceived as an ‘adult’ tool, not a pediatric one. Thus, the preliminary questions are: does it work in pediatric patients and if the answer is positive, what could be the interest of this device in pediatric patients? As indicated above, the BIS is only derived from adult EEG traces while EEG traces in young children differ from adult traces. Roughly, from infancy to adulthood, the amplitude of EEG decreases and dominant frequency increases (in other words, EEG becomes composed of faster waves of smaller amplitude with increasing age). However, the effects of anesthetic agents on EEG tracings are comparable throughout life. BIS values recorded in pediatric patients are inversely correlated with endtidal sevoflurane (18–20) and isoflurane concentrations (21) as in adults. BIS values are better

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correlated with sevoflurane concentrations than changes in heart rate or systolic arterial pressure in preschool children (22). In infants, endtidal sevoflurane concentration corresponding to a BIS value of 50 (CI 95%) is higher compared with that of children aged over 2 years (1.55% vs. 1.25%) (20). At recovery BIS changes are less progressive and exhibit an on-off profile in infants whereas changes are more progressive in older children and adults. In children, BIS-guided anesthesia allows for a reduced consumption of anesthetic agent during surgery and a quicker recovery but only in children over 3 years of age. These results are in agreement with those reported in adult patients.

Specific limitations have been observed with BIS monitoring during anesthesia in pediatric patients. First BIS values describe a paradoxical profile during inhalational induction in children and are neither correlated with clinical events nor with the clinically assessed depth of anesthesia (23,24). The typical BIS during rapid inhalational induction with sevoflurane shows an early and abrupt drop after loss of consciousness followed by increase of BIS values when deepening anesthesia. The nadir of the BIS is usually observed 120–180 s after the beginning of induction and reflects the very low EEG frequency observed around the second minute of induction (23). The subsequent increase in BIS reflects the shift of EEG rhythms towards faster frequencies. BIS monitor also displays paradoxical high values during seizure activity (25). This is of special concern in children anesthetized with high concentrations of sevoflurane. Indeed despite the existing controversy regarding the true incidence of epileptiform activity during sevoflurane anesthesia, it is becoming clear that epileptiform EEG tracings may be observed at very deep levels of sevoflurane anesthesia (26). Periodic epileptiform discharges are usually observed before the appearance of burst suppression (27–29). Thus, one of the potential interest of BIS monitor in children may be to avoid too deep levels of anesthesia (maybe BIS values below 20) in order to reduce the risk of sevoflurane-induced epileptiform activity, and perhaps to reduce the risk of hypothetical brain function impairment associated with deep anesthesia in young children (30–32).

In adults, one of goal of BIS monitoring is to decrease the risk of awareness during anesthesia in at-risk patients. This may be of lesser concern in children but awareness is yet poorly described and evaluated in pediatric patients. Two early studies performed more than 20 years ago suggested that in children the incidence of awareness during anesthesia was 0 and 5%, respectively (33,34). In the former study, patients were anesthetized using the ‘Liverpool technique’ based on nitrous oxide–oxygen and relaxant and 19% of children reported dreams after anesthesia but no patient reported awareness. A recent abstract found an incidence of awareness of 8% in children with a significant relationship between multiple attempts for tracheal intubation and awareness (35). This incidence is much higher than expected with modern anesthesia and this needs further investigation.

The use of BIS for monitoring consciousness during sedation procedures (36–38), in comatose children (39) or in intensive care unit (40,41) seems promising. Significant correlation was observed between BIS scores and a validated observational pediatric sedation scale, the University of Michigan Sedation Scale (UMSS) when hypnotics such as pentobarbital or midazolam were employed, but poor correlation was found when ketamine or a combination of chloral hydrate, hydroxyzine and meperine was used in children (37). The BIS monitor will probably be of great interest when sedation is administered by non-anesthesiologists in order to avoid too deep sedation (36,42). Potential indications of BIS monitoring in intensive care unit such as titration of barbiturate coma, titration of sedation, sedation assessment during mechanical ventilation are currently under evaluation (40).

Thus the BIS monitor is definitely a useful tool that may help the anesthesiologist to avoid too light a level of anesthesia and its risk of awareness or too deep anesthesia which may promote undesirable cardiovascular effects in compromised patients or potential anesthesia-induced brain damage in the youngest. The prerequisite to correctly interpret BIS changes is to be aware of the specific effects of anesthetic agents on EEG and to know specific EEG changes associated with anesthesia stages.

References


