Clinical Advantages of Depth of Consciousness Monitoring in the Ambulatory Setting

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Abstract

Purpose: Consciousness monitors allow for intraoperative titration of hypnotic depth. This review examines the efficacy and advantages of these monitors in the ambulatory setting.

Scope: This review summarizes the possible clinical advantages of consciousness monitors in the ambulatory setting. Included in the discussion are potential savings of time and cost, avoidance of intraoperative recall, and improvement in clinical outcomes.

Conclusions: Monitoring consciousness in the ambulatory population may result in earlier recovery, reduced PACU stay, and a reduction in the incidence of intraoperative recall. Use of consciousness monitoring may aid in providing a safer and more efficient anesthetic, allowing for adjustment of dosing of hypnotics to individual patient needs.

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Keywords: Apnea, Depth of Consciousness, Monitored Anesthesia Care.

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Introduction

For over 150 years, physicians have used surrogate measures of consciousness (such as respiratory pattern, pulse, blood pressure, and exhaled anesthetic concentration) to determine and adjust anesthetic depth. With the advent of inexpensive and rapid computing power over the past thirty years, the ability to readily measure the effects of anesthetics on the brain (which is, afterall, the target organ for the hypnotic effects of anesthetics) has become possible. Modern processed EEG technology allows a more direct assessment of the brain's response to these medications and presumably a more accurate estimate of the level of sedation.

The primary goal of ambulatory surgery is to provide safe healthcare to patients in a way that is both time and cost effective. Consciousness monitors have been touted as a means to trim perioperative costs, improve anesthetic technique, and enhance patient safety. The purpose of this discussion, therefore, is to review the clinical advantages that these monitors can deliver in the ambulatory and office based settings.

Although frequently referred to as "depth of anesthesia" monitors, it is important to point out that of the components of anesthesia, these devices only monitor consciousness (or hypnosis, which is synonymous). Experiments that have examined the correlation between consciousness and movement during various anesthetic regimens have not shown a predictable correlation between the two [1]. MAC does not equate with consciousness, as shown in animal experiments revealing that MAC does not change despite forebrain removal [2].

Many attempts have been made to identify a single ideal value for interpretation of the EEG for perioperative use. 95% spectral edge and median frequency were among the first derivatives used in clinical practice with varying degrees of success. Following a series of experiments that confirmed the utility of a proprietary algorithm for EEG processing in the early 1980s, Aspect Medical Systems was formed in 1987. The first literature detailing the Bispectral Index® (BIS®) was published in the early1990s, with over 12 million patients monitored by 20053. Physiometrix and General Electric followed suit, and there are currently three primary monitoring choices available:

The Bispectral Index® (BIS®) reports a number between 100 (fully-awake) and zero (isoelectric EEG) to predict level of hypnosis, with values under 60 generally correlating with anesthetic level indicating loss of consciousness and absence of recall. Similarly the PSA-4000 monitor (and the soon-to-be-released "SEDLine"), initially developed by Physiometrix and now manufactured by Hospira, reports a number (known as Patient State Index, or PSI) between 100 and zero, with 50 generally representing appropriate surgical anesthetic depth [4]. The Entropy monitor (General Electric) translates the disorder in both EEG and EMG into two separate measures of consciousness: State Entropy (SE) which reflects cortical activity of the brain, and Response Entropy (RE) which reflects both cortical activity and frontalis EMG activity [5]. Technologies utilizing audio evoked potentials have also been introduced, but are no longer available for sale in the United States.

A plethora of studies have explored the ability of these monitors of consciousness to reduce drug use, speed recovery time, aid in anesthetic titration, and potentially reduce morbidity and mortality. In effect, an attempt has been made to show that these monitors allow for delivery of an anesthetic that is cheaper, faster, and better.

Do consciousness monitors save time/ money?

Drug use

A number of well designed studies have shown that patients receiving an anesthetic titrated with a consciousness monitor received less drug without untoward consequences. In a study examining recovery in ambulatory patients, anesthesia providers titrating anesthetic without a BIS monitor used 38% more volatile anesthetic and had significantly slower recovery times than providers that titrated to BIS [6]. Similarly, in a study of propofol consumption, patients with anesthetic titrated to BIS required less propofol, were extubated sooner, were more likely to be oriented in the PACU, and were eligible for discharge sooner [7].

Advantages of reduced drug use include the possibility for reduction of anesthetic related side effects. For instance, the incidence of

postoperative nausea and vomiting is reduced when anesthetic is titrated to level of consciousness [8,9]. Furthermore, an enhanced ability to titrate drug allows for potentially safer titration in patients that have altered pharmacodynamic profiles, such as the obese and elderly, that make up more and more of our ambulatory surgical population .

Recovery

Many studies have examined the effect of consciousness monitors on time to awakening, orientation upon arrival in the PACU, length of PACU stay, and time to PACU discharge with both positive and negative results. In a meta-analysis of healthy ambulatory patients, Liu showed that although recovery room time was slightly reduced in patients monitored with BIS (as was anesthetic consumption and risk of PONV), their overall time spent in the ambulatory surgical unit was not [10]. Wong and colleagues found that anesthetic titrated to BIS in the elderly population resulted in a nearly four minute faster time to orientation in the PACU as well as a more rapid time to achieve an Aldrete score >9 (16.9 vs. 19.1 minutes), suggesting the potential for earlier discharge in this vulnerable population [11]. However, earlier discharge was not demonstrated.

Sedation

Apnea during monitored anesthesia care is common, and has been reported to occur between 25-50%. Furthermore, it is more likely to occur as level of consciousness is progressively depressed [12,13]. In a recent study of MAC sedation, BIS prior to apnea was frequently in the range of general anesthesia (i.e. <60) [13]. Monitoring depth of consciousness and preventing unwanted oversedation with processed EEG may result in an improvement in patient safety during procedural sedation, especially when sedation is administered by non-anesthesia providers with limited training in resuscitation and airway management.

Do consciousness monitors prevent recall of intraoperative events?

A number of studies have sought to determine the incidence of explicit recall following general anesthesia. Using well constructed questionnaires and statistical methodology, the incidence has been determined to be somewhere between 1 in 500 and 1 in 1000 cases [14, 15]. Although most subjects recall only auditory stimuli (rather than pain), a significant subset of patients (50%) have been found to have evidence of post-traumatic stress two years after the event [16]. As a result of this disturbing data, attempts were made to determine whether consciousness monitors could potentially reduce or eliminate this risk.

Ekman and colleagues examined the incidence of recall in patients receiving a balanced anesthetic in a large medical center before and after introduction of BIS technology [17]. Although their initial incidence of recall was 0.18% (similar to what was previously published) they found a 77% reduction to 0.04% in this incidence when BIS technology was introduced. Myles and colleagues randomized nearly 2500 patients at high risk for recall (including those with hypovolemia, chronic benzodiazepine or opiate use, those undergoing high-risk cardiac surgery, rigid bronchoscopy, etc.) to receive anesthesia titrated with either BIS or with standard practice monitoring (heart rate, end-tidal gas concentration, etc) [18]. Similar to Ekman's findings, patients monitored with BIS had an 82% reduction in recall to 0.16% versus the 0.9% incidence in the standard practice group.

As is evident from the literature, recall does occur regularly, the incidence is higher with certain patient populations and anesthetic tehniques, and consciousness monitoring can help reduce this incidence. In part due to the findings of these studies, the FDA approved a new indication for the BIS monitor: "Use of BIS monitoring to help guide anesthetic administration may be associated with the reduction of the incidence of awareness with recall in adults during general anesthesia and sedation." . In 2004, the Joint Commission on Accreditation of Healthcare Organizations issued a 'sentinel alert' warning of the risk, requiring accredited organizations to develop a comprehensive recall awareness policy at all locations performing general anesthetics (Table 1) [19].

Table 1 JCAHO recommendations to help prevent and manage awareness.

Develop and implement an anesthesia awareness policy that addresses the following:

- Education of clinical staff about anesthesia awareness and how to manage patients who have experienced awareness.
- Identification of patients at proportionately higher risk for an awareness experience, and discussion with such patients, before surgery, of the potential for anesthesia awareness.
- The effective application of available anesthesia monitoring techniques, including the timely maintenance of anesthesia equipment.
- Appropriate post-operative follow-up of all patients who have undergone general anesthesia, including children.
- The identification, management and, if appropriate, referral of patients who have experienced awareness.

Assure access to necessary counseling or other support for patients who are experiencing post-traumatic stress syndrome or other mental distress.

Do consciousness monitors improve clinical outcomes?

A retrospective chart review by Monk and colleagues examined the incidence of mortality at one year following major non-cardiac surgery under general anesthesia [20]. The mortality rate of the 1064 patients reviewed was approximately 5% at one year, and slightly higher in the elderly subset. Independent predictors of increase mortality were coexisting disease, intraoperative hypotension (<80 BPS), and cumulative time of BIS <45. It was found that every hour a patient was kept below this level resulted in a 24% increased chance of mortality at one year. It has long been known that mediators of inflammation increase in the perioperative period, and it has been suggested that depth of anesthetic state may alter the inflammatory cascade, affecting survival. However, the low BIS values may also simply be a marker of underlying disease. Multicenter randomized prospective trials are needed to determine the impact of anesthetic depth on long-term outcomes, and no conclusions can be made at this time regarding the phenomenology described, especially in the

younger/healthier population usually treated in the ambulatory setting.

Cost analysis

A recent meta-analysis examining the issues of drug/time savings vs. device costs found that use of consciousness monitors would increase costs by approximately five dollars per patient [10]. Cost analysis of consciousness monitoring technology, however, must take into consideration not only the expense of the device, but also the potential benefits in terms of patient safety. The price of avoiding a single case of awareness and its sequelae (both medical and legal) is unclear. An intriguing analysis published by Gan and colleagues in 2003 suggested that patients assign a very high intrinsic value to the prevention of awareness, and that they would be willing to pay up to $34 for a monitor that would aid in preventing this complication [21]. Similarly a study by Macario and colleagues from 1999 found that patients would assign approximately $14 out of $100 to prevent recall without pain [22].

Summary

It is evident that consciousness monitors can aid in anesthetic titration. Monitors of consciousness give a glimpse into the effects of anesthetic on the brain, which is, after all, the end-organ of consciousness, and as such provide insights beyond that given by hemodynamics alone.

Monitoring consciousness in the general population results in earlier recovery, reduced PACU stay, and a reduction in the incidence of intraoperative recall. Incorporating consciousness monitoring into standard practice in the ambulatory setting may aid in providing a safer and more efficient anesthetic, allowing for adjustment of dosing of hypnotics to individual patient needs.

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