

Awareness With Recall: A Systematic Review

Caitlin Sullivan, DNAP, CRNA

This article provides a systematic review of awareness with recall, also called intraoperative awareness. Major topics of this review include the incidence and causes of this phenomenon, in addition to an examination of current strategies for prevention of intraoperative awareness. Awareness with recall creates substantial physical and/or psychological distress for the patient, representing a continued threat to patient safety. Factors related to cases of awareness include those of the patient, surgical procedure, anesthesia provider, and system in which providers deliver care. Anesthesia providers today consider use of electro-

encephalographic depth-of-anesthesia monitors such as the bispectral index monitor (BIS, Covidien, now Medtronic), as a potential tool for preventing awareness. This Journal course explores evidence related to the utility and limitations of this monitor in clinical practice. It also reviews evidence-based practices that may decrease the incidence of awareness with recall, including avoidance of muscle relaxants and protocol-driven approaches to awareness prevention.

Keywords: Anesthesia awareness, depth-of-anesthesia monitors, electroencephalogram.

Objectives

At the completion of this course, the reader should be able to:

1. Describe the effects of anesthesia awareness on the patient's intraoperative and postoperative experience.
2. Describe patient factors that contribute to cases of anesthesia awareness.
3. Identify potential benefits and limitations of bispectral index monitors.
4. Discuss the results of recent studies with regard to outcomes of bispectral index–guided anesthesia compared with anesthesia guided by end-tidal anesthetic concentration on the incidence of anesthesia awareness.
5. Discuss position statements issued by the Joint Commission, the American Association of Nurse Anesthetists, and the American Society of Anesthesiologists regarding awareness with recall.

Introduction

Intraoperative awareness, defined when “a patient becomes conscious during a procedure performed under general anesthesia and subsequently has recall of these events,” has the potential to result in severe psychological distress for those it affects.^{1,2} Although this traumatic phenomenon is rare, up to 70% of patients who experience recall may exhibit posttraumatic stress disorder

(PTSD).^{3,4} This Journal course is a systematic review of the literature on the topic of anesthesia awareness, with the goal of exploring patient, surgical, provider, and systems factors that contribute to its incidence.

Literature Review Methods

Search criteria of 2 databases (The Cochrane Collaboration and PubMed) included the following search terms: *anesthesia awareness, awareness, recall, and BIS monitor*. The review focused on research studies published since 2014 and included case studies and review articles published since the year 1984. One research study authored by a paid consultant to Aspect Medical Systems was excluded because of the potential for bias. Bibliographies of research articles provided additional references for this review.

Incidence and Stages of Awareness With Recall

Awareness under general anesthesia occurs in the United States about 1 to 2 times per 1,000 patients. This incidence may seem relatively small, but it equates to 20,000 to 40,000 cases per year.^{3,5,6} Reported rates of awareness under anesthesia varies between countries. For example, the 2013 5th National Audit Project (NAP5) in the United Kingdom and Ireland documented a lower incidence, about 1 in 19,000.⁷ (Of note, this study relied

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on patients' self-reporting.⁷) Awareness during general anesthesia represents a threat to patients' safety and outcomes, and erodes their overall trust in anesthesia providers. The Joint Commission, the American Association of Nurse Anesthetists (AANA), and the American Society of Anesthesiologists (ASA) have issued statements detailing the importance of preventing and managing the impact of recall during and after general anesthesia.

Authors describe awareness under anesthesia using terms such as *intraoperative awareness*, *accidental awareness during general anesthesia*, and *awareness with recall* (AWR), to name a few.^{2,8,9} For the purposes of this *Journal* course, AWR denotes the phenomenon of awareness under anesthesia. Awareness with recall includes 2 major components: (1) the experience of consciousness during a procedure performed under general anesthesia and (2) subsequent recall of these events.^{2,3} The ASA defines the terms *consciousness*, *general anesthesia*, and *recall* as follows: "Consciousness is a state in which a patient is able to process information from his or her surroundings.... General anesthesia is a drug-induced loss of consciousness during which patients are not arousable, even by painful stimulation.... [R]ecall is the patient's ability to retrieve stored memories."¹

Amnesia, or the loss of memory formation, is one goal of general anesthesia. In cases of AWR with explicit (conscious) recall, the patient remembers spoken words, experiences, and sensations from the general anesthetic. Patients also may experience implicit (unconscious) recall, which creates almost equally traumatic psychological consequences following surgery. These patients do not remember spoken words or sensations, yet still unconsciously experience vague psychological difficulties in the postoperative period.¹⁰ Explicit memory is more sensitive to general anesthesia than is implicit memory. Low or modest depths of anesthesia may abolish explicit memory but may be insufficient to prevent implicit memory formation.

Kaul and Bharti¹¹ described 4 stages of awareness: (1) conscious awareness with explicit recall, (2) conscious awareness with no explicit recall, (3) subconscious awareness with implicit recall, and (4) no awareness or recall. In a 2006 Practice Advisory, the ASA acknowledged that awareness cannot be measured intraoperatively. The recall component is the defining factor for AWR and can be obtained only from the patient in a postoperative interview.¹ Administration of benzodiazepines impairs new memory formation, while previously formed memories remain intact. As the dose of benzodiazepines increases, memory impairment increases. Anesthesia providers should consider amnestic drugs such as midazolam or scopolamine in cases where light anesthesia becomes necessary.¹⁰

Patients undergoing anesthesia often report that the risk of recall is a substantial cause of worry.^{8,9} Those who

experience AWR recount feelings of helplessness, inability to breathe, pain, panic, anxiety, and impending death. These patients later experience sleep disturbances, flashbacks, depression, fear about future anesthesia, and hospital avoidance. Many such patients report recall after anesthesia to be their "worst hospital experience" and may refuse future surgeries as a result. Up to 70% of patients who have recall after anesthesia experience PTSD.^{2,4,12} In her book titled, *Silenced Screams*, Dr Liska¹³ described her life-changing experience with AWR. "[T]he surgeon's electric knife... tore into my skin. It felt like a blowtorch. Lightning bolts of pain more intense than any pain I had ever experienced surged and ricocheted through my torso... But I was the only one who heard my own tortured screams..."

Causes of Awareness under General Anesthesia

In a 2004 Sentinel Event Alert, the Joint Commission indicated that it is difficult for anesthesia providers to detect AWR.⁴ Autonomic responses (eg, sudden hypertension, tachycardia, lacrimation, sweating, and pupil dilation) are unreliable indicators of the depth of anesthesia. Beta-blockers or calcium-channel blockers may decrease the sympathetic response to surgical stimulation, which can mask hemodynamic changes in response to AWR.^{1,14} Administration of neuromuscular blocking drugs during general anesthesia prevents the patient from moving, which could otherwise alert the provider of inadequate depth of anesthesia. Movement in a nonparalyzed patient allows the provider to deepen the anesthetic depth, thereby potentially decreasing the risk for AWR. Providers should consider the minimum dose of muscle relaxants required for adequate surgical exposure and should avoid total paralysis.⁶ Even if muscle relaxants are not used during general anesthesia, providers must maintain vigilance, as many factors can contribute to AWR. A 1997 prospective study by Nordström et al¹⁵ investigated 1,000 patients anesthetized with total intravenous anesthesia (TIVA). The authors found no difference in the rate of AWR in TIVA-based anesthesia compared with any other type of anesthesia for paralyzed patients.

Inadequate depression of the central nervous system during anesthetic care is the primary culprit of AWR and may be related to both human and systems factors. Medication errors and infusion pump malfunction are examples of specific, identifiable causes of AWR. In the 2013 NAP5 study, human factors contributed to up to 68% of AWR cases; these factors included failure to fill vaporizers, premature discontinuation of anesthesia before the end of surgery, and accidental administration of muscle relaxants to awake patients.¹⁶ Although some of these errors depict examples of inadequate provider oversight, they sometimes represent manifestations of latent errors in the systems in which providers operate. The 2013 NAP5 study reported that system factors, such

as staff shortages, production pressure, and distractions during critical moments, contributed to cases of AWR.¹⁶

Certain patient populations exhibit higher risk of awareness after general anesthesia, including those undergoing cardiac, obstetric, or major trauma surgery.¹⁰ Cardiac surgery often requires cardiopulmonary bypass (CPB); the anesthetic gas concentration emerging from the exhaust gas port of the CPB oxygenator is not routinely monitored. This fact, combined with a lack of heart rate and blood pressure generated by the patient during CPB, creates a challenge for depth-of-anesthesia monitoring during cardiac surgery.¹⁷

Paech et al¹⁸ found the incidence of AWR after obstetric surgeries to be 0.4%. Parturients have an increased cardiac output, resulting in rapid redistribution of induction agents. Therefore, a potential period of light anesthesia before the volatile agent reaches an adequate partial pressure to prevent AWR may exist shortly after induction. Ensuring adequate administration of the volatile agent to induce adequate central nervous system depression to obstetric patients has the potential to decrease AWR, yet concerns remain for the effect of these agents on uterine tone and neonatal drug exposure.¹⁸

Consequences of major trauma include hypotension, acidemia, anemia, and hypothermia. Bogetz and Katz¹⁹ found an increased incidence of AWR during trauma surgery when factors characteristic of severe injury necessitated a decrease in the level of anesthesia. Other high-risk patient factors for AWR include a history of addiction, long-term use of analgesics, female gender, young age, high ASA score, or previous experience of awareness.² Anesthesia providers should consider preoperative discussion of the risk of AWR with patients identified as at high risk.^{1,10}

In the 2015 NAP5 study, authors wrote that “the period from the start of induction of anaesthesia to the start of the surgical intervention ... is the time when [awareness after general anesthesia] most commonly occurred.”⁷ This represented a novel finding that is not currently supported by other studies in the literature, including a 2009 review of reported cases of AWR that found awareness occurred most frequently during the maintenance phase of anesthesia.⁶ Intraoperative hemodynamic instability, in addition to premature discontinuation of appropriate anesthetic dosing toward the end of surgery, also may contribute to the incidence of AWR.¹

Depth-of-Anesthesia Monitoring

Providers consider many factors when administering general anesthesia. Some of these factors include subjective methods such as observation of clinical signs (including hemodynamic changes, lacrimation, sweating, movement, and pupil size) that may be affected by a wide range of factors unrelated to anesthetic depth.¹¹ Observation of end-tidal anesthetic gas concentration

(ETAC) is another consideration when titrating anesthetic delivery. An ETAC alarm set to at least 0.7 age-adjusted minimum alveolar concentration (MAC) represents one potential component of an awareness prevention protocol.³ However, major shortcomings of this approach are its lack of applicability during TIVA-based anesthesia and the unique patient variability in the MAC response.

Anesthesia providers may also use brain function monitoring as an objective guide for depth of anesthesia. These monitors include both electroencephalographic (EEG) monitors (monitoring spontaneous electrical activity) and auditory evoked potential monitors (monitoring evoked electrical activity).¹ Although much research focuses on the bispectral index (BIS, Covidien, now Medtronic), other depth-of-anesthesia monitors exist, including E-Entropy (GE Healthcare) and Narcotrend (MT MonitorTechnik GmbH & Co). Electroencephalographic monitors such as BIS include a sensor (placed on the patient's forehead), a monitor, and a signal converter. Based on electrical signals from the cerebral cortex, BIS technology uses algorithms to create a numeric value between 0 (no detectable brain activity) and 100 (fully awake).^{5,20} This number correlates with the patient's depth of anesthesia, or hypnosis, with values between 40 and 60 implying a state of general anesthesia.^{5,21} These numeric values typically lag behind the current anesthetic state of the brain by 15 to 30 seconds because of processing time for the EEG signal. During times when rapid changes in anesthetic levels occur (eg, induction and intubation), this delay may decrease the utility of these monitors.¹⁴ An additional limitation of BIS monitoring includes paradoxical increases in BIS readings when nitrous oxide or ketamine is used.¹¹ A 2014 study by Lee et al²² investigated general anesthesia performed in the beach-chair position and its effects on BIS values. The authors found this position correlated with a time-dependent decrease in BIS values compared with supine positioning.²² Mallick et al²³ discovered that a Trendelenburg tilt position greater than 30 degrees showed higher BIS values than the same tilt at less than 30 degrees. Of note in this study, BIS values returned to baseline levels when the patient reassumed the supine position. The authors referenced the potential effect of large shifts in intracranial blood distribution as a source of variation in BIS values.²³ Both the potential utility and limitations of this monitor must be considered for safe anesthesia care (Table 1).

With the advent of physiologic depth-of-anesthesia monitors such as the BIS, the question arises: Does BIS-guided anesthesia prevent awareness compared with anesthesia guided by other protocols? A 2011 study titled “BIS or Anesthetic Gas to Reduce Explicit Recall Trial” (BAG-RECALL) failed to demonstrate superiority of the BIS in preventing recall compared with ETAC monitoring in high-risk surgical patients.³ In 2012, Mashour et

Pros	Cons
<ul style="list-style-type: none"> • May decrease total anesthesia consumption, recovery times, and incidence of postoperative delirium^{24,28} • As part of protocol-guided anesthesia, may decrease risk of AWR (especially when used in combination with ETAC monitoring)²¹ • Offers depth-of-anesthesia monitoring during TIVA (when ETAC cannot be monitored)²⁴ 	<ul style="list-style-type: none"> • 15- to 30-second delay due to EEG processing time¹⁴ • BIS values may paradoxically increase with ketamine or nitrous oxide use¹¹ • Beach-chair position may decrease BIS values,²² whereas Trendelenburg position may increase BIS values compared with supine position²³ • BIS < 60 does not eliminate the risk of AWR³

Table 1. Pros and Cons of Bispectral Index Monitoring

Abbreviations: AWR, awareness with recall; BIS, bispectral index; EEG, electroencephalogram; ETAC, end-tidal anesthesia concentration; TIVA, total intravenous anesthesia.

al⁵ examined the use of the BIS in an unselected surgical population, noting similar results to the BAG-RECALL trial. Other large studies and meta-analyses reviewed use of the BIS and found it to be associated with a lower incidence of awareness compared with anesthesia guided by clinical signs, but once again did not demonstrate superiority in awareness rates compared with ETAC-guided anesthesia.^{5,8,12,24} A systematic review of 22 randomized controlled trials in 2013 by Shepherd et al¹² found BIS monitoring was associated with a statistically significant decrease in AWR in high-risk patients. However, the authors of this research advised caution when interpreting the results because of heterogeneity and bias in many of the trials.¹²

Prevention of Awareness With Recall in Clinical Practice

Studies reveal that protocol-driven approaches, in addition to standard clinical monitoring, may be effective in preventing AWR. Routine setting of audible ETAC alarms to at least 0.7 MAC is one example of an evidence-based protocol. Implementing an ETAC-based protocol requires measurement of exhaled anesthetic gas concentrations and the ability to routinely set alarms for ETAC values.³ For several anesthetic gas monitoring systems, it is relatively easy to set audible ETAC alarms. Use of audible ETAC alarms, as part of a systems approach to preventing AWR, is a cost-effective option in the noisy and distracting environment of the operating room.²⁵ In addition to protocol-driven approaches, studies documented that midazolam premedication (compared with opioid premedication) corresponded with a reduced incidence of AWR.⁸

In 2014, Schneider et al²¹ found that a combination of ETAC monitors set to at least 0.7 MAC, in addition to use of BIS, was superior to use of either ETAC or BIS monitoring alone. In addition, Mashour et al⁵ noted in their post hoc analysis that use of a BIS-guided protocol decreased awareness compared with anesthesia delivered with no protocol. Bispectral index monitors may help prevent an excessively deep level of anesthesia (or cumulative deep hypnotic time, BIS < 45), which was a sig-

nificant independent predictor on 1-year mortality.^{26,27} In a 2013 study that examined 1,277 patients over the age of 60 years, patients experienced a decreased risk of postoperative delirium after BIS-guided anesthesia.²⁸ This study found that extremely low BIS values (< 20) correlated with an increased incidence of postoperative delirium in elderly patients.²⁸ Several studies suggested that BIS-guided anesthesia decreased total anesthesia consumption, in addition to decreased recovery times, compared with anesthesia administered based on clinical signs alone.^{12,24,26} Although these benefits are noteworthy, they may not necessarily equate to improved patient outcomes or cost savings.

The importance of BIS and ETAC-guided protocols is no substitute for provider vigilance. Careful consideration of the effect of drugs administered, use of the smallest dose of muscle relaxants necessary for surgical exposure, and ensuring the functionality of all equipment are critical components in the prevention of AWR. Recognition of contributory systems factors, such as distractions and miscommunication in the operating room, should guide protocol development at an institutional level.

Recommendations of Other Organizations

Preventing AWR is of paramount importance for any facility in which providers administer general anesthesia. The AANA recommended that each facility create and maintain a policy to prevent and manage awareness under anesthesia. This policy should include clinical guidelines that address identification of high-risk patients preoperatively, in addition to intraoperative recommendations for practice.²⁹ In a Sentinel Event Alert issued in 2004, the Joint Commission suggested provision of support services (such as counseling or a referral to a psychiatrist or psychologist) to patients who experience AWR.⁴ The ASA 2006 Practice Advisory endorsed multiple modalities in clinical practice to prevent AWR: observation of clinical signs, standard ASA monitoring, and case-by-case consideration of use of brain function monitoring.¹ Providers may reference these statements when developing clinical guidelines or protocols to prevent AWR (Table 2).

Organization	AANA ²⁹	Joint Commission ⁴	ASA ¹
Type of statement, year issued	Position statement, 2005	Recommendation, 2004 ^a	Practice advisory, 2006
	<p>Facilities using GA should develop a well-defined policy regarding management of AWR.</p> <ol style="list-style-type: none"> Suggested inclusion criteria: <ol style="list-style-type: none"> Staff education on AWR Identification of patients at high risk of AWR Identification and management of AWR occurrence Establish referral pathway for AWR cases Prevention strategies for AWR Required perioperative debriefings after cases of AWR Encourages CRNAs to participate in policy development 	<p>Facilities using GA should develop a policy on AWR addressing:</p> <ol style="list-style-type: none"> Staff education regarding management of awareness Identification of high-risk patients, discussion with patient preoperatively regarding awareness risk Application of anesthesia monitoring techniques Postoperative follow-up with all patients who have undergone GA <p>For patients with suspected AWR:</p> <ol style="list-style-type: none"> Interview patient and record his/her experience Apologize if AWR has occurred Explain what happened and potential reasons why Offer psychiatric support and referral to specialist Notify surgeon, nurse, and other personnel involved with case 	<p>Preoperative evaluation to include:</p> <ol style="list-style-type: none"> Focused history Physical Examination Identify patients at high risk of AWR Inform selected patients of possibility of AWR <p>Preinduction phase of anesthesia:</p> <ol style="list-style-type: none"> Check function of anesthesia delivery systems (vaporizers, infusion pumps, fresh gas flow, intravenous lines) Administer benzodiazepine or scopolamine on a case-by-case basis for high-risk patients <p>Intraoperative monitoring:</p> <ol style="list-style-type: none"> Should rely on multiple modalities Use of brain-function monitor on a case-by-case basis <p>Intra- and postoperative interventions</p> <ol style="list-style-type: none"> Administer benzodiazepine or scopolamine on case-by-case basis if AWR is suspected Interview all patients who report AWR <ol style="list-style-type: none"> Complete occurrence report

Table 2. Summary of Recommendations Regarding Awareness With Recall

Abbreviations: AANA, American Association of Nurse Anesthetists; ASA, American Society of Anesthesiologists; AWR, awareness with recall; CRNA, Certified Registered Nurse Anesthetist; GA, general anesthesia.

^a Sentinel event alert has since been retired.

Conclusion

The rate of AWR is unacceptably high given the significant risk of PTSD that this phenomenon carries. One of the most important findings of recent studies is that protocol-guided anesthesia (eg, BIS or ETAC-guided protocols) decreased the incidence of AWR compared with anesthesia guided by clinical signs alone. Both BIS monitoring and ETAC-guided protocols are acceptable in the prevention of AWR. When considering use of a protocol, providers should first consider the availability of depth-of-anesthesia monitors in their facility. With the advent of physiologic brain function monitors in recent years, one must recognize both the utility and potential limitations of these monitors in safe anesthesia practice. Bispectral index monitoring can be an appropriate component of an institution's protocol with careful consid-

eration of both its clinical benefits and shortcomings. Protocol implementation represents one important part of a facility's policy, which must also address identification of high-risk patients and follow-up for patients who experience AWR. Sufficient evidence exists to suggest that anesthesia providers use the smallest dose of muscle relaxant necessary for surgical exposure, routinely check the functionality of all anesthesia delivery equipment, and consider protocol-guided anesthesia in their practice.

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AUTHOR

Caitlin Sullivan, DNAP, CRNA, is a nurse anesthetist at Cleveland Clinic in Cleveland, Ohio. Email: ckenny316@gmail.com.

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