

AWARENESS DURING ANESTHESIA-AN UPDATE

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Introduction

General anesthesia is a reversible state characterized by unconsciousness, analgesia, muscle relaxation, and depression of reflexes which is achieved by the administration of chemical agents¹. It is a balance between the amount of anesthetic drugs administered and the state of arousal of the patient. As the intensity of surgical stimulation varies during a surgical procedure, so does the requirement of anesthetic agents. The organ system effects of anesthetic drugs may limit the amount that can be given safely. This would, at occasions, create a critical imbalance between anesthetic requirement and anesthetic drug administration resulting in varying depth of anesthesia.

Awareness during anesthesia (unintended intraoperative awareness) occurs when a patient can recall some or all of the events happening during a surgical procedure. The history of awareness dates back to the history of general anesthesia itself. The first patients given nitrous oxide anesthesia by Horace Wells in the 1845 and by William TG Morton in 1846 were “half-awake” and reported feeling pain during surgery². The introduction of curare-like drugs in the 1940s and 1950s has led to increased number of reports of awake-paralyzed patients. Since then, it has generally been accepted that “Spontaneous recall” during general anesthesia is confined almost entirely to such patients². However,

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nonparalyzed patients may be aware-awake too, the incidence being lower than paralyzed patients³. The occurrences of awareness continue to happen even in modern anesthetic practice. The issue of awareness during anesthesia is currently undergoing a re-evaluation because of recent studies suggesting that it is relatively a common event associated with well described adverse outcome^{2,3,4}.

Definitions

Consciousness is a state in which a patient is able to process information from his or her surroundings⁵. Consciousness is assessed by observing a patient's purposeful responses to various stimuli.

Recall is the patient's ability to retrieve stored memories⁵. Recall is assessed by a patient's report of previous events, in particular, events that occurred during general anesthesia. Explicit memory⁵ is assessed by the patient's ability to recall specific events that took place during general anesthesia. Implicit memory is assessed by changes in performance or behavior without the ability to recall specific events that took place during general anesthesia that led to those changes⁵.

'Wakefulness' has been used to describe patients who are able to react meaningfully to stimuli during general anesthesia but are not able to recall either the stimuli or their reactions postoperatively⁶. There is evidence that a large number of such patients exist. There is also some evidence that wakefulness without explicit recall might be detrimental for the patient⁷ but this has not been definitely proven⁸.

A dream during anesthesia has been defined as any experience (excluding awareness) which a patient thought occurred between the induction of anesthesia and the first moment of consciousness after anesthesia⁹.

The term **"awareness during general anesthesia"** is, however, almost universally accepted by both medical and legal circles, and its meaning is well understood. Awareness is defined as "Post-operative recall of events occurring during general anesthesia"⁴.

Incidence of Awareness

An incidence of awareness during anesthesia and surgery is either determined by formally interviewing patient's postoperatively¹⁰ or patients reported themselves. Some patients also may not recall events shortly after surgery but may recall even one to two weeks after surgery¹¹. A possible contributing factor for a low incidence of awareness is under reporting. A study by Moerman¹² showed that people do not tell anesthetist about awareness because of fear of disbelief or ridicule, fear of insanity or dementia and misunderstanding of events, until later.

The risk of intraoperative awareness varies among countries, depending on their anesthetic practices. In the United States, the incidence of intraoperative awareness is 0.1% to 0.2% of patients undergoing general anesthesia¹³. In Europe, a large prospective trial³ investigated conscious awareness in 11,785 patients who underwent general anesthesia. The incidence of intraoperative awareness with explicit recall was 0.1% without the use of neuromuscular blocking agents. With the use of these agents, it was 0.18%. Another European study reported the incidence of recall of intraoperative events and dreams during operation in nonobstetric surgeries as 0.2% and 0.9%, respectively¹⁰. A study from Saudi Arabia¹⁴ investigated the incidence of intraoperative awareness in 4,368 patients undergoing surgery. In this study, all patients were given a premedicant. This study reported no incidence of intraoperative awareness and 100% patient satisfaction. The AIMS (Anaesthetic Incident Monitoring Study) database in Australia⁴ showed that, from 8,372 incidents reported, there were 50 cases of definite awareness and 31 cases of a high probability of awareness.

Researchers have found a group of patients and surgical procedures which are at high risk for intraoperative awareness, and prevention would be difficult in these cases. These include trauma patients and surgical procedures like coronary artery bypass grafting (CABG) and Cesarian section^{15,16,17}. So far, trauma patients have reported the highest incidence of intraoperative awareness (11% - 43%)¹⁵. A study from Finland¹⁶

investigated awareness in 929 patients who had cardiac surgery. The incidence of definite awareness with recall was 0.5%, and the incidence of possible recall was 2.3%. Additionally, in a survey of 3,000 patients who had general anesthesia for Cesarean section, an incidence of about 0.9% for any recall and 7% for dreaming, was reported¹⁷.

Why Does it Happen?

The awareness incidents identified in the AIMS database⁴ are broadly divided into incidents with no obvious cause, incidents due to low inspired volatile concentration or inadequate hypnosis and incidents due to drug error. The US multicenter study¹³ demonstrated an association of awareness with increased ASA physical status, final disposition to the ICU, and procedure (abdominal, thoracic, cardiac and ophthalmology versus others). In European awareness trial³, the probable reasons for awareness were: vaporizer was not turned on after a refill during anesthesia, rocuronium dose was administered before thiopentone, insufficient dose of hypnotic agent at induction and in patients who had difficult intubation.

The majority of cases of awareness and recall seem to be due to preventable problems in the anesthetic apparatus and administration of anesthesia. A smaller fraction of patients seem to suffer from this complication because of individual differences in pharmacokinetics and pharmacodynamics of anesthetic agents. The major causes of awareness are summarized in Table 1.

Why Awareness is important for anesthetist?

An anesthetist core business is to make sure that patients are properly and safely anesthetized, and avoiding awareness is part of our contract with the patient. Awareness has its own anesthetist's and patient's perspective. In anesthetist point of view, it puts effect on professional issues, feeling of guilt, adverse publicity and litigation.

Table 1
Causes of Intraoperative Awareness

Light anesthesia	<ul style="list-style-type: none"> Specific anesthetic techniques such as the use of nitrous oxide, opioids and muscle relaxants Difficult intubation Premature discontinuation of anesthetic Hypotension Cesarean section
Machine malfunction or misuse of the technique	<ul style="list-style-type: none"> Failure to check equipment Vaporizer and circuit leaks Errors in intravenous infusion Accidental administration of muscle relaxants to patients who are awake
Increased anesthetic requirement	<ul style="list-style-type: none"> Individual variability in anesthetic requirements Chronic alcohol, opioids, or cocaine abuse

Cases of awareness represent between 2% (ASA Closed Claims Analysis)¹⁸ to 2.2% (British data)¹⁹ of claims against anesthesiologists. In the USA, the median payment¹⁸ for such cases is \$ 81,000 although recently, there have been several cases in which much larger claims have been settled.

Consequences of Awareness to the patient

“Suddenly I felt that I could not breathe. I was totally alert. I could not feel my chest rising and I had no sensation of air moving in or out. It was a terrifying feeling”²⁰. This quotation is from a physician describing her almost unbearable pain when she was aware during laparoscopy.

Awareness during anesthesia is important because of the distress that the patient may experience during the episode itself and because of the long-term complications that the episode may cause. In the study of Moerman¹², 70% of patients who had experienced awareness during

general anesthesia had unpleasant after-effects and 6% of patients had needed psychotherapeutic help. Shwender and co-workers²¹ showed that 48.9% of patients had after-effects, anxiety (55.0%) and nightmares (52.4%) being the most common ones. Post-traumatic stress disorder (PTSD) was found in 14.3%.

Of the long term after-effects, the most important is post-traumatic stress disorder (PTSD). Such a syndrome may develop after a frightening or unpleasant life experience. Characteristic symptoms include anxiety and irritability, insomnia, repetitive nightmares, depression, a preoccupation with death, and a concern with sanity that makes the patients reluctant to discuss their symptoms¹⁵. There may be a fear of doctors, hospital and particularly future operation.

Management of Awareness

Intraoperative Detection of Awareness

Many methods have been used to monitor the anesthetic state, especially to detect an insufficient depth of general anesthesia. These methods do not measure learning or possibility for later recall, but consciousness. There is a thorough review of the methodology and an update including the most recent methods by Bruhun²² et al and Drummond²³.

Clinical signs

The signs of awareness are generated through sympathetic activation. Tachycardia, hypertension, sweating, pupillary dilatation, lacrimation and sweating are often used as clinical signs of an inadequate level of anesthesia secondary to sympathetic activation²⁴. However, the signs of increased autonomic activity may be absent during treatment with many drugs like opioids, cholinergic and beta-adrenergic antagonists, vasodilators, and antihypertensive agents²⁴. Traditional clinical monitoring modalities during anesthesia are ineffective in preventing

awareness. For example, hypertension and tachycardia are generally not associated with reported awareness^{12,13} and end tidal anesthetic concentration is also ineffective³. Intermitting checking for clinical signs has a low sensitivity and specificity for detecting awareness but, when used in combination with one of the other methods, the sensitivity and specificity are increased²⁴.

Depth of Anesthesia (DoA) Monitors

The most commonly used method of monitoring for awareness is measurement of the patients' end tidal volatile agent concentration²⁴. Assurance of 0.8-1 MAC of exhaled anesthetic agent is likely to assure lack of awareness. However, certain factors may cause end tidal concentration to misrepresent the brain partial pressure of volatile agent like hypotension, bronchodilators, and emphysema.

Both spontaneous EEG and mid-latency auditory-evoked responses (MLAEP) offer information about the hypnotic state of the patient²². The electroencephalogram (EEG) is the result of combined effect of synchronized, mostly rhythmic, potentials from many apical dendrites of cortical neurons²⁵. In general, there is a decrease of the fast activity and an increase in the high-amplitude, slow-frequency components in the EEG during anesthesia²⁵. Spontaneous EEG is of different types, like traditional EEG measures, Bispectral Index (BIS), Patient State Index, Narcotrend Index, Entropy and Auditory evoked potentials²².

The BIS monitor (Aspect Medical Systems, Newton, MA, USA) is complex, processed electroencephalogram that uses a computer algorithm to assign a numerical value to the probability of consciousness²⁶. BIS algorithm based on burst suppression analysis, power spectral analysis and Bispectral analysis²². In this, the signal is acquired via skin sensors applied to the forehead, which is connected to either a free standing monitor or a module incorporated into all major integrated monitors. BIS-XP is the latest version of the algorithm, which has improved rejection of artifacts from electromyography (EMG) and diathermy.

The emerging data suggests that BIS monitoring is effective in reducing the incidence of awareness¹³. When anesthesia was guided with BIS, a 77% reduction in the incidence of awareness was found²⁷. Myles and colleagues found in a double blind study of patients at high risk for awareness, that BIS guided anesthesia resulted in an 82% reduction in the incidence of awareness²⁸. FDA has also approved BIS monitoring for prevention of awareness.

There are limitations to this technology²³. It does not consistently reflect anesthetic depth for different anesthetic drug combinations and has not been studied extensively in the presence of concomitant medications²⁶. The BIS algorithm may be altered by preoperative opioids and anticonvulsants use. There is large variability in the BIS values at times of measured awareness²⁹, which limits the predictability of awareness based on BIS number. A case report³⁰ confirmed explicit recall with BIS of 47. One of the major issues is the cost of monitor and their electrodes. With a cost of routine BIS monitoring at 16\$US per use in Australia and a number needed to treat of 138, the cost²⁸ of preventing one case of awareness in high-risk patients is about \$ 2200.

Auditory evoked potentials (AEP) are the electrical responses of the brainstem, the auditory radiation, and the auditory cortex to sound stimuli delivered through headphones³¹. The early cortical responses and the middle-latency AEP change with increasing depth of anesthesia with either inhaled or intravenous agents, whereas the brainstem responses are relatively insensitive to anesthetic effects³¹. Newton et al³² have demonstrated the change in specific components of AEP during anesthesia and recovery. Potent inhalational agents tend to increase the latencies of brain stem AEP waves III and V as anesthetic deepens. They also increased the latency and decreased the amplitude of early cortical AEP.

Using evoked potentials to monitor depth of anesthesia entails some technical, clinical and practical complexities of recording evoked responses. Many confounding artifacts can alter evoked potentials like stimulus characteristics (intensity, duration, inter-stimulus interval), electrode placement, technique, age and gender of the subject and choice of anesthetic drugs³³.

Post-Operative Detection of Awareness

Awareness during general anesthesia requires questioning the patient postoperatively for recall and/or recognition of intraoperative events³⁴. The modern practice prevents many of anesthetists from seeing their patients postoperatively, and so do not get an opportunity to ask.

The timing of the interview has raised much discussion. Anesthetists are reluctant to question patients about awareness and immediate postoperative period is often not the best time to question patients. There is evidence that assessment of learning during anesthesia is more successful later rather than sooner after exposure to inhalational agents³⁵. Recently, it has been shown by Sandin and co-workers that more than one interview over a time period of at least two weeks increases the number of detected cases of awareness³.

The postoperative interview should be structured³⁴, otherwise a lower incidence of awareness is likely to be found. In a study done by Sebel and colleagues, relevant questions in relation to awareness were asked in the postoperative interview¹³ (Table 2).

Table 2
Questions Asked in the Postoperative Interview¹¹

What is the last thing you remember before you went to sleep?
What's the first thing you remember when you woke up?
Do you remember anything in between?
Do you have any dreams?
What was the worst thing about your operation?

Prevention of Awareness

Several recommendations have been published^{5,15,24} on avoiding awareness with recall. These methods^{5,24} advocate: premedication with amnesic drugs like benzodiazepines, administering more than a sleep dose of induction agents if followed by tracheal intubation, avoiding muscle paralysis unless absolutely necessary, supplement N₂O and opioids with volatile agents with end-tidal concentrations of 0.6 minimum alveolar concentration (MAC) or more, administer at least 0.8-1 MAC when

volatile anesthetics are used alone, use small doses of amnesic drugs, e.g. midazolam, in cases where light anesthesia is deemed necessary, meticulous checking of anesthesia machine before administration of anesthesia, discuss the potential for awareness in certain high risk procedures and use anesthetic depth monitor.

Treatment

Intraoperative

If intraoperative clinical signs or monitored values suggest that a patient may be experiencing noxious stimuli that may be recalled, anesthesia should be deepened immediately²⁴. If hypotension is present, despite insufficient anesthetic agent, anesthesia should be deepened whilst supporting arterial pressure with intravenous fluids, or vasopressors. Administration of an intravenous benzodiazepine (e.g. midazolam 3-5 mg) may reduce postoperative recall.

Postoperative

If patient complains of intraoperative awareness in the postoperative period, the anesthetist should interview the patient, and take a detailed account of his or her experience. The anesthetist should establish the perioperative timing of the episode and distinguish between dreaming and awareness²⁴. He should apologize to the patient if awareness has occurred and sympathize with the patient's suffering. A logical attempt should be made to explain what happened and its possible reasons, e.g. the necessity to administer light anesthesia in the presence of significant cardiovascular instability. Often the patient needs consultation from psychiatrist³⁶.

Joint Commission Recommendation

Awareness during anesthesia is under-recognized and under-treated in health care organizations. The Joint Commission recommends that

health care organizations which perform procedures under general anesthesia should take the following steps in prevention and management of awareness during anesthesia³⁷:

1. Develop and implement an “awareness during anesthesia” policy that addresses the following: education of clinical staff about awareness during anesthesia 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 awareness during anesthesia, the effective application of available anesthesia monitoring techniques, including the timely maintenance of anesthesia equipment, appropriate postoperative 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.
2. Assure access to necessary counseling or other support for patients who are experiencing post-traumatic stress disorder or other mental distress.

Conclusion

The waking of patients during anesthetic administration is an uncommon occurring which may be distressing for both patients and anesthesiologists. A multimodal strategy that includes the use of brain function monitoring in high risk cases is useful for the prevention of awareness. Awareness may be unavoidable under certain challenging anesthetic conditions. After-effects of awareness during general anesthesia range from no effects to chronic PTSD. Continuous attention should be paid to prevent intraoperative awareness which is usually feasible in most of the cases.

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