Patient Awareness During General Anaesthesia : A Review

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ABSTRACT

An estimated 1% to 2% of patients experience awareness while under general anesthesia, generally during induction and emergence. Awareness can occur with or without pain, and a form of perception can occur without conscious awareness. Inability to recall intraoperative events does not preclude awareness of those events. Patients who experience awareness later report feeling severe anxiety, panic, fear that some aspect of the surgical procedure or anesthesia has gone wrong, and dread of imminent death. Awareness can be experienced by very ill patients, patients undergoing surgery for major trauma and cardiac or obstetric procedures, or those for whom tracheal intubation is difficult to perform; situations where inadequate anesthesia may be administered. To minimize the occurrence of awareness, the addition of midazolam to the anesthetic regimen is recommended.

In 1845, William Morton used diethyl ether to anesthetize a patient who later reported that he had been aware of the surgery but had felt no pain.[1] Since then, a continuous flow of case reports, surveys, and controlled studies have described the occurrence of awareness under anesthesia. Nevertheless, after 150 years, anesthetists still have no reliable means of monitoring the depth of anesthesia to determine whether a patient is conscious during surgery.

One of the difficulties that arises in attempting to analyze and seek solutions to the problem is the lack of exact definitions of such terms as awareness, memory, and recall.[1] Awareness implies a state of vigilance or watchfulness. Confusion over the term arises because patients may respond to instructions during anesthesia but are unable to recall the action later. Other patients may fail to respond to instructions, but report some memory of the instructions after waking. It is therefore useful to make a distinction between memory and awareness. Memory involves storage and retrieval of information. Awareness is generally a limited memory, lasting only few seconds, of whatever a person is thinking about at the moment. Wakefulness and consciousness can be equated with awareness.

Memory may be characterized as explicit or implicit.[2] In explicit memory, a conscious effort is required to recall a previous event. In implicit memory, a patient may perform a postanesthetic task in response to intaoperative instructions without conscious input. It appears that the level of anesthesia required to suppress unconscious learning (implicit memory) is greater in stimulated patients, such as those during surgery, than in unstimulated patients, such as those during anesthesia only.[3] This may be a catecholamine effect on learning ability.

INCIDENCE OF PATIENT AWARENESS

The overall incidence of awareness is estimated to range from 1% to 2% for patients under a variety of anaesthetic regimens for a variety of surgical procedures, with rates as low as 0.2% obtained using a structured interview technique (Table 1).[4-8] The most common time for the occurrence of awareness is during or soon after skin incision.[9] Most causes of awareness can be readily identified (Table 2)[10]; prevention, although a challenge to anaesthetic management, can usually be achieved.

Despite an increasing number of reports of awareness, there is no evidence of an actual increase in its incidence. The most likely explanations for this apparent increase are greater public awareness of the phenomenon[2] as a result of lawsuits reported in the media; declining use of scopolamine (which is an effective antiawareness agent, but produces undesirable anticholinergic side effects such as tachycardia, dry mouth, delirium, and relaxation of the lower esophageal sphincter); increased use of muscle relaxants; and economic pressure to facilitate rapid emergence from anaesthesia and quick turnaround in the operating room.

Most data on what patients recall from surgery under general anaesthesia come from reviews of case reports rather than rigidly controlled trials.[1] Early on, the predominant reason for recall was insufficient

Table 1. Incidence of Awareness Obtained From Structured Interviews			
Reference	No. Of Patients	Awareness (%)	Dreaming (%)
Hutchinson[5]	656	1.2	3.0
Harris[6]	120	1.6	26.0
Mckenna[7]	200	1.5	—
Wilson[8]	490	0.8	7.7
Liu[4]	1,000	0.2	0.9

Table data adapted from Liu et al.[4]

depth of anaesthesia. Many anesthetic techniques have been involved. In some of the first reports, anaesthesia was induced by a mixture of nitrous oxide in oxygen combined with a muscle relaxant, with or without a supplementary opioid agent. More recent cases involved the use of volatile anaesthetic agents such as halothane or IV anaesthetic agents such as ketamine, fentanyl1, and propofol.[1]

It is unlikely that anaesthesiologists can routinely identify instances of awareness from the anaesthetic record. Despite monitoring of blood pressure and the heart rate during anaesthesia, these records are of limited value in investigations to determine why and when awareness occurred.

EFFECTS OF SPECIFIC ANAESTHETIC DRUGS ON MEMORY

Nitrous oxide. Memory is substantially impaired by inhalation of subanaesthetic concentrations of nitrous oxide, as shown in tests in which patients are asked to repeat numbers in correct ascending or descending order.[11] Most tests, however, were administered to patients who knew that they were being tested. Other attempts to gauge impairment by asking for free associations of words have demonstrated resistance to memory impairment.[1]

Halothane, enflurane, and isoflurane. Halothane and enflurane have shown dose-related impairment of number counting and some psychomotor functions.[12] Memory also seems to be impaired. Enflurane has been observed to slow reaction time in short-term memory formation.[13]

Thiopental, Ketamine, and benzodiazepines. Results of trials of thiopental have been mixed, but in one of the more definitive trials, the drug was shown to impair memory: patients were unable to make simple word associations.[1] Thiopental has also impaired learning and retention. IV infusions of ketamine have impaired both immediate and delayed recall by interfering with the retrieval process. Benzodiazepines impair new formation of long-term memories, but have little effect on other memory functions.[14] There is no evidence that benzodiazepines stop the patient from being "awake" during anesthesia; other agents are required to do this. However, it has a powerful effect on reduction of recall and minimizing its sequelae.

METHODS FOR TESTING AWARENESS

A wide variety of techniques are used to monitor for awareness during surgery (Table 3). Among them are the isolated forearm technique, time to correct response, surface electromyography, clinical signs of return to consciousness, electroencephalography, sensory-evoked responses, and experiments into the minimum alveolar anesthetic concentration-awake (MAC-awake). While there is a good association between the end-tidal levels and administered concentrations of volatile anesthetic agents, the relationship between dosage rate and plasma concentration of IV agents is much more variable.[15]

Table 2. Potential Factors Contributing to Anesthetic Awarenss
Inadequate anesthetic technique
No premedication
Ultra short-acting IV induction agent
Excessive or unnecessary neuromuscular blockade
Difficult and /or prolonged intubation
Equipment failure
ASA status IV or V
Obstetric patient
Morbidly obese patient
Cardiac surgery patient
Inexperienced anesthesiologist
Bronchoscopy
Pharmacologic autonomic blockade
Anesthesia at high altitude
Increased anesthetic requirement
Table data adapted from Bailey and Stanley.[10]

Using the isolated forearm technique to monitor the anesthetic state, a pneumatic tourniquet is inflated to isolate the forearm from the circulation once general anesthesia has been achieved.[1] After a muscle relaxant is injected, the anesthetized patient is instructed to move the nonparalyzed arm. Results, however, have been mixed. Often patients who seem to respond to the instructions have no recall of intraoperative events. Inability to recall intraoperative events does not preclude awareness of those events when they occur. In the "time to correct response," patients are given a simple command every 15 seconds after discontinuation of nitrous oxide. A correct response is interpreted as a sign of returning consciousness. This measure reveals only the depth of anesfthesia at the end of surgery, however.

Surface electromyography shows that frontalis muscle activity decreases as the patient loses consciousness, and increases as the patient awakens.[1] A wide range of measurement values has been found among patients, however, thus making it impossible to determine a single value range that indicates inadequate anesthesia.

No clinical signs identify return to consciousness while apparently anesthetized. When anesthesia becomes too light during surgery, the patient may move and demonstrate signs of sympathetic activity such as tachycardia, sweating, and hypertension. However, the administration of muscle relaxants and other agents may blunt these responses. Furthermore, the appearance of these signs does not necessarily serve as a predictor of postoperative complaints about awareness during the procedure.

Table 3. Techniques of Monitoring the Depth of Anesthesia[5]
Motor response to noxious stimuli
Minimum alveolar concentration (MAC)
Minimum infusion rate (MIR)
End-tidal volatile agent concentration
Autonomic changes
Heart rate
Blood pressure
Lacrimation
Sweating
Mechanical changes
Isolated limb
Esophageal contraction
Electrical
Frontalis electromyography
Electroencephalography
Unprocessed
Processed
Aperiodic analysis
Auditory-evoked potentials

Electroencephalography has not proved to be of value in identifying intra-anesthetic consciousness.[1]

Studies of sensory-evoked responses as a determinant of anesthesia depth have produced inconsistent correlations between the clinical signs of light anesthesia (increased blood pressure, pulse rate, sweating, and lacrimation) and response to command. To be acceptable guides to depth of anesthesia, these measures need to reflect changes in surgical stimulation as well as anesthetic concentrations.

It has been suggested that a device capable of monitoring variations in respiratory sinus arrhythmia (reflecting alterations in parasympathetic tone from the brain stem) could not be used to monitor the depth of anesthesia.[1] However, development of such a monitor appears well into the future. A more promising direction lies in utilizing evidence of catecholamine release—tachycardia, hypertension, and sweating—as a sign that the level of anesthesia is inadequate and that awareness may be occurring in this scenario.

Research by Chortkoff et al[16] suggests that the MAC-awake, at which 50% of patients respond meaningfully to a verbal stimulus, may be only slightly higher than the level of anesthesia needed to abolish learning and memory. There is interest in the concept of MAC-awake as an indication of time to arousal after cessation of anesthesia. This measure may help determine some form of end point for awareness.

Table 4. When to Anticipate Awareness
Most likely time
Induction
Emergence
Most likely circumstances
Major trauma
Patient very ill
Cardiac surgery
Obstetric procedure
Difficult intubation

POSTOPERATIVE INTERVIEW

Patients cannot be relied on to volunteer what they may have learned or remembered from their surgical experience. To get this information requires a structured postoperative interview, ideally within 24 hours of the procedure. Patients should be asked what they last remembered before going to sleep, the first thing they remembered on waking, and whether they remembered any events in between. Reassurance, support, and consideration of early psychological referralare essential if evidence of an episode of awareness is detected.

PERCEPTION DURING AWARENESS

Patient awareness can occur with or without pain, and some form of perception can take place without conscious awareness. It should be noted that cases with the most adverse sequelae are associated with pain felt during the procedure. Moerman et al[17] interviewed 26 patients who recalled being aware during general surgery. The two most frequent complaints were being able to hear and feelings of weakness or paralysis. The third most frequent complaint was pain. Reports of visual perception were also common. The patients emphasized feelings of severe anxiety and panic. They believed they were awake because the surgical procedure and anesthesia were not under control. Some feared that death was imminent; others were more concerned about feeling pain. The inability to communicate their fears during surgery because of the administration of a muscle relaxant was particularly distressing. Most of the patients also reported unpleasant aftereffects, and flash-backs and anxiety during waking hours.

Awakening during surgery does not by itself appear to be the most distressing aspect of the phenomenon. What patients report as the most frightening or emotionally upsetting is the discovery that they cannot move their limbs or open their mouths to speak. Unable to understand or interpret surrounding events, patients are seized with panic and anxiety.

The most likely times for awareness to occur are during induction and emergence (Table 4). Higher incidences have been reported in situations where light anesthesia is used and may therefore be inadequate. These situations include childbirth, major trauma, the seriously ill surgical patient, cardiac surgery, and difficult intubation.

Table 5. Suggestions to Prevent or Minimize Awareness
Use appropriate dosages of agents
Verify functioning of equipment
Use amnesic agents such as midazolam
Minimize the impact
Warn the patient before surgery
Avoid paralysis if possible
Control the auditory environment
Conduct a postoperative visit

Acute psychic trauma can result from the memory of awakening during surgery, particularly if there is associated pain. The patient may become anxious and irritable, and experience nightmares or become preoccupied with death. Resuming a normal working and family life may be difficult. The patient may feel depressed or enraged if this awareness is discussed, but full and open discussion is to be encouraged. Preoperative anxiety may play an important role in the psychologic consequences of awareness.

RECALLING INTRAOPERATIVE EVENTS THROUGH HYPNOSIS

There is evidence that postoperative hypnosis of patients can elicit recollections (particularly of negative comments made about them by the surgical team), descriptions of the operating room, and events that they could not have imagined.1 Those who promote the therapeutic application of this practice maintain that it establishes rapport with patients, removes barriers to recall of trauma, and makes use of what is known as state-dependent memory. State-dependent memory means that information acquired and stored in one state, eg, anesthesia, is more easily recalled in a similar state. A hypnotic state is claimed to be similar to the anesthetic state.

Numerous trials have been conducted to test this hypothesis and demonstrate clinical efficacy. Few, however, have been well designed and carefully controlled. The Council of Scientific Affairs of the American Medical Association reports: "Recollections obtained during hypnosis can involve confabulation and pseudomenmories and not only fail to be more accurate, but actually appear to be less reliable than nonhypnotic recall."[18]

Attempts have been made to improve postoperative outcomes by presenting positive therapeutic suggestions to patients during surgery by means of audiotapes and other media.[1] In some of these studies, the quality of the outcomes has been assessed by the length of the hospital stay. Results have been inconsistent, perhaps because duration of hospital stay depends on many factors. There is no evidence of significant benefits from this technique.

PREVENTION OF RECALL

In most cases, it ought to be possible to prevent recall.[1] Careful management of anesthesia machinery, close monitoring of the composition of inspired and expired gases, correct functioning of syringe pumps, and vigilance throughout the procedure should rule out equipment failure as a cause.

Table 6. Rationale for the Use of Midazolam
Strong amnesic effect
Reduction of induction agent dosage
Reduction of narcotic need
Preinduction anxiolysis and sedation
Prevention of sudden awakening in recovery room

Maintaining adequate levels of anesthesia can prevent recall. Guidelines have been suggested to achieve this goal.[19] They include premedication of the patient with an amnestic agent such as midazolam, increasing the dose of induction agents immediately preceding administration of succinylcholine and tracheal intubation, conservative use of muscle paralysis, and supplementing nitrous oxide and opioid agents with volatile agents to maintain and end-tidal concentration of at least 0.6% MAC when using 60% or higher nitrous oxide. When has been inhalational agents alone, at least 0.8 to MAC has been recommended.[20]

Reliance on IV agents only for total anesthesia may permit consciousness and recall if the plasma concentration of the drug falls too far in proportion to the arousal intensity of a surgical stimulus. Variable rate infusion schemes can be operated by computer technology that can make nearly instantaneous adjustments in plasma concentrations to much the patient's needs.[21] These may be shown to reduce the incidence of this problem.

Preoperative visits by the anesthesiologist are clearly beneficial in relieving present anxiety and in preventing future anxiety in patients. Although postoperative visits are not routine every where, they do provide the opportunity to identify patients in need of psychologic support at an early stage (Table 5). Even the opportunity of vocalizing problems associated with an awareness episode to a believing and caring person can convey a major positive therapeutic benefit.

MIDAZOLAM AS AN ANTIAWARENESS AGENT

Amnesic agents, including midazolam and other benzodiazepines, can prevent postoperative recall and its after-effects. Given prior to induction, midazolam provides anxiolysis and sedation (Table 6).

My colleagues and I have reported on the use of midazolam as a highly effective antiawareness agent in day-surgery gynecologic patients. (Unpublished data, 1996). In the double-blind trial, 87 patients were randomized to placebo or midazolam 0.03 mg/kg or 0.06 mg/kg or upon entering the operating room. They were asked postoperatively if they had any recollection of any events that occurred in the operating room. In the placebo group, 10% had no recall while in the 2 midazolam groups, 43% of the patients on 0.03 mg/kg and 79% of those on 0.06 kg/mg had no recall.

A concern about the use of benzodiazepines in daysurgery cases is the possibility of postoperative sedation and prolonged recovery room and unit stay. In our study, recovery times for both groups of patients given midazolam were not significantly lobber than those for the place-bo group. The quality of emergence was judged to be satisfactory and comparable between the control group and the 0.03 mg/kg midazolam group; however, quality of emergence in the 0.06 mg/kg group was judged to be fair or poor in significantly more patients. Thus midazolam 0.03 mg/kg as an amnestic agent for day-surgery patients seems to be an acceptable compromise.

CONCLUSION

Even under the best of circumstance, we cannot give our patients an ironclad guarantee that they will not awaken while under anesthesia. This should be explained to patients in advance. giving patients the opportunity to discuss potential anesthetic problems postoperatively and providing reassurance and explanations in appropriate circumstances will help allay untoward effects of awareness.

Why does the problem of awareness exist at all? Perhaps the reason lies with limitations of our skills, insufficient time for an adequate preoperative assessment of the patient or a postoperative visit, errors in dosing, or errors in managing newer technologies. Clearly, part of the problem arises from the complexity of the microhistology and biochemistry of the central nervous system. By way of illustration, consider the pharmacology of some of the new centrally acting drugs. At least for the present, the best approaches to managing the problem of awareness consist of prevention, recognition, and skilled anesthetic management.

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stretching are usual causes of phrenic nerve injury in open heart surgery. Diaphragmatic dysfunction is usually unilateral. Phrenic nerve injury is suspected when chest x-ray evidence of an elevated left hemidiaphragm is present and confirmed by transcutaneous nerve stimulation. Clinically paradoxical subcostal movements during inspiration are seen.

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QUICK ACTION PLANS

LIFE THREATENING UPPER AIRWAY OBSTRUCTION

1. Give 100%O_2
2. Insert through cricothyriod membrane.
   a) a specially designed circothyroidotomy cannula. or
   b) A 16G Tuohy needle putting a surgical clamp on the needle at the skin to mark the position and minimize movement.
3. Connect to an oxygen source (400kpa) using a jet injector system (i.e. Sanders injector).
4. As an alternative quick, make-shift connection, cut the proximal end off the barrel of a Iml syringe with scissors and push the cut end into the length of non-complaint oxygen tubing attached to the fresh gas outlet of the anaesthetic machine. Insert the male end of the syringe into the Tuohy needle or cannula and press the oxygen flush to produce inflation.
5. Jet ventilate whether patient apnoeic or capable of spontaneous breathing.
6. Check patient expires through glottis, otherwise disconnect at needle or cannula to allow expiration.

Notes:

1. Locate the trachea by aspiration of air during insertion of the needle. Take care not to penetrate the posterior wall of trachea.
2. A 10-14G IV cannula can be used but it may kink.
3. A needle or cannula offers too much resistance for spontaneous respiration, therefore, assist with jet ventilation.
4. If the problem is likely to be prolonged perform percutaneous dilatational cricothyroidotomy, surgical cricothyroidotomy or formal tracheostomy by the surgeon.

(Brig M. Salim)