# Risk Factor for Intraoperative Awareness

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**Summary:** Nunes RR, Porto VC, Miranda VT, Andrade NQ, Carneiro LMM – Risk Factors for Intraoperative Awareness.

**Background and objectives:** The intraoperative awareness is an adverse event in the general anesthesia, and may occur in approximately 20,000 cases per year, which justifies the study of the risk factors for this event. The objective of this study was to review this subject in order to reduce the incidence of intraoperative awareness and psychological sequelae incurring from this incident, which may result in post-traumatic stress disorder with negative repercussions on the surgical patient social, psychic and functional development.

**Content:** It was conducted a review of the intraoperative awareness assessing its different phases during general anesthesia such as dreaming, wakefulness, explicit and implicit memory, as well as the analysis, consequences and prevention of its main related factors.

**Conclusions:** The reduction of awareness incidence during anesthesia is related to the anesthesiologist improved scientific and technical performance, involving issues such as monitoring, comprehension of the anesthesia activity components, hypnotic and analgesic drugs, neuromuscular blocking agents, autonomic and motor reflex control, in addition to the risk factors involved in this event.

**Keywords:** Anesthesia; Electroencephalography; Intraoperative Awareness; Stress Disorders, Post-Traumatic.



## INTRODUCTION

The intraoperative awareness after surgery conducted with general anesthesia is not very often. However, it is well described by the patient and the anesthesiologist as an adverse and undesirable effect since its very first report when a Horace Wells patient stated that the pain during surgery was "as if his skin had been scratched with a hoe". The causes for this event are frequently a consequence of inadequate anesthesia technique, device failure, addicted patients, excessive use of neuromuscular blocking agents and inadequate monitoring. Specific conditions such as major traumas, obstetric intercurrences, cardiopulmonary bypass, which are considered to be a risk factor for the intraoperative awareness may nowadays be well-conducted given the specific and potent therapeutic drugs arsenal, in addition to the currently available quality on monitoring.

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### General anesthesia and intraoperative awareness

The purpose of anesthesia is to induce unconsciousness through the administration of drugs. Therefore, it is fundamental to provide patients with analgesia, anxiolysis, amnesia and suppression of hormonal, cardiocirculatory and motor responses in the surgical stress setting [1].

Awareness during anesthesia with intraoperative memory occurs when the patient is able to process information and produce specific responses to several stimuli [2].

The different phases of intraoperative awareness or memory are independent. Explicit or declarative memory is when the patient remembers facts, events or experiences that occurred during general anesthesia [3]. Regarding implicit or procedural memory, defined as the memory of motor and sensorial capacities and abilities [4], the patient is unable to verbally express his experience during anesthesia, but there are changes in his postoperative behavior, habits and performance in such a way that psychological tests are required to detect the implicit memory [3].

Another intraoperative awareness phase is the state of wakefulness, when the patient is able to react to stimuli during surgery, but does not recall nor is conscious of the experienced reactions [5].

Dreaming is a phase that still raises issues regarding the classification of the awareness type. It is considered to be a transitional state between the explicit and implicit memory [1], i.e. any experience beginning at the moment of the anesthesia induction until the first moment of post-anesthesia consciousness.

The experience of consciousness is not the same for all patients. They may be collected as memories (hearing perception, tactile sensation, paralysis sensation and difficulty to move and breath, helplessness sensation, panic, anxiety, chronic fear and medical fear, insomnia and recurrent nightmares), [6] and neurosis, known as post-traumatic stress disorder [7] and requiring psychiatric treatment.

Awareness during anesthesia is not frequently experienced and it is difficult to collect data regarding the incidence of this event, making hard to establish effective preventive measures, as well as to identify and assess the risks, causal factors and psychosocial sequelae [8]. An awareness incidence of 1.2% has been documented in 1960 [9], but recent studies show an incidence of 0.1% to 0.2%, which may change according to biological types, anesthetic drugs and applied surgical procedures [10,11]. A multicenter study with 19,575 patients showed an intraoperative awareness incidence of 0.13% [12].

Risk factors for intraoperative awareness, according to epidemiological studies, may be classified in three main groups:

Patient related.
Surgery type related.
Anesthetic technique related.

## Patient related

### *Gender*

Studies indicate that the intraoperative awareness incidence is three times higher in women than in men, mainly because women recover faster from anesthesia [13,14].

### *Age*

A higher awareness incidence has been described in young patients during general anesthesia [12,15], however, Pollard et al. [16] have showed a higher incidence in the elderly. In children, the awareness incidence may reach up to 0.8% according to some published studies [17,18].

### *Previous history of alcohol, amphetamines, opioids and other drugs use*

The addicted patient requires greater amounts of anesthetic drugs as a consequence of tolerance development and, thus, intraoperative awareness may be experienced [19,20]. Previous awareness history - present in up to 1.6% of the cases - is a predisposing factor for a new intraoperative awareness incident [8].

### *Physical condition and pre-anesthetic medication*

There is an increased risk for intraoperative awareness in ASA III and IV patients who are submitted to major surgeries [12]. Patients who make use of antihypertensive drugs and beta blockers are susceptible to experience awareness episodes if exposed to low doses of general anesthetic agents in the attempt to avoid episodes of systemic blood hypotension. The preoperative use of benzodiazepines reduces the incidence of awareness [21,22].

### *Difficult airways*

The injection of an anesthetic inductor single dose in the tracheal management and intubation in difficult airways management favors the intraoperative awareness in 4.5% to 7.5% [23].

## Surgery type related

### *Obstetric anesthesia*

According to different studies, the incidence ranges from 0.4% to 1.3% [20,24,25], and occurs in the period between skin incision and fetal extraction, moment of greatest surgical stimulus and in many times with lower anesthetic concentrations [26]. These are considered to be triggering factors: 1) quick sequence induction without opioids to avoid depressing respiratory effects on the newborn; and 2) reduced inhaled fraction of inhalation anesthetics to avoid tocolytic effects and resulting uterine bleeding effect [27].

### *Cardiac surgery*

The awareness incidence ranges from 1.1% to 23%, mainly in surgeries where cardiopulmonary bypass is used [28,29]. Phillips et al. [30], in a study with 837 patients submitted to extracorporeal circulation, have reported an awareness incidence of 1.14%, with no differences found among the drugs used in the patients with or without memories of the intraoperative events. Ranta et al. [31] have showed a higher awareness incidence in the young and yet a reduction of such incidence when anesthesiologists are paying close attention to such complication. Continuous infusion of an anesthetic before, during and after extracorporeal circulation in 617 patients has showed an awareness incidence of 0.3% [32].

### *Emergency surgery in polytraumatized patients*

Intraoperative awareness may occur in up to 43% of the cases [33,34]. Hemodynamics instability, hypothermia and acute intoxications are factors that may induce an undue anesthetic amount use [19,35], and it may alter the incidence of such complication in polytraumatized patients.

## Anesthesia technique related

### *Inhalation anesthesia*

Reported awareness cases with techniques using inhalation anesthesia in general seem to be associated with issues in the vaporizers or lack of anesthetic gas monitoring; Bergman et al. [36] have reported in their study that in the 13% of the

patients who experienced awareness there had been a failure in the supply of nitrous oxide or volatile agents as a malfunctioning of the equipment, showing that in most cases the anesthetic agent concentrations (exhaled and inhaled) had not been monitored.

The efficacy of inhalation anesthetics low concentrations added to the additive effect of other simultaneously used drugs are considered to be important issues in the prevention of intraoperative awareness, even if the minimum concentration which ensures memory lack cannot be definitely established [37].

### *Total venous anesthesia*

A prospective observational study conducted with 4,001 patients by Errando et al. [38] has showed a higher awareness incidence in patients administered total venous anesthesia during the surgical process when compared to balanced anesthesia. In general, it is associated with late start of the infusion after the induction dose; inadequate administration modes; and frequently failure in the administration pumps, system disconnection and obstruction of the intravenous flow.

#### *Administration of neuromuscular blocking agents*

A meta-analysis demonstrated that up to 85% of the patients suffering with awareness were receiving neuromuscular blocking agents [8]. The use of neuromuscular blocking agents is recommended only if necessary, as a useful and simpler way to check patient's awareness is through his movements [39,40]. Movement observation as a reflexive somatic response to surgical stimulus, a support for the minimum alveolar concentration (MAC) concept, is considered to be a reliable method to detect intraoperative awareness. In a study of 11,780 patients administered general anesthesia, an awareness incidence of 0.18% associated with anxiety and late neurotic symptoms was observed in those patients who received neuromuscular blocking agents, and an awareness incidence of 0.1% was observed in those patients who did not receive neuromuscular blocking agents [41]. The use of neuromuscular blocking agents is associated with a higher intraoperative awareness incidence, as well as with implicit memory [42]. A recent study by Nunes et al. [43] assessing 20 volunteers administered a depolarizing neuromuscular blocking agent alone has showed an important reduction in BIS and in the electromyographic potency to values considered to be within the surgical range. A $T_1$ lesser than $1.9 \pm 3.18\%$ was reported, concluding that in spite of the fact that the BIS algorithm does not include an electromyography, its reduction directly changes BIS values; thus, the importance of maintaining $T_1$ above 5% so that BIS values do not represent a false positive. Other studies by Nunes et al. [44,45] have also showed significant reductions in the values of the entropies (response and state), as well as in the cerebral state index (CSI) in volunteers after the use of succinylcholine. Figure 1 shows a scheme that represents cortical impulse generation associated with facial electromyography (EMG). Reduced EMG after the use of neuromuscular blocking agents may influence the anesthetic adequacy indexes (AA).

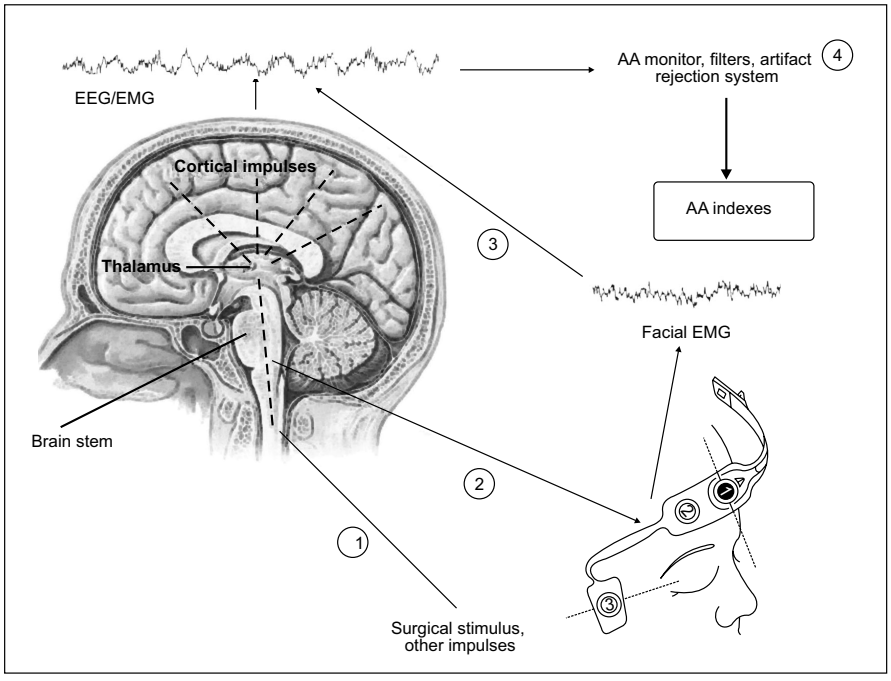


**Figure1 –** Relation among Peripheral Stimulus (1), Electromyographic Activity Generation (2 and 3) and EEG. In (4), EMG and EEG biological electrical signs are processed and digitalized resulting in AA indexes.
EFG Electrical Activity of the Cerebral Cortex; EMG: facial electromyography; AA: anesthetic activity.

In general, in patients presenting with intraoperative awareness risk there are several conditioning factors. The most frequent causes of motor paralysis complaints in awaken patients are errors made in the administration or identification of intravenous drugs. Among of which succinylcholine is the most frequently related with the wrongful administration in place of the sedative or hypnotic agents in the anesthetic induction [36].

**Intraoperative awareness consequences**

Some patients who have experienced awareness in the intraoperative setting may progress without psychological disorders. The most feared complication is the post-traumatic stress disorder (PTSD) [7,13]. This is a type of psychic disorder that may be experienced in a specific stress situation with the presence of psychic, functional and social impairment that may persist for many months and, if not properly treated, progress to a chronic psychic disorder in 25% of the cases [46]. The subject experiencing PTSD shows difficulties to have a steady sleep, anxiety, irritability, concentration and humor disorders, fear of anesthesia, depression and nightmares. Ghoneim et al. [8] have demonstrated in their study that 19% of the patients experienced sleeping disorders, 21% nightmares and up to 17% daily anxiety. Treatment is based on a behavioral cognitive therapy with cognitive restructuration of the traumatic episode whether or not associated with the administration of psychotherapeutic agents [47,48]. There are also the general psychological sequelae, suffering conditions and emotional disturbances that usually hinder social functioning and development, and are distinct from those present in the PTSD condition [10] with an incidence of 0% to 78% [49].

**Intraoperative awareness prevention**

The risk for intraoperative awareness may be minimized with specific clinical practice principles being strictly followed and complied with [50]:

- Never abandon the patient in the surgery room.
- Preoperative visit is fundamental and mandatory. Identify patients whose specific needs for anesthetic drugs have been modified: chronic alcohol use, hypernatremia, hyperthermia, monoamine oxidase inhibitors, tricyclic antidepressants, amphetamines, cocaine etc. Assess airway passage and, even in patients considered to have a difficult airway passage ensure, that tracheal intubation is conducted causing the least trauma possible.
- Check previously all devices involved in the anesthetic procedure before each new patient and regularly during the anesthetic procedure: respirators, vaporizers, respiratory system, and infusion pumps.
- Register in the patient's record his answers to the following questions: "What is the last thing you remember before fallen sleep?"; "What is the first thing you remember after waking up?"; "Can you remember anything in between these two moments?" and "Did you have any dreams during surgery?" [20].
- Use neuromuscular blocking agents with caution, introducing in the practice: monitoring of the neuromuscular function and maintaining T1 above 5% [42,43].
- Whenever possible, use agents with amnesic properties [20].
- Inhalation anesthetics must be monitored with gas analyzers and concentration (MAC) never inferior to 0,8 [20].
- Never use nitrous oxide as the only anesthetic without complementing it with another potent anesthetic agent either an inhalation agent or a venous one.
- Maintain BIS value below 60.
- The anesthetic act is a dynamic event. Each patient according to his clinical condition must be cautiously assessed, establishing among the anesthetic components which are the ones that must be blocked so that the patient is submitted to a surgical procedure under anesthesia without intraoperative awareness.

**CONCLUSION**

Terror described by patients submitted to general anesthesia and who experienced intraoperative awareness is a unique fact for such patient. The unpredictable effect in his life and long term results are immeasurable. The fall of awareness incidence during anesthesia is related to the anesthesiologist improved scientific and technical performance, involving issues such as comprehension of the anesthesia activity components, hypnotic and analgesic drugs, neuromuscular blocking agents, autonomic and motor reflex control, in addition to the risk factors involved in this event. Monitoring and interpretation of data collected and clinical signs during the anesthetic surgical procedure must be based on clinical judgment specific for each patient and each surgical procedure.

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