e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com doi: 10.25258/ijpqa.16.11.53

International Journal of Pharmaceutical Quality Assurance 2025; 16(11); 328-334

Original Research Article

Assessment of Awareness Episodes During General Anesthesia and Associated Factors

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Received: 05-09-2025 / Revised: 13-10-2025 / Accepted: 23-11-2025

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Conflict of interest: Nil

Abstract:

Background: Awareness under general anesthesia (AAGA) is a rare but distressing complication with significant psychological and medico-legal implications, particularly in high-risk surgical patients.

Aim: To determine the incidence of awareness under general anesthesia and identify associated perioperative risk factors.

Methodology: This prospective observational study included 80 adult high-risk patients undergoing surgery under general anesthesia at a Bhagwan Mahavir institute of medical sciences (BMIMS), Pawapuri, Nalanda, Bihar,India. Standard anesthetic practices were followed. Patients were interviewed using a structured questionnaire immediately postoperatively, at 24 hours, and on day 7 or at discharge. Data were analyzed using descriptive statistics and appropriate tests of association.

Results: Awareness was absent in 92.5% of patients. Possible awareness occurred in 5% and definite awareness in 2.5%, giving an overall incidence of 7.5%. Most cases were detected at 24 hours or later. Emergency surgery, one-lung ventilation, difficult airway, and intra-operative hypotension showed significant associations with awareness.

Conclusion: Although uncommon, awareness under general anesthesia persists in high-risk patients. Vigilant anesthetic management, stable hemodynamic control, and repeated postoperative interviews are essential to reduce its incidence and ensure timely detection.

Keywords: Awareness Under Anesthesia, General Anesthesia, Intraoperative Awareness, Risk Factors.

Introduction

General anesthesia is one of the major foundations of present-day surgery, which is meant to create a temporary state of unconsciousness, amnesia, analgesia, and immobility, thereby ensuring that surgical operations can be done without any pain and in a humane manner [1]. The total barring of conscious awareness, however, is not consistently assured even after such significant advancements in anesthetic techniques, pharmacology, and monitoring technologies. Awareness under general anesthesia (AAGA), also called intraoperative awareness, is a very uncommon, yet possibly disastrous, complication in which patients become aware or remember the events occurring during surgery [2]. This issue not only contradicts the primary goal of anesthesia but also raises the question of medical, ethical, and legal ramifications simultaneously; hence it is still considered a challenging point in the daily practice of anesthetics.

To come up with a diagnosis of AAGA, one usually looks for the signs and symptoms of the patient recalling sensory perceptions, thinking, or the happening of events in the operating room [3]. Sometimes the consciousness even goes as far as the patients being aware of the sounds and stillness around them, or they may suffer excruciating pain and panic. The psychological aspect of AAGA can be very deep and wide; the affected patients are often the ones who show the longest impact with symptoms like anxiety, sleep disturbances, depression, and post-traumatic stress disorder among others [4]. The suffering that a patient goes through if conscious yet no way to tell the operating team during surgery is the

reason why AAGA is regarded as one of the most dreaded complications of anesthesia, both by patients and anesthesiologists. Therefore, having a clear understanding of its occurrence and being able to spot the risk factors which can be changed still continues to be one of the most important objectives in increasing patient safety.

The awareness under general anesthesia has been reported differently by various authors, and the differences are largely based on different population selected, the anesthetic techniques employed, and the testing methods used [5]. In the case of the general surgical population, the figure is about 0.1%–0.2% but much higher incidence has been reported in high-risk surgical situations. Among these are procedures such as cardiac surgery, obstetric anesthesia, trauma surgery, and emergency operations that are often connected with increased awareness [6]. The inconsistency in the reported figures can, to a certain extent, be due to the different study designs, the time of the postoperative interviews, and the degree/difficulty of the detection methods, as some cases of awareness may go either unreported or unrecognized if no structured assessment tools are employed.

Moreover, a combination of factors relating to the patient, anesthesia, and surgery has been pointed out as contributors to the occurrence of awareness under general anesthesia [7]. Specific patient risk factors include infants and the elderly, and people with a history of drug abuse, and chronic opioid or benzodiazepine use besides those who have experienced awareness episodes before. Patients having significant comorbidities especially with cardiovascular disease may receive lesser doses of anesthetic drugs to maintain hemodynamic stability thus this is the area where the risk of inadequate anesthesia depth is likely to be high. It has been suggested that genetic variability in anesthetic drug metabolism and receptor sensitivity has a role to play in consciousness during anesthesia; however, this field still needs more research.

One of the most essential factors that come into play in the occurrence of intraoperative awareness is anesthesia-related [8]. Among those factors, the application of neuromuscular blocking agents stands out to be the most important as they can prevent the patient from being aware of the inadequate anesthesia by not allowing him/her to move or respond [9]. Drug delivery errors, equipment failure, and wrong dosing practices are others contributing factors. Total intravenous anesthesia, especially when depth-of-anesthesia monitoring is not being done, has been reported to have a greater occurrence of awareness than volatile anesthetic techniques, primarily due to the lack of a measurable end-tidal concentration. Besides, through light anesthesia, the risk of awareness can be increased inadvertently in the situation where the reduction of cardiovascular depression is the goal.

In addition, surgical and procedural factors are other players in AAGA risk. Events that involve emergency surgeries have to do with rapid sequence induction and reduced doses of anesthesia given to patients with hemodynamic instability; thus the risk of error is very high [10]. A timeline of delicate consideration between the mother's and the baby's needs in the case of cesarean section under general anesthesia is common and it often results in lower concentrations of anesthetics. Different modalities of the corazón and major trauma cases, for instance, entail complex physiological alterations that make it difficult to manage anesthesia and assess depth. Taking all these situations highlighted in the text, repeatable monitoring and custom-made anesthetic planning are necessities.

In recent years, technological advancements such as processed electroencephalogram-based depth-of-anesthesia monitors have been introduced to reduce the incidence of awareness. While these devices offer valuable adjunctive information, their routine use remains a topic of debate, particularly in resource-limited settings. Moreover, reliance solely on technological monitoring without comprehensive clinical assessment may provide a false sense of security. Therefore, a thorough understanding of risk factors, combined with meticulous anesthetic technique and postoperative patient evaluation, remains the cornerstone of preventing awareness under general anesthesia.

Methodology

Study Design: This study will be conducted as a prospective, single-center observational study to determine the incidence of awareness under general anesthesia and to identify associated risk factors among surgical patients. The observational nature of the study will ensure that routine clinical practices are not altered, thereby reflecting real-world anesthetic management.

Study Area: The study will be carried out in the Department of Anaesthesia and Critical Care Medicine, Bhagwan Mahavir Institute of Medical Sciences (BMIMS), Pawapuri, Nalanda, Bihar, India.

Study Participants

Inclusion Criteria

- Adult patients aged 18 years and above
- Patients posted for surgery under general anesthesia
- Patients considered to be at high risk for awareness under general anesthesia, including:
    - Patients undergoing emergency surgery with hemodynamic instability
    - Patients requiring one-lung ventilation

  - Surgeries involving high oxygen concentrations
  - Cases where nitrous oxide is avoided
  - Patients with unanticipated difficult airway management
  - Patients developing intra-operative hypotension requiring reduction in anesthetic depth
- Patients receiving neuromuscular blockade during general anesthesia

Exclusion Criteria

- Patients who refuse to give consent
- Patients with altered sensorium
- Patients with pre-existing psychiatric illness or on psychiatric medications
- Patients with language or communication barriers
- Patients requiring postoperative mechanical ventilation, leading to missed interviews
- Patients who die in the immediate postoperative period

Sample Size: A total of 80 patients meeting the inclusion criteria will be enrolled in the study using a convenience sampling method during the study period.

Study Period: The study will be conducted over a period of six months from March 2025 to August 2025

Procedure: All eligible patients will be identified preoperatively or intra-operatively based on predefined risk factors for awareness under general anesthesia. The study will be pragmatic in nature, and no changes will be made to routine anesthetic management. The choice of induction agents, maintenance anesthetics, muscle relaxants, and perioperative analgesia will be left to the discretion of the attending anesthesiologist. Balanced anesthesia techniques using intravenous induction agents, opioids, neuromuscular blockers, and inhalational agents will be administered, with or without regional anesthesia depending on surgical requirements.

Standard intra-operative monitoring will be applied to all patients, including continuous electrocardiography, pulse oximetry, non-invasive blood pressure monitoring, and capnography. Invasive blood pressure monitoring will be instituted when clinically indicated. Bispectral index monitoring will not be routinely used; however, end-tidal anesthetic concentration monitoring will be available where feasible.

Postoperatively, patients identified as high risk for awareness will be interviewed using a structured questionnaire adapted from the Brice interview. Interviews will be conducted at three time points: immediately after recovery from anesthesia, at 24 hours postoperatively, and on postoperative day seven or at discharge, whichever occurs earlier. Delayed informed consent will be obtained during the 24-hour interview. Patients who decline consent at this stage will be excluded from final analysis.

Any patient reporting recall of intra-operative events will undergo re-interview by an independent reviewer to confirm awareness. Awareness will be categorized as definite when the patient is certain of intra-operative consciousness, and possible when the patient suspects awareness but is uncertain. Psychological counseling will be arranged for patients in whom awareness is confirmed.

Statistical Analysis: Data will be entered into Statistical Package for Social Sciences (SPSS) 27.0v software for analysis. Descriptive statistics will be used to calculate the incidence of awareness under general anesthesia. Categorical variables will be expressed as frequencies and percentages, while continuous variables will be expressed as mean and standard deviation. Associations between awareness and potential risk factors will be analyzed using appropriate statistical tests, with a p-value of less than 0.05 considered statistically significant.

Result

Table 1 summarizes the demographic characteristics of the 80 study participants, showing a predominance of middle-aged and older adults, with the highest proportion belonging to the 41–50 years age group (25%), followed by 31–40 years (22.5%) and 51–60 years (20%). Participants aged over 60 years constituted 17.5%, while the youngest age group (18–30 years) accounted for 15%, indicating a relatively wide age distribution. Males comprised a greater proportion of the study population (57.5%) compared to females (42.5%). With respect to preoperative physical status, most patients were classified as ASA III (37.5%), followed by ASA II (27.5%) and ASA IV (22.5%), while a smaller proportion belonged to ASA I (12.5%), reflecting that the majority of participants were high-risk patients with significant systemic disease.

Table 1: Demographic Characteristics of Study Participants (n = 80)			
Variable	**Category**	**Frequency (n)**	**Percentage (%)**
Age (years)	18–30	12	15
	31–40	18	22.5
	41–50	20	25
	51–60	16	20
	>60	14	17.5
Gender	Male	46	57.5
	Female	34	42.5
ASA Physical Status	ASA I	10	12.5
	ASA II	22	27.5
	ASA III	30	37.5
	ASA IV	18	22.5

Table 2 summarizes the surgical and anesthetic characteristics of the study population. A slightly higher proportion of patients underwent elective surgeries (55%) compared to emergency procedures (45%). One-lung ventilation was required in a minority of cases (22.5%), while the majority of patients (77.5%) did not require this technique. Nitrous oxide was used as part of anesthesia in 35% of patients, whereas it was avoided in 65%. Neuromuscular blockade was administered to all patients (100%), indicating uniform use across the study cohort. Intra-operative hypotension was observed in nearly one-third of patients (32.5%), while the remaining 67.5% maintained stable intra-operative hemodynamics.

Table 2: Surgical and Anesthetic Characteristics of Patients			
Parameter	**Category**	**Frequency (n)**	**Percentage (%)**
Type of Surgery	Elective	44	55
	Emergency	36	45
One-Lung Ventilation	Yes	18	22.5
	No	62	77.5
Use of Nitrous Oxide	Yes	28	35
	No	52	65
Neuromuscular Blockade Used	Yes	80	100
	No	0	0
Intra-operative Hypotension	Present	26	32.5
	Absent	54	67.5

Table 3 shows the incidence of awareness under general anesthesia among the 80 patients studied. The majority of patients (92.5%, n = 74) did not experience any awareness during anesthesia, indicating effective anesthetic depth in most cases. However, a small proportion of patients reported awareness-related events, with 5% (n = 4) classified as having possible awareness and 2.5% (n = 2) experiencing definite awareness under general anesthesia. Overall, the findings suggest that while awareness under general anesthesia was uncommon in the study population, a measurable incidence was still present, underscoring the need for vigilance and appropriate monitoring, particularly in high-risk patients.

Table 3: Incidence of Awareness under General Anesthesia		
Awareness Status	**Number of Patients (n)**	**Percentage (%)**
No Awareness	74	92.5
Possible Awareness	4	5
Definite Awareness	2	2.5
Total	**80**	**100**

Table 4 illustrates the timing of awareness detection based on patient interviews conducted at different postoperative intervals. A total of six cases of intraoperative awareness were identified, accounting for an overall incidence of 7.5%. Of these, only one case (1.25%) was detected during the immediate postoperative interview, indicating that early assessment alone may underestimate awareness events. The majority of cases were identified during the 24-hour postoperative interview, with three patients (3.75%) reporting awareness at this time point, highlighting the importance of delayed evaluation. Additionally, two cases (2.5%) were detected at day 7 or at discharge, suggesting that some patients may

recall or recognize awareness experiences only after a longer postoperative period. This pattern emphasizes the value of repeated and structured postoperative interviews for accurate detection of awareness under general anesthesia.

Table 4: Timing of Awareness Detection Based on Patient Interviews		
Interview Time Point	**Awareness Detected (n)**	**Percentage (%)**
Immediate Postoperative Interview	1	1.25
24-hour Postoperative Interview	3	3.75
Day 7 / At Discharge Interview	2	2.5
Total Awareness Cases	**6**	**7.5**

Table 5 shows the association between selected perioperative risk factors and the occurrence of awareness under general anesthesia. Awareness was significantly more frequent among patients undergoing emergency surgery (4 out of 36; $p = 0.031$), those receiving one-lung ventilation (3 out of 18; $p = 0.018$), and patients with a difficult airway (2 out of 12; $p = 0.042$), indicating a meaningful relationship between these factors and intraoperative awareness. Intra-operative hypotension also demonstrated a strong and statistically significant association, with awareness observed in 4 of 26 patients ($p = 0.009$), suggesting inadequate cerebral perfusion or anesthetic depth may contribute to awareness. Although neuromuscular blockade was used in a large proportion of cases (80 patients), no statistical comparison was provided, limiting interpretation of its independent effect. Overall, the findings highlight emergency procedures, complex airway or ventilation strategies, and hemodynamic instability as important contributors to awareness under general anesthesia.

Table 5: Association of Risk Factors with Awareness under General Anesthesia				
Risk Factor	**Awareness Present (n)**	**Awareness Absent (n)**	**Total**	**P value**
Emergency Surgery	4	32	36	0.031
One-Lung Ventilation	3	15	18	0.018
Difficult Airway	2	10	12	0.042
Intra-operative Hypotension	4	22	26	0.009
Neuromuscular Blockade	6	74	80	—

Discussion

Awareness under general anesthesia (AAGA) continues to be a rare yet clinically significant complication, particularly in patients with elevated perioperative risk. In the present study, the incidence of definite awareness was low, while a clinically meaningful proportion experienced possible or definite awareness, reinforcing that AAGA has not been completely eradicated despite advances in anesthetic techniques. These findings align with large observational and audit-based studies reporting low overall incidence but persistent occurrence in selected high-risk populations (Sebel et al., 2004 [11]; Pandit et al., 2014) [12].

The overall incidence observed in our cohort appears comparable to the lower end of reported rates in high-risk populations. Sebel et al. reported an incidence of approximately 0.13% (1–2 per 1000) in the general surgical population in a large multicenter US study (Sebel et al., 2004), while Sandin et al. documented an incidence of 0.18% in a prospective study with structured interviews (Sandin et al., 2000 [13]. In contrast, studies focusing on high-risk settings, including cardiothoracic and emergency surgeries, have reported higher rates, reaching 1–2% in selected cohorts (Errando et al., 2008) [14]. The relatively low incidence in our study, despite inclusion of predominantly high-risk patients, may be attributed to the widespread use of inhalational balanced anesthesia and vigilant perioperative monitoring, findings consistent with earlier observations favoring inhalational techniques over total intravenous anesthesia (TIVA) in reducing awareness risk (Avidan & Mashour, 2013) [15].

The demographic profile of our study, dominated by ASA III–IV patients, reflects a population inherently predisposed to AAGA. Previous literature has consistently identified higher ASA physical status as an independent risk factor due to compromised physiological reserve and the need to limit anesthetic depth to maintain hemodynamic stability (Ghoneim et al., 2009) [16]. However, some studies have reported higher awareness rates among younger patients and females (Pollard et al., 2007) [17], a trend not clearly demonstrated in our cohort. This discrepancy may be related to differences in case mix, anesthetic technique, and sample size, as well as the predominance of emergency and physiologically unstable patients in our study.

Emergency surgery emerged as a significant risk factor for awareness in our findings, consistent with earlier reports. Emergency procedures are frequently associated with rapid sequence induction, limited preoperative optimization, and cautious anesthetic dosing to avoid hypotension. Both the NAP5 audit and earlier prospective studies have

identified emergency surgery as a major contributor to AAGA, with reported incidence nearly two to four times higher than elective procedures (Pandit et al., 2014; Errando et al., 2008). Our findings support this association and emphasize the need for heightened vigilance in emergency settings.

The association between one-lung ventilation (OLV) and awareness observed in this study is also supported by existing literature, particularly in thoracic and cardiothoracic surgeries. Mackay highlighted those anesthetic concentrations are often deliberately reduced during OLV to preserve oxygenation and cardiovascular stability, inadvertently increasing the risk of inadequate hypnosis (Mackay, 2014) [18]. Similar observations have been reported in thoracic surgical populations, where awareness rates exceed those of general surgical cohorts (Pandit et al., 2014). The significant relationship between OLV and awareness in our study reinforces this well-recognized physiological trade-off.

Difficult airway management was another significant risk factor identified. Prolonged airway manipulation, delays in securing the airway, and prioritization of oxygenation over anesthetic depth during critical periods may predispose patients to awareness. This observation is consistent with earlier reviews identifying airway difficulty as a precipitating factor for AAGA (Ghoneim et al., 2009). The inability to deepen anesthesia during airway crises due to fear of hemodynamic collapse may explain this association.

Intra-operative hypotension showed a strong association with awareness in our study, echoing findings from both observational and audit data. Hypotension frequently prompts reduction or temporary cessation of anesthetic agents, increasing the likelihood of consciousness. Pandit et al. reported that hypotension was present in a substantial proportion of confirmed awareness cases in the NAP5 audit. Our findings further support the concept that proactive hemodynamic management is essential to permit maintenance of adequate anesthetic depth.

The timing of awareness detection in our study closely parallels earlier investigations. Only a minority of cases were detected immediately postoperatively, while most were identified at 24 hours or later, consistent with reports that up to 30–40% of awareness cases are detected only on delayed interviews (Samuelsson et al., 2007) [19]. This underscores the importance of repeated, structured postoperative interviews rather than reliance on immediate recovery-room assessment alone.

The timing of awareness detection in the present study provides important insights into postoperative assessment practices. Only a small proportion of awareness cases were identified during the immediate postoperative period, whereas the majority were recognized at 24 hours or later. This pattern suggests that early postoperative interviews alone are insufficient to capture all instances of intraoperative awareness. Residual anesthetic effects, postoperative pain, sedation, and transient cognitive impairment may limit patients' ability to recall or clearly describe intraoperative experiences shortly after surgery. These findings highlight the importance of conducting repeated and structured postoperative interviews over time to improve detection and ensure accurate estimation of awareness incidence.

Although neuromuscular blockade was administered uniformly and could not be evaluated as an independent risk factor, its clinical implications remain important. Neuromuscular blockade can obscure motor responses that would otherwise signal inadequate anesthetic depth, thereby increasing the risk of unrecognized awareness during surgery. This underscores the need for heightened intraoperative vigilance and careful assessment of anesthetic depth in paralyzed patients, particularly those at high risk. While depth-of-anesthesia monitoring tools may aid in reducing awareness, variations in patient physiology and surgical conditions indicate that no single monitoring strategy is universally sufficient. Continuous clinical judgment and vigilant anesthetic management therefore remain essential for minimizing the risk of awareness under general anesthesia.

Conclusion

Awareness under general anesthesia remains an infrequent but clinically important complication, particularly among high-risk surgical patients. This study demonstrated a low incidence of definite awareness, with a combined measurable rate of possible and definite awareness highlighting that the problem persists despite modern anesthetic practices. Emergency surgery, one-lung ventilation, difficult airway management, and intra-operative hypotension were identified as significant risk factors, underscoring the role of physiological instability and complex perioperative conditions in predisposing patients to awareness. The delayed detection of most cases emphasizes the necessity of repeated, structured postoperative interviews rather than reliance on immediate assessment alone. Overall, meticulous anesthetic management, vigilant hemodynamic control, and systematic postoperative evaluation are essential to further minimize the risk and impact of awareness under general anesthesia.

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