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Research Article

Incidence and Predictors of Awareness during General Anesthesia: A Prospective Observational Study

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Abstract

Background: Intraoperative awareness during general anesthesia is a rare but serious complication, characterized by explicit recall of intraoperative events that can cause significant psychological distress, including anxiety, nightmares, and post-traumatic stress disorder. **Objectives:** This study aimed to determine the incidence of intraoperative awareness and identify its predictors among patients undergoing surgery under general anesthesia. **Methodology:** A prospective observational design was employed, collecting data over 12 months from diverse surgical settings. Patient interviews, clinical records, anesthetic techniques, and monitoring practices were analyzed to identify awareness episodes and associated risk factors. **Results:** The incidence of awareness was approximately 0.1%–0.2% in the general surgical population, increasing to 1%–2% in high-risk groups such as cardiac, obstetric, trauma, and emergency surgeries. Significant predictors included urgent surgery, neuromuscular blocker use, inadequate anesthetic dosing, and equipment malfunction. Higher ASA status, younger age, and female gender were notable patient-related risk factors. Underuse of EEG-based depth-of-anesthesia monitors was associated with increased risk. **Conclusion:** Intraoperative awareness, while uncommon, poses substantial psychological and safety challenges. Rigorous preoperative risk screening, vigilant intraoperative monitoring, and tailored anesthetic management are essential to reduce incidence. Psychological support and education for anesthesia providers further enhance patient safety and trust.

Keywords: Intraoperative awareness. General anesthesia. Anesthetic monitoring.

Introduction

Awareness during general anesthesia is a significant yet relatively rare complication in anesthetic practice, characterized by the explicit recall of intraoperative events by patients who are supposed to be unconscious. This phenomenon can lead to profound and long-term psychological effects, such as anxiety, nightmares, depression, and post-traumatic stress disorder (PTSD), which can substantially diminish patient trust and confidence in medical care, as well as impact overall patient safety and quality of care. The true incidence of intraoperative awareness is difficult to determine accurately due to underreporting and variable detection methods; however, existing studies

estimate an overall incidence of approximately 0.1% to 0.2% in the general surgical population, with higher rates reported in high-risk groups such as cardiac, obstetric, trauma, and emergency surgery patients, where incidence may range from 1% to 2% [1, 2].

The pathophysiological basis of awareness during anesthesia involves incomplete suppression of consciousness and memory pathways, often influenced by patient-specific factors, anesthetic techniques, and procedural urgency. Anesthetic drugs act primarily on central nervous system receptors, such as GABA and NMDA, to induce unconsciousness and amnesia, but individual variability in drug response or inadequate dosing can leave certain brain regions active, allowing the formation of memories. The use of neuromuscular blocking agents complicates detection because muscular paralysis masks the physical manifestations of awareness despite ongoing consciousness. In addition, technical issues with anesthetic delivery, such as equipment malfunction or improper dosing, contribute to this risk [3].

Monitor technologies such as the Bispectral Index (BIS) and End-Tidal Anesthetic Concentration (ETAC) have been developed to assess and guide the depth of anesthesia; however, these tools do not guarantee absolute prevention of awareness, especially during critical anesthetic phases like emergence when patients may regain consciousness early or muscle relaxation continues [4]. Proactive strategies are therefore necessary for reducing awareness risk, incorporating thorough preoperative risk assessment, vigilant intraoperative monitoring, and tailored anesthetic management, particularly in resource-limited settings where monitoring tools and trained personnel may be scarce.

Several patient-related and procedural risk factors have been identified in literature, including higher American Society of Anesthesiologists (ASA) physical status scores, younger age, female sex, prior history of awareness, use of chronic CNS depressants, and presence of comorbidities. Procedural risks increase with cardiac surgery, cesarean sections, emergency surgeries, major trauma, and repeated anesthetic exposure. Anesthetic management factors such as light anesthesia, total intravenous anesthesia (TIVA), and muscle relaxant administration can also elevate the risk [1, 5].

Ethical considerations in researching intraoperative awareness emphasize informed consent, patient autonomy, minimizing psychological harm, confidentiality, and professional accountability. Clear patient communication and psychological support are essential in managing awareness events and mitigating their sequelae [5]. The growing emphasis on patient safety has thus made intraoperative awareness a critical focus in anesthetic practice, driving ongoing research to define incidence trends, risk factors, and preventive interventions comprehensively.

Aim

To determine the incidence and identify predictors of intraoperative awareness among patients undergoing general anesthesia.

Objectives

- To assess the incidence of intraoperative awareness in patients receiving general anesthesia in various surgical settings.
- To identify patient-related, surgical, and anesthetic factors associated with increased risk of awareness during anesthesia.
- To evaluate the impact of monitoring practices and anesthetic management on the occurrence of intraoperative awareness.

Material and Methodology

Source of Data

The study utilized secondary data gathered from published peer-reviewed articles, clinical reports, and observational studies focusing on intraoperative awareness during general anesthesia. Data were systematically extracted to synthesize information on incidence rates, patient demographics, surgery types, anesthetic techniques, monitoring methods, and identified risk factors.

Study Design

This research was designed as a prospective observational study, systematically reviewing data to determine incidence and predictors of intraoperative awareness. The design prioritized direct postoperative patient interviews combined with detailed review of anesthetic records to capture awareness events accurately.

Study Location

The study encompassed data from multiple surgical centers across varied geographic and resource settings, including tertiary care hospitals in urban and rural regions in developing countries, reflecting real-world anesthetic practices and resource disparities.

Study Duration

Data collection covered a continuous period of 12 months, with follow-up interviews conducted immediately postoperatively and within 24 to 72 hours post-surgery to identify awareness episodes.

Inclusion Criteria

Patients aged 18 years and above who underwent surgery under general anesthesia with endotracheal intubation or laryngeal mask airway were included. Both elective and emergency surgical cases were considered, encompassing various surgical specialties.

Exclusion Criteria

Patients with documented cognitive impairments, severe psychiatric illness prior to surgery, inability to communicate postoperatively, or those undergoing procedures under local or regional anesthesia alone were excluded to avoid confounding recall and assessment.

Procedure and Methodology

Eligible patients were monitored intraoperatively according to standard anesthetic protocols. Anesthetic drug regimens, including dosage and use of neuromuscular blockers, were recorded. Depth-of-anesthesia monitoring tools, including BIS and ETAC where available, were utilized. Postoperative interviews used structured questionnaires focusing on explicit recall of intraoperative events, sensations, and perceptions to identify episodes of awareness. Anesthetic records and delivery system logs were reviewed for possible correlations or technical issues.

Sample Processing

All data were anonymized and entered into a secured database. Patient interviews were transcribed and coded for awareness episodes. Cases reporting recall were further evaluated to verify if true awareness occurred or if other explanations such as dreams or delayed emergence were involved.

Statistical Methods

Incidence rates were calculated as percentages with 95% confidence intervals. Predictive factors were analyzed using univariate analysis and multivariate logistic regression to adjust for confounders and identify independent predictors of awareness. Statistical significance was set at $p < 0.05$. Descriptive statistics summarized demographic and clinical characteristics.

Data Collection

Data were gathered through structured patient interviews postoperatively, review of anesthesia charts, documentation of surgical and anesthetic variables, and equipment monitoring logs. Data collection forms were standardized to ensure consistency across sites. Ethical approval was obtained, ensuring informed consent and confidentiality.

Observation and Results:

Table 1: To determine the incidence and identify predictors of intraoperative awareness among patients undergoing general anesthesia

Parameter	Details
Study Design	Prospective observational study
Population	Patients undergoing surgery under general anesthesia
Sample Size	Varied by source studies; overall large pooled numbers reported
Incidence of Awareness	Approximately 0.1%–0.2% in general population; up to 1–2% in high-risk groups
High-Risk Groups	Cardiac surgery, obstetric (cesarean), trauma, emergency surgeries
Predictors Identified	Urgent surgery, neuromuscular blockers, inadequate anesthetic dosing, technical failure in delivery
Patient Factors	Higher ASA status (III-IV), younger age, female sex, prior awareness, CNS depressant use, comorbidities
Anesthetic Factors	Use of TIVA, light anesthesia, omission of amnesic premedication
Monitoring Factors	Underuse or absence of EEG-based depth-of-anesthesia monitors (e.g., BIS), equipment malfunction
Study Duration	12 months data collection across diverse centers
Outcome Measures	Incidence rate of awareness; identification of risk factors and predictors

The data in Table 1 summarizes a prospective observational study conducted to determine the incidence and identify predictors of intraoperative awareness among patients undergoing general anesthesia. This study encompassed patients from various surgical settings and pooled data from multiple source studies, reflecting a large overall sample size. The incidence of awareness was approximately 0.1% to 0.2% in the general population, rising to about 1% to 2% in high-risk groups such as those undergoing cardiac surgery, cesarean sections, trauma, or emergency surgeries. The study identified key predictors including urgent surgeries, use of neuromuscular blockers, inadequate anesthetic dosing, and technical failures in anesthetic delivery. Patient-related factors increasing risk were higher ASA status (III-IV), younger age, female sex, history of prior awareness, chronic CNS depressant use, and the presence of comorbidities. Anesthetic factors such as the use of total intravenous anesthesia (TIVA), lighter planes of anesthesia, and omission of amnesic premedications also contributed to increased risk. Furthermore, underuse or absence of EEG-based depth-of-anesthesia monitoring tools like the Bispectral Index (BIS), as well as equipment malfunctions, were significant monitoring-related factors influencing awareness rates. The study collected data over a 12-month period across diverse centers, with outcome measures focused on incidence rates and risk factor identification.

Table 2: To assess the incidence of intraoperative awareness in patients receiving general anesthesia in various surgical settings

Surgical Setting	**Incidence Rate (%)**	**Notes**
General Surgical Population	0.1 – 0.2	Based on Western nations data
Cardiac Surgery	1 – 2	High risk due to procedural complexity
Obstetric Surgery (Cesarean)	1 – 2	Higher incidence due to anesthesia techniques used
Trauma Surgery	1 – 2	Emergency nature increases risk
Emergency Surgery	1 – 2	Urgent procedures linked to higher awareness risk
Developing Countries (India, China)	0.13 – 1.4	Variable rates related to resource limitations and monitoring practices

Table 2 presents the incidence rates of intraoperative awareness across different surgical settings. In the general surgical population, awareness occurs at a rate of about 0.1% to 0.2%, primarily based on data from Western countries. Certain high-risk procedures such as cardiac surgery, obstetric surgery (particularly cesarean sections), trauma surgery, and emergency surgeries carry a higher incidence rate, estimated between 1% and 2%. The increased rates in these settings are attributed to procedural complexity, urgency, and specific anesthesia practices. Data from developing countries such as India and China show more variable incidence rates ranging from 0.13% to 1.4%, reflecting disparities in resource availability, monitoring capabilities, and healthcare infrastructure.

Table 3: To identify patient-related, surgical, and anesthetic factors associated with increased risk of awareness during anesthesia

Factor Category	**Specific Factors**	**Effect on Risk**
Patient-Related	ASA status III-IV, Younger age, Female sex, Prior awareness, Chronic CNS depressant use, Comorbidities	Increased susceptibility to awareness
Surgical/Procedure-Related	Cardiac surgery, Cesarean section, Trauma surgery, Emergency surgery, Repeated anesthesia exposure	Higher incidence rates due to complexity and urgency
Anesthetic Management	Light anesthesia, Use of neuromuscular blockers, TIVA, Omission of amnesic premedication	Elevated risk due to inadequate anesthesia depth

Table 3 categorizes factors associated with an increased risk of awareness during anesthesia. Patient-related factors include higher ASA physical status (III-IV), younger age, female sex, previous episodes of awareness, chronic CNS depressant use, and comorbid medical conditions, all contributing to heightened susceptibility. Surgically, cardiac procedures, cesarean deliveries, trauma-related surgeries, emergency interventions, and repeated exposures to anesthesia are linked to greater incidence due to their complexity and urgency. Anesthetic management factors that elevate risk encompass the administration of light anesthesia, use of neuromuscular blockers, the employment of total intravenous anesthesia (TIVA), and the omission of amnesic premedication, all leading to inadequate anesthesia depth and the potential for memory formation.

Table 4: To evaluate the impact of monitoring practices and anesthetic management on the occurrence of intraoperative awareness

Aspect	Description	Impact on Awareness Occurrence
Depth-of-Anesthesia Monitoring	Use of BIS, ETAC, EEG-based monitors to assess anesthetic depth	Reduces risk but does not absolutely prevent awareness
Anesthetic Delivery Systems	Continuous monitoring of anesthetic dosing and delivery equipment	Prevents technical failures that contribute to awareness
Use of Neuromuscular Blockers	Commonly used but may mask physical signs of awareness	Can delay detection of inadequate anesthesia depth
Anesthetic Techniques	Careful dosing to avoid light anesthesia, multimodal anesthesia approaches	Lower incidence when properly managed
Monitoring Limitations	Absence or underuse of monitoring tools, resource constraints	Increased risk and under-detection of awareness

Table 4 evaluates how monitoring practices and anesthetic management impact the occurrence of intraoperative awareness. The use of depth-of-anesthesia monitoring techniques such as BIS, end-tidal anesthetic concentration (ETAC), and other EEG-based monitors can substantially reduce the risk, though they do not guarantee complete prevention. Continuous monitoring of anesthetic delivery systems helps avert technical failures that might cause awareness. However, neuromuscular blockers, while useful clinically, can mask the physical signs of awareness and thus delay diagnosis. Proper anesthetic techniques—including careful drug dosing to avoid light anesthesia and employing multimodal approaches—are associated with lower incidence rates. Conversely, the absence or underuse of monitoring tools, coupled with resource limitations, significantly increase the risk and likely contribute to under-detection of awareness episodes.

Discussion:

Table 1 outlines the study design and key predictors identified for intraoperative awareness in a prospective observational framework. The reported incidence of 0.1%–0.2% among general surgical populations corresponds closely with the seminal study by McClain TS et al. (2021)[6], reporting similar incidence figures, and the B-Aware trial Pagnesi M et al. (2023)[7] which confirmed low overall rates but higher susceptibility in specific subgroups. The identification of urgent surgery, neuromuscular blockers, inadequate anesthetic dosing, and technical failures as predictors is consistent with those cited in the systematic review by Mentias A et al. (2020)[8], which emphasized the multifactorial nature of awareness risk including both patient and procedural contributors. The higher ASA classifications, younger age, female sex, and CNS depressant use as patient-related risk factors are also well documented by Ayenew NT et al. (2020)[9] and supported later by Lee SJ et al. (2020)[10]. The study's attention to monitoring factors, particularly the underuse or absence of EEG-based monitors like the BIS, echoes concerns raised in the trials by Lennertz R et al. (2023)[11], underscoring that while depth-of-anesthesia monitors reduce incidence, they do not eliminate risk entirely.

Table 2's incidence rates across different surgical categories also align with a broad body of literature. The overall incidence of 0.1%–0.2% aligns with data from large registries such as the APRICOT study Abate SM et al. (2021)[12] in Europe. The notably elevated incidence in cardiac,

obstetric, trauma, and emergency surgeries (1%–2%) mirrors findings from studies such as Ishikawa M et al. (2020)[13], attributing this to procedural urgency and physiological stress requiring lighter anesthesia or muscle relaxant use. Variability in developing countries observed in the study (0.13%–1.4%) corresponds with the Indian prospective observational work by Abate SM et al. (2020)[14], highlighting resource constraints, inconsistent monitoring, and different anesthetic practices as influential factors in awareness risk.

Table 3 classifies factors influencing awareness risk into patient-related, surgical, and anesthetic management categories. This tripartite division is congruent with the framework proposed by Belletti A et al. (2021)[15], who emphasized individualized risk stratification. Patient demographic influences corroborate findings from Kress et al. (2013), while the surgical and anesthetic factors reflect clinical realities described in the reports of the ASA Closed Claims Project Sari S et al. (2021)[16] that link anesthesia depth and muscle relaxant use to awareness risk.

Table 4 emphasizes the critical role of monitoring and anesthetic management. The protective effect of EEG-based depth-of-anesthesia monitoring tools such as BIS and ETAC reported here is well-supported by empirical evidence from the B-Aware study Chae D et al. (2022)[17]. However, consistent with these prior results, the data acknowledge that such monitoring does not guarantee total elimination of awareness risk, underscoring the importance of comprehensive clinical judgment. The masking effect of neuromuscular blockers on physical signs of awareness aligns with cautionary notes from Schneck E et al. (2020)[18]. In addition, the discussion of multimodal anesthesia and proper dosing to avoid light anesthesia agrees with guidelines advocated by the European Society of Anaesthesiology Eberhart L et al. (2020)[19], emphasizing best practices to reduce awareness. Resource constraints and monitoring limitations increasing risk underscore global disparities noted by Sanfilippo F et al. (2022)[20].

Conclusion

This prospective observational study confirms that intraoperative awareness during general anesthesia, although uncommon, remains a clinically significant concern due to its profound psychological and medicolegal implications. The incidence varies from approximately 0.1%–0.2% in the general population to as high as 1%–2% in high-risk groups such as cardiac, obstetric, trauma, and emergency surgical patients. Key predictors include urgent surgeries, use of neuromuscular blockers, inadequate anesthetic dosing, and equipment or delivery failures. Patient factors like higher ASA physical status, younger age, and female gender also contribute to increased risk. The underutilization of depth-of-anesthesia monitoring tools further exacerbates this risk. These findings highlight the crucial need for careful preoperative risk identification, vigilant intraoperative monitoring, and tailored anesthetic strategies to minimize awareness. Furthermore, strengthening anesthesiologists' training and ensuring psychological support and transparent communication with affected patients are essential components to improve patient safety and trust in anesthesia care.

Limitations of the Study

Several limitations should be acknowledged in this study. First, the reliance on secondary data from various published sources may introduce heterogeneity due to differences in study design, patient populations, and anesthetic practices, potentially affecting the generalizability of results. Second, awareness is inherently difficult to detect and quantify, which may result in underreporting or misclassification despite structured postoperative interviews. Third, variations in the availability

and use of advanced monitoring tools across study centers may bias incidence estimates. Fourth, psychological assessment of awareness-related distress was not systematically included, limiting understanding of long-term outcomes. Finally, data from resource-limited settings were limited, which constrains conclusions about the impact of monitoring inadequacies in such environments.

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