

Intraoperative Awareness: Comparison Between Total Intravenous Anesthesia (TIVA) and Balanced Anesthesia: A Prospective Observational Study

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Correspondence: Salvatore Pagliaro - Department of Surgical, Medical, Molecular Pathology and Critical Care, University of Pisa, Pisa, Italy. Email: salvatore.pagliaro@med.unipi.it

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Marta De Luca¹, Francesco Forfori^{2,3}, Salvatore Pagliaro⁴

¹ Endocrine Surgery Unit, Pisa University Hospital, Pisa, Italy

² Department of Surgical, Medical, Molecular Pathology and Critical Care, University of Pisa, Pisa, Italy

³ Interdepartmental Anesthesia and Intensive Care Unit, Pisa University Hospital, Pisa, Italy

⁴ Department of Surgery and Endocrine-Metabolic Medicine and Transplantation, Pisa University Hospital, Pisa, Italy

Abstract

Introduction. Intraoperative awareness is a rare but clinically significant complication of general anesthesia characterized by the recovery of consciousness, with or without explicit recall, during surgery. Although its incidence is generally low, awareness may result in relevant psychological consequences, including anxiety, intrusive memories, sleep disturbances, and post-traumatic stress disorder. The risk may vary according to anesthetic technique and the adequacy of anesthetic depth monitoring. This study aimed to assess the occurrence of intraoperative awareness among patients undergoing general anesthesia and to describe its occurrence according to the use of total intravenous anesthesia (TIVA) or balanced anesthesia.

Methods. A prospective observational study was conducted among 100 adult patients undergoing endocrine surgery under general anesthesia. Data were collected at two time points. During the intraoperative phase (T0), clinical characteristics, anesthetic technique, monitoring modalities, and signs potentially suggestive of awareness were recorded. One hour after emergence from anesthesia (T1), patients completed the Modified Brice Questionnaire to identify memories, dreams, or perceptions related to the intraoperative period.

Results. Of the 100 patients included, 76 underwent TIVA and 24 received balanced anesthesia. One case of intraoperative awareness was identified, corresponding to an overall

incidence of 1%. The episode occurred during TIVA and was associated with intraoperative involuntary movements and increased heart rate. Postoperative assessment confirmed recollection compatible with awareness. Most participants reported no intraoperative memories or unusual perceptions. **Discussion.** Intraoperative awareness was uncommon in this sample but occurred during TIVA. These findings support careful assessment of anesthetic depth and the use of appropriate monitoring strategies, particularly during total intravenous anesthesia. Standardized protocols and continuous clinical surveillance remain important components of perioperative patient safety.

Keywords: Intraoperative Awareness, General Anesthesia, Total Intravenous Anesthesia, Balanced Anesthesia, Anesthetic Depth Monitoring, Patient Safety

Introduction

General anesthesia represents one of the most significant tools of modern medicine, enabling the performance of complex surgical procedures through the pharmacological induction of a reversible state of unconsciousness, amnesia, analgesia, and muscle relaxation. Despite advances in pharmacological agents and monitoring techniques, the management of anesthetic depth remains a critical challenge, as inadequate anesthesia may lead to significant clinical risks, including the phenomenon of intraoperative awareness.

Intraoperative awareness is a rare but clinically significant phenomenon, characterized by a patient's consciousness during surgery under general anesthesia, with the possibility of recalling intraoperative events either explicitly or implicitly (Ghoneim, 2009). Although its incidence in the general population is low, estimated at approximately 0.1–0.2% of cases (Sebel et al., 2004), intraoperative awareness can have substantial emotional and psychological consequences, including anxiety, sleep disturbances, depression, and, in more severe cases, the development of post-traumatic stress disorder (PTSD) (Leslie et al., 2010). The severity of these effects depends on factors such as the presence of pain, paralysis, or a perceived sense of helplessness during the procedure, as well as the patient's ability to recall the intraoperative experience in detail (Sandin et al., 2000).

The risk of intraoperative awareness may vary

depending on several factors, including patient clinical characteristics, the type of surgical procedure, and, in particular, the anesthetic technique used (Ghoneim, 2009). Among the main modalities of general anesthesia, this study aimed to analyze and compare Total Intravenous Anesthesia (TIVA) and balanced inhalational anesthesia. As reported in the literature, the TIVA technique, based on the continuous administration of intravenous anesthetics such as propofol, may make the assessment of anesthetic depth more challenging (Avidan et al., 2011), whereas balanced anesthesia allows for more direct monitoring through clinical parameters and the measurement of minimum alveolar concentration (MAC) (Myles & Leslie, 2017).

The possibility that the anesthetic technique may influence the occurrence of intraoperative awareness has led the scientific community to investigate the comparison between TIVA and balanced anesthesia. In recent years, numerous studies and literature reviews have examined whether one of these approaches may be more effective in reducing the risk of intraoperative awareness (Mashour et al., 2012; Pandit et al., 2014). The aim of this study is to observe the incidence of intraoperative awareness in patients undergoing general anesthesia.

Methods

Study Design and Setting

This study compares two different anesthetic

techniques, Total Intravenous Anesthesia (TIVA) and balanced anesthesia, in order to evaluate whether the method employed may influence the risk of intraoperative awareness. Episodes were recorded using standardized tools, and the results were analyzed in relation to the available scientific evidence.

To address the research question, a prospective observational study was conducted.

The study was conducted at the Azienda Ospedaliero-Universitaria Pisana (AOUP), in the Endocrine Surgery Operating Unit, a highly specialized setting for the management of patients undergoing endocrine surgery, between July and September 2025.

Ethical Considerations

The study was conducted following authorization from the Director of the Endocrine Surgery Unit and the Department of Nursing Professions of AOUP, in accordance with the study protocol, Version 1.0 dated October 17, 2024, which was approved according to the procedures established by the relevant Ethics Committee.

Data processing was performed in full compliance with Italian Legislative Decree No. 196/2003 and Regulation (EU) No. 679/2016 on personal data protection. Participants were free to withdraw from the study at any time without any consequences.

Data Collection Instruments

Data collection was carried out using two distinct instruments, subsequently integrated into a single structured and comprehensive observational form (see Appendix 1):

1. Intraoperative observational form (T0), specifically designed and developed by the researcher for this study and completed during surgery. It allowed the recording of demographic data (age, sex), clinical data (type and duration of surgery), anesthesiological data (drugs administered, technique used, intraoperative parameters), and the presence of any variations or complications (see Appendix 1).
2. Modified Brice Questionnaire (T1), used

to detect any episodes of intraoperative awareness in the postoperative period.

The Intraoperative observational form was specifically developed to systematically monitor the phenomenon of intraoperative awareness. The tool was designed to ensure accurate and standardized recording of relevant clinical and care-related variables, with the aim of identifying any episodes of intraoperative awareness during surgery.

The form is structured into four main sections, allowing for comprehensive data collection throughout the entire perioperative pathway:

- The first three sections of the observational form are completed by the researcher at Time Zero (T0), corresponding to the intraoperative phase, and include:
 1. Patient profile: includes essential demographic and clinical data (age, sex, BMI, type of surgery, ASA score, and comorbidities), as well as any ongoing pharmacological therapies that may interfere with the anesthetic response.
 2. Anesthesiological conditions: collects information regarding the type of anesthesia administered (TIVA or balanced anesthesia), drugs used during premedication and induction, duration of anesthesia, and type of monitoring applied, with particular reference to the presence or absence of BIS monitoring.
 3. Intraoperative awareness episode: documents the possible occurrence of physiological or behavioral signs suggestive of intraoperative awareness (changes in heart rate or blood pressure, involuntary movements, respiratory alterations, or increased EtCO₂), indicating the timing and duration of the episode.
- The fourth section is completed at Time One (T1), one hour after emergence from general anesthesia, and includes:
 4. Modified Brice Questionnaire (Brice et al., 1970), used to explore the presence of memories, dreams, or perceptions during the intraoperative phase.

The Modified Brice Questionnaire is a validated and widely used tool in the literature, derived from the original questionnaire proposed by Brice et al. (1970) and subsequently modified to increase its sensitivity (Mashour

et al., 2013; Tasbihgou et al., 2018). The questionnaire consists of targeted open-ended questions, including (see Appendix 1):

- What is the last thing you remember before going to sleep?
- What is the first thing you remember after waking up?
- Do you remember anything between going to sleep and waking up?
- Did you dream during your procedure?
- Were your dreams disturbing to you?

Numerous studies have shown that the use of the Modified Brice Questionnaire allows the identification of a significantly higher number of awareness episodes compared to spontaneous patient reports (Mashour et al., 2013; Pandit et al., 2014). Furthermore, early and repeated administration reduces the risk of underestimation, as some patients report delayed memories only hours or days after surgery (Samuelsson et al., 2007).

In the present study, the Modified Brice Questionnaire was administered 1 hour after awakening in the Recovery Room (T1), in order to promptly detect any episodes of intraoperative awareness. This timing allowed the evaluation of patients' perceptions and memories in a very early postoperative phase, within a protected and controlled environment, ensuring maximum accuracy in data collection.

The integration of objective data collected at T0 and subjective data obtained at T1 allows for the construction of a comprehensive and accurate clinical picture, useful for assessing the incidence of intraoperative awareness and comparing the results with the evidence reported in the scientific literature.

Data Collection Methods

Data were collected at two different time points:

Time Zero (T0): Intraoperative Phase

During the intraoperative phase, the researcher completed the first three sections of the observational form, recording patient clinical data, the anesthetic technique used, vital parameters, and any occurrence of signs compatible with possible intraoperative awareness.

Time One (T1): 1 Hour Postoperative

Corresponding to one hour after emergence from general anesthesia. In the Recovery Room, the Modified Brice Questionnaire (Brice et al., 1970) was administered to investigate the presence of any memories, dreams, or perceptions related to the intraoperative phase.

Eligibility Criteria

Inclusion criteria. Adult patients aged between 18 and 70 years undergoing endocrine surgery in the endocrine surgery operating rooms, under general anesthesia performed using either TIVA or balanced anesthesia.

Exclusion criteria. Patients undergoing local or regional anesthesia without general sedation, or patients unable to complete the postoperative questionnaire due to their clinical conditions.

Results

A total of 100 patients were included in the study, of whom 56 were female (56%) and 44 were male (44%), with a mean age of 45 years. The most frequent surgical procedures were total thyroidectomy (53%), followed by partial thyroidectomy (29%), parathyroidectomy (15%), and lateral neck dissection (3%). The mean durations of the procedures were 75, 40, 50, and 125 minutes, respectively. These data, summarized in Table 1, describe a clinically heterogeneous yet representative sample of the institution's surgical activity.

Alongside demographic and surgical data, major pre-existing conditions and ongoing therapies were recorded, including cardiovascular, metabolic, respiratory, and neurological disorders, as well as the use of medications potentially interfering with the anesthetic response (e.g., beta-blockers, antihypertensives, antiepileptics, antidepressants, benzodiazepines).

The systematic collection of these variables, reported in Table 2, was essential to identify potential predisposing factors that, according to the literature, may influence sensitivity to anesthetic agents or increase vulnerability to intraoperative awareness (Ghoneim, 2009; Myles & Leslie, 2017).

Table 1. Patient characteristics.

Clinical Indicators	Data	%
Mean Age	45 years	
18–35 years	17	17%
35–50 years	48	48%
>50 years	35	35%
Sex		
Male	44	44%
Female	56	56%
Type of surgery		
Total Thyroidectomy	53	53%
Partial Thyroidectomy	29	29%
Parathyroidectomy	15	15%
Lateral neck dissection	3	3%
Mean BMI	28	
Severe underweight	0	0%
Underweight	0	0%
Normal weight	36	36%
Overweight	48	48%
Class I obesity	10	10%
Class II obesity	2	2%
Class III obesity	4	4%
ASA score		
I	12	12%
II	72	72%
III	16	16%

Table 2. Pre-existing conditions and ongoing pharmacological therapies.

Clinical Indicators	Data	%
Pre-existing conditions		
Cardiovascular diseases	12	12%
Metabolic diseases	5	5%
Renal diseases	1	1%
Respiratory diseases	0	0%
Neurological diseases	3	3%
None	79	79%
Pharmacological Therapy		
None	88	88%
Benzodiazepines	2	2%
Beta-blockers	9	9%
Opioids	0	0%
Antidepressants	1	1%
Antiepileptic	0	0%

During the intraoperative phase at Time Zero (T0), patients were classified according to the anesthetic technique used, as shown in Figure 1: 76 subjects (76%) underwent TIVA, while 24 (24%) received balanced anesthesia.

This distribution allowed for a direct

comparison between two techniques known to differ significantly in terms of anesthetic depth monitoring. Indeed, several studies report that TIVA, although a safe and widely used technique, is more sensitive to unintentional variations in the hypnotic level, particularly in the absence of dedicated monitoring tools such as BIS or Entropy (Avidan et al., 2011; Mashour et al., 2012). Our findings are consistent with these observations.

TYPE OF GENERAL ANESTHESIA

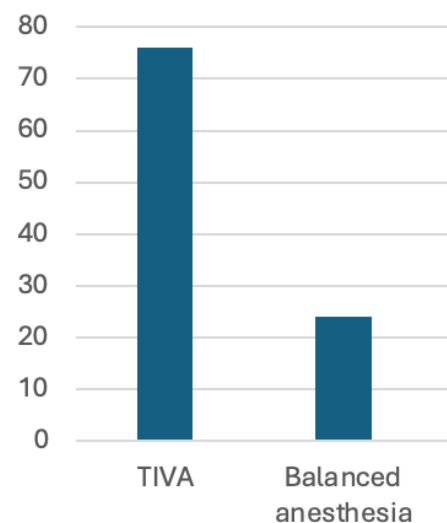


Figure 1. Type of general anesthesia administered to patients.

Table 3. Occurrence of intraoperative awareness in the study population.

Intraoperative Awareness	Data	n (%)
Yes	1	1%
No	99	99%

During the entire observation period, intraoperative awareness was identified in only one patient (1%), as reported in Table 3. The episode occurred during a partial thyroidectomy performed under TIVA and manifested during the maintenance phase of anesthesia (T2). Intraoperative data documented the occurrence of involuntary movements and an increase in heart rate, both indicators consistent with a possible partial return of consciousness. According to the literature, many awareness episodes occur during transitional phases of anesthesia, particularly during maintenance when titration is not adequately stable or properly monitored

(Sebel et al., 2004; Ghoneim, 2009).

The observed incidence (1%) is slightly higher than that reported in most international studies (0.1–0.2%), but it falls within the range described in analyses conducted in settings with heterogeneous protocols or limited sample sizes, such as the study by Xu et al. (2009), which reports incidences of up to 0.41%. Considering the observational nature of the study and the relatively small sample size, this difference should not be interpreted as an anomaly, but rather as confirmation of the variability of the phenomenon and the need to investigate it even through smaller samples.

One hour after emergence, at Time One (T1), all patients were administered the Modified Brice Questionnaire, a tool considered the gold standard for the retrospective detection of awareness (Brice et al., 1970). Analysis of the responses, summarized in Figure 2, showed that the majority of subjects did not recall anything from the intraoperative phase. Only 9% of participants reported dreaming, and only one patient (1%) described an unpleasant or distressing dream. The single confirmed case of awareness was fully consistent with what had been observed at T0, thereby reinforcing the validity of the assessment.

Percentage distribution of responses to the Modified Brice Questionnaire

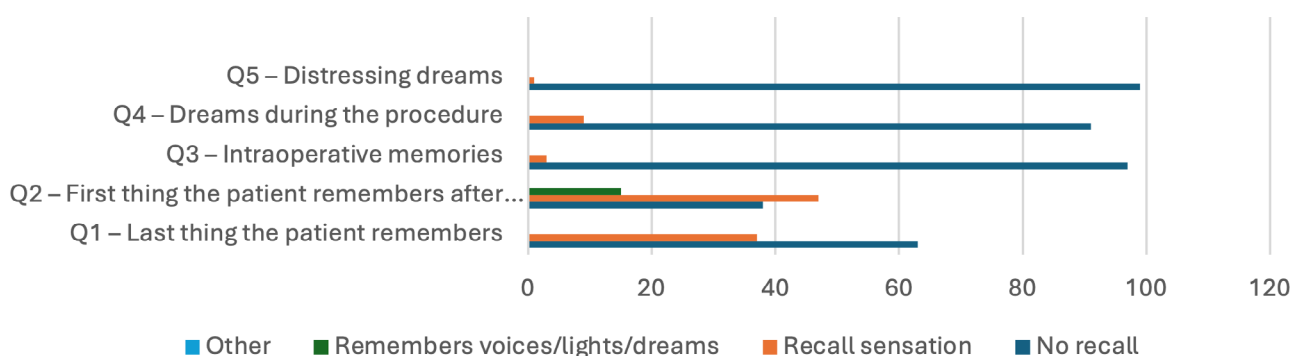


Figure 2. Overall distribution of responses to the modified brice questionnaire (T1).

Discussion

Overall, the results obtained are largely consistent with the available scientific evidence and reaffirm some key principles of anesthetic practice. First, intraoperative awareness, although a rare phenomenon, represents a clinically significant event due to the potential severity of its psychological consequences, which may include anxiety, intrusive memories, and in more severe cases, post-traumatic stress disorder (Ghoneim, 2009; Mashour et al., 2012).

Second, the increased vulnerability associated with TIVA highlighted by the single case observed in this study is fully consistent with findings reported in numerous international analyses, which recommend the systematic

use of depth of anesthesia monitoring in total intravenous techniques (Avidan et al., 2011; Myles & Leslie, 2017).

Finally, the results emphasize the importance of a multimodal anesthetic approach based on the combination of continuous monitoring, standardized protocols, and adequate training of healthcare personnel. Even in the presence of a single episode, awareness is a sensitive indicator of the quality and safety of care and highlights the need to maintain high standards of clinical vigilance throughout all phases of general anesthesia.

Conclusions

This study confirms that intraoperative awareness is a rare but clinically and

psychologically significant phenomenon, with an observed incidence (1%) consistent with the variability reported in the international literature. Even a single episode may result in relevant consequences for patient well-being, including anxiety, intrusive memories, or, in more severe cases, post-traumatic stress disorder. For this reason, the prevention of awareness represents a primary objective in anesthetic safety.

An initial consideration concerns the limitations of the study, particularly the small sample size and the relative homogeneity of the surgical procedures analyzed. Future studies should include a larger and more diverse sample in order to achieve greater statistical robustness and a more accurate characterization of risk factors associated with different anesthetic techniques.

The results also highlight the crucial role of anesthetic depth monitoring. The systematic use of dedicated tools, such as BIS or Entropy, appears to be essential, especially in total intravenous techniques, where the absence of objective parameters such as MAC makes the control of the hypnotic level more challenging. The adoption of standardized and shared protocols, together with continuous training of the anesthesiology team, represents an additional key element in reducing the risk of awareness episodes.

In addition to technical aspects, this phenomenon also raises a central ethical dimension: the protection of patient dignity, trust, and psychological integrity. Every episode of intraoperative awareness, even if isolated, should be considered an opportunity for learning and continuous improvement for the professionals involved.

This study reiterates the need to continue exploring and understanding intraoperative awareness as an integral part of the continuous improvement process in anesthetic practice. It is not only a matter of identifying the clinical or pharmacological causes underlying this phenomenon, but also of recognizing that behind every possible episode of awareness there is a person, with their vulnerability, fears, and trust in healthcare professionals. For this reason, every experience of awareness, even if isolated, should be considered an opportunity for learning and professional growth for the entire surgical team. Studying these events

contributes to the advancement of anesthetic safety while also promoting a culture of care centered on prevention, attentiveness, and professional awareness.

In conclusion, intraoperative awareness is not merely a potential clinical issue, but a phenomenon that strongly calls attention to the ethical and human dimension of care. Preventing this phenomenon means not only avoiding a clinical risk, but also safeguarding patient dignity, trust, and psychological integrity, ensuring that the surgical experience remains safe in all its aspects.

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References

- Avidan, M. S., Jacobsohn, E., Glick, D., Burnside, B. A., Zhang, L., Villafranca, A., Karl, L., Kamal, S., Torres, B., O'Connor, M., Evers, A. S., Gradwohl, S., Lin, N., Palanca, B. J., & Mashour, G. A. (2011). Prevention of intraoperative awareness in a high-risk surgical population. *New England Journal of Medicine*, 365(7), 591–600. <https://doi.org/10.1056/NEJMoa1100403>
- Brice, D. D., Hetherington, R. R., & Utting, J. E. (1970). A simple study of awareness and dreaming during anaesthesia. *British Journal of Anaesthesia*, 42(6), 535–542. <https://doi.org/10.1093/bja/42.6.535>
- Ghoneim, M. M., Block, R. I., Haffarnan, M., & Mathews, M. J. (2009). Awareness during anesthesia: Risk factors, causes and sequelae: A review of reported cases in the literature. *Anesthesia & Analgesia*, 108(2), 527–535. <https://doi.org/10.1213/ANE.0b013e318193c634>
- Leslie, K., Chan, M. T. V., Myles, P. S., Forbes, A., & McCulloch, T. J. (2010). Posttraumatic stress disorder in aware patients from the B-Aware trial. *Anesthesia & Analgesia*, 110(3), 823–828. <https://doi.org/10.1213/ANE.0b013e3181b8b6ca>
- Mashour, G. A., Kent, C. D., Picton, P., Ramachandran, S. K., Tremper, K. K., Turner, C. R., Shanks, A., & Avidan, M. S. (2013). Assessment of intraoperative awareness with explicit recall: A comparison of 2 methods. *Anesthesia & Analgesia*, 116(4), 889–891. <https://doi.org/10.1213/ANE.0b013e318281e9ad>
- Mashour, G. A., Shanks, A., Tremper, K. K., Kheterpal, S., Turner, C. R., Ramachandran, S. K., & Avidan, M. S. (2012). Prevention of intraoperative awareness with explicit recall in an unselected surgical population. *Anesthesiology*, 117(4), 717–725. <https://doi.org/10.1097/ALN.0b013e31826904a6>
- Myles, P. S., & Leslie, K. (2017). Awareness and anaesthesia: Time to take it seriously. *British Journal of Anaesthesia*, 119(4), 655–657. <https://doi.org/10.1093/bja/aex274>
- Pandit, J. J., Andrade, J., Bogod, D. G., Hitchman, J. M., Jonker, W. R., Lucas, N., Mackay, J. H., Nimmo, A. F., O'Connor, K., O'Sullivan, E. P., Paul, R. G., Palmer, J. H. M. G., Plaat, F., Radcliffe, J. J., Sury, M. R. J., Torevell, H. E., Wang, M., Hainsworth, J., & Cook, T. M. (2014). 5th National Audit Project (NAP5) on accidental awareness during general anaesthesia: Summary of main findings and risk factors. *British Journal of Anaesthesia*, 113(4), 549–559. <https://doi.org/10.1093/bja/aeu313>
- Samuelsson, P., Brudin, L., & Sandin, R. H. (2007). Late psychological symptoms after awareness among consecutively included surgical patients. *Anesthesiology*, 106(1), 26–32. <https://doi.org/10.1097/00000542-200701000-00009>
- Sandin, R. H., Enlund, G., Samuelsson, P., & Lennmarken, C. (2000). Awareness during anaesthesia: A prospective case study. *The Lancet*, 355(9205), 707–711. [https://doi.org/10.1016/S0140-6736\(99\)11010-9](https://doi.org/10.1016/S0140-6736(99)11010-9)
- Sebel, P. S., Bowdle, T. A., Ghoneim, M. M., Rampil, I. J., Padilla, R. E., Gan, T. J., & Domino, K. B. (2004). The incidence of awareness during anesthesia: A multicenter United States study. *Anesthesia & Analgesia*, 99(3), 833–839. <https://doi.org/10.1213/01.ANE.0000130261.90896.6C>
- Tasbihgou, S. R., Vogels, M. F., & Absalom, A. R. (2018). Accidental awareness during general anaesthesia: A narrative review. *Anaesthesia*, 73(1), 112–122. <https://doi.org/10.1111/anae.14124>
- Xu, L., Wu, A. S., & Yue, Y. (2009). The incidence of intra-operative awareness during general anesthesia in China: A multi-center observational study. *Acta Anaesthesiologica Scandinavica*, 53(7), 873–882. <https://doi.org/10.1111/j.1399-6576.2009.01985.x>