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COMPARISON BETWEEN TIVA AND INHALATIONAL ANESTHETICS, RISKS AND BENEFITS

Original Research

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ABSTRACT

Background: General anesthesia is administered to over 300 million individuals annually worldwide, with inhalational anesthesia (IA) and total intravenous anesthesia (TIVA) being the two principal maintenance techniques. IA commonly involves the use of volatile agents like sevoflurane, desflurane, or isoflurane, whereas TIVA relies on continuous infusion of intravenous agents such as propofol. As surgical techniques evolve, it is increasingly important to assess the clinical outcomes, recovery profiles, and patient-centered metrics associated with these anesthesia modalities to inform individualized anesthetic planning.

Objective: To compare postoperative complications, recovery characteristics, and patient satisfaction between TIVA and inhalational anesthesia, and to explore future implications for anesthetic practice.

Methods: This cross-sectional, randomized study included 98 adult patients undergoing elective and emergency surgeries at three tertiary care hospitals. Patients were equally divided into TIVA (n=49) and IA (n=49) groups. Parameters assessed included intraoperative and postoperative complications, time to eye opening, postoperative pain scores, and overall patient satisfaction. Data were collected through structured observation and analyzed using SPSS version 26. Chi-square and independent t-tests were applied, with $p<0.05$ considered statistically significant.

Results: TIVA resulted in a smoother recovery experience (77.8%) compared to IA (62%), with a statistically significant difference ($p=0.006$). Mean time to eye opening was shorter in the TIVA group (8.84 minutes) than in the IA group (9.73 minutes, $p<0.001$). Postoperative nausea and vomiting occurred in 22.2% of TIVA patients and 20% of IA patients ($p=0.830$). Mean postoperative pain scores were higher in the TIVA group (4.06) than in the IA group (3.71), showing statistical significance ($p=0.0481$). Patient satisfaction was significantly higher in the TIVA group (77.8% vs. 62%, $p=0.044$).

Conclusion: TIVA demonstrated superior outcomes in terms of recovery time and patient satisfaction, although it was associated with slightly higher postoperative pain scores. The choice of anesthetic technique should be tailored to patient-specific factors, surgical needs, and anesthetic expertise.

Keywords: Anesthesia, Intravenous; Anesthesia, Inhalation; Anesthetics, Intravenous; Postoperative Complications; Propofol; Recovery of Function; Patient Satisfaction.

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INTRODUCTION

The ongoing comparison between inhalational anesthesia and total intravenous anesthesia (TIVA) remains a central concern in perioperative medicine due to its direct implications for patient safety, recovery quality, and healthcare resource optimization. As anesthesia plays a pivotal role in modern surgical procedures, understanding the relative benefits and drawbacks of these techniques is critical for guiding clinical decisions. Inhalational anesthesia, commonly administered via volatile agents like sevoflurane, offers simplicity, cost-effectiveness, and flexibility, particularly valuable in resource-limited settings. However, concerns persist regarding its association with postoperative nausea and vomiting (PONV), delayed cognitive recovery, and environmental impact (1,2). On the other hand, TIVA—particularly when using propofol and adjuncts delivered via target-controlled infusion (TCI) systems—has garnered attention for minimizing PONV, enhancing hemodynamic control, and facilitating faster emergence from anesthesia, especially in outpatient and elderly populations (3,4). Advancements in anesthetic delivery technologies have improved the precision of TIVA, bolstering its safety profile and promoting its use in diverse clinical contexts. The emergence of TCI and enhanced depth-of-anesthesia monitoring has further contributed to its adoption, allowing anesthesiologists to maintain optimal anesthetic depth and reduce the risks of intraoperative awareness or delayed emergence (5,6). The COVID-19 pandemic also accelerated the use of intravenous techniques due to concerns about aerosol-generating procedures, thereby reigniting interest in newer intravenous agents such as ciprofol and midazolam (7). Moreover, intravenous techniques are associated with a negligible environmental footprint compared to the greenhouse gas emissions of volatile anesthetics, which has become a growing ethical consideration within global health systems (8).

Despite these advantages, TIVA is not without its limitations. It requires specialized equipment, trained personnel, and carries the potential for hypotension and injection site discomfort, necessitating vigilant perioperative monitoring (9,10). Furthermore, while the drug costs for TIVA may be higher, the overall cost-benefit analysis often reveals savings through reduced recovery times and fewer postoperative complications (9). Pediatric and geriatric populations in particular may benefit from TIVA's favorable cognitive recovery profile and decreased risk of emergence delirium (10). Given the clinical and economic stakes, there is a pressing need to systematically evaluate both modalities not only in terms of pharmacological efficacy but also in relation to patient-centered outcomes and long-term cognitive safety. While inhalational techniques remain predominant in many institutions, the paradigm is gradually shifting toward more individualized anesthetic planning, where the unique benefits of TIVA are increasingly leveraged in specific surgical and patient scenarios (11). The objective of this review is to explore the clinical implications of choosing between inhalational anesthesia and TIVA, examining their respective pharmacologic properties, recovery profiles, environmental impact, and cost-effectiveness. It aims to provide a rational framework for integrating evidence-based anesthetic techniques into perioperative care while identifying areas where further research is essential to ensure optimal patient outcomes and safety across diverse clinical contexts.

METHODS

This research employed a randomized, cross-sectional observational design to compare the risks and benefits associated with total intravenous anesthesia (TIVA) and inhalational anesthesia in adult patients undergoing elective short-duration surgical procedures. The study was conducted over a period of four months following the approval of the research synopsis by the institutional ethical review boards. It was carried out across three tertiary care hospitals in Lahore: Jinnah Hospital, Mayo Hospital, and Chaudhry Muhammad Akram Teaching and Research Hospital. Ethical clearance was obtained from the respective institutional review boards prior to the commencement of data collection, and written informed consent was secured from all participants before enrollment, ensuring compliance with ethical standards for human subject research. A total of 98 adult patients, aged 18 years or older, scheduled for elective surgical procedures under general anesthesia, were recruited. The participants were divided into two equal groups of 49 patients each—one group receiving TIVA and the other inhalational anesthesia. The sample size was calculated using the formula $n = (z^2 \times p \times (1–p)) / d^2$, assuming a 95% confidence level and 80% power, based on expected differences in outcomes between the two anesthesia modalities (12). Non-probability consecutive sampling was employed to include patients meeting the eligibility criteria. Inclusion criteria were adult patients classified as American Society of Anesthesiologists (ASA) Physical Status I–II, capable of providing informed consent, and scheduled for elective surgeries such as laparoscopic, orthopedic, or neurosurgical procedures. Exclusion criteria included patients with significant comorbid conditions such as advanced cardiac, pulmonary, renal, or hepatic diseases; pregnant or breastfeeding women;

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individuals with known allergies to anesthetic agents like propofol or sevoflurane; and those with diagnosed neurological disorders such as epilepsy or Parkinson's disease.

Data collection was structured in three phases: preoperative, intraoperative, and postoperative. Preoperative data included demographic details, medical history, and ASA classification. Intraoperative data focused on hemodynamic parameters, anesthetic agent dosage, and intraoperative events. Postoperative data included assessments of recovery time, incidence of postoperative nausea and vomiting (PONV), pain scores, and any adverse effects. All information was recorded using a standardized data collection form developed for the study. Statistical analysis was performed using SPSS software. Descriptive statistics such as means, standard deviations, frequencies, and percentages were used to summarize the data. Inferential statistics included independent-sample t-tests for comparing continuous variables and chi-square tests for categorical variables. A p-value of <0.05 was considered statistically significant when evaluating differences between the TIVA and inhalational anesthesia groups in terms of risks and benefits (13,14).

RESULTS

A total of 98 patients were enrolled in the study, equally divided between the TIVA and inhalational anesthesia groups. The mean age of patients in the TIVA group was 35.67 years, with a median of 35 years. The gender distribution revealed a higher proportion of female participants (55.6%) compared to males (44.4%). TIVA was administered exclusively in one study arm, with the most frequently used combinations being propofol with fentanyl and ketamine with midazolam. In terms of intraoperative complications among TIVA recipients, the most commonly observed event was hypertension (9.3%), followed by hypoxia (5.6%) and bradycardia (3.7%). A majority of patients (53.7%) experienced a satisfactory intraoperative course without adverse events. Postoperative complications primarily included nausea and vomiting, reported in 22.2% of TIVA cases, while other complications such as bradycardia, dizziness, and hypotension occurred in smaller proportions. Satisfactory postoperative outcomes were reported in 40.7% of patients, indicating favorable recovery.

Pain severity was assessed postoperatively using a numerical rating scale, with the mean pain score being 4.06 among TIVA patients. Recovery was classified as smooth in 77.8% of individuals, while delayed recovery was noted in 22.2%. Time to eye opening following anesthesia cessation was observed to be quicker in the TIVA group, with a mean of 8.84 minutes. The mean patient satisfaction score was 4.06 out of 5, with 77.8% expressing high satisfaction. When compared with the inhalational anesthesia group, the TIVA group demonstrated a statistically significant higher rate of smooth recovery (77.8% vs. 62%, $p=0.006$). Although the incidence of postoperative nausea and vomiting was slightly higher in the TIVA group (22.2% vs. 20%), this difference was not statistically significant ($p=0.830$). Pain scores were marginally higher in TIVA patients (mean 4.06) compared to those receiving inhalational anesthesia (mean 3.71), and this difference was statistically significant ($p=0.0481$). Time to eye opening was shorter with TIVA (mean 8.84 minutes) compared to inhalational anesthesia (mean 9.73 minutes), with this difference being highly significant ($p<0.001$). Satisfaction rates were also significantly higher in the TIVA group (77.8% vs. 62%, $p=0.044$), reinforcing its acceptability in clinical settings.

Table 1: Postoperative Complications and Recovery

Variable	TIVA Group (%)	Inhalational Group (%)
Nausea/Vomiting	22.2	20
Other Complications (e.g., bradycardia, hypotension)	37.1	42
Smooth Recovery	77.8	62
Delayed Recovery	22.2	38

Table 2: Clinical Outcomes and Comparative Analysis

Outcome	TIVA Group	Inhalational Group	p-value
Mean Pain Score	4.06	3.71	0.0481
Time to Eye Opening (min)	8.84	9.73	<0.001
Patient Satisfaction (%)	77.8	62	0.044

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Table 3: Descriptive Statistics of Patients Receiving Total Intravenous Anesthesia (TIVA)

Statistics						
		Age	Gender	Anesthesia Type	Primary Agent Used	Intrapore Complications
N	Valid	49	49	49	49	49
	Missing	0	0	0	0	0
Mean		35.67				
Median		35.00				
Mode		35				

Table 4: Postoperative Outcomes and Recovery Parameters in TIVA Group

Statistics						
		Postop Complications	overall patient satisfaction	Postop Pain Severity	Recovery and Satisfaction	Time to Eye Opening (min)
N	Valid	49	49	49	49	49
	Missing	0	0	0	0	0
Mean			4.06	3.51		8.84
Median			4.00	3.00		9.00
Mode			4	3		10

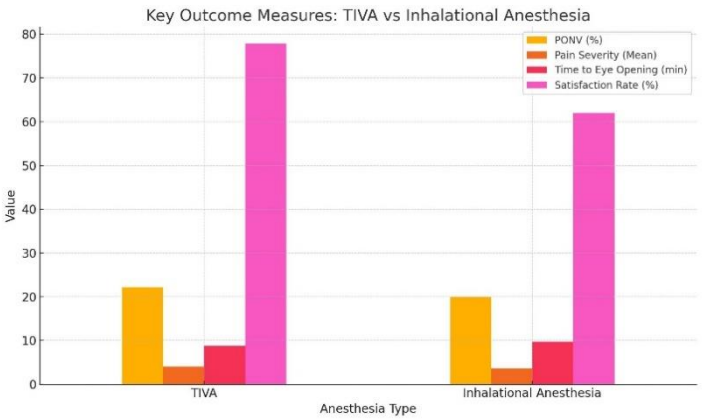

Figure 1Key Outcomes Measures: TIVA vs Inhalational Anesthesia

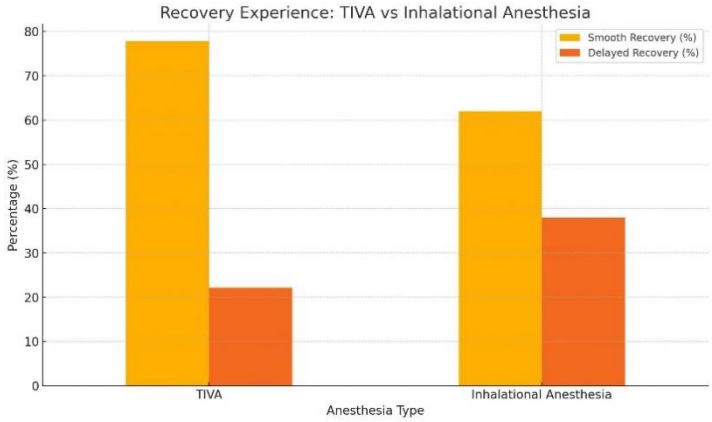

Figure 2 Recovery Experience: TIVA vs Inhalational Anesthesia

DISCUSSION

This study provided a comparative evaluation of total intravenous anesthesia (TIVA) and inhalational anesthesia (IA), focusing on key outcomes such as postoperative complications, time to eye opening, recovery profile, and patient satisfaction. The results contribute meaningfully to the ongoing debate regarding the optimal anesthetic modality across various surgical contexts and patient demographics. By aligning these findings with existing literature, important clinical implications emerge for anesthesia selection based on patient-specific risk factors and surgical requirements. Postoperative complications remain a primary determinant of patient recovery and healthcare resource utilization. The study demonstrated that postoperative nausea and vomiting (PONV), a frequent and distressing complication, occurred in 22.2% of TIVA cases compared to 20% with inhalational anesthesia. Although this difference was not statistically significant, existing literature consistently supports the antiemetic benefits of propofol-based TIVA. Propofol's pharmacological profile, characterized by minimal emetogenic activity and its action on neurotransmitter pathways, contributes to a reduction in PONV incidence (15,16). In contrast, inhalational agents like sevoflurane and isoflurane are associated with gastrointestinal irritation and activation of the chemoreceptor trigger zone, both of which exacerbate emetic responses (17). These observations reinforce

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the preferential use of TIVA in patients with known susceptibility to PONV or those undergoing ambulatory or ENT procedures where emesis may pose serious complications (18,19).

Another critical dimension of this analysis was the neurocognitive safety profile of each technique. Inhalational anesthesia was associated with a small proportion (2%) of postoperative delirium or agitation, whereas no such cases were observed in the TIVA group. This aligns with previous evidence suggesting that volatile anesthetics can alter cerebral perfusion and neurotransmitter balance, particularly in elderly or neurologically vulnerable individuals, thereby elevating the risk of postoperative cognitive dysfunction (20). TIVA, particularly when administered with propofol, has been shown to minimize such effects due to its neuroprotective mechanisms, rapid clearance, and limited neuroinflammatory activation (21). These attributes position TIVA as a safer modality in geriatric or neurosurgical populations where cognitive preservation is vital. Intraoperative hemodynamic stability remains a cornerstone of anesthetic safety. The study noted that hypotension and bradycardia occurred in 3.7% of TIVA patients, attributable to propofol's vasodilatory and myocardial depressant properties. Conversely, patients in the inhalational anesthesia group exhibited a higher incidence of hypertension and tachycardia, likely due to sympathetic stimulation by volatile agents (22). These findings have important clinical relevance, particularly for patients with pre-existing cardiovascular diseases. TIVA may be more advantageous in hypertensive patients requiring controlled blood pressure, while IA may be cautiously considered in those at risk of hypotension (23). This stratification allows clinicians to align anesthetic choice with the patient's cardiovascular profile, enhancing intraoperative safety.

The respiratory profile of each anesthetic technique further informs decision-making. TIVA demonstrated favorable outcomes in patients with reactive airway diseases such as asthma and chronic obstructive pulmonary disease, primarily by avoiding the bronchial irritation associated with volatile anesthetics. On the other hand, inhalational anesthesia facilitated smoother induction in pediatric cases, where intravenous access may be challenging. These differences underscore the importance of tailoring anesthetic techniques based on the interplay between surgical setting, patient age, and pre-existing pulmonary status (22,23). Patient satisfaction, time to recovery, and pain control are vital indicators of quality perioperative care. The study confirmed that TIVA provided a shorter mean time to eye opening and higher overall satisfaction compared to IA. However, pain scores were marginally higher in the TIVA group. Although statistically significant, the clinical relevance of this difference is debatable and may relate to variations in adjunct analgesic use or subjective pain perception.

The strengths of this study include its comparative design across two prominent anesthetic modalities and its focus on patient-centered outcomes such as satisfaction, recovery quality, and complications. Conducted across multiple tertiary hospitals, the study captured data from a real-world clinical context, enhancing the generalizability of findings. However, several limitations warrant consideration. The sample size, although sufficient for preliminary comparisons, may lack the power to detect small but clinically meaningful differences across subgroups. Additionally, the study's non-probability sampling and absence of randomization in the intervention arms may introduce selection bias, affecting internal validity. The exclusion of detailed subgroup analyses by age, comorbidities, or surgery type limited the granularity of findings. Furthermore, the study focused primarily on short-duration surgeries; thus, extrapolation to major or prolonged procedures should be approached with caution. Future research should prioritize randomized controlled trials with larger and more diverse populations. Investigating long-term cognitive outcomes, detailed stratification by patient risk factors, and cost-effectiveness analyses would provide a more comprehensive understanding of the relative merits of TIVA and IA. Moreover, incorporating environmental sustainability assessments could offer broader perspectives given the ecological impact of volatile anesthetics. In summary, the findings of this study support the preferential use of TIVA in clinical contexts where PONV reduction, cognitive preservation, and rapid recovery are critical, while reaffirming the practicality of inhalational anesthesia in pediatric and select cardiovascular cases. These insights underscore the need for personalized anesthetic strategies that prioritize safety, efficacy, and patient-centered care.

CONCLUSION

This study concluded that both total intravenous anesthesia (TIVA) and inhalational anesthesia (IA) have distinct advantages and limitations, making their selection highly dependent on clinical context and individual patient needs. TIVA was found to support smoother recovery, greater patient satisfaction, and reduced cognitive side effects, while IA maintained its value in scenarios requiring ease of administration, particularly in pediatric cases. The findings highlight the importance of individualized anesthetic planning, emphasizing the role of TIVA in modern surgical practice where precision, rapid emergence, and respiratory comfort are priorities. Looking ahead, advancements such as target-controlled infusion systems and automation in anesthesia delivery are set to enhance the

safety, accuracy, and environmental sustainability of anesthetic techniques, making personalized care more achievable across diverse surgical settings.

AUTHOR CONTRIBUTION

Author	Contribution
M. Farhan Tahir	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Waleed Ahmad*	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Naheed Ahmad	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Nuzhat Waseem	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Ayesha Naz	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Huria Shahzad	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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