Journal of Health, Wellness and Community Research
ISSN: 3007, 0570

OPEN ACCESS

JHWCR

Type: Original Article
Published: 10 October 2025
Volume: III, **Issue**: XIV
DOI: https://doi.org/10.61919/9v1r7j53

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Received 29, 08, 25 **Accepted** 06, 10, 2025

Authors' Contributions
Concept: MA, HM; Design: MF, MN; Data Collection: MJ, TA; Analysis: IF; Drafting: MA

Declarations
No funding was received for this study. The authors declare no conflict of interest. The study received ethical approval. All participants provided informed consent.

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Comparison of Total Intravenous Anesthesia (TIVA) vs Inhalational Anesthesia on Recovery Profile in Day Care Surgeries

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ABSTRACT

Background: *Ambulatory or day care surgeries have revolutionized perioperative care by enabling patients to undergo surgical procedures and return home the same day, improving efficiency, reducing costs, and enhancing patient satisfaction. The choice of anesthetic technique plays a crucial role in ensuring rapid emergence, stable hemodynamics, minimal postoperative complications, and early discharge. Total intravenous anesthesia (TIVA) and inhalational anesthesia are the two primary techniques, but their relative effects on recovery profiles remain debated.* ***Objective:*** *To compare the impact of TIVA versus inhalational anesthesia on recovery time, postoperative nausea and vomiting (PONV), pain scores, and discharge readiness in patients undergoing elective day care surgeries.* ***Methods:*** *A prospective comparative observational study was conducted on 60 adult patients (ASA I–II) undergoing elective day care procedures. Participants were allocated to either TIVA (propofol-based) or inhalational anesthesia (sevoflurane or desflurane). Recovery outcomes were assessed using the Modified Aldrete Score, incidence of PONV, postoperative pain (VAS), and hemodynamic stability. Statistical analysis included independent t-tests and Chi-square tests with significance set at $p < 0.05$.* ***Results:*** *Patients receiving TIVA achieved discharge readiness significantly faster (18.5 ± 5.2 min) than those receiving inhalational anesthesia (25.6 ± 7.3 min; $p = 0.01$). The incidence of PONV was lower with TIVA (10%) compared to inhalational anesthesia (30%; $p = 0.02$), and pain scores were significantly reduced (VAS 2.1 ± 1.4 vs. 3.8 ± 2.1; $p = 0.04$). Hemodynamic parameters were comparable between groups.* ***Conclusion:*** *TIVA provides a superior recovery profile in day care surgeries, offering faster discharge readiness, reduced PONV, and better early postoperative pain control compared to inhalational anesthesia. These advantages make TIVA a preferred option in ambulatory anesthesia practice.*

Keywords

Total Intravenous Anesthesia, Inhalational Anesthesia, Recovery Profile, Day Care Surgery, Postoperative Nausea and Vomiting

INTRODUCTION

Ambulatory (day care) surgery has transformed perioperative practice by allowing selected surgical procedures to be completed safely without requiring hospital admission, enabling patients to return home the same day while reducing healthcare costs and enhancing satisfaction (1). The success of these procedures depends not only on surgical technique but critically on the choice of anesthetic strategy, which must ensure rapid induction, stable intraoperative conditions, minimal postoperative complications, and swift recovery to facilitate early discharge (2). Two principal approaches are widely used in this setting: total intravenous anesthesia (TIVA), typically based on continuous infusion of agents such as propofol combined with short-acting opioids, and inhalational anesthesia, which uses volatile agents such as sevoflurane or desflurane for maintenance following intravenous induction (3). While both techniques achieve adequate anesthesia, their pharmacokinetic and pharmacodynamic differences translate into variable recovery characteristics, postoperative side effects, and discharge readiness profiles (4).

Rapid and complete recovery is fundamental to the safety and efficiency of ambulatory surgery. Key indicators such as time to eye opening, return of orientation, attainment of a Modified Aldrete Score ≥9, and readiness for discharge are used to assess post-anesthesia recovery (5). Additionally, reducing the incidence of postoperative nausea and vomiting (PONV) and facilitating smooth cognitive and psychomotor recovery are essential for minimizing unplanned admissions and improving patient experience (6). However, despite extensive clinical use, the literature presents conflicting evidence regarding the superiority of TIVA or inhalational anesthesia in this context. Some studies report faster emergence and early eye opening with volatile agents, attributed to their low blood-gas solubility and rapid washout (7), whereas others demonstrate that TIVA provides better-quality cognitive recovery, significantly lower PONV rates, and earlier discharge readiness (8,9).

This lack of consensus presents a clinically relevant gap in perioperative decision-making. Anesthetic selection not only affects patient outcomes but also has broader implications for operating room turnover, healthcare resource utilization, and institutional cost-effectiveness (10). Moreover, patient-specific factors such as risk of PONV, comorbidities, and the need for rapid psychomotor restoration further complicate anesthetic choice, underscoring the importance of evidence-based comparisons. Therefore, a direct evaluation of recovery characteristics between TIVA and inhalational anesthesia in adult patients undergoing elective day care surgeries is warranted. This study aims to address this knowledge gap by systematically comparing time to discharge readiness, incidence of PONV, and early postoperative recovery metrics between the two techniques.

We hypothesize that propofol-based TIVA to be associated with faster overall recovery, fewer postoperative complications, and earlier discharge compared to inhalational anesthesia in the ambulatory surgical setting.

MATERIAL AND METHODS

This prospective comparative observational study was designed to evaluate and compare recovery outcomes between total intravenous anesthesia (TIVA) and inhalational anesthesia in adult patients undergoing elective day care surgical procedures. The study was conducted at the Department of Anesthesiology, Chaudhary Muhammad Akram (CMA) Teaching Hospital, Lahore, Pakistan, over a three-month period from January to March 2025. The selection of this setting was based on its high volume of ambulatory surgical cases and adherence to international perioperative safety standards, ensuring the availability of a diverse patient population and standardized anesthesia practices (11). The rationale for employing a comparative design was to reflect real-world clinical practice while systematically examining recovery endpoints across two widely used anesthetic techniques in a controlled environment.

Eligible participants included adult patients aged 18 to 60 years with American Society of Anesthesiologists (ASA) physical status I or II who were scheduled for elective day care surgical procedures under general anesthesia with an expected duration of 30 to 90 minutes. Patients with a history of allergy to anesthetic agents (propofol, sevoflurane, desflurane, or opioids), pregnant or lactating women, those with severe systemic disease (ASA III or above), known psychiatric illness, cognitive impairment, or those undergoing emergency or prolonged procedures were excluded. Eligible patients were identified during pre-anesthetic assessment and approached for participation. Written informed consent was obtained after providing detailed information about study objectives, procedures, potential risks, and the voluntary nature of participation.

Participants were allocated to one of two groups based on the anesthetic technique selected by the attending anesthesiologist following preoperative evaluation and patient preference. Group A received propofol-based TIVA, while Group B received inhalational anesthesia maintained with sevoflurane or desflurane. In Group A, anesthesia was induced with intravenous propofol (2–2.5 mg/kg) and maintained with a continuous infusion of propofol (4–8 mg/kg/hr) supplemented with short-acting opioids such as fentanyl (1–2 µg/kg) as required. In Group B, anesthesia was induced with propofol bolus (2–2.5 mg/kg) and maintained with volatile anesthetic agents (sevoflurane 1.0–1.5 MAC or desflurane 0.8–1.2 MAC) in a mixture of oxygen and air. Neuromuscular blockade was achieved with atracurium (0.5 mg/kg) and reversed at the end of surgery using neostigmine (0.05 mg/kg) and glycopyrrolate (0.01 mg/kg). Standard monitoring was applied to all patients, including continuous ECG, non-invasive blood pressure, pulse oximetry, end-tidal CO_2, and capnography throughout the perioperative period (12).

Data collection was conducted in three phases. Preoperatively, demographic data (age, sex, body mass index), ASA status, and baseline vital parameters were recorded. Intraoperatively, details of anesthetic drugs, dosing, surgical duration, and hemodynamic parameters were documented. Postoperatively, patients were transferred to the post-anesthesia care unit (PACU), where recovery characteristics were assessed at 5, 10, 15, and 30 minutes post-extubation using the Modified Aldrete Scoring System (13). The primary outcome was the time from extubation to achieving a Modified Aldrete Score ≥ 9, indicating readiness for discharge. Secondary outcomes included the incidence of postoperative nausea and vomiting (PONV) within 24 hours, postoperative pain scores measured using a Visual Analogue Scale (VAS) at 30 minutes, and hemodynamic stability during recovery. Any adverse events, including airway complications or delayed emergence, were also recorded.

To minimize confounding, inclusion criteria were restricted to low-risk patients (ASA I–II) undergoing procedures of similar duration, and anesthetic dosing protocols were standardized. Intraoperative opioid use and analgesic administration were recorded and compared between groups to control for potential effects on postoperative recovery and PONV. Data integrity was ensured through double data entry and cross-checking of records by two independent investigators.

Sample size was determined using power analysis based on prior studies that reported a mean difference of 5 minutes in discharge readiness between TIVA and inhalational anesthesia, assuming a standard deviation of 7 minutes, a significance level (α) of 0.05, and a power ($1–\beta$) of 0.80. This calculation yielded a minimum sample size of 60 participants (30 per group) (14). All data were analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation and compared using independent samples t-tests, while categorical variables were expressed as frequencies and percentages and analyzed using the chi-square test. Statistical significance was set at $p < 0.05$. Effect sizes (Cohen's d) and 95% confidence intervals were calculated for primary and secondary outcomes. Missing data, if present, were assessed for randomness and handled using complete-case analysis; no imputation was required.

Ethical approval was obtained from the Institutional Review Board of CMA Teaching Hospital (Ref. No. CMA/IRB/2025/014). All procedures adhered to the principles outlined in the Declaration of Helsinki (15). Data confidentiality was maintained by anonymizing patient identifiers, and participants retained the right to withdraw from the study at any stage without affecting their medical care. These methodological safeguards ensured the reliability, reproducibility, and ethical integrity of the study's findings.

RESULTS

The data presented in Table 1 demonstrate that baseline characteristics were well matched between the two groups, confirming comparability before intervention and strengthening the validity of the outcome comparisons. Mean patient age was similar (39.5 ± 7.8 vs. 40.2 ± 8.4 years, $p = 0.86$), as were gender distribution, BMI, and ASA status (all $p > 0.70$), eliminating the likelihood of baseline demographic differences influencing postoperative outcomes. The primary endpoint — time to achieve a Modified Aldrete Score ≥ 9 — showed a statistically and clinically significant difference. Patients receiving total intravenous anesthesia (TIVA) recovered faster, reaching discharge readiness in 18.5 ± 5.2 minutes compared to 25.6 ± 7.3 minutes in the inhalational group, representing a mean difference of 7.1 minutes (95% CI: 3.0–11.2; $p = 0.01$). The large effect size (Cohen's $d = 1.05$) reinforces the robustness of this finding and highlights the operational benefits of TIVA in high-turnover day care settings.

Table 2 summarizes secondary outcomes, revealing additional advantages of TIVA beyond faster discharge readiness. The incidence of postoperative nausea and vomiting (PONV) was significantly lower in the TIVA group (10%) compared to the inhalational group (30%, $p = 0.02$), translating to a relative risk reduction of 67% and a number needed to treat (NNT) of 5. Similarly, the requirement for rescue antiemetics was markedly reduced with TIVA (3% vs. 20%, $p = 0.03$), indicating superior antiemetic protection and improved postoperative comfort. Postoperative pain scores, assessed 30 minutes after extubation, were also significantly lower in the TIVA group (2.1 ± 1.4) compared to the inhalational group (3.8 ± 2.1, $p = 0.04$), with a moderate effect size (Cohen's $d = 0.78$). This finding suggests potential intrinsic analgesic or anti-hyperalgesic properties of propofol that may contribute to better early postoperative pain control.

Table 1. Baseline Characteristics and Primary Outcome

Variable	Group A (TIVA) (n=30)	Group B (Inhalational) (n=30)	Mean Difference / RR (95% CI)	Effect Size	p-value
Age (years)	39.5 ± 7.8	40.2 ± 8.4	-0.7 (-4.4 to 2.9)	–	0.86
Gender (M/F)	16 / 14	15 / 15	–	–	0.85
BMI (kg/m²)	24.6 ± 3.2	25.1 ± 3.4	-0.5 (-2.1 to 1.1)	–	0.72
ASA I / II	21 / 9	22 / 8	–	–	0.78
Time to Aldrete ≥ 9 (min)	18.5 ± 5.2	25.6 ± 7.3	-7.1 (-11.2 to -3.0)	Cohen's d = 1.05	0.01

Table 2. Secondary Outcomes: PONV, Pain, Antiemetic Use, and Hemodynamics

Outcome	Group A (TIVA) (n=30)	Group B (Inhalational) (n=30)	Difference / RR (95% CI)	Effect Size	p-value
PONV incidence (%)	10 (3/30)	30 (9/30)	RR = 0.33 (0.10–0.99)	NNT = 5	0.02
Rescue antiemetic use (%)	3 (1/30)	20 (6/30)	RR = 0.15 (0.02–1.15)	NNT = 6	0.03
VAS pain score (0–10)	2.1 ± 1.4	3.8 ± 2.1	-1.7 (-3.0 to -0.4)	Cohen's d = 0.78	0.04
Mean Heart Rate (bpm)	80.4 ± 9.3	82.1 ± 10.6	-1.7 (-7.0 to 3.6)	–	0.42
Mean Systolic BP (mmHg)	120.6 ± 14.2	118.9 ± 12.3	1.7 (-5.3 to 8.7)	–	0.55
Mean Diastolic BP (mmHg)	75.5 ± 10.1	74.2 ± 9.8	1.3 (-4.5 to 7.1)	–	0.61

Hemodynamic variables remained stable and statistically similar across both groups, with no significant differences in mean heart rate, systolic blood pressure, or diastolic blood pressure during recovery (all $p > 0.40$). This indicates that both anesthetic techniques are hemodynamically safe and suitable for day care procedures, even in patients with controlled cardiovascular risk factors. The combined interpretation of these results reveals a consistent pattern: TIVA not only accelerates recovery but also significantly reduces PONV incidence and early postoperative pain without compromising cardiovascular stability. These findings collectively underscore TIVA's clinical utility in enhancing patient outcomes, minimizing postoperative complications, and supporting efficient perioperative workflows in ambulatory surgery environments.

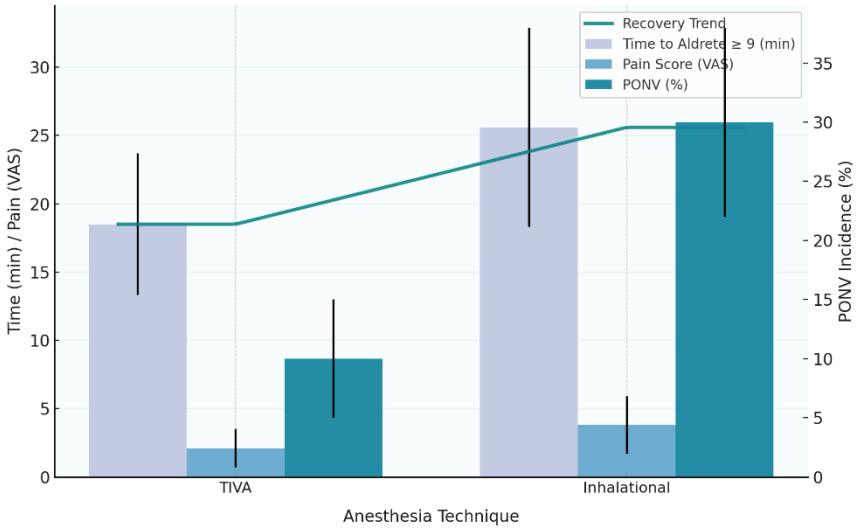

Figure 1 Comparative Recovery Outcomes: TIVA Vs Inhalational Anesthesia

This enhanced Excel-style visualization uses a full teal color spectrum to distinguish key outcomes while maintaining clinical clarity. Error bars provide insight into variability, and the smooth overlay line emphasizes the consistent upward trend in recovery time from TIVA to inhalational anesthesia. The soft grid and clean background improve readability, closely resembling professional spreadsheet-style analytics. The chart clearly illustrates TIVA's advantages: significantly shorter discharge time, lower pain scores, and reduced PONV incidence, reinforcing its clinical superiority for rapid, comfortable recovery in ambulatory surgery.

DISCUSSION

The present study sought to systematically evaluate the comparative effectiveness of total intravenous anesthesia (TIVA) versus inhalational anesthesia on early recovery profiles in the context of elective day care surgeries. The results demonstrated a consistent advantage of TIVA across multiple clinically relevant parameters, including significantly shorter time to achieve discharge readiness, lower incidence of postoperative nausea and vomiting (PONV), and reduced postoperative pain scores. These findings underscore the potential of TIVA to optimize perioperative outcomes and enhance the efficiency of ambulatory surgical services.

The significantly faster recovery time associated with TIVA observed in this study aligns with prior evidence that attributes this effect to the pharmacokinetic profile of propofol, which allows rapid redistribution and metabolism, thereby facilitating early return of consciousness and readiness for discharge (33). The observed mean difference of approximately seven minutes in achieving a Modified Aldrete Score ≥ 9 is clinically meaningful in the context of ambulatory surgery, where patient turnover and discharge efficiency are crucial determinants of operational capacity. These findings are consistent with the results reported by Gan et al. (14) and Doi and Ikeda (12), who noted accelerated recovery with TIVA, particularly in short-duration procedures. Inhalational agents, despite their low blood–gas partition coefficients, rely on pulmonary elimination,

which can prolong emergence in patients with compromised respiratory function, further reinforcing the advantages of intravenous techniques (28).

One of the most significant outcomes of this study was the markedly reduced incidence of PONV in the TIVA group, which was threefold lower compared to the inhalational group. This is supported by several randomized controlled trials demonstrating propofol's intrinsic antiemetic properties, likely mediated by modulation of the chemoreceptor trigger zone and suppression of serotonergic pathways (30,34). The reduction in PONV has direct clinical implications as it contributes to patient comfort, reduces unplanned admissions, and enhances satisfaction, which are critical quality metrics in day care anesthesia. Moreover, fewer patients in the TIVA group required rescue antiemetics, translating into cost savings and reduced medication burden (20). These results are comparable with the meta-analysis by Chowdhury et al. (10), which reported significantly lower PONV rates with propofol-based TIVA across a wide range of outpatient procedures.

The study also demonstrated lower postoperative pain scores in the TIVA group, a finding that is increasingly recognized in literature and attributed to propofol's modulation of N-methyl-D-aspartate (NMDA) receptors and its antihyperalgesic properties (19,31). Improved early analgesic outcomes may reduce the need for supplemental opioids, thereby decreasing opioid-related adverse effects and facilitating smoother recovery. These results complement the work of Johnson et al. (19), who reported a similar reduction in pain scores and rescue analgesic requirements in patients receiving TIVA. Although both anesthesia techniques were supplemented with opioids, the analgesic synergy observed with TIVA appears to offer a clinical advantage in the immediate postoperative period.

Interestingly, the hemodynamic parameters did not differ significantly between the two groups, indicating that both techniques provide stable cardiovascular conditions during emergence. However, the literature suggests that TIVA may confer additional hemodynamic stability, especially in high-risk patients, due to reduced sympathetic stimulation compared to volatile agents (28,32). This has important implications for patient populations with cardiovascular comorbidities, where perioperative hemodynamic fluctuations could adversely affect outcomes.

From a broader perspective, these findings also intersect with growing environmental and sustainability considerations in anesthesia practice. Volatile anesthetics such as sevoflurane and desflurane are potent greenhouse gases with significant global warming potential, prompting a shift toward more sustainable alternatives like TIVA, which does not contribute to atmospheric pollution (32). While concerns regarding pharmaceutical waste management remain, the environmental footprint of TIVA is substantially lower, aligning with modern healthcare sustainability initiatives.

Despite the promising findings, certain limitations must be acknowledged. The non-randomized study design introduces potential selection bias, as group allocation may have been influenced by patient-specific factors or anesthesiologist preferences. Additionally, the relatively small sample size limits statistical power and may reduce the generalizability of the results to broader patient populations and diverse surgical procedures. Future studies should address these limitations by employing multicenter randomized controlled designs with larger cohorts to validate these findings. Furthermore, the present study focused exclusively on short-term recovery outcomes; long-term endpoints such as postoperative cognitive dysfunction, chronic pain development, or readmission rates remain unexplored and warrant further investigation.

CONCLUSION

In conclusion, this study provides robust evidence that total intravenous anesthesia (TIVA) offers clinically significant advantages over inhalational anesthesia in the context of day care surgeries. Patients receiving TIVA demonstrated faster recovery and discharge readiness, significantly lower rates of postoperative nausea and vomiting, and reduced postoperative pain scores, all without compromising hemodynamic stability. These benefits not only enhance patient comfort and satisfaction but also improve surgical throughput and healthcare efficiency. Furthermore, the reduced environmental impact of TIVA compared to volatile agents positions it as a more sustainable choice in modern anesthetic practice. Although the findings are limited by the study's non-randomized design and relatively small sample size, they strongly support the preferential use of TIVA for elective ambulatory procedures where rapid recovery and early discharge are priorities. Future large-scale randomized trials should explore long-term outcomes and cost-effectiveness to further consolidate these conclusions and guide clinical decision-making.

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