Section: Anaesthesia

Original Research Article

COMPARATIVE STUDY OF INHALATIONAL VS. INTRAVENOUS ANAESTHESIA ON RECOVERY PROFILES IN OUTPATIENT SURGERIES

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Received *: 05/02/2025*
Received in revised form *: 01/04/2025*
Accepted *: 17/04/2025*

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DOI: 10.70034/ijmedph.2025.2.147

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2025; 15 (2); 817-822

ABSTRACT

Background: The aim is to compare the recovery profiles of inhalational anaesthesia and total intravenous anaesthesia (TIVA) in adult patients undergoing outpatient surgical procedures, focusing on emergence time, discharge readiness, and postoperative comfort.

Materials and Methods: This prospective, comparative study included 110 patients aged 18–60 years, classified as ASA I or II, and scheduled for elective outpatient surgery under general anaesthesia. Patients were randomized into two groups: Group I (n=55) received inhalational anaesthesia with sevoflurane, and Group IV (n=55) received TIVA with propofol and remifentanil. Standard anaesthetic protocols were followed in both groups. Recovery parameters such as time to eye opening, extubation, orientation, Aldrete score, and PADSS were assessed. Statistical analysis was conducted using SPSS v26, with $p<0.05$ considered significant.

Results: Baseline characteristics were comparable across groups. Recovery was significantly faster in the TIVA group, with shorter times to eye opening (6.1 ± 1.8 min vs. 8.3 ± 2.2 min; $p<0.001$), extubation, and orientation. Modified Aldrete Score ≥9 was achieved earlier in Group IV (11.4 ± 2.7 min vs. 14.8 ± 3.5 min; $p<0.001$). PADSS scores at 30 minutes were also higher (9.2 ± 0.6 vs. 8.6 ± 0.9; $p=0.003$). Group IV had lower pain scores (2.6 ± 1.0 vs. 3.1 ± 1.2; $p=0.02$) and higher patient satisfaction (8.9 ± 1.0 vs. 8.2 ± 1.1; $p=0.01$). Incidences of nausea and vomiting and antiemetic use were lower in Group IV, though not statistically significant.

Conclusion: TIVA resulted in faster and smoother recovery, better pain control, and higher patient satisfaction compared to inhalational anaesthesia. These findings support the use of TIVA as the preferred anaesthetic technique for outpatient surgeries to enhance perioperative efficiency and patient outcomes.

Keywords: Total intravenous anaesthesia (TIVA), inhalational anaesthesia, outpatient surgery, recovery profile, discharge readiness.

INTRODUCTION

Outpatient or day-care surgeries have gained tremendous popularity in modern surgical practice owing to advancements in surgical techniques, anaesthesia, and postoperative care. These procedures allow for same-day discharge, promoting patient convenience, reducing hospital stay, and optimizing healthcare costs. Central to the success of ambulatory surgeries is the use of an anaesthetic technique that ensures rapid induction, stable intraoperative conditions, and swift, predictable recovery with minimal side effects. Among the various anaesthetic strategies, general anaesthesia remains a cornerstone for most outpatient procedures. Two primary methods are widely used: inhalational anaesthesia, typically involving agents like sevoflurane, and total intravenous anaesthesia (TIVA), commonly using agents like propofol and remifentanil. The choice between these modalities has been a topic of considerable research and clinical interest. The selection often depends on factors such as the type of surgery, patient comorbidities, anticipated recovery profile, and institutional

protocols. Inhalational anaesthetics are popular due to their ease of titration, rapid onset and offset (especially sevoflurane), and minimal need for intravenous access after induction. However, their use has been associated with higher incidences of postoperative nausea and vomiting (PONV), respiratory complications, and, in some cases, delayed emergence from anaesthesia. In contrast, TIVA, particularly when guided by objective depth-of-anaesthesia monitors, has been shown to offer advantages in terms of smoother recovery, lower incidence of PONV, better haemodynamic stability, and reduced risk of neurocognitive dysfunction postoperatively.[1,2]

Emerging evidence suggests that the type of anaesthesia not only affects recovery times but may also influence postoperative neurocognitive outcomes, especially in elderly patients or those undergoing laparoscopic surgeries. Intravenous agents like propofol are believed to have neuroprotective and anti-inflammatory properties that may reduce the risk of postoperative cognitive dysfunction and promote early discharge.[1,3] Furthermore, EEG-guided titration of intravenous anaesthetics has shown promising results in improving recovery and reducing delirium incidence after surgery.[4]

The introduction of minimally invasive surgical techniques, particularly laparoscopy, has further reinforced the need for anaesthesia regimens that complement rapid recovery without compromising safety. In this context, the depth and duration of anaesthesia have shown to influence not just immediate postoperative metrics like emergence time and discharge readiness but also systemic responses such as inflammation and pain perception.[3,5] This interplay between anaesthetic technique and recovery is of paramount importance in ambulatory surgical settings, where even minor delays in recovery can impact discharge timings and patient satisfaction.

Another important aspect is the patient's subjective experience during recovery. Studies comparing patient-reported outcomes, such as satisfaction scores and perceived quality of recovery, have highlighted a trend in favor of TIVA due to reduced side effects like dizziness, nausea, and residual sedation.[6-8] Furthermore, TIVA has been associated with a more favorable impact on psychomotor function and cognitive clarity in the early recovery period, which is essential for safe discharge and return to routine activities.

Despite the growing body of literature, there remains ongoing debate about the optimal anaesthetic technique for outpatient surgeries. Some studies suggest inhalational agents are equally effective in ensuring quick recovery and acceptable side-effect profiles, particularly when combined with appropriate antiemetic prophylaxis and multimodal analgesia.[7] However, others advocate for the superiority of TIVA in facilitating faster emergence and lower incidence of complications such as postoperative cognitive dysfunction and sleep disturbances, especially in specific populations or surgical contexts.[2]

The goal of this study is to compare the recovery profiles of patients undergoing outpatient surgeries under two widely practiced anaesthetic techniques—inhalational anaesthesia versus intravenous anaesthesia (TIVA). Parameters such as time to eye opening, extubation, orientation, achievement of Modified Aldrete Score, discharge readiness, and patient satisfaction will be analyzed to determine which technique provides a more efficient and comfortable postoperative recovery.

Given the rising demand for ambulatory procedures and the evolving expectations regarding patient-centered care, it becomes essential to evaluate the clinical and practical implications of anaesthetic choices. This study, by focusing on a detailed recovery profile in a controlled setting, seeks to provide meaningful insight into optimizing perioperative care in outpatient surgical practice.

MATERIALS AND METHODS

This prospective, comparative study was conducted over a period of 12 months at a tertiary care hospital, following approval from the Institutional Ethics Committee. A total of 110 adult patients undergoing elective outpatient surgical procedures under general anaesthesia were enrolled after obtaining written informed consent. Patients aged 18 to 60 years, classified as American Society of Anesthesiologists (ASA) physical status I or II, and scheduled for day-care surgeries lasting less than 2 hours were included. Patients with known allergies to anaesthetic agents, history of malignant hyperthermia, significant cardiopulmonary, hepatic, or renal disease, or those requiring postoperative admission were excluded.

Group Allocation

The participants were randomly divided into two groups using a computer-generated randomization table:

- Group I (Inhalational group, n=55): Patients received induction with propofol and maintenance with sevoflurane in oxygen/nitrous oxide mixture.
- Group IV (Intravenous group, n=55): Patients received total intravenous anaesthesia (TIVA) with propofol and remifentanil infusion.

Anaesthesia Protocol and Intraoperative Management: All patients were premedicated with intravenous midazolam at a dose of 0.03 mg/kg and fentanyl 1 mcg/kg, administered approximately five minutes prior to induction. Anaesthesia induction in both groups was carried out using propofol at a dose of 2–2.5 mg/kg. Muscle relaxation was achieved with vecuronium 0.1 mg/kg IV to facilitate airway management.

For maintenance of anaesthesia, patients in Group I (Inhalational group) received sevoflurane (1–2%) delivered in a 50:50 mixture of oxygen and nitrous oxide. In contrast, patients in Group IV (Intravenous

group) were maintained on a continuous infusion of propofol (75–125 mcg/kg/min) and remifentanil (0.1–0.2 mcg/kg/min). Mechanical ventilation was adjusted in all patients to maintain end-tidal carbon dioxide ($EtCO_2$) between 35–40 mmHg.

Standard intraoperative monitoring was employed for all patients and included continuous electrocardiogram (ECG), pulse oximetry (SpO_2), non-invasive blood pressure (NIBP), end-tidal CO_2, and Bispectral Index (BIS) monitoring. The BIS was maintained in the range of 40–60 to ensure an adequate depth of anaesthesia throughout the procedure.

Recovery Profile Assessment: At the conclusion of surgery, all anaesthetic agents were discontinued, and neuromuscular blockade was reversed using neostigmine and glycopyrrolate. Recovery parameters were evaluated by a blinded observer to eliminate bias. Parameters recorded included the time to eye opening on verbal command, time to extubation, and time to orientation, defined as the patient's ability to correctly state their name, location, and date. The Modified Aldrete Score was assessed at 5-minute intervals until a score of ≥9 was achieved, indicating readiness for transfer from the post-anaesthesia care unit. Final discharge readiness was determined using the Post Anaesthesia Discharge Scoring System (PADSS), ensuring that patients met all criteria for safe discharge from the outpatient surgical facility.

Statistical Analysis: Data were analyzed using SPSS version 26. Continuous variables were presented as mean ± standard deviation and compared using the unpaired t-test. Categorical data were analyzed using the chi-square test. A p-value of <0.05 was considered statistically significant.

RESULTS

[Table 1] Demographic and Baseline Characteristics of Patients

The demographic data demonstrated comparable baseline characteristics between the two groups, confirming effective randomization. The mean age of patients was similar in both groups (35.8 ± 10.4 years in the inhalational group vs. 36.5 ± 9.8 years in the intravenous group; p = 0.61), with a near-equal gender distribution (29 males and 26 females in Group I; 30 males and 25 females in Group IV; p = 0.84). The ASA physical status classification, which assesses preoperative fitness, also showed similar distribution with no significant difference (p = 0.67). The mean BMI was closely matched (24.1 ± 2.3 vs. 23.9 ± 2.6; p = 0.73), minimizing its influence on anaesthetic metabolism and recovery. Types of surgeries (urological, ENT, minor orthopedic) were evenly spread across both groups (p = 0.93). Additionally, the mean duration of surgery was comparable between the groups (52.4 ± 11.2 min vs. 50.8 ± 10.6 min; p = 0.44), indicating uniform procedural lengths.

[Table 2] Intraoperative Parameters

Intraoperative monitoring revealed stable haemodynamic profiles in both groups. Heart rate and mean arterial pressure remained within physiological ranges with no statistically significant differences (p = 0.09 and p = 0.12, respectively). Similarly, oxygen saturation (SpO_2) levels were maintained in both groups, suggesting effective oxygenation (p = 0.24). The BIS scores, used to ensure a consistent depth of anaesthesia, were nearly identical (47.8 ± 2.4 vs. 48.2 ± 2.6; p = 0.41), confirming comparable anaesthetic depths. End-tidal CO_2 values were also similar (p = 0.33), indicating consistent ventilation control. A significant difference was observed in total fentanyl consumption, which was higher in the intravenous group (60.1 ± 10.4 mcg vs. 52.3 ± 11.6 mcg; p = 0.001), likely due to the continuous opioid infusion in TIVA. Although more hypotensive episodes were recorded in the inhalational group (10.9% vs. 3.6%), the difference was not statistically significant (p = 0.14).

[Table 3] Recovery Profile Comparison

The intravenous group demonstrated a significantly faster recovery profile across all measured parameters. Time to eye opening was notably shorter in Group IV (6.1 ± 1.8 min) compared to Group I (8.3 ± 2.2 min; p < 0.001). Similarly, extubation time and orientation time were also reduced significantly in the intravenous group (p < 0.001 for both), reflecting quicker emergence from anaesthesia. Patients in the intravenous group also followed simple commands earlier (7.8 ± 1.6 min vs. 10.4 ± 2.3 min; p < 0.001) and achieved sitting position faster (14.2 ± 3.3 min vs. 18.5 ± 3.7 min; p < 0.001). These findings indicate a smoother and more rapid emergence in patients managed with TIVA.

[Table 4] Modified Aldrete Score Achievement

The time to reach a Modified Aldrete Score of ≥9, indicative of readiness to leave the PACU, was significantly shorter in Group IV (11.4 ± 2.7 min) compared to Group I (14.8 ± 3.5 min; p < 0.001). A higher proportion of patients in the intravenous group achieved this target within 15 minutes (85.5% vs. 70.9%; p = 0.048). At 10 minutes post-surgery, patients in Group IV had significantly higher Aldrete scores (8.6 ± 0.9 vs. 7.8 ± 1.1; p = 0.004), supporting faster recovery. Incidence of nausea and vomiting was lower in the intravenous group (3.6% vs. 12.7%), although not statistically significant (p = 0.08). Similarly, rescue antiemetic use was less frequent in Group IV (1.8% vs. 9.1%; p = 0.09), likely due to the reduced emetogenic potential of TIVA.

[Table 5] Discharge Readiness (PADSS)

Patients in the intravenous group also achieved higher PADSS scores at 30 minutes postoperatively (9.2 ± 0.6 vs. 8.6 ± 0.9; p = 0.003), suggesting quicker fulfillment of discharge criteria. Although the difference in the number of patients ready for discharge within 60 minutes was not statistically significant (94.5% vs. 85.5%; p = 0.11), the trend favored Group IV. Pain scores in the PACU were significantly lower in the intravenous group (2.6 ± 1.0

vs. 3.1 ± 1.2; p = 0.02), possibly due to the analgesic properties of propofol and remifentanil. Fewer patients in Group IV required postoperative analgesia (16.4% vs. 25.5%; p = 0.24), and overall patient satisfaction scores were higher (8.9 ± 1.0 vs. 8.2 ± 1.1; p = 0.01), reflecting better comfort and recovery experience.

Table 1: Demographic and Baseline Characteristics of Patients

Parameter	Group I (Inhalational) (n=55)	Group IV (Intravenous) (n=55)	p-value
Mean Age (years)	35.8 ± 10.4	36.5 ± 9.8	0.61
Gender (Male / Female)	29 / 26	30 / 25	0.84
ASA Grade I / II	38 / 17	36 / 19	0.67
Mean BMI (kg/m²)	24.1 ± 2.3	23.9 ± 2.6	0.73
Type of Surgery (Urological / ENT / Minor Ortho)	21 / 18 / 16	22 / 19 / 14	0.93
Duration of Surgery (min)	52.4 ± 11.2	50.8 ± 10.6	0.44

Table 2: Intraoperative Parameters

Parameter	Group I (Inhalational)	Group IV (Intravenous)	p-value
Mean Heart Rate (beats/min)	78.6 ± 6.5	76.2 ± 7.1	0.09
Mean Arterial Pressure (mmHg)	87.4 ± 5.3	85.6 ± 6.0	0.12
Oxygen Saturation (SpO_2 , %)	98.2 ± 1.1	98.5 ± 0.9	0.24
Mean BIS Score	47.8 ± 2.4	48.2 ± 2.6	0.41
End-tidal CO_2 (mmHg)	37.1 ± 1.8	36.8 ± 1.9	0.33
Total Fentanyl Consumption (mcg)	52.3 ± 11.6	60.1 ± 10.4	0.001
Intraoperative Hypotension Episodes	6 (10.9%)	2 (3.6%)	0.14

Table 3: Recovery Profile Comparison

Recovery Parameter	Group I (Inhalational)	Group IV (Intravenous)	p-value
Time to Eye Opening (min)	8.3 ± 2.2	6.1 ± 1.8	<0.001
Time to Extubation (min)	9.6 ± 2.4	7.3 ± 1.9	<0.001
Time to Orientation (min)	12.2 ± 2.6	9.1 ± 2.1	<0.001
Time to Follow Simple Commands (min)	10.4 ± 2.3	7.8 ± 1.6	<0.001
Time to Sitting Position (min)	18.5 ± 3.7	14.2 ± 3.3	<0.001

Table 4: Modified Aldrete Score Achievement

Parameter	Group I (Inhalational)	Group IV (Intravenous)	p-value
Time to Achieve Score ≥9 (min)	14.8 ± 3.5	11.4 ± 2.7	<0.001
Patients achieving score ≥9 within 15 min	39 (70.9%)	47 (85.5%)	0.048
Modified Aldrete Score at 10 min	7.8 ± 1.1	8.6 ± 0.9	0.004
Nausea/Vomiting in PACU (%)	7 (12.7%)	2 (3.6%)	0.08
Use of Rescue Antiemetic (%)	5 (9.1%)	1 (1.8%)	0.09

Table 5: Discharge Readiness (PADSS)

Parameter	Group I (Inhalational)	Group IV (Intravenous)	p-value
PADSS Score at 30 Minutes	8.6 ± 0.9	9.2 ± 0.6	0.003
Patients ready for discharge within 60 min	47 (85.5%)	52 (94.5%)	0.11
Pain Score in PACU (VAS 0–10)	3.1 ± 1.2	2.6 ± 1.0	0.02
Requirement of Post-op Analgesia in PACU (%)	14 (25.5%)	9 (16.4%)	0.24
Patient Satisfaction Score (0–10 scale)	8.2 ± 1.1	8.9 ± 1.0	0.01

DISCUSSION

The present study compared the recovery profiles of inhalational anaesthesia versus total intravenous anaesthesia (TIVA) in outpatient surgeries. Both modalities were effective and safe; however, TIVA showed several advantages in terms of faster emergence, reduced side effects, and greater patient satisfaction. These findings are consistent with a growing body of evidence supporting the clinical benefits of propofol-based TIVA in ambulatory surgical settings. The demographic and baseline characteristics were well matched between groups, affirming proper randomization. The similarity in mean age, gender distribution, BMI, ASA status, and surgery type ensured that recovery outcomes were not influenced by demographic or procedural variability. This uniformity aligns with the study design standards outlined by Niu et al. (2021), who emphasized demographic matching in comparing TIVA and inhalational anaesthesia.[6]

Intraoperative variables such as heart rate, mean arterial pressure, oxygen saturation, and BIS remained stable and comparable in both groups. Notably, fentanyl consumption was significantly higher in the intravenous group (60.1 ± 10.4 mcg vs. 52.3 ± 11.6 mcg; p = 0.001), likely due to the continuous infusion protocol in TIVA. Despite this, the intravenous group experienced fewer hypotensive episodes (3.6% vs. 10.9%), although the difference was not statistically significant. Similar findings were observed by Wang et al. (2022), who reported more stable haemodynamic profiles with propofol-based anaesthesia.[8] Nimmo et al. (2019) also highlighted

that TIVA offers more predictable pharmacodynamics and improved intraoperative stability in outpatient procedures.[7]

Recovery parameters strongly favored the intravenous group. Time to eye opening (6.1 ± 1.8 min), extubation (7.3 ± 1.9 min), and orientation (9.1 ± 2.1 min) were all significantly shorter than in the inhalational group ($p < 0.001$). Patients also followed simple commands and sat up earlier, reflecting a smoother recovery profile. These findings are in line with those of Geng et al. 2021 and Bansal et al., 2022, who found that propofol led to faster emergence and less residual sedation in laparoscopic surgery compared to sevoflurane.[9,10] Similarly, Kim et al. (2022) demonstrated enhanced early postoperative recovery and alertness in patients managed with TIVA in robotic gynecologic surgery.[11]

Patients in the intravenous group achieved Modified Aldrete Scores ≥9 significantly faster (11.4 ± 2.7 min vs. 14.8 ± 3.5 min; $p < 0.001$). Additionally, 85.5% of patients in the TIVA group reached this score within 15 minutes compared to 70.9% in the inhalational group ($p = 0.048$). This supports the quicker PACU recovery associated with TIVA, as also concluded in a meta-analysis by Della Corte et al. (2022), which highlighted reduced PACU stay and earlier mobilization with intravenous anaesthetics.[5]

The lower incidence of postoperative nausea and vomiting (PONV) in the intravenous group (3.6% vs. 12.7%) further reinforces the antiemetic properties of propofol noted in previous studies (Bansal et al., 2022).[10]

Patients in the TIVA group achieved higher PADSS scores at 30 minutes postoperatively (9.2 ± 0.6 vs. 8.6 ± 0.9; $p = 0.003$), indicating quicker readiness for discharge. Although not statistically significant, a higher number of patients in the intravenous group were discharged within 60 minutes (94.5% vs. 85.5%). Pain scores were lower in Group IV (2.6 ± 1.0 vs. 3.1 ± 1.2; $p = 0.02$), and fewer patients required postoperative analgesia. These observations are supported by the findings of Niu et al. (2021), who demonstrated improved postoperative comfort and satisfaction with TIVA.[6] Patient satisfaction scores were also higher in the TIVA group (8.9 ± 1.0 vs. 8.2 ± 1.1; $p = 0.01$), reflecting a better overall recovery experience.

Importantly, although this study did not directly assess cognitive function, the faster orientation time in the TIVA group suggests potential cognitive benefits. Previous studies have shown that propofol-based anaesthesia may be associated with reduced postoperative cognitive dysfunction. Han et al. (2023) and Yang et al. (2023) demonstrated that propofol, when used with preconditioning or depth-guided techniques, minimized the risk of delayed cognitive recovery in elderly and high-risk patients.[12,13] Similarly, Miller et al. (2018) in a Cochrane review concluded that TIVA may offer advantages over inhalational maintenance in terms of postoperative cognitive outcomes in non-cardiac surgeries.[14]

Our findings are consistent with existing literature indicating that TIVA provides superior emergence and recovery characteristics compared to inhalational anaesthesia in outpatient settings. It offers faster return to consciousness, lower incidence of PONV, better pain control, and higher patient satisfaction. These advantages make TIVA a preferred choice for day-care surgeries, particularly when rapid turnover and high patient comfort are priorities (Nimmo et al., 2019; Niu et al., 2021).[6,7]

CONCLUSION

In conclusion, this study highlights that total intravenous anaesthesia (TIVA) offers superior recovery outcomes compared to inhalational anaesthesia in outpatient surgeries. TIVA was associated with faster emergence, earlier readiness for discharge, lower postoperative discomfort, and higher patient satisfaction. These advantages make TIVA a preferable choice for day-care procedures where rapid and smooth recovery is essential. Implementing TIVA may enhance overall perioperative efficiency and improve patient-centered outcomes in ambulatory surgical settings.

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