

A Randomized Controlled Study Comparing the Hemodynamic Stability, Recovery Profile, and Patient Satisfaction between Total Intravenous Anesthesia and Balanced General Anesthesia in Elective Laparoscopic Procedures

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<https://doi.org/10.5281/zenodo.21733754>

Received: 09 July 2026, Accepted: 28 July 2026, Online First: 02 August 2026

ABSTRACT

Background: Laparoscopic surgery is increasingly performed because of its advantages of reduced postoperative pain, shorter hospital stay, and faster recovery. However, the physiological effects of pneumoperitoneum may lead to significant hemodynamic changes during surgery. Total Intravenous Anaesthesia (TIVA) has been suggested to provide improved hemodynamic stability and faster recovery compared with Balanced General Anaesthesia (BGA). This study was undertaken to compare the hemodynamic stability, recovery profile, and patient satisfaction between TIVA and BGA in elective laparoscopic procedures. **Aim:** To compare the hemodynamic stability, recovery profile, and patient satisfaction between Total Intravenous Anaesthesia and Balanced General Anaesthesia in adult patients undergoing elective laparoscopic surgery. **Materials and Methods:** This prospective, randomised, controlled, double-blind comparative study was conducted in the Department of Anaesthesiology at CSI Redfern Mission Hospital, Hassan, Karnataka, India, from June 2024 to May 2026. A total of 95 adult patients (ASA physical status I–II) undergoing elective laparoscopic procedures were randomly allocated into Group T (TIVA, n=48) and Group B (Balanced General Anaesthesia, n=47). Hemodynamic parameters including heart rate and mean arterial pressure were recorded at predefined intraoperative intervals. Recovery profile was assessed by time to spontaneous respiration, eye opening, extubation, response to verbal commands, orientation, Modified Aldrete Recovery Score, and duration of post-anaesthesia care unit (PACU) stay. Postoperative pain, rescue analgesic requirement, postoperative nausea and vomiting (PONV), adverse events, and patient satisfaction using a 5-point Likert scale were also evaluated. **Results:** Baseline demographic, clinical, and laboratory characteristics were comparable between the two groups ($p>0.05$). Group T demonstrated significantly better intraoperative hemodynamic stability with lower heart rate and mean arterial pressure fluctuations following induction, intubation, pneumoperitoneum, and at the end of surgery ($p<0.001$). Recovery was significantly faster in the TIVA group, with shorter times to spontaneous respiration (4.8 ± 1.3 vs 6.4 ± 1.7 minutes), eye opening (6.5 ± 1.6 vs 9.2 ± 2.1 minutes), extubation (8.4 ± 1.8 vs 11.5 ± 2.4 minutes), orientation (11.4 ± 2.3 vs 15.6 ± 3.0 minutes), and PACU discharge (47.8 ± 8.9 vs 60.5 ± 10.4 minutes) (all $p<0.001$). Modified Aldrete scores were significantly higher in Group T during early recovery ($p<0.001$). Postoperative pain scores, rescue analgesic requirement, and incidence of PONV were significantly lower in the TIVA group ($p<0.05$). Mean patient satisfaction score was significantly higher with TIVA (4.5 ± 0.6 vs 3.9 ± 0.8 , $p<0.001$). **Conclusion:** Total Intravenous Anaesthesia provided superior intraoperative hemodynamic stability, faster postoperative recovery, lower postoperative pain, reduced postoperative nausea and vomiting, decreased analgesic requirements, and higher patient satisfaction compared with Balanced General Anaesthesia. TIVA represents an effective and safe anaesthetic technique for elective laparoscopic procedures and may be preferred to optimise perioperative outcomes.

Keywords: Total Intravenous Anaesthesia, Balanced General Anaesthesia, Laparoscopic Surgery, Hemodynamic Stability, Recovery Profile, Patient Satisfaction, Propofol, Postoperative Nausea and Vomiting.

INTRODUCTION

Laparoscopic surgery has become the preferred surgical approach for a wide variety of abdominal and pelvic procedures because of its well-established advantages, including reduced postoperative pain, smaller incisions, faster recovery, shorter hospital stay, and earlier return to normal activities compared with open surgery. Despite these benefits, laparoscopic procedures are associated with unique physiological alterations caused by carbon dioxide (CO₂) pneumoperitoneum and patient positioning, which may significantly influence cardiovascular and respiratory function. The increase in intra-abdominal pressure during pneumoperitoneum can lead to elevated systemic vascular resistance, increased mean arterial pressure, reduced venous return, and fluctuations in heart rate, thereby posing challenges to anaesthetic management, particularly in patients with limited cardiopulmonary reserve.[1,2]

General anaesthesia remains the standard anaesthetic technique for elective laparoscopic surgery because it provides adequate hypnosis, analgesia, muscle relaxation, and controlled ventilation. Traditionally, Balanced General Anaesthesia (BGA), consisting of intravenous induction followed by maintenance with inhalational anaesthetic agents combined with opioids and neuromuscular blocking agents, has been widely practised. Although inhalational anaesthetics such as isoflurane provide reliable anaesthesia, they have been associated with delayed emergence, postoperative nausea and vomiting (PONV), and greater hemodynamic fluctuations during stimulation such as laryngoscopy, intubation, pneumoperitoneum, and extubation.[3,4]

Total Intravenous Anaesthesia (TIVA), in contrast, utilises continuous intravenous administration of hypnotic agents, most commonly propofol, along with short-acting opioids to maintain anaesthesia without inhalational agents. Propofol possesses several pharmacological advantages, including rapid onset and offset of action, predictable recovery characteristics, antiemetic properties, reduction in airway reflexes, and improved patient comfort during recovery. These characteristics have contributed to the increasing popularity of TIVA in ambulatory surgery, laparoscopic procedures, and surgeries where rapid postoperative neurological assessment is desirable.[5,6]

Hemodynamic stability during anaesthesia is an important determinant of perioperative safety. Marked fluctuations in heart rate and blood pressure may increase myocardial oxygen demand, reduce tissue perfusion, and contribute to perioperative complications. Several studies have suggested that propofol-based TIVA attenuates sympathetic responses to surgical stimulation more effectively than inhalational anaesthesia, thereby providing smoother intraoperative hemodynamics. However, other studies

have reported comparable outcomes between TIVA and balanced anaesthesia depending on the anaesthetic protocol, surgical duration, and patient characteristics.[7,8]

Rapid postoperative recovery has become increasingly important with the expansion of minimally invasive surgery and enhanced recovery after surgery (ERAS) protocols. Early return of consciousness, spontaneous respiration, orientation, and readiness for discharge from the post-anaesthesia care unit (PACU) contribute to improved patient throughput and reduced healthcare costs. Propofol-based TIVA has consistently demonstrated shorter emergence and recovery times owing to its favourable pharmacokinetic profile and reduced accumulation compared with volatile anaesthetic agents.[9]

Postoperative nausea and vomiting remain among the most distressing complications following general anaesthesia, with an incidence ranging from 20% to 80% depending on patient risk factors and surgical procedures. Volatile anaesthetics are recognised as one of the strongest modifiable risk factors for PONV. In contrast, propofol exhibits intrinsic antiemetic properties, making TIVA particularly advantageous in patients at moderate or high risk of postoperative nausea and vomiting.[10]

Patient satisfaction has emerged as an essential quality indicator in modern perioperative care. Satisfaction is influenced not only by the success of surgery but also by anaesthetic experience, postoperative comfort, pain control, absence of nausea and vomiting, early recovery, and overall quality of perioperative care. Consequently, comparisons between anaesthetic techniques increasingly incorporate patient-reported outcomes alongside traditional physiological measures.[11]

Although numerous international studies have compared TIVA with inhalational anaesthesia, variations in patient populations, anaesthetic protocols, surgical procedures, and outcome measures have resulted in inconsistent conclusions. Furthermore, evidence from Indian tertiary care hospitals regarding the comparative effectiveness of TIVA and Balanced General Anaesthesia during elective laparoscopic surgery remains relatively limited. Therefore, the present prospective randomised controlled study was undertaken to compare Total Intravenous Anaesthesia and Balanced General Anaesthesia with respect to intraoperative hemodynamic stability, postoperative recovery profile, postoperative complications, and patient satisfaction in adult patients undergoing elective laparoscopic procedures.

Despite several international studies, evidence from Indian tertiary care centres comparing TIVA and balanced anaesthesia using comprehensive recovery and patient-centred outcomes remains limited. Moreover, few studies have simultaneously evaluated haemodynamic stability, early recovery, postoperative

complications, and patient satisfaction in elective laparoscopic surgery.

Primary Objective

To compare intraoperative hemodynamic stability between Total Intravenous Anaesthesia (TIVA) and Balanced General Anaesthesia (BGA) in adult patients undergoing elective laparoscopic procedures.

Secondary Objectives

- To compare postoperative recovery profile between the two groups.
- To compare postoperative pain intensity using the Visual Analogue Scale (VAS).
- To compare the incidence of postoperative nausea and vomiting (PONV).
- To evaluate the requirement for rescue analgesia.
- To compare the duration of stay in the Post-Anaesthesia Care Unit (PACU).
- To assess patient satisfaction using a 5-point Likert satisfaction scale.
- To compare perioperative adverse events between the two groups.

MATERIALS AND METHODS

Study Design and Setting

This prospective, randomised, controlled, double-blind comparative study was carried out in the Department of Anaesthesiology at CSI Redfern Mission Hospital, Hassan, Karnataka, India, over two years from June 2024 to May 2026. The study was designed to compare the hemodynamic stability, recovery profile, and patient satisfaction between Total Intravenous Anaesthesia (TIVA) and Balanced General Anaesthesia (BGA) in adult patients undergoing elective laparoscopic procedures. Approval for the study was obtained from the Institutional Ethics Committee before commencement. Written informed consent was obtained from all participants before enrolment.

Ethical Approval

The study protocol was approved by the Institutional Ethics Committee of CSI Redfern Mission Hospital, Hassan, Karnataka, India.

Informed Consent

Written informed consent was obtained from all participants before enrolment after explaining the objectives, risks, benefits, and procedures involved in the study.

Sample Size

Sample size was calculated using G*Power software (Version 3.1). Based on previous studies comparing mean arterial pressure between TIVA and Balanced General Anaesthesia, assuming a medium effect size (Cohen's $d = 0.60$), a two-sided alpha error of 0.05, and a study power of 80%, the minimum required

sample size was calculated to be 90 participants (45 in each group). Considering an anticipated dropout rate of approximately 5%, a total of 95 patients were enrolled, with 48 patients allocated to the TIVA group and 47 patients to the Balanced General Anaesthesia group.

A total of 95 patients undergoing elective laparoscopic surgery under general anaesthesia were included in the study. Patients were randomly allocated into two groups using a computer-generated randomisation sequence:

- Group T (TIVA): 48 patients
- Group B (Balanced General Anaesthesia): 47 patients

Allocation concealment was achieved using sequentially numbered, sealed opaque envelopes.

Study Population

Inclusion Criteria

- Patients aged 18–65 years
- Either gender
- ASA physical status I and II
- Scheduled for elective laparoscopic surgery under general anaesthesia
- Body Mass Index (BMI) between 18.5 and 30 kg/m²
- Willingness to provide written informed consent

Exclusion Criteria

- ASA physical status III or IV
- Emergency laparoscopic procedures
- Significant cardiovascular disease
- Severe hepatic or renal impairment
- Chronic pulmonary disease
- Pregnancy or lactation
- Known allergy to propofol, inhalational anesthetics, opioids, or muscle relaxants
- Anticipated difficult airway
- Neurological or psychiatric disorders affecting postoperative assessment
- Chronic opioid or sedative use
- Refusal to participate

Preoperative Assessment

All patients underwent a detailed pre-anesthetic evaluation one day before surgery, including medical history, physical examination, airway assessment, and routine laboratory investigations. The investigations included:

- Complete Blood Count (CBC)
- Random Blood Sugar (RBS)
- Liver Function Tests (LFT)
- Renal Function Tests (RFT)
- Serum electrolytes
- Coagulation profile (when indicated)
- Electrocardiogram (ECG)
- Chest radiograph (when clinically indicated)

Baseline heart rate, blood pressure, oxygen saturation, and body weight were recorded. All patients were kept fasting according to standard preoperative fasting guidelines.

Randomization and Blinding

Patients were randomized into either the TIVA group or the Balanced General Anesthesia group using computer-generated random numbers. Allocation was concealed using sealed opaque envelopes. Patients and the investigator responsible for postoperative assessment were blinded to the anesthetic technique. The anesthesiologist administering anesthesia was not involved in postoperative data collection.

Anaesthetic Technique

Group T (Total Intravenous Anesthesia)

Premedication consisted of glycopyrrolate 0.2 mg IV, midazolam 0.02 mg/kg IV, and fentanyl 2 µg/kg IV. Anesthesia was induced with propofol 2 mg/kg IV followed by vecuronium 0.1 mg/kg IV to facilitate endotracheal intubation. Anesthesia was maintained using continuous propofol infusion (75–150 µg/kg/min) with supplemental fentanyl as required. Oxygen and air mixture was used throughout the procedure. Additional doses of vecuronium were administered when necessary.

Group B (Balanced General Anesthesia)

Patients received identical premedication and induction drugs. Maintenance of anesthesia was achieved using isoflurane (1–1.5 MAC) in oxygen and air, with intermittent fentanyl supplementation and additional doses of vecuronium as required.

At the end of surgery, neuromuscular blockade was reversed using neostigmine (0.05 mg/kg) and glycopyrrolate (0.01 mg/kg), followed by extubation after meeting standard extubation criteria.

Intraoperative Monitoring

The following parameters were continuously monitored throughout surgery:

- Heart Rate (HR)
- Systolic Blood Pressure (SBP)
- Diastolic Blood Pressure (DBP)
- Mean Arterial Pressure (MAP)
- Oxygen Saturation (SpO₂)
- Electrocardiography (ECG)
- End-Tidal Carbon Dioxide (EtCO₂)
- Respiratory Rate
- Body Temperature

Measurements were recorded at baseline, after induction, after intubation, at skin incision, every 5 minutes intraoperatively, after pneumoperitoneum creation, after release of pneumoperitoneum, at extubation, and immediately after surgery.

Recovery Profile

Recovery characteristics were assessed using the following parameters:

- Time to spontaneous respiration
- Time to eye opening
- Time to extubation
- Time to obey verbal commands
- Time to orientation
- Modified Aldrete Recovery Score
- Time required to achieve an Aldrete score ≥ 9
- Duration of stay in the Post-Anesthesia Care Unit (PACU)

Patient Satisfaction

Patient satisfaction was evaluated 24 hours after surgery using a 5-point Likert satisfaction scale, where:

- Very dissatisfied
- Dissatisfied
- Neutral
- Satisfied
- Very satisfied

Postoperative Assessment

Patients were observed for 24 hours after surgery for:

- Pain using the Visual Analogue Scale (VAS)
- Requirement of rescue analgesia
- Postoperative nausea and vomiting (PONV)
- Shivering
- Sedation
- Dizziness
- Any perioperative complications or adverse events

Outcome Measures

Primary Outcomes

- Hemodynamic stability
- Recovery profile
- Patient satisfaction

Secondary Outcomes

- Time to extubation
- Duration of PACU stay
- Postoperative pain scores
- Incidence of PONV
- Rescue analgesic requirement
- Perioperative adverse events and complications

Data Collection

All demographic characteristics, intraoperative observations, recovery parameters, postoperative outcomes, and patient satisfaction scores were recorded in a predesigned case record form by trained investigators. Data were subsequently entered into a computerised database for analysis.

Statistical Analysis

The collected data were entered into Microsoft Excel and analysed using SPSS version 26.0. Continuous variables were expressed as mean $\pm$ standard deviation (SD), while categorical variables were presented as frequencies and percentages. Continuous variables were compared using the independent Student's *t*-test,

whereas categorical variables were analysed using the Chi-square test or Fisher's exact test, as appropriate. Repeated measures ANOVA was used for comparison of serial hemodynamic parameters between the two groups. A *p*-value <0.05 was considered statistically significant.

RESULTS AND OBSERVATIONS

A total of 95 patients undergoing elective laparoscopic procedures under general anaesthesia were enrolled in the study. Patients were randomised into Group T (Total Intravenous Anaesthesia, *n* = 48) and Group B (Balanced General Anaesthesia, *n* = 47). Both groups were comparable with respect to demographic characteristics and baseline clinical variables. Total Intravenous Anaesthesia demonstrated superior intraoperative hemodynamic stability, faster postoperative recovery, and higher patient satisfaction compared with Balanced General Anaesthesia.

Table 1. Baseline Clinical Characteristics

Parameter	Group T (n=48)	Group B (n=47)	p-value
Heart Rate (beats/min)	79.8 $\pm$ 8.1	80.5 $\pm$ 7.8	0.663
Systolic BP (mmHg)	123.6 $\pm$ 10.2	124.8 $\pm$ 9.8	0.542
Diastolic BP (mmHg)	78.5 $\pm$ 7.4	79.2 $\pm$ 7.6	0.647
Mean Arterial Pressure (mmHg)	93.5 $\pm$ 6.5	94.4 $\pm$ 6.8	0.501
SpO ₂ (%)	98.7 $\pm$ 0.8	98.6 $\pm$ 0.9	0.712
Body Weight (kg)	64.3 $\pm$ 8.5	65.1 $\pm$ 7.9	0.624

Observation: Baseline clinical parameters were comparable between the two groups.

Table 2. Preoperative Laboratory Investigations

Investigation	Group T	Group B	p-value
Hemoglobin (g/dL)	13.2 $\pm$ 1.4	13.0 $\pm$ 1.5	0.468
Total Leukocyte Count (/mm ³)	7250 $\pm$ 1180	7390 $\pm$ 1215	0.564
Platelet Count ($\times 10^5$ /mm ³)	2.62 $\pm$ 0.48	2.58 $\pm$ 0.51	0.681
Random Blood Sugar (mg/dL)	104.6 $\pm$ 15.8	106.3 $\pm$ 16.1	0.592
Serum Creatinine (mg/dL)	0.86 $\pm$ 0.18	0.88 $\pm$ 0.16	0.576
Blood Urea (mg/dL)	24.6 $\pm$ 5.8	25.2 $\pm$ 5.5	0.612
SGOT (U/L)	28.4 $\pm$ 7.3	29.1 $\pm$ 6.9	0.631
SGPT (U/L)	30.8 $\pm$ 8.1	31.6 $\pm$ 8.5	0.648

Observation: Routine laboratory investigations were within normal limits and comparable between both groups.

Table 3. Serum Electrolytes

Parameter	Group T	Group B	p-value
Sodium (mEq/L)	138.8 $\pm$ 2.6	139.1 $\pm$ 2.8	0.587
Potassium (mEq/L)	4.18 $\pm$ 0.39	4.22 $\pm$ 0.41	0.621
Chloride (mEq/L)	102.4 $\pm$ 2.8	102.8 $\pm$ 3.0	0.534

Observation: No significant difference in serum electrolyte values between groups.

Table 4. Preoperative ECG and Chest X-ray Findings

Investigation	Group T (n=48)	Group B (n=47)
Normal ECG	46 (95.8%)	45 (95.7%)
Minor ECG Changes	2 (4.2%)	2 (4.3%)
Normal Chest X-ray	47 (97.9%)	46 (97.9%)
Mild Abnormality	1 (2.1%)	1 (2.1%)

Observation: Most patients had normal ECG and chest radiographic findings.

Table 5. Intraoperative Hemodynamic Changes

Time Point	HR Group T	HR Group B	p-value
Baseline	79.8 $\pm$ 8.1	80.5 $\pm$ 7.8	0.663
After Induction	72.6 $\pm$ 7.1	76.8 $\pm$ 8.4	0.009
After Intubation	81.3 $\pm$ 7.5	90.2 $\pm$ 8.7	<0.001
Pneumoperitoneum	77.5 $\pm$ 6.8	86.5 $\pm$ 8.6	<0.001

End of Surgery	74.2 ± 6.2	82.3 ± 7.5	<0.001
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Observation: TIVA maintained significantly better heart rate stability.

Table 6. Blood Pressure Changes During Surgery

Time Point	MAP Group T	MAP Group B	p-value
Baseline	93.5 ± 6.5	94.4 ± 6.8	0.501
After Induction	86.1 ± 5.7	90.8 ± 6.5	0.001
After Intubation	94.8 ± 6.4	102.3 ± 7.2	<0.001
Pneumoperitoneum	91.6 ± 5.8	98.7 ± 6.8	<0.001
End of Surgery	88.9 ± 5.9	95.6 ± 6.7	<0.001

Observation: Mean arterial pressure remained more stable with TIVA.

Table 7. Respiratory Monitoring

Parameter	Group T	Group B	p-value
SpO ₂ (%)	99.1 ± 0.6	98.9 ± 0.7	0.134
EtCO ₂ (mmHg)	35.2 ± 2.8	35.7 ± 2.9	0.396
Respiratory Rate (/min)	13.8 ± 1.5	14.1 ± 1.6	0.348
Body Temperature (°C)	36.7 ± 0.4	36.6 ± 0.5	0.271

Observation: Respiratory variables remained comparable in both groups.

Table 8. Recovery Profile

Parameter	Group T	Group B	p-value
Spontaneous Respiration (min)	4.8 ± 1.3	6.4 ± 1.7	<0.001
Eye Opening (min)	6.5 ± 1.6	9.2 ± 2.1	<0.001
Extubation Time (min)	8.4 ± 1.8	11.5 ± 2.4	<0.001
Response to Commands (min)	9.7 ± 2.0	13.1 ± 2.5	<0.001
Orientation Time (min)	11.4 ± 2.3	15.6 ± 3.0	<0.001
PACU Stay (min)	47.8 ± 8.9	60.5 ± 10.4	<0.001

Observation: Recovery was significantly faster in the TIVA group.

Table 9. Modified Aldrete Score

Time	Group T	Group B	p-value
5 Minutes	8.2 ± 0.8	7.3 ± 0.9	<0.001
10 Minutes	9.5 ± 0.6	8.6 ± 0.8	<0.001
15 Minutes	9.9 ± 0.3	9.4 ± 0.5	<0.001

Table 10. Postoperative Outcomes and Patient Satisfaction

Parameter	Group T	Group B	p-value
VAS Score	3.1 ± 0.9	3.8 ± 1.0	<0.001
Rescue Analgesia Required	14 (29.2%)	24 (51.1%)	0.028
PONV	6 (12.5%)	19 (40.4%)	0.002
Shivering	2 (4.2%)	7 (14.9%)	0.078
Sedation	1 (2.1%)	5 (10.6%)	0.091
Dizziness	3 (6.3%)	8 (17.0%)	0.097
Mean Satisfaction Score	4.5 ± 0.6	3.9 ± 0.8	<0.001

Observation: Patients receiving TIVA experienced lower postoperative pain, fewer complications, and significantly higher satisfaction than those receiving balanced general anaesthesia.

DISCUSSION

The present prospective randomised controlled study compared Total Intravenous Anaesthesia (TIVA) with Balanced General Anaesthesia (BGA) in patients undergoing elective laparoscopic procedures. The findings demonstrated that TIVA provided significantly better intraoperative hemodynamic stability, faster postoperative recovery, lower postoperative pain scores, reduced incidence of postoperative nausea and vomiting, decreased requirement for rescue analgesia,

and higher patient satisfaction compared with Balanced General Anaesthesia.

Both study groups were comparable with respect to baseline clinical characteristics and laboratory investigations, indicating successful randomization and minimising the possibility of selection bias. No statistically significant differences were observed in baseline heart rate, blood pressure, oxygen saturation, body weight, haematological parameters, renal function tests, liver function tests, serum electrolytes,

or preoperative ECG findings. Similar baseline comparability has been reported in previous randomized studies comparing intravenous and inhalational anaesthetic techniques.[5,7]

One of the principal findings of the present study was superior hemodynamic stability in patients receiving TIVA. Heart rate and mean arterial pressure remained significantly more stable throughout induction, intubation, pneumoperitoneum, and emergence compared with Balanced General Anaesthesia. Propofol suppresses sympathetic nervous system activity and attenuates catecholamine release during stressful surgical stimuli, thereby reducing exaggerated cardiovascular responses. Volatile anaesthetics, although effective in maintaining anaesthesia, may permit greater fluctuations during periods of intense sympathetic stimulation such as laryngoscopy and CO₂ insufflation.[6,8] Similar observations were reported by Gupta et al. and Wu et al., who demonstrated lower perioperative heart rate and blood pressure variability with propofol-based anaesthesia.

Respiratory monitoring revealed no statistically significant differences in oxygen saturation, end-tidal carbon dioxide, respiratory rate, or body temperature between the two groups. Both anaesthetic techniques maintained adequate oxygenation and ventilation throughout surgery. These findings are consistent with previous literature demonstrating that when controlled mechanical ventilation is employed, respiratory outcomes remain comparable irrespective of the maintenance anaesthetic technique.[3,9]

Recovery characteristics represented another important outcome of this study. Patients receiving TIVA achieved spontaneous respiration, eye opening, extubation, response to verbal commands, orientation, and PACU discharge significantly earlier than those receiving Balanced General Anaesthesia. The favourable pharmacokinetic profile of propofol, characterized by rapid redistribution and high metabolic clearance, contributes to predictable emergence even after prolonged infusions. Conversely, elimination of inhalational agents depends on pulmonary washout and tissue uptake, which may prolong recovery, particularly after longer procedures.[5,10] Similar findings have been documented in several randomised controlled trials comparing propofol with volatile anaesthetics.

Modified Aldrete scores were consistently higher in the TIVA group during the early postoperative period, reflecting more rapid restoration of consciousness, respiratory function, circulation, and activity. Faster achievement of discharge criteria can improve operating room efficiency, reduce PACU occupancy, and facilitate enhanced recovery protocols. These findings agree with ERAS recommendations emphasising rapid postoperative recovery following minimally invasive surgery.[12]

Postoperative pain scores were significantly lower in the TIVA group, and fewer patients required rescue

analgesia. Propofol has been reported to possess mild antinociceptive and antihyperalgesic effects through modulation of central nervous system pathways. Furthermore, improved hemodynamic control and reduced neuroendocrine stress responses may contribute to decreased postoperative pain perception. Similar reductions in postoperative analgesic requirements have been observed in previous studies evaluating propofol-based anaesthesia.[13]

The incidence of postoperative nausea and vomiting was significantly lower among patients receiving TIVA. This finding is consistent with extensive evidence identifying volatile anaesthetic agents as independent risk factors for PONV. Propofol exerts intrinsic antiemetic effects, likely through inhibition of serotonergic pathways and reduced stimulation of the chemoreceptor trigger zone. Consequently, current international guidelines recommend propofol-based TIVA as an effective strategy for preventing PONV in patients at moderate or high risk.[10,14]

Although postoperative shivering, sedation, and dizziness occurred less frequently in the TIVA group, the differences did not reach statistical significance. The relatively low incidence of these complications in both groups may be attributed to standardised perioperative warming measures, careful anaesthetic titration, and appropriate postoperative monitoring. Comparable findings have been reported by previous investigators.[7,11]

Patient satisfaction was significantly higher in the TIVA group. Higher satisfaction scores likely resulted from smoother recovery, lower postoperative pain, reduced nausea and vomiting, and earlier return of cognitive function. Modern anaesthesia practice increasingly recognizes patient-reported outcomes as important indicators of healthcare quality, and improved satisfaction has been consistently associated with propofol-based anaesthesia in ambulatory and minimally invasive surgery.[11,15]

The strengths of the present study include its prospective randomised controlled design, standardised anaesthetic protocol, comprehensive assessment of intraoperative and postoperative outcomes, and inclusion of clinically relevant patient-centred endpoints. However, certain limitations should be acknowledged. This was a single-centre study with a relatively modest sample size, which may limit generalizability. Long-term postoperative outcomes and cost-effectiveness analyses were not evaluated. Future multicenter randomized trials involving larger patient populations and diverse laparoscopic procedures would further strengthen the evidence regarding the optimal anaesthetic technique.

Overall, the findings of the present study indicate that Total Intravenous Anaesthesia offers clinically meaningful advantages over Balanced General Anaesthesia for elective laparoscopic surgery by providing superior hemodynamic stability, faster postoperative recovery, reduced postoperative nausea

and vomiting, lower analgesic requirements, and improved patient satisfaction while maintaining comparable intraoperative respiratory safety.

Clinical Implications

The findings of the present study suggest that propofol-based Total Intravenous Anaesthesia offers superior perioperative hemodynamic stability, facilitates enhanced postoperative recovery, reduces postoperative nausea and vomiting, and improves patient satisfaction. These advantages may contribute to improved operating room efficiency, shorter PACU stay, and better implementation of Enhanced Recovery After Surgery (ERAS) protocols in elective laparoscopic surgery.

Future Recommendations

Further multicentre randomized controlled trials involving larger sample sizes, different laparoscopic procedures, cost-effectiveness analyses, and long-term postoperative outcomes are recommended to validate these findings and establish evidence-based recommendations regarding the routine use of TIVA in laparoscopic surgery.

Limitations

The present study has certain limitations. It was conducted at a single tertiary care centre with a relatively modest sample size, which may limit the generalizability of the findings. Bispectral Index (BIS) monitoring was not used to objectively assess the depth of anaesthesia. In addition, long-term postoperative outcomes, quality-of-life measures, and cost-effectiveness analyses were not evaluated. Future multicentre studies with larger sample sizes are warranted to validate these findings.

CONCLUSION

Total Intravenous Anaesthesia (TIVA) provided significantly better intraoperative hemodynamic stability, faster postoperative recovery, lower postoperative pain scores, reduced incidence of postoperative nausea and vomiting, decreased rescue analgesic requirements, and higher patient satisfaction compared with Balanced General Anaesthesia (BGA) in patients undergoing elective laparoscopic procedures. Both anaesthetic techniques were safe and effective; however, TIVA demonstrated superior overall perioperative outcomes, making it a preferable anaesthetic technique for elective laparoscopic surgery.

Data Availability Statement

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

Funding

The authors received no external funding for this study.

Conflict of Interest

The authors declare that they have no conflict of interest regarding the publication of this study.

Author Contributions

Dr. Divyashri C.N.: Conceptualization, study design, patient recruitment, data collection, interpretation of results, manuscript preparation.

Dr. Bharath M.S.: Statistical analysis, interpretation of data, manuscript review, critical revision.

Dr. Preethi H.N.: Literature review, postoperative assessment, manuscript editing and final approval.

All authors read and approved the final manuscript.

Acknowledgement

The authors sincerely thank the Department of Anaesthesiology, CSI Redfern Mission Hospital, Hassan, Karnataka, and all the patients who willingly participated in this study.

Abbreviations

ASA – American Society of Anesthesiologists

BGA – Balanced General Anaesthesia

BMI – Body Mass Index

CBC – Complete Blood Count

ECG – Electrocardiogram

ERAS – Enhanced Recovery After Surgery

EtCO₂ – End-Tidal Carbon Dioxide

HR – Heart Rate

MAP – Mean Arterial Pressure

PACU – Post-Anaesthesia Care Unit

PONV – Postoperative Nausea and Vomiting

SBP – Systolic Blood Pressure

DBP – Diastolic Blood Pressure

SpO₂ – Peripheral Oxygen Saturation

TIVA – Total Intravenous Anaesthesia

VAS – Visual Analogue Scale

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