e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2025; 16(12); 01-05

Original Research Article

Comparative Evaluation of Intraocular Pressure Changes in Trendelenburg Position: Propofol-Based TIVA versus Desflurane Anaesthesia in Laparoscopic Surgery

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Received: 25-09-2025 / Revised: 23-10-2025 / Accepted: 26-11-2025
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Conflict of interest: Nil

Abstract:

Background: Laparoscopic surgeries performed in steep Trendelenburg position with pneumoperitoneum cause significant intraocular pressure (IOP) elevation, posing a potential risk for perioperative ocular complications. Anaesthetic technique plays a crucial role in modulating these changes. This study compares the effects of Total Intravenous Anaesthesia (TIVA) using propofol versus desflurane-based inhalational anaesthesia on IOP and haemodynamic stability.

Methodology: A prospective, randomized comparative study was conducted on 60 patients (ASA I–II) undergoing elective laparoscopic surgery. Patients were assigned to either the Propofol TIVA group (Group P, n=30) or the Desflurane group (Group D, n=30). Intraocular pressure was recorded at baseline, post-induction, after pneumoperitoneum, and at 10, 30, and 60 minutes of Trendelenburg, followed by the return to supine position. Haemodynamic parameters were also assessed. Statistical analysis was performed using t-tests and chi-square tests, with $p<0.05$ considered significant.

Results: Baseline demographics were comparable across groups. Group D showed significantly higher IOP at all surgical stress points—after induction ($p=0.01$), after pneumoperitoneum ($p<0.001$), and during Trendelenburg at 10, 30, and 60 minutes (all $p<0.001$). IOP returned toward baseline after resuming supine position but remained significantly higher in Group D ($p<0.001$). Haemodynamic variables including mean arterial pressure showed no significant intergroup differences at any time point.

Conclusion: Propofol-based TIVA is more effective in attenuating intraoperative IOP rise than desflurane anaesthesia during laparoscopic surgeries requiring pneumoperitoneum and Trendelenburg position. Both techniques provide stable haemodynamics; however, TIVA may be preferable in patients at risk for ocular hypertension or glaucoma.

Keywords: Intraocular Pressure, TIVA, Desflurane, Trendelenburg Position, Laparoscopic Surgery, pneumoperitoneum.

Introduction

Laparoscopic surgery has become the preferred approach for many abdominal and pelvic procedures due to reduced postoperative pain, shorter hospital stay, and faster recovery. Many of these surgeries require the Trendelenburg position, which increases venous return, elevates central venous pressure, and raises intracranial and intraocular pressures (IOP). Elevated IOP during anaesthesia may predispose patients—particularly those with glaucoma or optic nerve vulnerability—to ischemic optic neuropathy or postoperative visual loss (POVL) [1,2].

IOP is influenced by multiple factors including systemic haemodynamics, extraocular muscle tone, aqueous humor dynamics, and venous drainage through episcleral veins [3]. During laparoscopic surgery, CO_2 pneumoperitoneum and the steep Trendelenburg position exacerbate venous congestion and impede aqueous outflow, leading to IOP rise [4]. Prolonged elevations or extreme peaks of IOP may compromise ocular perfusion pressure (OPP), which is determined by mean arterial pressure minus IOP. Decreased OPP has been linked with retinal ganglion cell dysfunction and postoperative visual changes [5].

The choice of anaesthetic agent influences IOP trends intraoperatively. Propofol-based total intravenous anaesthesia (TIVA) has been shown to reduce IOP by decreasing aqueous humor production, relaxing extraocular muscles, and

lowering systemic vascular resistance [6]. In contrast, desflurane, a volatile anaesthetic with low blood-gas solubility, may cause sympathetic stimulation at higher concentrations, leading to increased heart rate, blood pressure, and subsequently increased IOP [7]. Several studies have attempted to compare the effects of inhalational agents and TIVA on IOP. Propofol consistently demonstrates an IOP-lowering effect, while inhalational agents such as isoflurane, sevoflurane, and desflurane often show variable responses [8,9]. However, limited studies specifically compare Propofol TIVA and Desflurane in the context of Trendelenburg position combined with pneumoperitoneum, conditions known to exaggerate IOP elevations. Given the rising incidence of laparoscopic pelvic surgery and the increasing recognition of perioperative ocular safety, a direct comparative evaluation is clinically significant.

Understanding how common anaesthetic techniques influence IOP in these conditions will help anaesthesiologists select optimal agents, especially for patients with pre-existing ocular pathology. Therefore, this study aims to evaluate and compare changes in intraocular pressure during laparoscopic surgeries requiring Trendelenburg position under Propofol-based TIVA versus Desflurane anaesthesia.

Materials and Methods

Study Design: A prospective, randomized, comparative study was conducted in the Department of Anaesthesiology after obtaining institutional ethics committee approval and written informed consent from all participants.

Sample Size: A total of 60 adult patients (30 in each group) undergoing elective laparoscopic pelvic or lower abdominal surgery requiring Trendelenburg position were included.

Inclusion Criteria:

- ASA physical status I and II
- Age 18–60 years
- Elective laparoscopic surgery expected to require ≥30 minutes of Trendelenburg position

Exclusion Criteria:

- Known glaucoma or ocular hypertension
- Pre-existing optic nerve disorders
- Use of drugs affecting IOP
- Uncontrolled hypertension
- Anticipated difficult airway
- BMI > 35 kg/m²

Randomization: Patients were assigned into two groups using computer-generated random numbers:

- **Group P (Propofol TIVA)**
- **Group D (Desflurane Anaesthesia)**

Anaesthetic Technique:

Group P:

- Induction: Propofol 2 mg/kg
- Maintenance: Propofol infusion 100–150 µg/kg/min + Remifentanil infusion
- Muscle relaxation: Vecuronium

Group D:

- Induction: Propofol 2 mg/kg
- Maintenance: Desflurane 4–6% in oxygen-air mixture
- Muscle relaxation: Vecuronium

Surgical Conditions:

- Pneumoperitoneum maintained at 12–14 mmHg
- Trendelenburg position: 25–30 degrees
- Ventilation adjusted to maintain $EtCO_2$ between 35–40 mmHg

IOP Measurement: IOP was measured using a handheld Perkins applanation tonometer at:

- T0: Baseline (pre-induction)
- T1: After induction
- T2: After pneumoperitoneum
- T3: 10 min in Trendelenburg
- T4: 30 min in Trendelenburg
- T5: 60 min in Trendelenburg
- T6: After return to supine position

All measurements were taken by the same ophthalmologist to avoid inter-observer variation.

Haemodynamic Monitoring: Heart rate, mean arterial pressure, $EtCO_2$, and SpO_2 were recorded at corresponding intervals.

Statistical Analysis: Data were analysed using SPSS v26.

- Continuous variables: Mean ± SD
- Categorical variables: Chi-square
- Comparison between groups: Independent t-test
- $p < 0.05$ considered statistically significant

Results

Table 1: Demographic Profile of Patients

Variable	Group P (n=30)	Group D (n=30)	p- value
Age (years)	42.6 ± 8.1	41.8 ± 7.4	0.68
Gender (M/F)	14/16	13/17	0.79
BMI (kg/m²)	26.3 ± 2.5	26.7 ± 2.9	0.54
ASA I/II	18/12	17/13	0.80

Both groups were comparable in terms of age, gender distribution, BMI, and ASA physical status. No statistically significant difference was observed in any demographic variable ($p > 0.05$).

Table 2: Intraocular Pressure Changes (mmHg)

Time Interval	Group P (TIVA)	Group D (Desflurane)	p-value
T0 Baseline	14.2 ± 2.1	14.5 ± 2.3	0.60
T1 After induction	12.1 ± 1.8	13.4 ± 2.0	0.01*
T2 After pneumoperitoneum	16.5 ± 2.4	19.8 ± 2.6	<0.001*
T3 Trendelenburg 10 min	18.2 ± 2.8	22.4 ± 3.1	<0.001*
T4 Trendelenburg 30 min	19.5 ± 3.0	24.1 ± 3.4	<0.001*
T5 Trendelenburg 60 min	20.1 ± 3.3	25.7 ± 3.6	<0.001*
T6 After supine	15.8 ± 2.2	19.1 ± 2.7	<0.001*

*** Statistically significant.**

IOP increased in both groups after pneumoperitoneum and Trendelenburg position; however, the rise was significantly lower in the Propofol TIVA group at all intraoperative time points (T1–T6). Desflurane produced consistently higher IOP values, showing a statistically significant difference compared with TIVA ($p < 0.001$).

Table 3: Haemodynamic Parameters (Mean Arterial Pressure at Key Time Points)

Time	Group P	Group D	p-value
Baseline	94 ± 8	95 ± 7	0.62
After induction	82 ± 6	85 ± 7	0.08
After pneumoperitoneum	90 ± 7	92 ± 8	0.29
Trendelenburg 30 min	93 ± 6	94 ± 7	0.64

Mean arterial pressure remained stable and comparable between the two groups throughout the surgery. No significant haemodynamic differences were found at baseline, induction, pneumoperitoneum, or during Trendelenburg positioning ($p > 0.05$).

Discussion

The present study investigated intraocular pressure (IOP) changes during laparoscopic surgery performed in the Trendelenburg position and compared the effects of two commonly used anaesthetic techniques—Propofol-based total intravenous anaesthesia (TIVA) and Desflurane anaesthesia. Our findings show that while IOP increased in both groups after pneumoperitoneum and Trendelenburg positioning, the magnitude of increase was significantly lower in the Propofol TIVA group throughout the intraoperative period.

These results reinforce the existing understanding that anaesthetic choice plays an important role in modulating IOP, especially in settings where physiological factors predispose patients to ocular pressure elevations.

Trendelenburg Position and Pneumoperitoneum Influence on IOP: The steep Trendelenburg position required for pelvic and lower abdominal laparoscopic surgeries is known to increase IOP due to gravitational shifts, increased venous return, elevated intrathoracic pressure, and obstruction of episcleral venous drainage. In addition, CO_2 pneumoperitoneum raises intra-abdominal pressure and diaphragm elevation, leading to further increases in central venous pressure and IOP [10, 11]. Our study demonstrates similar trends, with a significant rise in IOP following pneumoperitoneum and continuing throughout 10, 30, and 60 minutes in Trendelenburg position. These findings align closely with previous research by Ozcan et al. and Cheng et al., who documented progressive IOP elevations during pneumoperitoneum and steep Trendelenburg [12, 2].

The increase in IOP can have important clinical implications. Elevated IOP decreases ocular perfusion pressure (OPP), defined as the difference between mean arterial pressure and IOP.

A reduction in OPP can compromise retinal ganglion cell function, increase the risk of ischemic optic neuropathy, and potentially contribute to postoperative visual loss (POVL), especially in prolonged surgeries [13, 14]. Although POVL remains rare, its devastating consequences warrant careful perioperative evaluation of risk factors.

Role of Anaesthetic Agents on IOP Regulation: Anaesthetic agents influence IOP through multiple mechanisms, including changes in systemic vascular resistance, modulation of aqueous humor production, and effects on extraocular muscle tone.

Propofol and volatile anaesthetics differ significantly in their physiological effects, which may explain the IOP trends observed in this study.

Propofol TIVA and Its Protective Effect on IOP: Propofol has consistently been shown to lower IOP by reducing aqueous humor production, decreasing extraocular muscle tone, and producing systemic hypotension, particularly during induction [6]. In our study, Propofol significantly decreased IOP after induction (T1), consistent with results report-

ed by Pandey et al. and Gupta et al. [6, 8]. This initial reduction contributes to an overall more stable IOP trajectory, even after pneumoperitoneum and Trendelenburg positioning. During Trendelenburg, although the IOP in the Propofol group did increase, the magnitude of rise remained significantly lower than in the Desflurane group at all recorded time points. This suggests that Propofol suppresses sympathetic activity and modulates the physiological factors that lead to increased IOP. These findings are in agreement with literature showing that Propofol provides better ocular protection during surgeries associated with hemodynamic fluctuations [15].

Furthermore, Propofol's ability to maintain a more stable ocular perfusion pressure compared with volatile agents may be clinically important for patients with glaucoma, ocular hypertension, or compromised optic nerves.

Desflurane and Its Effect on IOP Elevation: Desflurane, while advantageous due to its low blood-gas solubility and rapid emergence profile, has been associated with sympathetic stimulation, particularly when high concentrations are used or when rapid changes in concentration occur [16]. This sympathetic activation can increase blood pressure, heart rate, and consequently IOP. In the present study, IOP values in the Desflurane group remained consistently higher than those in the Propofol group after induction, after pneumoperitoneum, and at all intervals during Trendelenburg.

Kim et al. reported that Desflurane increases IOP due to its effects on sympathetic outflow and hemodynamics, a finding that mirrors the results of the current study [9]. Similarly, Ebert demonstrated that Desflurane causes dose-dependent sympathetic activation, which may exacerbate elevations in IOP under physiologically stressful conditions such as pneumoperitoneum [16].

However, it is worth noting that the haemodynamic parameters in our study remained comparable between the two groups, suggesting that IOP changes observed with Desflurane are not solely due to systemic hemodynamic changes but may involve direct ocular or episcleral venous effects.

Clinical Considerations for Anaesthetic Selection: The findings of this study underscore the importance of selecting an anaesthetic technique that minimizes IOP elevation for patients undergoing laparoscopic surgeries in the Trendelenburg position. In most healthy individuals, transient IOP elevations may not result in clinically significant outcomes.

However, in patients with pre-existing ocular conditions such as glaucoma, optic disc cupping, reduced ocular perfusion pressure, or retinal vascular disease, even moderate increases in IOP may heighten the risk of optic nerve damage.

Based on the results and the available literature, Propofol TIVA appears to provide a more favourable ocular profile. It may be preferred for:

- Patients with known glaucoma or ocular hypertension
- Surgeries requiring prolonged Trendelenburg positioning
- Elderly patients with compromised optic nerve perfusion
- Patients with cardiovascular risk factors where sympathetic stimulation is undesirable

Although Desflurane is widely used and offers advantages in terms of rapid induction and recovery, anaesthesiologists must be cautious when using it in surgeries where IOP management is critical. Slow, controlled adjustments in vapour concentration may help reduce sympathetic responses but do not completely mitigate the IOP rise associated with the agent.

Comparison with Previous Studies: The pattern of IOP increase observed in both groups corresponds well with previously published literature. Our findings are consistent with those of Ozcan et al., [12] who demonstrated significant rises in IOP in steep Trendelenburg [12]; and Cheng et al., who highlighted the role of pneumoperitoneum in IOP elevation [2]. Additionally, Gupta et al. found that Propofol TIVA was associated with lower IOP compared to inhalational agents during general anaesthesia [8], reinforcing the superior ocular profile of Propofol.Kim et al. observed significantly higher IOP values under Desflurane anaesthesia, particularly during physiological stress such as pneumoperitoneum, consistent with the results of our study [9].

Conclusion

Propofol-based TIVA produces significantly lower increases in intraocular pressure compared to Desflurane during laparoscopic surgeries requiring Trendelenburg positioning. Propofol may therefore be preferred in patients at risk of ocular hypertension.

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