ORIGINAL ARTICLE

# The effect of anesthetic agents on intraocular pressure during laparoscopic gynecological surgery performed in the Trendelenburg position: A randomized clinical trial

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## ABSTRACT

**BACKGROUND:** Intraocular pressure (IOP) increases due to pneumoperitoneum and the Trendelenburg position during laparoscopic surgery. Apart from ketamine and suxamethonium, anesthetic agents generally reduce IOP by various extents. The present study investigated the effects of combinations of four anesthetic agents on IOP during laparoscopic gynecological surgery.

**METHODS:** Patients (n=100) were assigned to one of the four groups: Group 1 (n=25; pentothal induction + desflurane/remifentanil maintenance), Group 2 (n=25; propofol induction + sevoflurane/remifentanil maintenance), Group 3 (n=25; propofol induction + desflurane/remifentanil maintenance), and Group 4 (n=25; pentothal induction + sevoflurane/remifentanil maintenance). The IOPs recorded before anesthesia induction, after intubation, after carbon dioxide insufflation, in the Trendelenburg position, and after extubation were compared among the groups. Hemodynamic parameters were also evaluated.

**RESULTS:** Induction in Group 2 and Group 3 used propofol. When the IOP in the Trendelenburg position was compared with the IOP before induction, there was no statistically significant difference in Groups 2 and 3 ($p>0.05$). In Groups 1 and 4, pentothal was used for induction. The IOP in Groups 1 and 4 was statistically significantly higher in the Trendelenburg position than it was before induction (0.027–0.001).

**CONCLUSION:** To minimize the variation in IOP in the Trendelenburg position during laparoscopic gynecological surgeries, we recommend the use of propofol for induction, independent of desflurane or sevoflurane use.

**Keywords:** Anesthetic agents; intraocular pressure; laparoscopic surgery.

## INTRODUCTION

Laparoscopic surgery has become preferred to conventional open surgery for its minimally invasive nature, with less bleeding, post-operative pain, and early discharge.[1,2] During laparoscopic surgery, carbon dioxide ($CO_2$) pneumoperitoneum (PP) and the Trendelenburg position, up to 45°, are used to obtain optimal visualization and appropriate images.[3] Abdominal visceral organs are removed from the operation site by the influence of gravity; however, prolonged Trendelenburg positioning is associated with adverse outcomes.[4] The circulatory and respiratory systems may be

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affected, although these effects are usually transient and well tolerated.[5,6]

In addition, there are several studies reporting increased intracranial pressure and intraocular pressure (IOP) with the Trendelenburg position and PP.[2,7] During laparoscopic surgery, PP and the Trendelenburg position are associated with increased IOP.[8,9] There are also reports suggesting the increased incidence of post-operative ocular complications and vision loss.[10,11] The effects on the visual system vary depending on several factors, such as the patient, surgeon, and method of anesthesia. Many studies have examined the effects of different anesthetics on IOP during laparoscopic surgery.[12,13]

We studied the effects of different anesthetic agents on IOP. We know IOP increases in the Trendelenburg position. We hypothesize that induction with propofol in laparoscopic gynecological operations using PP and the Trendelenburg position will minimize the effect of the Trendelenburg position on IOP. In our study, difference from other studies, two different intravenous anesthetic agents used in anesthesia induction were combined with two different inhalation anesthetics and their effects on IOP were investigated.

The main purpose of this study was to investigate the effects of combinations of four anesthetic agents on IOP and hemodynamic and respiratory parameters in patients undergoing laparoscopic gynecological surgery.

## MATERIALS AND METHODS

This prospective double-blind randomized clinical trial was conducted at the Department of Obstetrics and Gynecology Bakirköy Dr. Sadi Konuk Training and Research Hospital between October 1, 2017, and February 15, 2018. The study protocol was approved by the Ethics Committee of Health Science University, Bakirköy Dr. Sadi Konuk Training and Research Hospital, İstanbul, Turkey. (date: July 07, 2017; no. 2017/168). Written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki. One hundred patients, 18–70 years of age, were included in the study. Patients were randomized according to a computerized randomization scheme.

The inclusion criteria included patients with an American Society of Anesthesiologists (ASA) Functional Status Class I–III undergoing elective laparoscopic gynecological surgery.

The exclusion criteria included known glaucoma, a chronic eye infection or disease, prior eye surgery, neurological disorders affecting the eye(s), high refraction defects, and a body mass index (BMI) >40 kg/m$^2$.

A detailed medical history of eye conditions was obtained from each patient. All patients were monitored with non-invasive blood pressure, electrocardiography, and peripheral oxygen saturation ($SPO_2$) measurements in the operating theater. A 20-G peripheral intravenous cannula was inserted for a crystalloid fluid infusion at a rate of 4–6 mL/kg/h.

The ophthalmologist measuring IOP was blinded to the anesthesia method used. After pre-operative measurements, the ophthalmologist left the operating room so that the anesthesia expert could anesthetize the patients. The expert left before the ophthalmologist returned to the operating room. Patients were monitored during the surgery by a different anesthesiologist who was unaware of the anesthetic medications administered (the anesthesiologist giving anesthesia to the patient is different from the anesthesiologist following the patient). The patient was also unaware of the anesthetic method used.

The patients (n=100) were divided into four groups as follows:
Group 1 (n=25): Induction with 4–7 mg/kg of pentothal, 0.6–0.8 mg/kg of rocuronium, and 2 μg/kg of fentanyl; maintenance with desflurane inhalation at a minimum alveolar concentration (MAC) rate of 0.8–1 and 0.05–0.1 μg/kg/min of remifentanil infusion.

Group 2 (n=25): Induction with 2–2.5 mg/kg of propofol, 0.6–0.8 mg/kg of rocuronium, and 2 μg/kg of fentanyl; maintenance with sevoflurane inhalation at a MAC rate of 0.8–1 and 0.05–0.1 μg/kg/min of remifentanil.

Group 3 (n=25): Induction with 2–2.5 mg/kg of propofol, 0.6–0.8 mg/kg of rocuronium, and 2 μg/kg of fentanyl; maintenance with desflurane inhalation at a MAC rate of 0.8–1 and 0.05–0.1 μg/kg/min of remifentanil infusion.

Group 4 (n=25): Induction with 4–7 mg/kg of pentothal, 0.6–0.8 mg/kg of rocuronium, and 2 μg/kg of fentanyl; maintenance with sevoflurane inhalation at a MAC rate of 0.8–1 and 0.05–0.1 μg/kg/min of remifentanil infusion.

Following anesthesia induction, orotracheal intubation was performed and mechanical ventilation was provided in the volume-controlled mode with a tidal volume of 6–8 mL/kg, positive end-expiratory pressure of 5–7 cm $H_2O$, and end-tidal $CO_2$ ($EtCO_2$) of 30–40 mmHg. The ASA scores, BMI values, systolic blood pressure (SBP), diastolic blood pressure (DBP), peak heart rate (PHR), and $EtCO_2$ values were recorded.

IOP was measured by an experienced ophthalmologist using an Icare rebound tonometry device (Icare PRO; Icare Finland Oy, Helsinki, Finland). Two measurements were taken from the right and left eyes, and the average of four measurements was taken. The tonometer used was suitable for IOP measurements in a supine position. The device uses the impact rebound technique and does not require constant calibration.[14] A tiny probe was accelerated opposite the cornea and the bounce acceleration was measured and converted to the IOP.[14,15] No

local anesthesia was required during the measurements. Six consecutive measurements were made and averaged.

The IOP measurement was performed in accordance with a predefined standard protocol at specified time points:

1. Before anesthesia induction in the supine position (t1);
2. After intubation (t2); after $CO_2$ insufflation and 1 min after the intra-abdominal pressure reached 12 mmHg (t3); 30 min after Trendelenburg positioning at 35–45° (t4); 5 min after extubation in the supine position (t5).

The rates of the remifentanil and crystalloid fluid infusions were reduced and increased, respectively, if the mean arterial pressure (MAP) became >80% of the pre-induction value. The total volume of IV fluids given from the onset of anesthesia was recorded. When SBP does not respond to fluid therapy, 5 mg of ephedrine were administered. If the heart rate fell below 45 bpm, 0.5 mg of atropine was administered. The remifentanil infusion was increased when the MAP reached >20% of the pre-induction value.

All patients were positioned on the operating table in the Trendelenburg position at 35° and were operated on by a single surgeon. In addition, PP was induced at 12–14 mmHg through $CO_2$ insufflation.

For the prophylactic treatment of post-operative nausea and vomiting, 8 mg of ondansetron (GlaxoSmithKline, Brentford, UK) were intravenously administered. After surgery was completed, 2 mg/kg of sugammadex (100 mg/mL; Depomer Otomasyon Ltd. Şti., Bursa, Turkey) was intravenously administered to reverse the neuromuscular block. When the protective airway reflexes were completely reversed, the patient was extubated and transferred to the recovery unit. Patients with a modified Aldrete recovery score ≥9 were transferred to the ward.

In addition to IOP measurements at each time point, SBP, DBP, PHR, $EtCO_2$, and $SPO_2$ were recorded.

## Statistical Analysis

Statistical analysis was performed using SPSS statistical software for Windows, version 22.0 (IBM Corp., Armonk, NY, USA). The mean pre-operative right IOP was 18.8±3.9 mmHg, while one study reported a mean right IOP before coronary artery bypass surgery of 11.6±2.6 mmHg.[16] Using the G-Power version 3.1.9.4 (Universität Kiel, Germany), alpha error of 0.05, power of 0.80, numerator df of 7.2, four groups, and effect size of 0.4 were accepted and the required sample size was 97. The normality of the distribution was evaluated using the Shapiro–Wilk test. Normally distributed data were analyzed for differences with one-way analysis of variance with post hoc Tukey test and expressed as mean±SD. Abnormally distributed data were analyzed for differences using the Kruskal–Wallis and Mann–Whitney U tests and expressed as medians. The Chi-squared test was used to compare categorical data and Fisher's exact test was used to analyze for differences. The Fisher's exact test was used if Chi-squared test conditions were not met. Categorical data were expressed as percentages. For all data, $p<0.05$ was considered statistically significant.

# RESULTS

The Consort 2010 flow diagram is given in Figure 1.

The mean age of the patients was 35 years with no significant difference among the groups. The BMI and ASA scores were also similar among the four groups (Table 1).

## IOP Measurements

When the groups were separately compared in terms of IOP at t1, t2, t3, t4, and t5, there were no statistically significant differences between the groups (Table 2).

When the IOPs at t1, t2, t3, t4, and t5 were separately compared within the four groups, there were statistically significant differences (Table 2).

**Table 1.** Demographic characteristics of patients (Mean±SD) and (n%)

| | Group 1 (n=25) | Group 2 (n=25) | Group 3 (n=25) | Group 4 (n=25) | p |
|---|---|---|---|---|---|
| Age (years) | 34.8±6.6 | 35.1±6.4 | 34.2±6.1 | 35.1±6.2 | 0.950 |
| BMI (kg/m$^2$) | 28.1±3.4 | 28.2±3.6 | 30.4±4.0 | 29.3±5.1 | 0.064 |
| Total intravenous volume (mL) | 1991.6±820.3 | 1820±896 | 1955.5±1019.3 | 2119.4±948.2 | 0.811 |
| Duration of Anesthesia (minute) | 129.7±40.8 | 121.9±38.7 | 118±43.5 | 145±33.9 | 0.188 |
| Operation time (minute) | 117.78±40.3 | 112.2±42.1 | 106.1±43 | 131.4±33.3 | 0.277 |
| ASA Class, n (%) | | | | | |
| I | 10 (40) | 6 (24) | 3 (12) | 6 (24) | 0.292 |
| II | 12 (48) | 19 (64) | 18 (72) | 16 (76) | |
| III | 3 (12) | 0 (12) | 4 (16) | 3 (0) | |

BMI: Body mass index; ASA: American Society of Anesthesiologists; SD: Standard deviation.

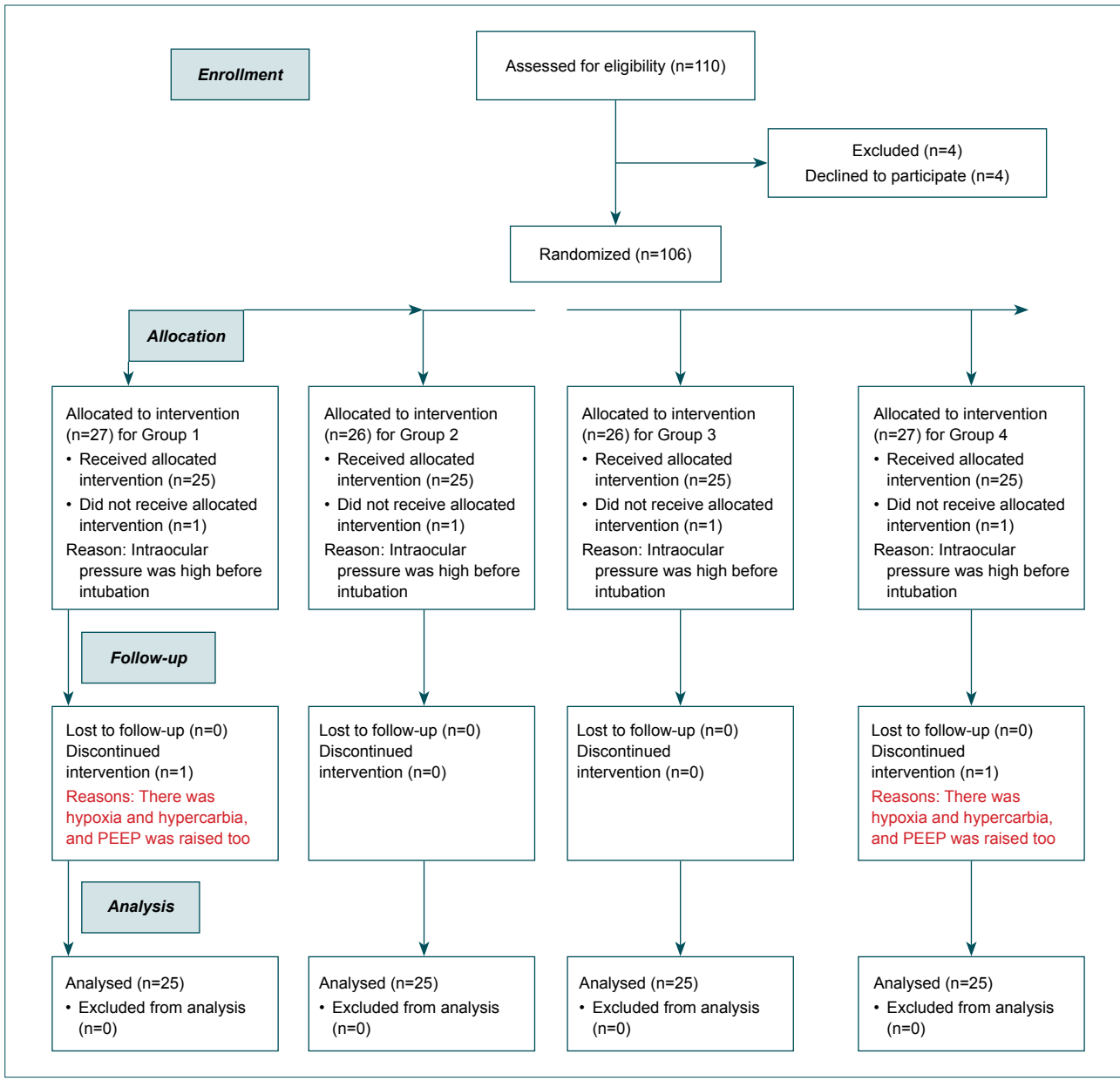


**Figure 1.** The Consort 2010 flow diagram.

In Group 1, the IOP at t4 (25.36±3.12 mmHg) was statistically significantly greater than at t1 (21.12±5.12 mmHg). Similarly, the IOPs at t4 and at t5 (23.75±5.73 mmHg) were statistically significantly higher than the IOP at t2 (18.43±4.00 mmHg).

**Table 2.** IOP measurements according to the patient groups (Mean±SD)

| | Group 1 (n=25) | Group 2 (n=25) | Group 3 (n=25) | Group 4 (n=25) | p |
|---|---|---|---|---|---|
| t1 | 21.12±5.12 | 19.31±4.12 | 24.19±8.13 | 23.61±5.05 | 0.051 |
| t2 | 18.43±4.00 | 17.43±5.09 | 18.63±4.96 | 19.09±5.34 | 0.666 |
| t3 | 19.44±4.72 | 20.05±5.25 | 20.27±4.69 | 20.35±6.34 | 0.930 |
| t4 | 25.36±3.12 | 24.65±5.25 | 24.91±5.76 | 24.52±4.87 | 0.936 |
| t5 | 23.75±5.73 | 20.99±5.56 | 22.09±5.56 | 23.11±5.81 | 0.331 |
| p* | <0.001 | <0.001 | 0.002 | 0.002 | |

*Statistically significant. IOP: Intraocular pressure; SD: Standard deviation.

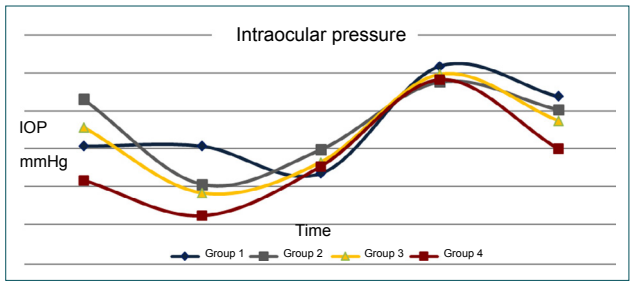


**Figure 2.**?The IOP values by time in groups. IOP: Intraocular pressure.

The IOPs at t4 and at t5 were statistically significantly greater than at t3 (19.44±4.72 mmHg).

In Group 2, the IOP at t2 (17.43±5.09 mmHg) was statistically significantly less than at t1 (19.31±4.12 mmHg) and at t4 (24.65±5.25 mmHg). The IOP at t4 was statistically significantly greater than at t3 (20.05±5.25 mmHg).

In Group 3, the IOP at t4 was 24.91±5.76 mmHg, at t3 was 20.27±4.69 mmHg, and at t2 was 18.63±4.96 mmHg. The IOP at t4 was higher than at t3 and t2. The IOP at t4 was significantly higher than at t3 and at t2.

In Group 4, the IOP was 24.52±4.87 mmHg at t4, 20.35±6.34 mmHg at t3, 19.09±5.34 mmHg at t2, and 23.61±5.05 mmHg at t1. The IOP at t4 was statistically significantly greater than the IOPs at t3, t2, and t1.

The IOP values by groups are given graphically in Figure 2.

## PHR Measurements

When the groups were compared in terms of PHR values at t1, t2, and t3, there were statistically significant differences between the groups (Table 3 and 4). At t1, Group 4 had 90.4±14.7 beats/min, Group 3 had 85.9±16.2 beats/min, and Group 2 had 101.0±22.9 beats/min. There were statistically significant differences between Group 4 and Groups 3 and 2. At t2, PHR was 84.6±25.9 beats/min in Group 4 and 98.7±17.9 beats/min in Group 2. Group 2 had statistically significantly higher values than Group 4. At t3, Group 4 (66.9±11.9 beats/min) had statistically significantly lower values than Groups 2 (85.4±17.4 beats/min) and 1 (78.1±16.4 beats/min).

In Group 1, the PHR values were 95.00±18.90 beats/min, 96.8±13.8 beats/min, 78.1±16.4 beats/min, 78.40±9.20 beats/min, and 86.4±15.2 beats/min at t1, t2, t3, t4, and t5, respectively. The PHR at t1 was statistically significantly higher than at t3 and t4. The PHRs at t2 and at t5 were statistically significantly higher than at t3 and t4.

In Group 2, the PHR values were 101.0±22.9 beats/min, 98.7±17.9 beats/min, 85.4±17.4 beats/min, 85.90±13.20 beats/min, and PHR = 90.3±16.5 beats/min at t1, t2, t3, t4, and t5, respectively. The PHRs at t1 and t2 were statistically significantly higher than at t3 and t4. The PHR at t5 was statistically significant greater than at t3 and t4.

**Table 3.** Finding a group that makes a difference in IOP measurements at t1, t2, t3, t4 and t5 (Tukey test)

| Groups | | | p* |
|---|---|---|---|
| Group 1 | t1 | t4 | 0.027 |
| | t2 | t4 | <0.001 |
| | | t5 | 0.001 |
| | t3 | t4 | <0.001 |
| | | t5 | 0.013 |
| Group 2 | t1 | t2 | 0.030 |
| | t4 | t2 | 0.005 |
| | | t3 | 0.048 |
| Group 3 | t2 | t4 | 0.001 |
| | t3 | t4 | 0.048 |
| Group 4 | t1 | t4 | 0.001 |
| | t2 | t4 | <0.001 |
| | t3 | t4 | 0.013 |

*Statistically significant. IOP: Intraocular pressure.

In Group 3, the PHRs were 85.9±16.2 beats/min, 87.0±16.7 beats/min, 72.8±19.3 beats/min, 76.70±12.50 beats/min, and 85.2±14.1 beats/min at t1, t2, t3, t4, and t5, respectively. The PHRs at t1 and at t2 were statistically significantly higher than at t3 and t4. Similarly, the PHR at t3 was significantly higher than at t4 and t5, while the PHR at t5 was significantly higher than at t4 (Table 4–6).

In Group 4, the PHR value at t1 was 90.4±14.7 beats/min, at t3 was 66.9±11.9 beats/min, at t4 was 74.00±8.00 beats/min, and at t5 was 83.4±14.1 beats/min. The PHR at t1 was statistically significantly higher than at t3, t4, and t5. The value at t4 was also statistically significantly higher than at t3. Likewise, the value at t5 was statistically significantly great than at t4.

## SBP Measurements

The comparison of SBP measurements in each group at t1, t2, t3, t4, and t5 revealed many statistically significant differences (Table 7).

In Group 1, the SBP was 132±18.40 mmHg at t1, 113.6±21.6 mmHg at t3, 107.20±11.90 mmHg at t4, and 129.5±18.8 mmHg at t5. The SBPs at t1 and t5 were statistically significantly higher than at t3 and t4.

In Group 2, SBP at t1 was 131.50±18.00 mmHg, at t2 was 113.7±19.6 mmHg, at t3 was 115.5±13.9 mmHg, and at t4 was 113.90±14.30 mmHg. The SBP at t1 was statistically significantly higher than at t2, t3, and t4.

**Table 4.** SBP, DBP, PHR, $EtCO_2$ and $SPO_2$ values according to the patient groups (Median±SD)

| | | Group 1 (n=25) | Group 2 (n=25) | Group 3 (n=25) | Group 4 (n=25) | p |
|---|---|---|---|---|---|---|
| t1 | SBP (mmHg) | 132±18.40 | 131.50±18.00 | 137±20.70 | 134.80±16.70 | 0.613 |
| | DBP (mmHg) | 81.90±9.30 | 80.20±13.10 | 77.40±12.60 | 82.20±12.00 | 0.580 |
| | PHR (Beat/minute) | 95.00±18.90 | 101.0±22.9 | 85.9±16.2 | 90.4±14.7 | *0.005 |
| | $SPO_2$ (%) | 98.6±1.3 | 99.0±1.1 | 98.2±2.3 | 99.1±1.0 | 0.392 |
| t2 | SBP (mmHg) | 120.7±23.2 | 113.7±19.6 | 116.4±18.7 | 111.3±16.9 | 0.555 |
| | DBP (mmHg) | 70.4±12.6 | 74.6±9.4 | 74.9±13.0 | 72.7±13.3 | 0.492 |
| | PHR (Beat/minute) | 96.8±13.8 | 98.7±17.9 | 87.0±16.7 | 84.6±25.9 | *0.020 |
| | $SPO_2$ (%) | 99.5±0.7 | 99.5±0.6 | 99.4±0.7 | 99.6±0.7 | 0.488 |
| | $EtCO_2$ (mmHg) | 34.0±5.1 | 32.2±5.7 | 35.2±11.9 | 32.1±10.8 | 0.208 |
| t3 | SBP (mmHg) | 113.6±21.6 | 115.5±13.9 | 119.3±22.9 | 112.4±17.6 | 0.560 |
| | DBP (mmHg) | 65.3±10.5 | 70.3±12.6 | 69.8±11.3 | 69.0±10.0 | 0.347 |
| | PHR (Beat/minute) | 78.1±16.4 | 85.4±17.4 | 72.8±19.3 | 66.9±11.9 | *0.001 |
| | $SPO_2$ (%) | 99.3±0.7 | 99.4±0.8 | 98.9±1.1 | 99.5±0.9 | 0.062 |
| | $EtCO_2$ (mmHg) | 33.6±5.0 | 31.5±4.7 | 33.3±6.1 | 32.8±6.3 | 0.454 |
| t4 | SBP (mmHg) | 107.20±11.90 | 113.90±14.30 | 112.60±16.60 | 104.20±19.50 | 0.234 |
| | DBP (mmHg) | 65.30±10.50 | 70.30±12.60 | 69.80±11.30 | 69.00±10.00 | 0.347 |
| | PHR (Beat/minute) | 78.40±9.20 | 85.90±13.20 | 76.70±12.50 | 74.00±8.00 | 0.186 |
| | $SPO_2$ (%) | 98.30±1.90 | 98.70±2.10 | 98.10±2.20 | 99.20±0.60 | 0.145 |
| | $EtCO_2$ (mmHg) | 37.00±3.70 | 34.50±4.30 | 35.90±5.20 | 34.90±6.00 | 0.255 |
| t5 | SBP (mmHg) | 129.5±18.8 | 129.9±37.0 | 135.8±32.7 | 119.1±27.0 | 0.131 |
| | DBP (mmHg) | 79.2±11.6 | 76.3±12.7 | 84.3±17.5 | 76.4±17.6 | 0.388 |
| | PHR (Beat/minute) | 86.4±15.2 | 90.3±16.5 | 85.2±14.1 | 83.4±14.1 | 0.881 |
| p value for SBP comparisons | | | | | | |
| at time t1, t2, t3, t4 and t5 | | *<0.001 | *0.004 | *0.003 | *<0.001 | |
| p value for DBP comparisons | | | | | | |
| at time t1, t2, t3, t4 and t5 | | *<0.001 | *0.063 | *0.007 | *0.021 | |
| p value for PHR comparisons | | | | | | |
| at time t1, t2, t3, t4 and t5 | | *<0.001 | *<0.001 | *<0.001 | *<0.001 | |
| p value for $ETCO_2$ comparisons | | | | | | |
| at time t2, t3 and t4 | | 0.120 | 0.231 | 0.794 | 0.613 | |
| p value for $SpO_2$ comparisons | | | | | | |
| at time t1, t2, t3, t4 and t5 | | 0.567 | 0.760 | 0.187 | 0.432 | |

*Statistically significant. SBP: Systolic blood pressure; DBP: Diastolic blood pressure; PHR: Peak heart rate; $EtCO_2$: End-tidal carbon dioxide; $SPO_2$: Peripheral oxygen saturation; SD: Standard deviation.

In Group 3, SBP was 112.60±16.60 mmHg at t4, 137±20.70 mmHg at t1, and 135.8±32.7 mmHg at t5. The SBP at t4 was statistically significantly lower than at t1 and t5.

In Group 4, SBP at t1 was 134.80±16.70 mmHg, at t2 was 111.3±16.9 mmHg, and at t4 was 104.20±19.50 mmHg. The SBP at t1 was statistically significantly higher than at t2 and t4.

## DBP Measurements

The comparison of DBP measurements at t1, t2, t3, t4, and t5 revealed statistically significant differences in DBP values in every group (Table 8).

In Group 1, the DBPs were 81.90±9.30 mmHg, 70.4±12.6 mmHg, 65.3±10.5 mmHg, 65.30±10.50 mmHg, and 79.2±11.6 mmHg at t1, t2, t3, t4, and t5, respectively. The DBP at t1 was statistically significantly higher than at t3 and t4, while the DBP at t5 was statistically significantly higher than at t2 and t4.

In Group 2, the DBP at t1 (80.20±13.10 mmHg) was statisti-

**Table 5.** The group that makes a difference in PHR in terms of PHR measured at time t1, t2 and t3 (Tukey test)

| Groups | | | p* |
|---|---|---|---|
| t1 | Group 3 | Group 4 | 0.003 |
| | Group 4 | Group 2 | 0.048 |
| t2 | Group 2 | Group 4 | 0.047 |
| t3 | Group 1 | Group 4 | 0.001 |
| | Group 2 | Group 4 | 0.033 |

*Statistically significant. PHR: Peak heart rate.

**Table 6.** Determining the moment that makes a difference in PHR measurements at t1, t2, t3, t4 and t5 in groups (Tukey test)

| Groups | | | p* |
|---|---|---|---|
| Group 1 | t1 | t3 | 0.001 |
| | | t4 | <0.001 |
| | t2 | t3 | <0.001 |
| | | t4 | <0.001 |
| | t3 | t5 | <0.001 |
| | t4 | t5 | <0.001 |
| Group 2 | t1 | t3 | <0.001 |
| | | t4 | <0.001 |
| | t2 | t3 | 0.001 |
| | | t4 | <0.001 |
| | t3 | t5 | 0.001 |
| | t4 | t5 | <0.001 |
| Group 3 | t1 | t3 | 0.006 |
| | | t4 | <0.001 |
| | t2 | t3 | 0.011 |
| | | t4 | 0.001 |
| | t3 | t4 | 0.001 |
| | | t5 | 0.009 |
| | t4 | t5 | 0.001 |
| Group 4 | t1 | t3 | 0.003 |
| | | t4 | 0.001 |
| | | t5 | 0.009 |
| | t2 | t4 | <0.001 |
| | t3 | t4 | <0.001 |
| | t4 | t5 | <0.001 |

*Statistically significant. PHR: Peak heart rate.

cally significantly higher than at t4 (70.30±12.60 mmHg).

In Group 3, the DPB at t5 (84.3±17.5 mmHg) was statistically significantly higher than at t3 (69.8±11.3 mmHg) and t4 (69.80±11.30 mmHg).

**Table 7.** Determining the moment that makes a difference in SBP measurements at t1, t2, t3, t4 and t5 in groups (Tukey test)

| Groups | | | p* |
|---|---|---|---|
| Group 1 | t1 | t3 | 0.007 |
| | | t4 | 0.000 |
| | t3 | t5 | 0.045 |
| | t4 | t5 | 0.001 |
| Group 2 | t1 | t2 | 0.001 |
| | | t3 | 0.002 |
| | | t4 | 0.000 |
| Group 3 | t4 | t1 | 0.005 |
| | | t5 | 0.020 |
| Group 4 | t1 | t2 | 0.032 |
| | | t4 | 0.028 |

*Statistically significant. SBP: Systolic blood pressure.

**Table 8.** Determining the moment that makes a difference in DBP measurements at t1, t2, t3, t4 and t5 in groups (Tukey test)

| Groups | | | p* |
|---|---|---|---|
| Group 1 | t1 | t3 | 0.046 |
| | | t4 | 0.000 |
| | t2 | t4 | 0.015 |
| | | t5 | 0.004 |
| Group 2 | t1 | t4 | 0.010 |
| Group 3 | t3 | t5 | 0.002 |
| | t5 | t4 | 0.002 |
| Group 4 | t1 | t4 | 0.032 |

*Statistically significant. DBP: Diastolic blood pressure.

In Group 4, the DBP at t1 (82.20±12.00 mmHg) was statistically significantly greater than at t4 (69.00±10.00 mmHg).

## $EtCO_2$ Measurements

There was no significant difference in $EtCO_2$ values at t2, t3, and t4 among the groups (Table 3). Even within groups at t2, t3, and t4, there were no statistically significant differences between these values (Table 3).

## $SPO_2$ Measurements

There was no significant difference in $SPO_2$ values in t1, t2, t3, t4, and t5 among the groups (Table 4). There were no statistically significant differences within each group between the $SPO_2$ values at t1, t2, t3, t4, and t5 (Table 3).

## DISCUSSION

The previous studies have shown that IOP increases with PP and the Trendelenburg position during laparoscopic surgery.[8–11] The comparison between the study groups in terms of IOP at t1, t2, t3, t4, and t5 yielded no statistically significant differences. The IOPs of Groups 1 and 4 at t4 were statistically significantly higher than at t1. In Groups 2 and 3, there was no statistically significant difference between IOP at t4 and at t1. These results indicate that propofol induction causes decreased changes in IOP, independent of sevoflurane or desflurane use. In addition, there were no statistically significant differences between the IOPs in supine position after extubation and before intubation. Thus, the IOP values in supine position after extubation were not affected by the anesthesia technique. In all groups, the IOPs at t4 were statistically significantly higher than at t3. Consequently, rather than PP, Trendelenburg position increased IOP values by higher amounts; however, measurements were taken 1 min after PP, which may not have been sufficient for IOP to increase.

Hwang et al.[17] investigated the effects of surgical positioning and anesthetic agents on increased IOP due to PP during laparoscopic surgery. They compared propofol and desflurane in pelvic laparoscopic surgery in Trendelenburg and laparoscopic cholecystectomy in reverse Trendelenburg. The authors found that the IOP was lower, independent of the anesthetic agent used, in the cholecystectomy, and the IOP was significantly increased with desflurane in the pelvic surgery. They concluded that anesthetic agents might exert their effects on IOP depending on the surgical position during laparoscopy and that propofol was more effective in preventing ocular hypertension in the Trendelenburg position. Similarly, another study showed a relatively small increase in IOP with propofol compared to isoflurane and pentothal in patients undergoing laparoscopic gynecological surgery.[12] Another study showed similar IOP changes with desflurane-thiopental or propofol in patients who underwent laparoscopic cholecystectomy in the reverse Trendelenburg position.[18] In another study, propofol was associated with a smaller IOP increase than sevoflurane in patients undergoing laparoscopic surgery.[19] Consistent with these findings, propofol was associated with a smaller IOP increase in patients undergoing laparoscopic colorectal surgery.[20] Another study reported that propofol resulted in a higher rate of IOP increase than pentothal-isoflurane in the Trendelenburg position.[21] In our study, sevoflurane and desflurane were used in Groups 2 and 3, respectively, with propofol as induction. No statistically significant difference in the IOP at t4 and t1 was noted. Conversely, Groups 1 and 4 used pentothal for induction and the IOP at t4 was statistically significantly higher than at t1. Thus, propofol induction prevented the increase in IOP independent of the use of sevoflurane and desflurane.

Montazeri et al.[22] found a lower rate of IOP increase with propofol-remifentanil than with isoflurane-remifentanil in ophthalmic surgeries. Sator-Katzenschlager et al.[23] reported that the use of sevoflurane and propofol resulted in a similar decrease in IOP in non-ophthalmic open surgeries. The present study emphasizes the clinical relevance of interventions for use in patients at risk of intraoperative complications and more vulnerable to IOP increases. Our study revealed no statistically significant difference in the IOPs at t4 and t1 after propofol induction; however, the IOP at t4 was a statistically significantly greater than at t1 after pentothal induction.

In a study of 3684 patients, Klein et al.[24] reported a significant relationship between changes in IOP and SBP. In another study, Lauretti et al.[25] investigated the effects of continuous low-dose propofol sedation on IOP in 40 patients undergoing ambulatory trabeculotomy surgery. The IOP values were lower with greater patient satisfaction with an intravenous bolus dose of 0.5 mg/kg propofol followed by a 0.5 mg/kg/h continuous infusion than in the control group. The authors also reported that a propofol-induced IOP decrease was not associated with heart rate changes but with decreased aqueous humor drainage due to extraocular muscle relaxation and venous dilatation. The respiratory system may be affected by the use of anesthetics; however, these effects are usually transient and well tolerated.[5,26] In our study, PHR at t4 in all groups was statistically significantly lower than at t1. A comparison across all groups yielded no statistically significant difference in PHR at t2 and at t1. The rocuronium used during induction caused muscle relaxation and venous dilatation, likely muting any effect on IOP. The PHR at t1 was statistically significantly higher than at t3 and t4; thus, PHR does not have a significant effect on IOP. The PHR at t3 and t4 was likely statistically significantly lower due to the increased depth of anesthesia over time as tissues saturate with anesthetic gas. In Group 2, the SBP at t1 was statistically significantly higher than at t2, t3, and t4. In Groups 1, 3, and 4, the SBP at t1 was statistically significantly greater than at t3 and t4, but there was no statistically significant difference between those at t2 and t1. This is likely because the combination of sevoflurane and propofol caused deeper anesthesia and reduced the intubation response.

In another study, the effects of propofol and sevoflurane on IOP were compared during laparoscopic surgery. A 6.0 mmHg increase in IOP was reported with sevoflurane compared to the control in the Trendelenburg position.[13] A statistically insignificant lower increase in IOP (2.1 mmHg) was found in the propofol group, so the authors concluded that propofol resulted in a smaller IOP increase due to PP and prolonged Trendelenburg positioning. We did not find a statistically significant difference in IOPs at t4 and t1 with propofol induction; however, there was a statistically significant difference in IOPs at t4 and t1 with pentothal induction.

In another study, 28% of patients had visual problems and intraoperative ophthalmic examinations were recommended.[27] In addition, IOP measurements were recommended as

routine surgical follow-up parameters and, in the case of prolonged surgery, long-acting anti-glaucomatous drops were recommended for patients with chronic glaucoma or significant IOP increases.[28] In our study, we did not assess for post-operative vision problems in patients; however, we recommend using IOP as a routine monitoring parameter for chronic glaucoma patients receiving long effect antiglaucoma treatment and those with significantly increased IOP during lengthened surgeries.

## Conclusion

In our study, we did not see a significant difference in the IOP in the Trendelenburg position compared to in the supine position when propofol was used for the induction of anesthesia. The same comparison using pentothal for induction did yield a statistically significant difference. The IOP in Trendelenburg was significantly greater than that in the supine position. Thus, we recommend propofol for induction, regardless of the use of sevoflurane or desflurane, for more stable IOP values. We conclude that PHR has no effect on IOP. We also conclude that the use of sevoflurane and propofol allows for more stable SBPs after intubation. We recommend the use of IOP measurements as intraoperative monitoring parameters for surgeries with lengthened Trendelenburg positioning and in patients with chronic IOP elevation.

**Ethics Committee Approval:** This study was approved by the Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (Date: 17.07.2017, Decision No: 2017/168).

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ORİJİNAL ÇALIŞMA - *ÖZ*

## Trendelenburg pozisyonda yapılan laparoskopik jinekolojik cerrahi esnasında göz içi basıncı üzerine anestezik ajanların etkisi: Randomize klinik çalışma

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AMAÇ: Laparoskopik cerrahi sırasında pnömoperitoneum ve Trendelenburg pozisyonuna bağlı göz içi basıncı (GİB) artar. Ketamin ve süksametonyum dışında, anestezik ajanlar genellikle GİB'yi çeşitli oranlarda azaltır. Bu çalışmada, laparoskopik jinekolojik cerrahi sırasında dört anestezik ajan kombinasyonunun GİB üzerindeki etkileri araştırıldı.
GEREÇ VE YÖNTEM: Hastalar (n=100) dört gruptan birine ayrıldı: grup 1 (n=25; pentotal indüksiyon + desfluran/remifentanil idame), grup 2 (n=25; propofol indüksiyon + sevofluran/remifentanil idame), grup 3 (n=25; propofol indüksiyonu + desfluran/remifentanil idamesi) ve grup 4 (n=25; pentotal indüksiyon + sevofluran/remifentanil idamesi). Anestezi indüksiyonu öncesi, entübasyon sonrası, karbondioksit üfleme sonrası, Trendelenburg pozisyonunda ve ekstübasyon sonrası kaydedilen GİB'ler gruplar arasında karşılaştırıldı. Hemodinamik parametreler de değerlendirildi.
BULGULAR: Grup 2 ve grup 3'te indüksiyon propofol kullandı. Trendelenburg pozisyonundaki GİB ile indüksiyon öncesi GİB karşılaştırıldığında, 2. ve 3. gruplarda istatistiksel olarak anlamlı bir fark yoktu (p>0.05). Grup 1 ve 4'te indüksiyon için pentotal kullanıldı. Grup 1 ve 4'teki GİB, Trendelenburg pozisyonunda indüksiyon öncesine göre istatistiksel olarak anlamlı şekilde daha yüksekti (0.027–0.001).
TARTIŞMA: Laparoskopik jinekolojik ameliyatlar sırasında Trendelenburg pozisyonundaki GİB'deki varyasyonu en aza indirmek için, desfluran veya sevofluran kullanımından bağımsız olarak indüksiyon için propofol kullanılmasını öneriyoruz.
Anahtar sözcükler: Anestezik maddeler; göz içi basıncı; laparoskopik cerrahi.

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