

ORIGINAL RESEARCH

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Comparison of the effects of head-down and head-up position on intraocular pressure and haemodynamics during laparoscopic abdominal surgery

Zinet Asuman Arslan Onuk

Antalya Training and Research Hospital, University of Health Science, Department of Anesthesiology, Antalya, Turkey

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Abstract

The aim of our study was to compare intraoperative changes on the haemodynamics and intraocular pressure in the head-up and head-down position in laparoscopic cholecystectomy and gynaecologic surgery. This cohort study (prospective observational study) was made in Antalya Education and Research Hospital (Turkey) between 2015 and 2017. Seventy seven patients undergoing laparoscopic cholecystectomy (head-up position, n=42) and laparoscopic gynecology operations (head-down position=35) were included. The intraocular pressure (IOP) was measured for both eyes at defined intervals during the procedure with Schiotz tonometer. During of surgery, heart rate, mean arterial blood pressure, systolic arterial blood pressure, diastolic arterial blood pressure and ETCO_2 were also recorded. IOP was detected to be higher in Group II at the 5th minute of CO_2 insufflation (17.17 ± 2.91) and at the 5th minute of head-down position (17.97 ± 2.83), $P < 0.05$. In addition, IOP measurements were recorded 14.79 ± 4.92 for group I and 17.17 ± 3.03 for group II significantly higher immediately before post-op CO_2 desufflation ($P < 0.05$). Statistically meaningful difference was detected between groups in terms of operation and anaesthesia processes ($P = 0.044$, $P < 0.001$ respectively). The patient's position during surgery may represent a stronger risk factor for IOP increase than pneumoperitoneum-related intraabdominal pressure in surgical operations which are expected to last longer than two hours and in old patients. IOP increases with head-down position. We recommend preoperative and peroperative IOP measurement in laparoscopic and robotic surgery attempts, in surgical operations which are expected to last long and in old patients whether or not they have eye disease anamnesis.

Keywords: Intraocular pressure, head-down, head-up, laparoscopy, haemodynamics

Introduction

Laparoscopic surgical procedures are minimal invasive methods using intraperitoneal carbondioxide (CO_2) insufflation. Wide range, less blood loss and postoperative pain, shorter hospitalization interval and faster recovery are the advantages of this technique [1]. Many factors such as general anaesthesia application, patient position during surgery and increase in intraabdominal pressure may affect hemodynamics [2-4].

General surgeries, including laparoscopic, spinal and cardiac procedures, especially, with their demand for steep trendelenburg or prolonged prone positioning and hypotensive anesthesia, can induce intraocular pressure changes and ocular perfusion imbalance [5].

Laparoscopic surgery generally performed in head-up and head-down positions depending on the type of operation. These positions cause undesirable hemodynamic and intraocular pressure (IOP) changes [6-8].

Laparoscopic attempts, routinely used for gynecologic operations can be extended safely for cholecystectomy in uncomplicated cholelithiasis [9].

The aim of our research is to compare head-down in gynecologic procedures and head-up in cholelithiasis laparoscopic surgeries using same anaesthetic methods with regards to IOP (intraocular pressure) and hemodynamic changes.

Material and Methods

This cohort study (prospective observational study) was made in Antalya Education and Research Hospital (Turkey) between 2015 and 2017. 77 patients (58 F, 19 M) belonging to ASA I-II groups were included in the research after ethical board approval and patient consents. Patients who underwent laparoscopic cholecystectomy in head-up position were acknowledged as Group I (head-up n=42) and patients who underwent laparoscopic gynecological surgery in head-down position were acknowledged as Group II (head-down n=35). Patients with eye surgery history, cardiovascular disease, diabetes mellitus, chronic obstructive lung disease and high IOP anamnesis were excluded from the research. Patients had no premedication and anaesthesia induction obtained with 2,5 mg/kg propofol and 2µg/kg fentanyl and

*Corresponding Author: Zinet Asuman Arslan Onuk, Antalya Training and Research Hospital, University of Health Science, Department of Anesthesiology, Antalya, Turkey, E-mail: asumanonuk@hotmail.com

0,6 mg/kg rocuronium bromide (esmeron) and patients were intubated. Anaesthesia maintenance was obtained with 6-10 mg/kg/hr propofol, esmeron and intermittent fentanyl bolus (1µg/kg). Mechanical ventilation was supplied with 40-60% of air in order to procure 30-40 mmHg EtCO₂.

Pneumoperitoneum was created as previously recommended [8,9] and intraperitoneal insufflation of CO₂ was performed via a Palmer needle with the patient in the supine position. Throughout surgery, intraperitoneal pressure was maintained automatically at 12 mmHg by a CO₂ insufflator.

During surgery intraocular pressure (IOP), mean arterial pressure (MAP), systolic arterial pressure (SAP), diastolic arterial pressure (DAP), heart rate (HR), end-tidal CO₂ (EtCO₂) measured in both groups at the following time points:

- (T1) One minute of intubation in supine position (group I and II)
- (T2) 5th minute of insufflation CO₂ in head-down (group II) and head-up (group I) position
- (T3) 5th minute of head-down (group II) and head-up (group I) position,
- (T4) 10th minute head-down (group II) and head-up (group I) position,
- (T5) 20th minute head-down (group II) and head-up (group I) position,
- (T6) CO₂ desufflation, head-down (group II) and head-up (group I) position,
- (T7) before extubation in supine position. (group I and group II)

IOP measurements were recorded for each eye in previously determined 7 different time zones (Table 2, figure 1).

IOPs were measured with a Schiotz tonometer. The tonometer was calibrated and sterilized (alcohol swap or merthiolate solution) before each reading. In each patient, IOP was measured by 5,5 scale of Schiotz tonometer and the average of the two measurements was calculated for each eye; the mean of the IOPs for both eyes was used as the patient's.

Statistical Analysis

Paired t-test was used in intergroup comparisons and independent sample t-test was used in intragroup comparisons. P<0.05 was considered to be significant.

Results

Average age of the patients was 40.52±7.57 years in group I (head-up) and 50.45±1.31 years in group II (head-down), No statistically significant difference was found between the two groups. (P>0.05, P=0.06 table 1). Anaesthesia duration in group I was 119.78±41.97 min, surgery duration was 104.50±36.88 min (P<0.05, P=0.044) whereas anaesthesia duration in group II was 64.25±25.98 min, surgery duration was 70.60±99.61 min (P<0.05, P=0.001). There were statistically significant differences in anesthesia and surgery times between groups

Our research compares cholecystectomy (n=42) and gynecologic (n=35) operations for head-up and head-down positions respectively. Minimal invasive gynecologic surgical operations are common. Gynecological surgeries operated in head-down position

in our research are minimal invasive interferences (cystectomy, myomectomy, hysterectomy). We correspondingly detected that anaesthesia and operation durations were shorter in group II (head-down). Statistically meaningful difference was detected amongst groups in terms of operation and anaesthesia duration (P=0.044; P=0.001 respectively). 9 of 77 ASA I-II patients were hypertensive (7 patients in group I; 2 patients in group II).

At a result of the blood pressure; systolic arterial pressure (SAP) measurements in the first moment of intubation in group II (in head-down position) were recorded as high (P<0.05). As we evaluated the diastolic arterial pressure (DAP) measurements, we did not find statistically meaningful differences both in intergroup (P>0.05) and intragroup values (P>0.05). Similarly, we did not find statistically meaningful differences both in inter group (P>0.05) and intragroup values with respect to mean arterial pressure (MAP) (P>0.05). Nevertheless, SAP and MAP measurements in 1st minute of the operation were detected higher in head-down group (P<0.05, table 2).

Upon the evaluation of heart rate evaluations; heart rate in the first minute of intubation in group I was detected lower. Statistically meaningful changes were obtained in 10th minute after positioning the patient (P<0.05, table 2).

As we evaluated the intraocular pressure changes; we determined that IOP increased in head-down position. IOP in 5th minute of CO₂ insufflation 17.17±2.91 mmHg and in 5th minute of head-down position 17.97±2.83 mmHg was recorded higher in Group II (Head down group). Statistically meaningful difference was detected among groups (P<0.05) (Figure 1, table 2). After positioning the patients in the following of the surgical precedure, 20th minute IOP measurements were both detected in group I in head-up position and in group II in head-down position. We thought that CO₂ insufflation was also effective in IOP along with positioning in both groups. We also thought that increase in intraabdominal pressure was related with CO₂ insufflation. 20th minute IOP measurements 16.20±5.02 mmHg in group I; 16.98±3.45 mmHg in group II, in head-up and head-down positions and 5th minute CO₂ insufflation values 14.82±4.90 mmHg in group I; 17.17±2.91 mmHg in group II were recorded meaningfully high (P<0.05, table 2, figure 1).

In addition, IOP measurements 14.79±4.92 mmHg in group I; 17.17±3.03 mmHg in group II) just before CO₂ desufflation at the end of surgical operation were recorded meaningfully high (P<0.05, table 2, figure 1).

In consequence of EtCO₂ measurements; EtCO₂ values were detected to be high in group

II. Difference between group I (head-up) and group II (head-down) measurements was statistically meaningful (P<0.05).

All measurements were normal values in the first moment of intubation. As we evaluated the measurements of SAP, MAP, IOP and EtCO₂, values of head-up group were determined them to be lower (P<0.05, table 2).

1st minute measurements of intubation were detected higher than after CO₂ desufflation measurements in group II (P<0.05). Both

intragroup and intergroup measurements were detected statistically meaningfully high ($P<0.05$). These are related to high pressure associated with intubation. EtCO₂ values before intubation was detected statistically meaningfully higher than values of 1st minute

of the intubation in each groups ($P<0.05$). EtCO₂ values before intubation was detected higher in group II ($P<0.05$). Difference between groups were detected as statistically meaningful ($P<0.05$, table 2).

Table 1. Demographic data

	Grup I (head-up) n=42	Grup II (head-down) n=35	P
Age	40.5(7.57)	50.45(1.31)	P=0.060
Sex	23 male, 19 female	35 female	
Duration of anesthesia (min)	119.78(41.97)	64.25(25.98)	P=0.001
Duration of operation min)	104.50(36.88)	70.60(99.61)	P=0.044
Hypertension	7/42	2/35	

Data are presented as the mean±standard deviation where indicated.
P<0.05 was accepted to be statistically significant

Table 2. Hemodynamic Variables and Intraocular Pressure Values in Laparoscopic Surgery

Hemodynamic variables (group I and group II)	Operation stages (measurement time)						Pre-extubation
	Intubation.1.minute	CO ₂ insufflation (5.minute)	Position (5.minute)	Position (10.minute)	Position (20.minute)	CO ₂ desufflatio	
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD)	
SAP							
Head-up	128.38(19.45)	133.24(28.71)	138.19(28.27)*	130.74(21.28)	129.43(21.50)	130.19(23.59)	147.21(23.38)*
Head-down	150.31(22.00)	130.51(27.47)*	136.63(25.85)*	136.83(23.30)*	136.43(29.65)*	137.91(30.53)*	155.60(32.35)
DAP							
Head-up	87.38(21.75)	92.90(21.43)	92.02(20.19)	83.98(18.10)	81.14(18.14)*	81.50(15.18)	89.67(15.43)
Head-down	89.63(13.86)	85.06(17.37)	83.74(16.66)	83.09(11.60)*	82.06(12.33)*	79.06(12.57)*	92.54(13.63)
MAP							
Head-up	101.40(21.21)	107.67(23.98)	106.86(22.20)	100.33(18.18)	98.83(17.95)	97.29(18.94)	113.43(23.16)*
Head-down	112.69(14.01)	103.63(20.40)*	102.31(16.51)*	102.17(13.77)*	101.80(15.22)*	100.71(17.14)*	114.03(18.41)
Heart Rate							
Head-up	88.64(11.60)	77.86(13.07)*	76.62(13.07)*	74.05(11.53)*	73.43(12.98)*	73.71(15.47)*	85.76(16.62)
Head-down	83.62(16.70)	78.54(13.62)	80.00(18.75)	81.80(20.06)	78.43(17.33)	74.34(16.00)*	88.86(16.37)
IOP							
Head-up	12.75(4.19)	14.82(4.90)*	14.33(4.20)*	15.81(4.47)*	16.20(5.02)*	14.79(4.92)*	16.31(6.30)*
Head-down	15.03(2,81)	17.17(2.91)*	17.97(2.83)*	16.14(2.03)*	16.98(3.45)*	17.17(3.03)*	17.65(3.80)*
EtCO ₂							
Head-up	32.38(2.56)	31.43(3.78)	31.60(4.20)	31.64(4.90)	31.38(4.89)	31.80(3.62)	35.83(7.169)*
Head-down	35.09(4.88)	33.74(4.89)*	34.91(5.51)	35.31(5.18)	36.71(5.28)	37.83(5.37)*	40.83(7.670)*

Groups: Group I: Head-up group, Group II: Head-down group, SAP: Systolic arterial pressure, DAB: diastolic arterial pressure, MAP: Mean arterial pressure (mmHg), HR: Heart Rate (beat /minute), EtCO₂: end-tidal CO₂, IOP: Intraocular Pressure, Position 5., 10., 20. Minutes : head up and head down position, #P<0.05 intergroup comparison, *P<0.05 intragroup comparison (Head-up and Head-down groups). (compared to the 1.minute of intubation)

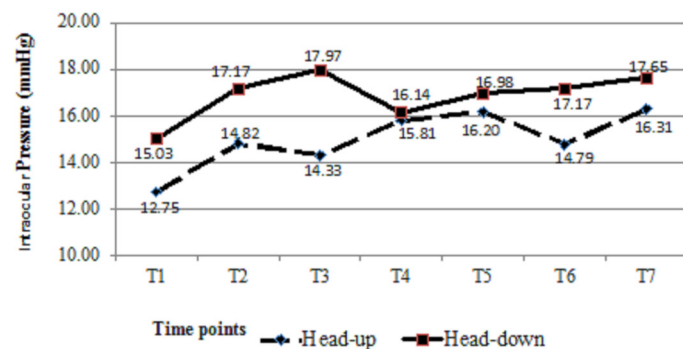


Figure 1. Time-dependent change in IOP in Head-up group and Head-down group

Discussion

Our research was made on laparoscopic cholecystectomy and gynecology patients operated in head-up or head-down positions. Pneumoperitoneum and head-up and head-down positions trigger changes in hemodynamics and IOP in patients under the effect of anaesthesia [5]. Limited data suggest that it is also useful as propofol for the maintenance of IOP during anaesthesia [10,11]. We used propofol in the induction and maintenance of anaesthesia.

IOP measurements in the 1st minute of intubation were recorded 12.75±4.19 mmHg in head-up group and 15.03±2.81 mmHg in head-down group. In addition to this we recorded higher

measurements of SAP, MAP and EtCO₂ in head-down group. These measurements which were not related to the positioning was thought to be related with the high preoperative values of the patient and with the anaesthesia induction.

Cheng and Young-Chul Yoo revealed that propofol might suppress IOP increase caused by perioperative hemodynamics, intubation and extubation under general anaesthesia in ophthalmic patients [7]. In our research, we detected that propofol infusion was useful to diminish the increase of IOP caused by head-down and head-up position and CO₂ insufflation in laparoscopic surgeries.

Hwank et al. investigated effects of surgical position and anaesthesia type on pneumoperitoneum depended IOP in laparoscopic surgeries. IOP was detected as low in laparoscopy patients operated in reverse trendelenburg position independently of anaesthetic agent whereas IOP showed significant increase in desflurane applied pelvic laparoscopic surgeries. They ultimately thought that effect of anaesthetics in laparoscopic surgeries to IOP was related to position and propofol was effective to increase IOP [3]. In addition, some researches stated that IOP increase was time-dependent and it deteriorated with excessive head-down position. Basal IOP values were detected to increase with age and systolic blood pressure was stated to be an effective factor on IOP values as it increased with age [7]. Rubin et al. recorded increase on heart rate and diastolic blood pressure, slight decrease in systolic blood pressure, and stable mean arterial pressure in head-up position [12].

In our study, 9 of patients was hypertensive and mean arterial pressures of the patients were recorded similar at the time of measurement. Intraocular pressure was significantly negatively correlated with systolic blood pressure [13].

These patients belonged to two separate groups. We did not excluded the hypertensive patients from the evaluation. There was no statistically significant difference in intragroup and intergroup comparison in terms of MAP ($P > 0.05$). Systolic arterial pressure was detected high during the 1st minute intubation measurements in group II (head-down position) ($P < 0.05$). We found low heart rate in the first minute measurement of intubation in cholecystectomy operations performed in head-up position ($P < 0.05$).

As Montazeri et al. suggested for ophthalmic surgeries, perioperative IOP measurement might be useful in need of laparoscopic surgery in trendelenburg position in which IOP increase expected to occur [14].

Borahay et al. detected that IOP increased significantly in laparoscopic and robotic hysterectomy patients in head-down position [13]. Even though further researches are needed to define this procedure, when aging population of patients with high risk of glaucoma are regarded, evaluation of preoperative eye health should be executed [14,15].

We also think that preoperative IOP measurement is beneficial in surgical interventions with positioning. Slight decrease was reported in blood pH with the increase of EtCO₂ and PCO₂ levels caused by CO₂ pneumoperitoneum in laparoscopic surgeries [16-18].

We observed normal range of EtCO₂ levels in both positions but increase was meaningful in head-down position ($P < 0.05$). We excluded patients with eye surgery history, cardiovascular disease, diabetes mellitus, chronic obstructive lung disease and high IOP anamnesis from the research.

Pinkney et al. stated that elevated IOP was detected in laparoscopic colorectal surgery patients in head down and prone position and perioperative vision loss might occur [19]. Preoperative IOP was recorded as 9-28 mmHg in head-down position and 120 minutes later IOP increased to 25-54 mmHg, ocular perfusion pressure (OPP) was recorded as 50-82 mmHg at the beginning and decreased to 21-75 mmHg in 120th minute. Increasing IOP and decreasing OPP was stated as statistically meaningful in head-down position ($P < 0.01$).

Recently, Yoo and friends defended that propofol and consistent deep neuromuscular blockage during laparoscopic radical prostatectomy had decreasing effect on IOP [20]. They defended the idea that perioperative vision loss was a catastrophic complication and surgeons should realise this.

In our research we did not observed any complaints about eye and any pathological examination findings in 24 hours of postoperative term.

Carey et al. investigated the effect of head-up position on IOP and they observed that IOP decreased in time [21]. These results were similar to our research.

Kyoichi Mizumoto et al. reported significantly meaningful time-dependent IOP increase in laparoscopic radical prostatectomy patients operated with 30 degrees head-down trendelenburg position (8.3 ± 12.5 right after induction in supin position, 19.7 ± 23.8 right after head-down position, 27.6 ± 31.5 in head-down position right before supin position) [22].

Results of this research is similar to our results. We detected statistically meaningful IOP increase with head-down position. IOP was high in group II at the 5th minute of CO₂ insufflation (17.17 ± 2.91) and in head down position (17.97 ± 2.83) at the 5th minute ($P < 0.05$). IOP at 20th minute was detected as high in both groups in reverse trendelenburg (Group I; head-up) and in trendelenburg (Group II; head down). Position and CO₂ insufflation are effective factors in IOP increase of both groups.

Andrea Grosso et al. detected slight and reversible increase in IOP in neutral position with standart pneumoperitoneum (< 14 or $= 14$ mmHg) in 45-85 years old colorectal surgery patients but they stated higher rate of IOP increase in head-down operated patients. 17 of 29 patients in head-down position showed 5 mmHg IOP increase which was stated to be

statistically meaningful ($P = 0.020$). They finally defend that head-down position was more risky than pneumoperitoneum [23].

A large study (458 patients) by Sanaa A. et al showed no statistically significant differences between intraocular pressures of men (15 mm Hg, range:6-28) and women (16 mm Hg, range:6-28) ($P = 0.26$). Therefore, we did not discriminate between male and female gender in cholecystectomy surgery [24].

Conclusion

In our research, we detected increase for IOP with head-down position. We think that CO₂ insufflation is also effective on IOP with head-down position.

We recommend preoperative and peroperative IOP measurement in laparoscopic and robotic surgery attempts, in surgical operations which are expected to last longer than two hours and in old patients whether or not they have eye disease anamnesis.

Financial Disclosure

All authors declare no financial support.

Ethical approval

The study was approved by the Ethics Committee of Antalya Education and Research Hospital and written informed consent from patients.

Zinet Asuman Arslan Onuk ORCID: 0000-0002-9189-2926

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