

Comparative evaluation of optic nerve sheath diameter in patients undergoing laparoscopic cholecystectomy using low and standard pressures of gas insufflations

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Abstract

Background and Aims: Intra-abdominal insufflation of CO₂ is associated with an increase of intracranial pressure (ICP). We conducted this randomized control trial to compare the impact of low vs standard pressure pneumoperitoneum on ICP through the ultrasonographic estimation of the optic nerve sheath diameter (ONSD).

Material and Methods: Patients of age group 18–80 years planned for laparoscopic cholecystectomy were randomly allocated into two groups; group S (standard pressure of 12–16 mmHg) and group L (low pressure of 8–10 mmHg) on the basis of intra-abdominal pressures used for the surgery. All were administered general anesthesia and end-tidal carbon dioxide (ETCO₂) was maintained between 35 and 40 mmHg and peak airway pressures less than 35 cmH₂O. ONSD was measured in either eye at a point 3 mm posterior to the globe at following time intervals; baseline, 5 min after induction, 10 min after insufflation, 10 min after reverse Trendelenburg, intraoperatively during surgery and after exsufflation in the supine position.

Results: The demographic profile and operative times were comparable. ONSD was measured in 100 patients in each group for both the eyes and no patient had values above the cutoff value of 5.0 mm. No significant difference in the ONSD was observed at the above mentioned time intervals between the groups. There was a statistically significant lower value of the heart rate and mean arterial pressure in the low-pressure group.

Conclusion: Intra-abdominal insufflation of CO₂ at standard and low pressures does not increase ICP in short duration surgeries and thus both the pressures can be safely used in adult patients operated in reverse Trendelenburg position. Advantages of low pressure were limited to better hemodynamic control.

Keywords: Laparoscopy, optic nerve sheath, ultrasonography

Introduction

Pneumoperitoneum with carbon dioxide (CO₂) during laparoscopy has shown to increase intracranial pressure (ICP).^[1,2] The standard technique for monitoring of ICP is the insertion of an intraventricular catheter connected to an external pressure transducer.^[3] Assessment of optic nerve sheath diameter (ONSD) with ultrasound is a precise

and noninvasive bedside technique for determining elevated ICP (>20 mmHg).^[4] The anatomical continuity of the dura with the optic nerve sheath (ONS) enables the use of this technology and thus a rise in ICP is transmissible across the subarachnoid space to the ONS and head.

The range of ONSD to identify an ICP >20 mmHg is 5.2 to 5.9 mm with 74–95% sensitivity and 74–100%, specificity).^[5-7] But for a sensitivity of 100%, we need to have a cutoff value of 5 mm.^[8]

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Pneumoperitoneum with lower pressures decrease the analgesic consumption after laparoscopic cholecystectomy but the effect of standard vs lower intra-abdominal pressures on ICP are lacking.^[9] We hypothesized that standard pressure of gas insufflations would increase ONSD but low pressure of gas insufflations would not cause a change. Primary aim was to compare ONSD between the two groups 10 min after CO₂ insufflation.

Material and Methods

The study was approved by the institutional ethics committee and trial was registered prospectively in clinical trials registry India (CTRI/2014/10/005124). Patients aged 18–80 years with American Society of Anesthesiologists (ASA) I-III physical status were enrolled. Patients with prior history of orbital trauma, past history of neurologic diseases, glaucoma, surgical duration beyond 2 h, known history of chronic obstructive pulmonary disease (COPD), history of heart disease, previous lung surgery, were removed from enrollment. Patients developing intraoperative hemodynamic instability, an ETCO₂ value greater than 45 mmHg, plateau pressure above 30 cmH₂O and peak inspiratory pressures above 35 cmH₂O were also excluded subsequently.

Prior to randomisation written informed consent, was taken from participants. They were randomized into two groups using random number tables and sealed envelope technique. Patients in group S underwent laparoscopic cholecystectomy using standard (12–16 mmHg) pressures whereas patients in group L underwent laparoscopy under low pressures (8–10 mm Hg).

All the participants were premedicated with Tablet alprazolam 0.5 mg previous night and early morning prior to surgery. After ensuring adequate fasting status patients were shifted to the operating room (OR) and standard monitors were attached; noninvasive blood pressure (NiBP) cuff, oxygen saturation (SPO₂) sleep dose of propofol, electrocardiogram (ECG). Induction was done using morphine (0.1 mg/kg), sleep dose of propofol and vecuronium (0.1 mg/kg). Endotracheal intubation was performed using appropriate size endotracheal tube (ETT) and anaesthesia was maintained with isoflurane in a mixture of 50% oxygen and nitrous targeting a BIS of 50 and a tidal volume of 8 mL/kg adjusted to keep the plateau pressure below 30 cmH₂O and peak inspiratory pressures below 35 cmH₂O. Respiratory rate was adjusted to maintain ETCO₂ levels of 35 to 40 mmHg. Anesthesia was administered using isoflurane and the BIS[®] was maintained between 40 and 60.

A portable software-controlled, ultrasonographic system (MicroMaxx ultrasound system, SonoSiteInc, Bothell, Washington, USA) with a 13–6 MHz, 38-mm broadband linear array transducer was used for measurement of ONSD. The probe was positioned over the closed eye in the axial plane and the ONS was determined by means of two hyperechoic lines posterior to the globe. Determination of the external limits of the hyperechoic lines was noted with electronic calipers 3 mm behind the papilla [Figure 1]. In all patients three measurements on each eye were taken. To neutralize intraoperative variability average of these measurements were taken. Measurements were taken in both eyes as asymmetrical values of the perineural sheaths have been reported.^[10]

ONSD measurements

Taken at following intervals separately in the right and the left eye.

T_{Baseline}: Before induction of anesthesia

T_{Induction}: 5 min after induction in supine position

T_{Insufflation}: 10 min post pneumoperitoneum

T_{Reverse Trendelenburg}: 10 min after 30-degree reverse Trendelenburg positioning

T_{Intraoperatively} (Pneumoperitoneum and reverse Trendelenburg): ONSD was subsequently measured at every 20 min interval with the patient in reverse Trendelenburg position in both the eyes and the average value of the measurements was compared between the groups



Figure 1: Ultrasonographic visualization of the optic nerve. The optic nerve sheath is seen as a sharply defined hypoechoic band in the sagittal plane. The optic nerve sheath diameter is measured using electronic calipers 3 mm behind and in a perpendicular vector with reference to the orbit

$T_{\text{Supineafter exsufflation}}$: After returning to supine position without pneumoperitoneum

A single anesthesiologist blinded to the study groups was recruited for all the measurements.

Statistical analysis

In a previous study, the authors calculated sample size as 24 patients in each group with a two-tailed significance level ($\alpha = 0.05$) and 90% power using ONSD of normal adults as 4.60 ± 0.41 mm and a cutoff value estimate of raised ICP as 5.0 mm and an effect size of 0.976.^[11] We used a sample of 100 patients in each group because no such similar study has been performed till date and a large sample size ensures reliability, precision, and power in the results.

Data were analyzed using SPSS (Windows ver. 12.0, SPSS Inc., Chicago, IL, USA) and all results are presented as mean \pm standard deviation. Statistical analysis was performed using Fisher's exact test, and Chi-square tests to evaluate statistical significance across the two groups. Values with $P < 0.05$ were considered statistically significant.

Results

Two hundred patients were equally allocated into either group after randomization using random number tables and sealed envelope technique [Figure 2]. The demographic characteristics and mean operative times were comparable. The surgical duration was less than 2 h in all cases. None of the patients in either group had values of ONSD above the normal cutoff value of 5.0 mm. There was no significant difference in the ONSD between the two eyes in the two groups at all the abovementioned time intervals [Table 1].

There was a statistically significant lower value of HR in the low-pressure group measured 10 min after 30-degree reverse Trendelenburg positioning which was approximately 20 min after insufflation. This significant difference remained during the subsequent intraoperative recordings but the value of HR became comparable after exsufflation and when the patient was positioned supine. The value of MAP was significantly higher in the standard pressure group at insufflations, reverse Trendelenburg positioning and intraoperatively but became comparable with the low pressure group at exsufflation [Table 2]. The surgeon was satisfied with operating condition in both the groups.

Discussion

Results of our study report that pneumoperitoneum at both low and standard intra-abdominal pressures do not increase ICP in short duration surgeries like laparoscopic cholecystectomy. In our study, the values of ONSD were comparable between the two groups and remained below 5 mm in both the groups, thus, ruling out the possibility of raised ICP.

The results of our study are similar to the work done by Kim *et al.*^[11] who measured ONSD in two different settings; patients in Trendelenburg position undergoing laparoscopic gynecological surgery vs patients in reverse Trendelenburg position undergoing laparoscopic cholecystectomy. They reported that the rise in ICP during laparoscopic surgery with short period of pneumoperitoneum is minimal and irrespective of change in patient positioning.^[11] In patients undergoing robot-assisted laparoscopic radical prostatectomy (RALRP) the authors report no statistically significant increase in the ONSD. Colomina *et al.*^[13] evaluated cerebral hemodynamics with^[12] transcranial Doppler in lengthy laparoscopic procedures requiring pneumoperitoneum and head-down positioning and similarly did not report any significant change in mean middle cerebral artery (MCA) blood-flow velocity.

Evaluation of ONSD is a fast, easy, secure, safe, easily accessible, reliable, inexpensive, noninvasive, bedside tool for screening and monitoring of patients at risk of increased ICPs.^[14] A systematic review and meta-analysis involving 460 subjects and recruiting nine observational studies and one randomized controlled trial determined that elevated ICP during laparoscopic procedure could be predicted by means of significant increase in the ONSD in the early (0–30 min) and later (30–120 min) period of CO₂ pneumoperitoneum.^[15] Studies conducted in patients undergoing RALRP have thus reported an increase in ONSD confirming an ICP above 20 mmHg during the surgery.^[16,17] The clinical and surgical settings, however, are different in this subset of patients which are operated in steep Trendelenburg position for a longer duration and their results cannot be compared with our study in which the duration of surgery is less and the positioning is also different.

Kamine *et al.*^[18] reported a sequential increase in ICP in a small subset of nine patients undergoing laparoscopy-assisted ventriculoperitoneal shunt (VPS) placements. But their results cannot be extrapolated to our settings as their subjects were undergoing management of hydrocephalus whereas our patients had no intracranial pathology.

Increase in pressure in sagittal sinus secondary to increased intrathoracic pressure (due to pneumoperitoneum), metabolically

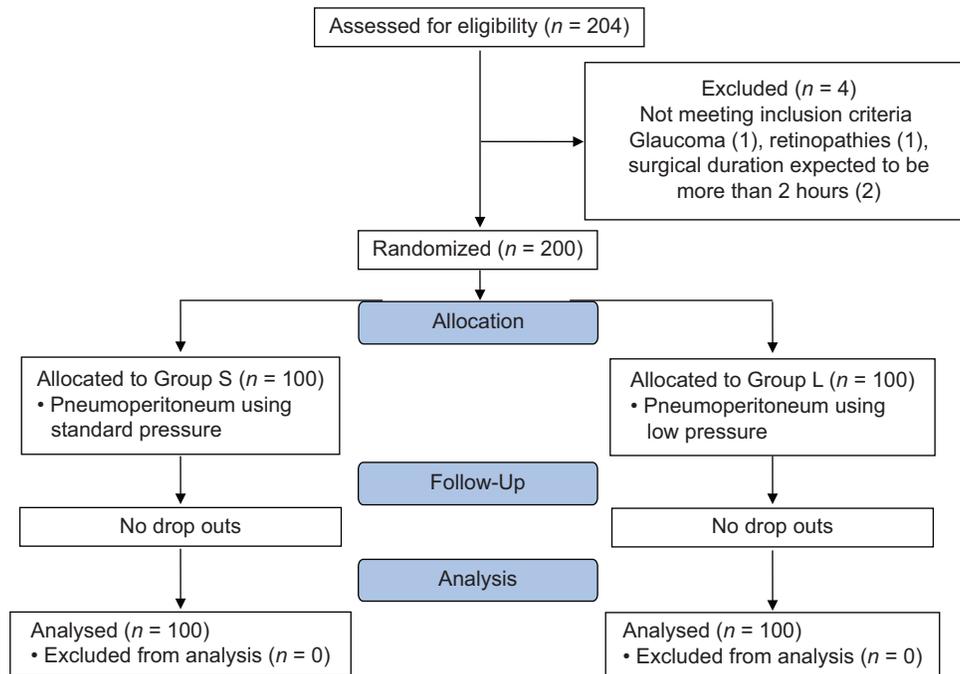


Figure 2: CONSORT flow diagram showing patient's participation

Table 1: Value of ONSD in both the groups at different time intervals

Time intervals	Value of ONSD in centimeters in both eyes				P	
	Group S (n=100)		Group L (n=100)			
	RE	LE	RE	LE	RE	LE
T _{Baseline}	0.383±0.06	0.388±0.06	0.384±0.05	0.383±0.05	0.994	0.649
T _{Induction}	0.399±0.05	0.404±0.06	0.391±0.05	0.387±0.05	0.508	0.197
T _{Insufflation}	0.418±0.08	0.428±0.07	0.410±0.05	0.410±0.04	0.606	0.169
T _{Reverse Trendelenburg}	0.415±0.08	0.425±0.06	0.410±0.04	0.414±0.05	0.723	0.414
T _{Intraoperatively}	0.410±0.06	0.417±0.06	0.411±0.05	0.418±0.04	0.969	0.968
T _{Supine after exsufflation}	0.396±0.07	0.402±0.06	0.404±0.05	0.405±0.05	0.527	0.807

RE: Right eye; LE: Left eye; ONSD: Optic nerve sheath diameter; Group S: Standard pressures (12-16 mmHg); group L: Low pressures (8-10 mmHg). All values are in mean ±SD. P<0.05 is significant

related rise in cerebral perfusion due to elevated PaCO₂ and ET_{CO}₂ and reduced absorption of CSF in lumbar cistern and the dural sleeves of spinal nerve roots lead to increased ICP.^[1,19,20]

In our study, the ET_{CO}₂ and peak airway pressures were monitored and their mean values were comparable. Patients with plateau pressure above 30 cmH₂O, peak inspiratory pressures above 35 cmH₂O and ET_{CO}₂ values above 45 mmHg (confirmed in arterial blood gas analysis) were excluded. Different ventilation modes are known to affect oxygenation and ventilation in laproscopic surgeries and, thus, are known to influence ICP through all the abovementioned mechanisms.^[21] In our study, we standardized these factors so as to minimize bias.

ONSD is the quickest and least invasive diagnostic modality to detect increased ICP. The use of fundoscopy is limited as blurring of disc margins and papilledema are both late signs of intracranial hypertension.^[22] Computed tomography,

magnetic resonance imaging, transcranial Doppler, electroencephalography power spectrum analysis, audiological and ophthalmological techniques are other noninvasive methods to measure ICP.^[23] Intraventricular catheters are associated with several complications such as infection, bleeding, blockage, and malpositioning and are not routinely used in patients with hemostatic abnormalities and severe brain swelling. Subdural and epidural devices are seldom used but lumbar assessments of CSF pressure are commonly done.

Hemodynamic changes observed in our study were minimum in the low-pressure group and are in concordance with results of previous studies.^[24,25] Statistically significant difference was noted in MAP after insufflations and in HR after reverse Trendelenburg position between the two groups.

Limitations with the use of ONSD are the inter-observer variation in the measurement. We minimized this bias by

Table 2: Hemodynamic data (HR and MAP) in both the groups at different time intervals

Hemodynamic parameter	Group S (n=100)	Group L (n=100)	P
HR (T _{Baseline})	78.88±11.76	75.50±9.58	0.163
HR (T _{Induction})	81.85±11.98	81.55±8.57	0.898
HR (T _{Insufflation})	80.98±10.68	82.98±8.17	0.350
HR (T _{ReverseTrendelenberg})	89.32±11.63	84.93±11.24	0.034*
HR (T _{Intraoperatively})	85.88±10.78	78.53±9.84	0.002*
HR (T _{Supine after exsufflation})	78.90±12.30	79.30±11.45	0.881
MAP (T _{Baseline})	80.98±10.68	82.98±8.17	0.350
MAP (T _{Induction})	101.30±10.91	99.53±7.39	0.397
MAP (T _{Insufflation})	104.18±13.32	83.78±9.59	0.001*
MAP (T _{Reverse Trendelenburg})	100.13±19.93	80.95±12.84	0.001*
MAP (T _{Intraoperatively})	96.38±12.20	89.68±8.15	0.005*
MAP (T _{Supine after exsufflation})	96.23±16.12	91.35±6.26	0.078

Group S: Standard pressures (12-16 mmHg); group L: Low pressures (8-10 mmHg). HR: Heart rate in beats/minute; MAP: Mean arterial pressure in mmHg. All values are in mean±SD. P<0.05 is significant

using a single anesthetist for all ONSD recordings and a double-blind technique (surgeon, anesthetist delivering GA, and anesthetist recording ONSD were blinded to the group allocation). We measured ONSD 5 min after induction and 10 min after insufflation and positioning and this might have prevented us from recording the immediate changes in ONSD. Various compensatory mechanisms are activated when increases in ICP are detected by the human brain. Dynamic equilibrium of parenchymal tissue, arterial and venous blood, and CSF (Monroe-Kellie doctrine) maintains cerebral autoregulation and prevents increase in ICP. This might explain the finding that none of the patients in either group had values of ONSD above the normal cutoff value of 5.0 mm and is one of the other limitations of this study.

Results of our study cannot be extrapolated to patients with concomitant head injuries or neurologic disorders because the compensatory mechanisms may be nonfunctional and increasing intra-abdominal pressures may increase ICP as has been reported in previous studies.^[23,26] We did not compare effect of intra-abdominal pressures on systemic inflammation and immune response, postoperative outcome, pain scores, etc., because evidence supporting use of low pressures in this context are existing.

Conclusion

Use of both standard (12–16 mmHg) and low (8–10 mmHg) intra-abdominal pressures for pneumoperitoneum do not cause intracranial hypertension during short duration surgeries like laparoscopic cholecystectomy. The value of ONSD are comparable between the two groups and below the cutoff value of 5.0 mm which is used to identify an ICP >20 mmHg.

Increase in HR and MAP after pneumoperitoneum was significantly more in standard pressure group.

NOTES:

We declare that we have shown compliance with ethical standards.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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