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RESEARCH ARTICLE
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EFFECT OF LOW VERSUS STANDARD PRESSURE PNEUMOPERITONEUM ON INTRACRANIAL PRESSURE USING ULTRASOUND ASSISTED OPTIC NERVE SHEATH DIAMETER IN LAPAROSCOPIC CHOLECYSTECTOMY UNDER GENERAL ANAESTHESIA

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ABSTRACT:
Background- Intra-abdominal carbondioxide insufflation is associated with an increase of intracranial pressure (ICP). This study was done to compare the impact of low versus standard pressure pneumoperitoneum on ICP through ultrasonographic estimation of optic nerve sheath diameter (ONSD). **Methods-**Patients in age group 20–65 years posted for laparoscopic cholecystectomy were randomly allocated into two groups:-group L (low pressure of 8–10 mmHg) and group S (standard pressure of 12–16 mmHg) on the basis of intraabdominal pressures used for surgery. General anaesthesia was administered to all patients and end-tidal carbon dioxide ($EtCO_2$) value was maintained in the range of 35 and 40 mmHg and peak airway pressures below 35 cmH_2O. ONSD was measured in both eyes at a point 3 mm lying posterior to the globe at following time intervals:- baseline, 5 minutes (mins) after induction, 10 mins after insufflation, 10 mins after reverse trendelenberg positioning, intraoperatively during surgery and after exsufflation of gas in supine position. **Results-**Mean ONSD in both eyes was found to be comparable between both groups with p-values found to be significant statistically at time intervals- T insufflation, T reverse trendelenberg and T intraoperative. Heart rate and MAP values were noted to be comparable between both groups L and S with values found to be non-significant statistically at initial time intervals then becoming statistically significant intraoperatively and then again non significant after returning to baseline. **Conclusion-**Intraabdominal CO_2 insufflation at both low and standard pressures does not elevate intracranial pressure during brief surgical procedures allowing for the safe use of either pressure in adult patients positioned in reverse trendelenberg position. The benefits of low pressure were confined to better hemodynamic control.

INTRODUCTION:

Laparoscopic cholecystectomy is a minimally invasive surgical technique for gallbladder removal which has become the preferred method over open cholecystectomy since 1900s.[1] However, it induces respiratory, haemodynamic and metabolic alterations associated with the patient's position and pneumoperitoneum.[2] The patient is positioned in a reverse trendelenberg position to facilitate visceral displacement due to gravity away from the operative site making it favourable for respiration.[3] This position further leads to reduced venous return, reduced pressure of right atria and lowered pulmonary capillary wedge pressure.[4] This can cause hypercarbia which negatively impacts cardiac contractility and left ventricular function.[5] Increase in intraabdominal pressure disrupts infra-diaphragmatic arterial and venous circulation and may cause cerebral edema leading to transient neurological impairment.[6]

Intracranial pressure measurement techniques include B-mode transcranial sonography, transcranial doppler and orbital sonography. Invasive measurements with intraventricular or intraparenchymal catheters are widely used in managing traumatic brain injury but may not be viable for all patients. Ultrasonographic ONSD estimation is a non-invasive, straightforward and expeditious method for identifying changes in ICP. Other non-invasive methods include computed tomography, MRI, transcranial doppler, electroencephalography, audiological and ophthalmological procedures. Point of care Optic nerve sheath ultrasound (ONSUS) is used to assess elevation in ICP.[7]

MATERIALS AND METHODS: A prospective, randomized, double-blind, interventional clinical study was conducted at our hospital after obtaining approval from the Institutional Ethics Committee with reference number 359_D-26/2022 and registered with CTRI with reference number CTRI/2024/07/071445. Informed and written consent from all the patients was taken before the procedure. 100 patients of American Society of Anaesthesiologists grade I and II aged 20-65 years undergoing elective laparoscopic cholecystectomy were included in our study. Patients with previous history of orbital trauma, neurological diseases, glaucoma, previous lung surgery, chronic obstructive pulmonary disease (COPD), heart disease and patients with $EtCO_2$ value more than 45 mm Hg, plateau pressure above 30cm H_20 and peak inspiratory pressures above 35 cm H_20 were excluded from our study. The patients were allocated into two groups (group L- low pressure of 8-10 mm Hg and group S-standard pressure of 12-16 mm Hg) of 50 each in a random manner using a computer generated random number table. The study was conducted with a primary aim to compare the impact of low (8-10mm Hg) versus standard pressure (12-16mm Hg) pneumoperitoneum on intracranial pressure (ICP) using ultrasound assisted optic nerve sheath diameter (ONSD) in patients undergoing elective laparoscopic cholecystectomy. Secondary aims were to compare haemodynamic changes observed in patients and to observe any complications.

Patients were then randomly divided into two groups based upon computerized randomization by a researcher who had no involvement in study. Sample size was calculated after consultation with a statistician based on previous study to get power more than 85% and considering alpha error of 5%, significance level significant at 95% confidence interval. For statistical analysis Software SPSS version 23 (SPSS Inc.; Chicago, Illinois, USA) was used and all results were presented as mean ± standard deviation.

In the operation theatre, an intravenous cannula 18/20 gauge was inserted and standard multipara monitors were used for monitoring of the patient. A software- controlled portable ultrasonographic system with a higher frequency 38 mm broadband linear array transducer was utilized for ONSD measurement. A sterile dressing was applied over the closed eye with copious ultrasound gel and high-frequency ultrasound transducer was placed over the eye with little to no contact with the sterile dressing in transverse plane. After measuring 3 millimeter posteriorly to globe, we used electronic callipers to measure the distance of decreased echogenicity between the hyperechoic demarcations of sheath. Once optimal images were captured in two planes, the mean was evaluated to estimate true ONSD value. Both eyes were scanned and bilateral values were taken at different time periods. Baseline value was noted for both eyes before start of induction procedure.

Premedications included midazolam 0.01 mg/kg, fentanyl 25 micrograms per kg, propofol 2 mg/kg as induction agent and vecuronium 0.1mg/kg as neuromuscular blocking agent. General anesthesia was maintained with 50% oxygen in 50% nitrous oxide, Isoflurane 1.2MAC and vecuronium 0.01 mg/kg maintenance. For analgesia, injection paracetamol infusion was given @ 15 mg per kg IV intraoperatively and injection ondansetron 4 mg was administered 15 minutes before end of procedure. The neuromuscular block was reversed with IV neostigmine (50 µg/kg) and glycopyrrolate (10 µg/kg) after return of spontaneous ventilation. Extubation was done on return of spontaneous ventilation. In recovery room, patient received oxygen via facemask and monitoring was done.

We observed finding correlation between set pneumoperitoneum pressures and its effect on ONSD at various time intervals. Other haemodynamic parameters were noted and then compared using relevant statistical tests.
ONSD measurements were estimated at following intervals separately in the right and the left eye:-

1.	T baseline	Before induction of anaesthesia
2.	T intubation	5 minutes after intubation in supine position
3.	T insufflation	10 minutes after pneumoperitoneum
4.	T reverse trendelenberg	10 minutes after 30-degree reverse trendelenberg positioning
5.	T intraoperative	ONSD measurement done at every 20 minutes interval with patient in reverse trendelenberg position in both eyes and average value of measurements was compared between groups
6.	T supine after exsufflation	After reverting to supine position without pneumoperitoneum

OBSERVATIONS AND RESULTS:

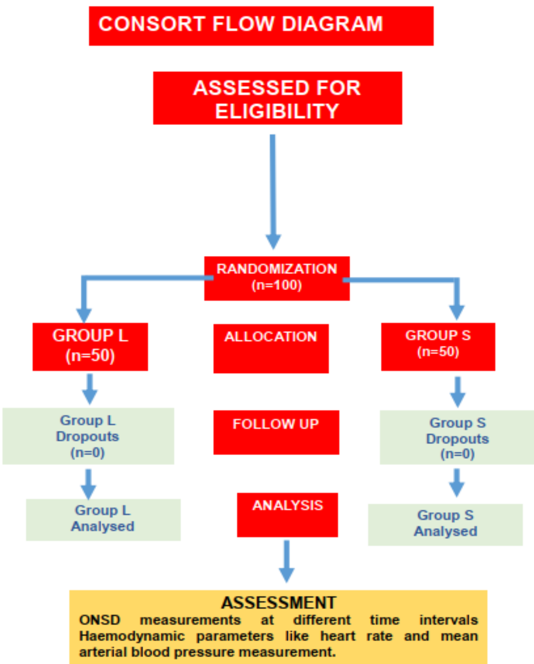

Figure 1: Consort flow chart

Demographic variables of the patient like age, gender and ASA grade were compared between both groups and showed no statistically significant differences as shown in Table-1.

Table-1: Demographic profile

Variables	Group L (n=50)	Group S (n=50)	p value
Age (years), (Mean±SD)	41.80±11.34	42.36±8.09	0.784 (NS)
Gender (Male/Female), (n)	43/7(86%/14%)	40/10(80%/20%)	0.424(NS)
ASA Grade (I/II), (n)	35/15(70%/30%)	37/13(74%/26%)	0.656 (NS)

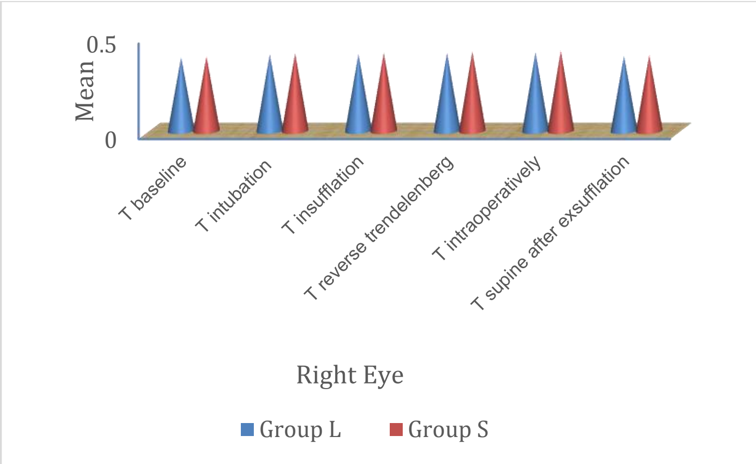

Figure 2 : Mean ONSD changes in Right eye

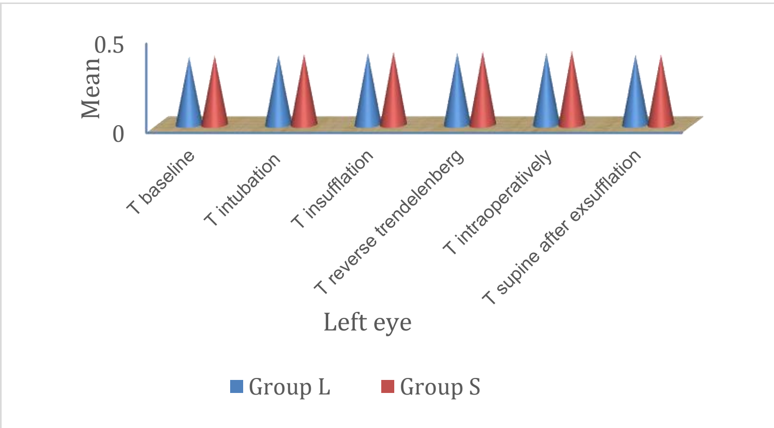

Figure 3: Mean ONSD changes in Left eye

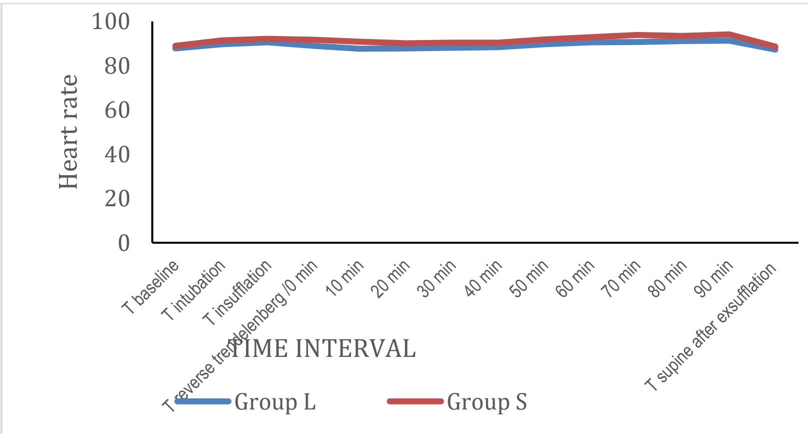

Figure 4: Intraoperative heart rate variation

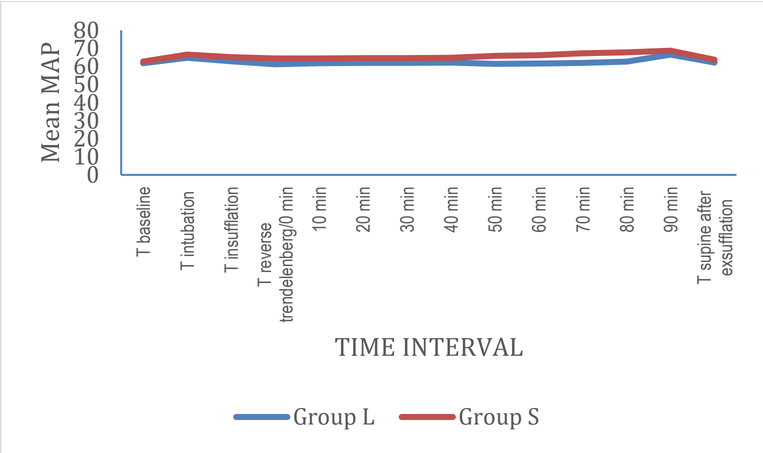

Figure 5: Intraoperative Mean arterial blood pressure variation

DISCUSSION:

The study found that both groups were comparable in terms of age, gender and ASA grading and were statistically non-significant as shown in Table 1. Mean age of L group was noted to be (41.80±11.34) years and in S group was (42.36±8.09) years. Out of total 100 patients, 86% were females in group L and 80% were females in group S. Sex distribution is in accordance with study conducted by Kara D et al.[8] This might be probably because our study was based upon laparoscopic cholecystectomy surgery predominantly done in female patients. On the contrary, male population was in predominance in study conducted by Whiteley JR et al[9] since they selected patients undergoing radical prostatectomy.

Mean ONSD in both eyes was found to be comparable between both groups. p-values were observed to be non-significant at baseline before induction (p=0.217 in right eye {RE} and p=0.109 in left eye {LE} and 5 minutes after intubation in supine position (p=0.121 in RE and p=0.092 in LE)in both eyes. ONSD values became significant statistically with p-values less than 0.05 at subsequent time intervals- 10 minutes after pneumoperitoneum (p=0.018 in RE and p=0.017 in LE), 10 minutes after 30-degree reverse trendelenberg positioning (p=0.014 in RE and p=0.012 in LE) and T intraoperative (p=0.020 in RE and p=0.014 in LE). ONSD again became non-significant statistically with p value=0.080 in RE and 0.365 in LE after reverting to supine position without pneumoperitoneum.

Saini V et al[10] in 2019 did a study in patients of laparoscopic cholecystectomy and concluded that intra-abdominal CO_2 insufflation at low and standard pressure does not allow ICP to rise in surgeries of short duration and hence both pressures can be used safely in patients who went through surgeries in reverse trendelenberg position. Benefits in using low pressure got reflected in better haemodynamic stability.

A study was conducted in 2021 by Erturk T et al[11]on patients posted for laparoscopic cholecystectomy. ONSD differences between right and left eyes at 15 and 30 minutes following CO_2 insufflation were found to be statistically significant ($p < 0.01$). A significant enhancement in values of ONSD was seen in direct correlation to rise in intraabdominal pressure. In 2023 Ponduru S et al[12] did a study and concluded that laparoscopic surgery utilizing low-pressure pneumoperitoneum may be a safer method especially for individuals predisposed to elevated intracranial pressure.

Our study observed changes in baseline mean arterial pressure (MAP), heart rate (HR) and end tidal carbondioxide ($EtCO_2$) in both groups at different time intervals namely- T baseline, T intubation, T insufflation, T reverse trendelenberg/ zero time (T0), T intraoperative at interval of 10 minutes upto 90 mins, T supine after exsufflation. Heart rate values were noted to be comparable between both groups L and S with values found to be non-significant statistically at T baseline (p=0.406) , T intubation (p=0.088) and T insufflation (p=0.122) time intervals. Heart rate values started increasing after T reverse trendelenberg time interval throughout the surgery and showed statistical significance with p-values less than 0.05. Heart rate returned to baseline following exsufflation of gas and values were noted to be statistically non-significant between both the groups (p-value=0.215) as shown by variation in Figure 4.

MAP values remained comparable between both groups and were non significant statistically at initial time intervals of T baseline (p=0.146), T intubation (p=0.055). Subsequently MAP values were noted to be significant statistically between both groups at T insufflation (p=0.008) and following time intervals intraoperatively. MAP values reverted to baseline values after deflation of pneumoperitoneum and found to be comparable between both groups(p=0.124) as shown by variation in Figure 5.

Saglam S et al[13] (2024) conducted a trial to assess changes in ONSD following laparoscopy assisted cholecystectomy in reverse trendelenberg position comparing complete intravenous anaesthesia to desflurane. Insignificant difference was observed in average ONSD values in both groups at all four time points. Their findings suggest that TIVA may be better suitable for patients undergoing procedure in the reverse trendelenberg position due to minimal alterations in ONSD.

Umar A et al[14] performed a study in 2012 in patients who underwent laparoscopic cholecystectomy allocated in three groups. In all groups, MAP value increased during CO_2 insufflation and elevation in value continued with increasing duration of pneumoperitoneum. A decline in MAP was noted at time of exsufflation and at ten minutes post exsufflation. Our study showed MAPs were similar between 2 groups and came out to be significant statistically after reverse trendelenberg positioning and returned towards baseline values subsequent to exsufflation and change over to supine posture. This rise in MAP with carbondioxide insufflation is due to increase observed in SVR due to release of humoral mediators and sympathetic effects of CO_2 absorbed from peritoneal cavity as a result of increased intra-abdominal pressure. After exsufflation, the decrease observed in MAP could be because of reverting back effects of CO_2 pneumoperitoneum.

End tidal carbondioxide values were seen comparable between both groups with p values above 0.05 at all defined time intervals suggestive of statistical non-significance.

CONCLUSION: Significant increase was noticed in ONSD values in direct proportion to intra-abdominal pressure increase in patients undergoing laparoscopic cholecystectomy surgery. High intra-abdominal pressure due to CO_2 insufflation is associated with more fluctuations in haemodynamic parameters and increased peritoneal absorption of CO_2 as compared with low intra-abdominal pressure. Low pressure pneumoperitoneum is ideal for laparoscopic cholecystectomy and minimizes adverse haemodynamic effects of CO_2 insufflation.

LIMITATIONS:

The limitations of our study are small sample size, a lack of established minimum ONSD cut-off value for detecting intracranial hypertension, operator-dependent measurement variability in results and inability to compare non-invasive and invasive methods. The study also suggests that orbital sonographic measurement could be supported by tonometry. Patients were advised for follow up after surgery for vision or eye-related complications but long-term follow-up was not feasible.

FUTURE GUIDELINES :

There is a necessity for further studies with a relatively large sample size. Proposal is to conduct additional studies in order to determine the effect of position and time on ONSD in patients undergoing laparoscopic procedures with standard and low pneumoperitoneum pressures particularly in steep trendelenberg position. This can help to decrease the probable complications observed in intra and post-operative period caused by rise of ICP in laparoscopic procedures and improve patient safety during these type of surgeries.

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