Section: Anaesthesia

Original Research Article

EFFECT OF DIFFERENT ANAESTHETIC FRESH GAS FLOW RATES ON OPTIC NERVE SHEATH DIAMETER IN PATIENTS UNDERGOING ELECTIVE LAPAROSCOPIC CHOLECYSTECTOMY UNDER GENERAL ANAESTHESIA

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Received : 28/02/2025
Received in revised form : 20/04/2025
Accepted : 06/05/2025

Keywords:
Fresh Gas flow, laparoscopy, ONSD, ICT.

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DOI: 10.47009/jamp.2025.7.3.29

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (3); 150-156

ABSTRACT

Background: Pneumoperitoneum in laparoscopy may lead to acute rise of intracranial tension(ICT), which can be indirectly measured by optic nerve sheath diameter (ONSD). Low fresh gas flows during laparoscopic procedure may lead on to carbon dioxide retention and hypercapnia. We aim to assess whether ONSD is affected when fresh gas flow (FGF) rates of 1.5L/min(Group 1) are used, compared to FGF 3L/min(Group 2) during laparoscopic cholecystectomy. **Materials and Methods:** After obtaining IEC clearance, CTRI registration, and informed consent, a prospective randomised control trial was done in 60 patients aged 18 to 60 years posted for elective Laparoscopic cholecystectomy under general anaesthesia. ONSD was measured at – T1 : Baseline before induction, T2 : 5 minutes after pneumoperitoneum, T3 : 30 minutes after pneumoperitoneum, and T4 : 15 minutes after extubation. The ETCO2 values were maintained between 30 to 35 in all patients. **Result:** At baseline T1, ONSD were similar in all patients. At T2 interval, ONSD was 4.86+/- 0.18 in group 1, and 5.02 +/-0.18 in group 2 with mean difference of 0.15(95% CI: -0.25 to -0.05) and p value of 0.002. At T3 mean ONSD were 4.92+/-0.19 in group 1, and 4.98+/-0.08 in group 2 with a difference of 0.06, and at T4 mean values were 4.80+/- 0.16 and 4.86+/-0.09 with difference of 0.06, showing no significant ONSD differences at T3 and T4 time intervals. **Conclusion:** Use of FGF rates at 3L/min may not change ONSD and ICT significantly when compared to FGF of 1.5L/min during general anaesthesia for laparoscopic Cholecystectomy.

INTRODUCTION

The use of laparoscopy has become the standard surgical technique for various procedures previously performed by conventional techniques. It benefits the patient with minimal surgical incisions, less postoperative pain, reduced need for post operative analgesia and shorter hospital stay. Laparoscopy is not free of adversities as the pneumoperitoneum is known to raise intracranial pressure (ICP) due to decreased cerebrospinal fluid (CSF) absorption, obstruction of lumbar venous plexus drainage, increased pressure in the vascular compartment of sacral spaces, and cerebral vasodilation brought on by hypercapnia,[1] and also reduces cerebral blood flow (CBF) which could lead to cerebral hypoxia,[2] Hence administration of anaesthetic fresh gas flow mixture adequately is of utmost importance.[3]

The most Important factor that prevents the low gas flow anesthesia technique from becoming routine practice is the possibility of hypoxia and hypercapnia occurring in the patient which can lead to increase in ICP. Increase in intracranial pressure (ICP) by hypoxia,[4] occurs through two mechanisms: vasodilatation and cerebral edema. In hypoxic ischemic brain injury (HIBI), ICP can increase from cerebral edema which in turn worsens hypoxemia and lead to increased ICP and impaired cerebral oxygenation. While Hypercapnia can increase intracranial pressure (ICP) by increasing cerebral blood volume as hypercapnia triggers vasodilation leading to changes in arterial partial pressure of carbon dioxide (PaCO2) which is strongly vaso-active,[5] resulting in corresponding changes in cerebral blood volume, and a subsequent increase in ICP.

With recent development of sophisticated monitoring equipment the trend for administration of low-flow anesthesia has emerged recently due to advantages of preventing operation room and environmental pollution, reducing costs,[6] minimizing heat loss by raising the temperature and humidity of the inspired gas in patients, better preservation of tracheobronchial physiology as well as reducing the consumption of anesthetics during inhalation anesthesia.

The most accurate way to measure and monitor ICP is intraventricular and intraparenchymal catheterization which is difficult to perform as it is invasive, while transorbital ultrasonography is the fast, easy and non invasive method which detects raised ICP by measuring increase in the optic nerve sheath diameter (ONSD). As the optic nerve is surrounded by cerebrospinal fluid (CSF), and thus any variation in CSF pressure, either due to reduced absorption or improper drainage, can directly influence the ONSD.[1]

The primary objective of the study was to assess if ONSD is affected when fresh gas flow(FGF) rates of 1.5L/min (Group 1) are used, compared to FGF 3L/min (Group 2) during laparoscopic cholecystectomy. The secondary objective was to measure changes in hemodynamic parameters (HR, BP, MAP, SPO2, ETCO2) at different fresh gas flow rates.

MATERIALS AND METHODS

A randomized control study was conducted after obtaining approval by the Institutional Ethical Committee (IEC 452), after CTRI registration (CTRI/2024/03/080664) and written informed consent. 60 Patients posted for elective Laparoscopic cholecystectomy under general anesthesia aged between 18 to 60 years of age belonging to American Society of Anaesthesiologists (ASA) class I and II were selected. Patients with acute or chronic eye disease, history of drug abuse, acute alcohol intoxication, chronic alcohol, patients with BMI more than 35kg/m^2 and patients with known history of neurological disorders were excluded from the study.

ONSD (Optic Nerve Sheath Diameter) was measured in the supine position by ultrasonographic measurement. A thick gel layer was applied to the closed upper eyelids of patients and the linear 7-12 MHz probe was carefully placed on the gel. Excessive pressure was avoided with gentle handling and the probe adjusted to display the entry of the optic nerve into the globe in the two-dimensional mode. After obtaining optimal contrast between the retrobulbar echogenic fat tissue and the vertical hypoechoic band, the ONSD was measured 3 mm behind the optic disc using an electronic caliper.

The predetermined time points of the study,[1] are defined as follows

T1: in the supine position before anesthesia induction;

T2: 5 min after pneumoperitoneum;

T3: 30 min after pneumoperitonium;

T4: 15 min after extubation.

On the previous day of surgery, after a thorough pre-anaesthetic evaluation of patients, written informed consent was taken. On the day of surgery, after confirming overnight fasting status, in the preoperative room, 18 gauge intravenous (IV) cannula was secured and maintenance IV fluids were given.

Patients were allotted equally to either of the group 1(n = 30) or group 2 (n = 30) as per computer generated random numbers using sealed opaque envelope technique.

After shifting the patient to the operation theater, baseline HR, SBP, DBP, MAP, SpO2, and baseline ONSD were recorded. Patients were pre-medicated with Inj. Glycopyrrolate 0.004mg/kg, Inj. Midazolam 0.02mg/kg, Inj. Ondansetron 0.1mg/kg, Inj. Fentany 2mcg/kg. Patients were induced with Inj. Propofol 2mg/kg, Inj. Atrarcurim 0.5mg/kg. Following endotracheal intubation, minute ventilation was used to maintain the end-tidal carbon dioxide (EtCO2) between 30 and 35 mmHg.

Patients in the group 1 had their fresh gas flow reduced from 4 l/min to 1.5 l/min after the first 10 minutes after intubation. In contrast, patients in the group 2 were given 4 L/min of fresh gas for the first 10 minutes after intubation, with the flow rate afterward being maintained at 3 L/min. A tidal volume of 7 ml/ kg of ideal body weight was used for all patients being mechanically ventilated at a rate of

ISSN (O): 2687-5365; ISSN (P): 2753-6556

12 breaths per minute. Minimum alveolar concentration (MAC) values were calculated as a function of age and shown in terms of their impact on the volume of air breathed in. Pneumoperitoneum was induced in all patients by insufflation with carbon dioxide (CO_2) at a pressure of 14 mmHg. Then the patients were positioned into reverse trendelenburg position.

HR, SBP, DBP, MAP, SpO_2, $ETCO_2$ were also measured at the interval of 5 minutes throughout the surgery. PONV, headache, tinnitus, diplopia and transient visual disturbances were assessed in the post-operative period.

Sample size

Based on the study done by A. Mermer, B. Kozanhan in 2023 the total number of patients required for this study is calculated by the formula is 52 participants, keeping the power 80% and confidence interval 95% and taking into consideration data from previously published studies.

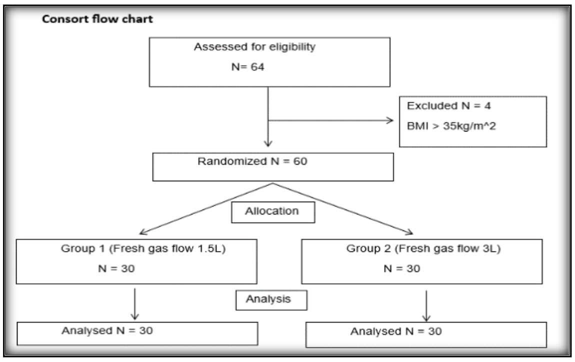
Assuming loss of follow up of 15%, the study size was set at 60 participants (30 in each group),

$N = (Z_{1-\alpha/2} + Z_{1-\beta})^2 * (\sigma_1^2 + \sigma_2^2) / (\delta^2)$

Where $Z_{1-\alpha/2}$ and $Z_{1-\beta}$ are the critical values of the normal distribution for the level of significance and power, respectively, and σ_1 and σ_2 are the standard deviations of the two groups. Δ is the difference in means between the two groups.

Statistical Analysis

Data was analyzed using the statistical package SPSS 26.0 (SPSS Inc., Chicago, IL) and level of significance was set at $P<0.05$. Inferential statistics was done using Independent T test and Chi square test.



RESULTS

A total of 64 patients were assessed for eligibility in this study. Four patients were excluded due to a BMI value over 35 kg/m2, so 60 patients were enrolled and randomly allocated 30 patients each to the Group 1 or the group 2 and all patients were included in the analysis. All the patients underwent laparoscopic cholecystectomy under general anaesthesia with no mortality until discharge time. The average age for the Group 1 was 35.8 years, while for group 2, the mean age was 33.1 years. The study included 20 females and 10 males for the group 1 and 18 females and 12 males for the group 2, with an mean BMI of 23.27 kg/m2 for group1 and 24.53 kg/m2 for group 2. Twenty seven patients in group 1 were in ASA physical status I, and the remaining 3 were in status II. For group 2, 21 were in ASA physical status I, and the remaining 9 were in status II. We did not find any statistically significant changes regarding demographic variables or ASA status [Table 1].

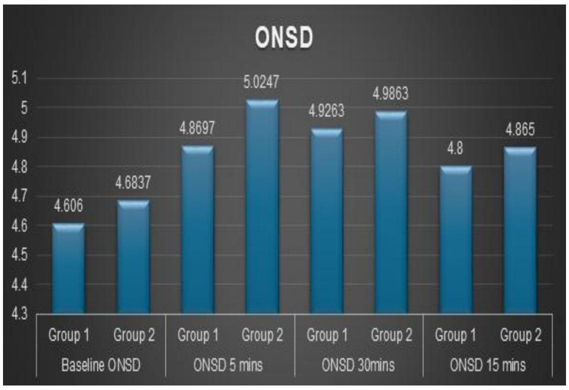
Table 1: Demographic characeristics in both the groups

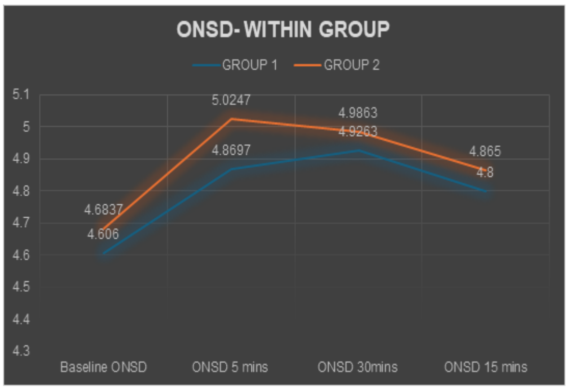
Variable	Group 1		Group 2		p value
Age	35.8+/-9.3		33.17+/-5.9		0.19
Gender	20F/10M		18F/12M		0.59
BMI	23.27+/-2.57		24.53+/-1.99		0.23
ASA	ASA1- 27	ASA-2 3	ASA-1 21	ASA-2 9	0.6

Table 2: Comparision of ONSD values

Variables	Group 1	Group 2	P value
Baseline ONSD T1	4.60+/-0.18	4.68+/-0.20	0.08
ONSD 5 mins T2	4.86+/-0.18	5.02+/-0.18	0.002*
ONSD 30mins T3	4.92+/-0.19	4.98+/-0.08	0.13
ONSD 15 mins after deflation T4	4.80+/-0.16	4.86+/-0.09	0.06

P<0.05 is statistically significant





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The ONSD measurements taken during the study protocol are listed in [Table 2]. Some changes were noted in ONSD during the study. Between the groups comparison by Independent T test analysis reported statistically significant change in 'ONSD' at 5 minutes interval(P<0.05). Independent T test did not report significant difference between the groups at Baseline, 30 mins & 15 mins after deflation (P>0.05). At baseline T1, ONSD were similar in all patients. At T2 interval, ONSD with a mean of 4.86mm and standard deviation of 0.18 was noted in group 1, and mean of 5.02mm and standard deviation of 0.18 was noted in group 2 with mean difference of 0.15(95% CI : -0.25 to -0.05) and p value of 0.002 which was found to be statistically significant. At T3 ONSD were 4.92+/-0.19 in group 1, and 4.98+/-0.08 in group 2 with a difference of 0.06, and at T4 mean values were 4.80+/- 0.16 and 4.86+/-0.09 with difference of 0.06, showing no significant ONSD differences at T3 and T4 time intervals.

The Hemodynamic parameters –HR, SBP, MAP, SPO2, ETCO2 in both the groups were comparable without any significant changes across all the measured time intervals. Hence the changes in fresh gas flow rates at 1.5L/min and 3L/min may not have any significant effects on them.

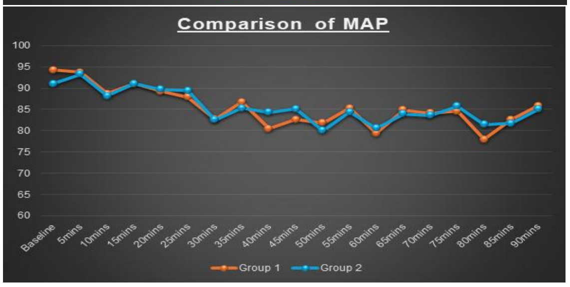
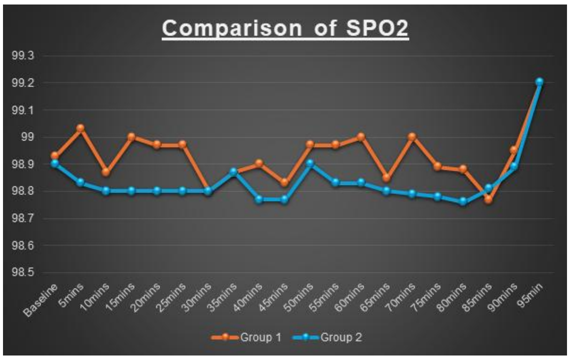


Table 3 - Comparison of HR

		N	Mean	Std. Deviation	P Value
Baseline	Group 1	30	83.10	6.925	0.148
	Group 2	30	78.67	15.059	
5mins	Group 1	30	82.20	7.029	0.767
	Group 2	30	82.83	9.304	
10mins	Group 1	30	81.13	9.652	0.126
	Group 2	30	84.83	8.793	
15mins	Group 1	30	79.10	8.260	0.211
	Group 2	30	81.90	8.860	
20mins	Group 1	30	81.33	9.459	0.278
	Group 2	30	83.97	9.159	
25mins	Group 1	30	81.37	6.494	0.686
	Group 2	30	82.07	6.838	
30mins	Group 1	30	80.77	8.245	0.293
	Group 2	30	83.20	9.474	
35mins	Group 1	30	84.03	10.994	0.361
	Group 2	30	81.63	9.099	
40mins	Group 1	30	81.67	6.682	0.497
	Group 2	30	82.90	7.275	
45mins	Group 1	30	81.43	6.867	0.281
	Group 2	30	83.67	8.907	
50mins	Group 1	30	85.77	8.744	0.853
	Group 2	30	85.33	9.301	
55mins	Group 1	29	84.07	8.298	0.573
	Group 2	30	82.97	6.568	
60mins	Group 1	29	80.17	8.018	0.283
	Group 2	30	82.73	9.993	
65mins	Group 1	27	81.56	7.154	0.141
	Group 2	28	84.89	9.243	
70mins	Group 1	26	83.50	5.398	0.734
	Group 2	29	82.86	8.012	
75mins	Group 1	22	82.86	6.875	0.09
	Group 2	25	82.68	7.273	
80mins	Group 1	21	85.05	6.637	0.053
	Group 2	23	80.57	6.748	
85mins	Group 1	14	82.86	7.210	0.286
	Group 2	18	85.83	8.039	
90mins	Group 1	11	86.73	4.798	0.330
	Group 2	11	84.18	6.969	

Table 4: Comparision of SBP

		N	Mean	Std. Deviation	P Value
Baseline	Group 1	30	94.30	12.825	0.328
	Group 2	30	91.03	12.843	
5mins	Group 1	30	93.73	11.252	0.879
	Group 2	30	93.30	10.771	
10mins	Group 1	30	88.73	13.308	0.869
	Group 2	30	88.20	11.633	
15mins	Group 1	30	91.03	12.056	0.991
	Group 2	30	91.00	11.971	
20mins	Group 1	30	89.23	12.036	0.880
	Group 2	30	89.70	11.859	
25mins	Group 1	30	87.90	9.953	0.540
	Group 2	30	89.40	8.846	
30mins	Group 1	30	82.67	10.730	0.966
	Group 2	29	82.55	10.140	
35mins	Group 1	30	86.70	8.832	0.579
	Group 2	29	85.34	9.795	
40mins	Group 1	29	80.48	13.909	0.248
	Group 2	29	84.28	10.633	
45mins	Group 1	29	82.59	14.608	0.457
	Group 2	29	85.14	11.074	
50mins	Group 1	30	81.80	13.296	0.607
	Group 2	30	80.03	13.156	
55mins	Group 1	30	85.27	7.506	0.669
	Group 2	30	84.40	8.105	
60mins	Group 1	30	79.40	11.388	0.679
	Group 2	30	80.53	9.673	
65mins	Group 1	27	84.89	10.040	0.711
	Group 2	29	83.97	8.479	
70mins	Group 1	26	84.12	6.433	0.764
	Group 2	29	83.59	6.560	
75mins	Group 1	23	84.61	7.209	0.613
	Group 2	27	85.74	8.319	
80mins	Group 1	22	77.91	11.571	0.237
	Group 2	26	81.46	8.963	
85mins	Group 1	20	82.65	6.302	0.620
	Group 2	23	81.74	5.667	
90mins	Group 1	13	85.80	7.315	0.921
	Group 2	19	85.00	6.127	



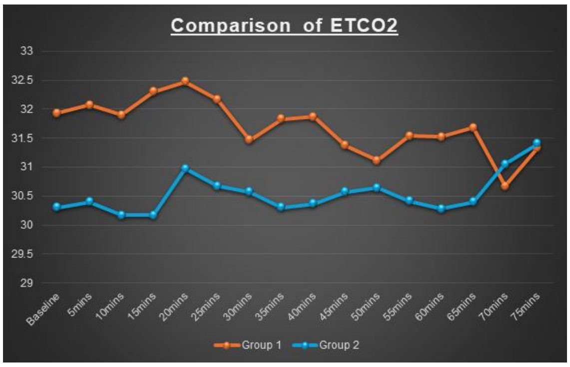


Table 5

		N	Mean	Std. Deviation	P VALUE
Baseline	Group 1	30	31.93	2.876	0.039
	Group 2	30	30.30	3.109	
5mins	Group 1	30	32.07	2.876	0.054
	Group 2	30	30.40	3.307	
10mins	Group 1	30	31.90	3.556	0.140
	Group 2	30	30.17	3.270	
15mins	Group 1	30	32.30	3.852	0.277
	Group 2	30	30.17	3.185	
20mins	Group 1	30	32.47	3.919	0.050
	Group 2	30	30.97	3.855	
25mins	Group 1	30	32.17	3.018	0.576
	Group 2	30	30.67	3.122	
30mins	Group 1	30	31.47	3.071	0.175
	Group 2	30	30.57	3.277	

35mins	Group 1	30	31.83	3.030	0.699
	Group 2	30	30.30	2.855	
40mins	Group 1	30	31.87	2.909	0. 042
	Group 2	30	30.37	2.906	
45mins	Group 1	27	31.37	3.200	0.023
	Group 2	30	30.57	3.081	
50mins	Group 1	27	31.11	3.191	0.063
	Group 2	28	30.64	2.984	
55mins	Group 1	24	31.54	3.401	0.048
	Group 2	27	30.41	2.886	
60mins	Group 1	23	31.52	3.409	0.339
	Group 2	25	30.28	2.821	
65mins	Group 1	22	31.68	3.372	0.204
	Group 2	25	30.40	3.416	
70mins	Group 1	18	30.67	2.951	0.203
	Group 2	21	31.05	3.122	
75mins	Group 1	12	31.33	2.934	0.956
	Group 2	15	31.40	3.180	

DISCUSSION

As per the study by Mermer et al,[1] in 2023 including 85 patients, during laparoscopic surgeries, the pneumoperitoneum was known to raise intracranial pressure (ICP) and reduce cerebral blood flow (CBF) and as a consequence could lead to cerebral hypoxia. Cerebrospinal fluid connects the optic nerve sheath, which is an outgrowth of the cerebral duramater, to the intracranial subarachnoid space. The diameter of the sheath that protects the optic nerve likewise grows larger in response to elevated ICP. Ultrasound-guided ONSD measurement being a simple and reliable method for estimating elevated ICP. Their study intended to investigate if ONSD was affected more by low-flow management or normal-flow anesthetic and noted that ONSD measurement shift of 0.3 mm or more was required for clinically meaningful findings. They concluded that the study demonstrated that low-flow anesthesia during laparoscopic cholecystectomy might have beneficial effects on ICP dynamics by preventing the rise of ONSD at a specific time point 30 minutes after endotracheal intubation.

This study's conclusion is in conjunction with the results found in our study which did not have any beneficial effect with use of higher fresh gas flows.

In a study by Onur A et al,[2] investigated the effects of minimal and high-flow anesthesia techniques on expiratory/inspiratory oxygen and carbon dioxide levels, hemodynamic parameters, and ONSD during laparoscopic gynecological surgery and found no statistically significant difference between the time-dependent hemodynamic parameters in two groups .A significant weak negative correlation was found between the ONSD and MAC values and a significant moderate positive correlation was observed between ONSD and $EtCO_2$ during minimal flow anesthesia, and concluded that minimal-flow anesthesia can be as safe as high-flow anesthesia using the ONSD measurement method by USG, which has been used in evaluating intracranial space in recent years.

The study by Kupusiak et al,[3] notes that the most popular mode of general anaesthesia used for laproscopic cholecystectomy is balanced anaesthesia with the use of fresh gases at a high flow of 6 l/min. The need to reduce pollution emissions in the operating room and to reduce treatment costs motivates more frequent use of general anaesthesia with small (0.5-1 l/min) or minimal (up to 0.5 l/min) fresh gas flow rates, especially when using such expensive resources as desflurane and isoflurane. Insufflation of the abdominal cavity with CO_2 during laparoscopy results in the increase of intra-abdominal pressure, reduction of functional residual capacity (FRC), decrease of pulmonary compliance, hypercapnia and increase of the systemic vascular resistance (SVR). All above factors together with Trendelenburg's position can cause a difficult to-estimate increase of the intracranial pressure and reduction in the cerebral blood flow (CBF) and as a consequence cerebral hypoxia. One way to avoid these problems might be the use of low-flow rate anaesthesia (LFA) during laparoscopic operations. Nevertheless, reduction of the fresh gas delivery should not influence the quality and safety of the anaesthesia.

As per Dinsmore et al,[4] the main findings were that mild acute changes in intracranial compliance induced by changes in $PETCO_2$ in fully awake and spontaneously breathing individuals can be detected as increases in ONSD as measured using ultrasonography. In addition, the ONSD changes were observed to be rapidly reversible upon returning $PETCO_2$ to participants' resting baseline values. The transorbital ultrasonographic measurement of ONSD can be used as an indirect, non-invasive technique for evaluating changes in ICP. However, most of their data was from patients in intensive care, with elevated intracranial pressure, and showed a significant correlation between elevated ICP (> 20 mmHg) and ONSD (> 5.7 mm)

In the study done by Ji-Hyun Chin et al,[7] the ONSD, as measured by ocular sonography, increased 3 min after the isolated steep Trendelenburg position in mechanically ventilated patients. In addition, we observed that the ONSD increased after the patient was placed in the steep Trendelenburg position combined with pneumoperitoneum. The ONSD

ISSN (O): 2687-5365; ISSN (P): 2753-6556

measured by ocular sonography has been found to correlate with ICP, suggesting that it could be used as a surrogate for ICP. Various cut-off values have been used to distinguish high from normal ICP. Several previous studies reported that the ONSD cut-off value of 5 mm was sensitive and specific for the identification of computed tomographic findings suggestive of increased ICP. Importantly, the ONSD cut-off value of 5 mm was found to be able to distinguish an ICP > 20 mmHg measured by ventriculostomy, showing an area under a receiver operator characteristics curve of 0.93 with a sensitivity of 88% and specificity of 93% in patients with clinical or radiologic signs of increased ICP

According to DeWaal,[11] insufflation of CO2 into the peritoneal cavity during laparoscopy and CO2 absorption by the peritoneal blood vessels leads to raised end-tidal CO2 concentration (ETCO2). It reduces the cerebral vascular resistance, and increases cerebral blood flow and partial pressure of oxygen in the brain.[7] There were no changes in the trends of cerebral oximetry measurements in both groups observed during the study. It resulted from maintaining normocapnia by ventilation increase and placing patients head up. This reduced cerebral hyperaemia and presumably balanced the earlier described effect. It suggests that cerebral oxygen metabolism is constant during the CO2 insufflation and the lowflow rate anaesthesia is safe he need to reduce

CONCLUSION

Use of higher Fresh Gas Flows rates may not reduce the CO2 buildup in the brain and hence FGF rates of 3L/min may not change ONSD and ICT significantly when compared to FGF of 1.5L/min during general anaesthesia for laparoscopic Cholecystectomy.

Limitations

Monitoring for depth of anaesthesia was not carried out in the patients during the surgery in our study.

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ISSN (O): 2687-5365; ISSN (P): 2753-6556