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Original Research Article

To observe the changes of optic nerve sheath diameter following the use of total intravenous anaesthesia with propofol or inhalational anaesthesia with desflurane during laparoscopic surgeries

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ABSTRACT

Background: Optic nerve sheath diameter measurement is a simple, non-invasive and yet accurate intracranial pressure (ICP) assessment technique during laparoscopic surgery. The pneumoperitoneum induced by insufflating carbon-dioxide and steep angle of trendelenburg position is associated with physiological changes resulting in increased ICP during laparoscopic surgery. We aimed to observe the changes of ONSD (surrogate marker of ICP) following the use of total intravenous anaesthesia in comparison to desflurane during laparoscopic surgery.

Materials and Methods: Patients scheduled for elective laparoscopic surgery were randomly assigned to the TIVA or DES group in this randomized study. Ultrasonographic measurements of ONSD were conducted before administration of anaesthesia (T0), 10 mins, 30 mins, 1 hr after the trendelenburg position (T1,T2,T3), 5mins after resuming the supine position (T4) and at post-anaesthetic care unit (T5). The primary outcome measure was the comparison of the mean ONSD of both the eyes of the patients of both the groups that is TIVA versus DES (inhalational anaesthetic) group.

Result: A total of 60 patients were analysed in our study. The mean ONSD value at T1, T2, T3 and T4 (for right eye p=0.002,0.001,<0.01,0.03 respectively and for left eye p=0.004,<0.01,<0.01,0.02 respectively) were significantly lower for patients in TIVA group as compared with those in DES group.

Conclusion: Our result suggests that TIVA may be a better option than inhalational anaesthesia to prevent rise in intracranial pressure in patients undergoing laparoscopic surgery and preventing devastating complications caused by raised intracranial pressure in succeptible patients.

1. Introduction

Majority of people prefer laparoscopy over open surgery as it has multiple advantages like smaller incisions, less painful, less chances of hemorrhage and faster post-operative recovery.[1] Despite these advantages, some adverse physiological changes occurs during laparoscopic surgery. Existing literature suggests that the rise in intra-abdominal pressure due to CO2 insufflation during pneumoperitoneum creation is associated with physiological changes resulting in a typical state of increased intraocular pressure (IOP) also during laparoscopic surgery.[2] If paired with a trendelenburg position, this rise in intraocular pressure is considerably exacerbated.[3]

Rise in intraocular pressure (IOP) and decreased ocular perfusion pressure (OPP) can often lead to ischaemic optic neuropathy, resulting in a catastrophic post-operative vision loss (POVL).[4] The incidence of POVL is very low (0.02% – 0.1%) yet it is a devastating complication.[5] Raised

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intracranial pressure (ICP) can also cause neurological complications like brain ischemia and seizures.[5] Hence, maintaining intraocular pressure (IOP) within normal range or attenuating an increase in intraocular pressure (IOP) in trendelenburg position during laparoscopic surgery remains one of the most important anaesthetic challenges.[6]

Regardless of the surgical procedure performed, it is clear that the three anaesthetic properties-sleep, pain-free, and muscle relaxation, after routine induction-can usually be maintained by two methods that is total intravenous anaesthesia (TIVA), in which the patient receives all anaesthetic drugs through an intravenous line; and inhalational anaesthesia, by which inhalational agents like desflurane, sevoflurane are delivered through the gases into the lungs.[7]

Ultrasonographic measurement of the optic nerve sheath diameter (ONSD) is a simple, non-invasive and yet accurate ICP assessment technique.[8] Previous studies have shown that ultrasonographic measurement of the optic nerve sheath diameter (ONSD) is a non-invasive and reproducible technique for evaluating elevated intracranial pressures.[9] Volatile anesthetics, which have been used in previous studies for robot assisted laparoscopic prostatectomy (RALP),[10,11] increase ICP by vasodilating the vascular smooth muscles.[12,13] By contrast, it has been shown that total intravenous anesthesia (TIVA) with propofol reduces cerebral blood flow (CBF) and thus decreases the intracranial pressure.[12] Hence the present study was conducted to observe the changes in ONSD during laparoscopic surgeries in response to TIVA and inhalational anaesthetic agent (desflurane). We hypothesized that TIVA would reduce the increase in ONSD during laparoscopic surgery when compared to inhalational anaesthetics.

2. Materials and Methods

This prospective randomised comparative hospital based study was conducted with 60 patients in surgical operation theatre, at Mahatma Gandhi Hospital, Jaipur. Approval was obtained from Institutional ethics committee and scientific committee. To detect a mean difference of 0.5 mm in ONSD between the groups, a sample size of 28 patients per group was required, with a type I error of 0.05 and a power of 90%, considering a 15% dropout rate. Patient with ASA class I/ II, aged between 18-60 years and patients written and informed consent were included in this study. Patients with a history of any respiratory or cardiovascular system disease and with any history of pre-existing neurologic or ophthalmic disease and any history of neurological or ophthalmic surgeries were excluded from the study. The Patients were randomly assigned into 2 groups – Group A(Total Intravenous Anaesthesia group - TIVA) and Group B (DES) by a chit and box method. The low solubility of desflurane in blood and body tissues causes a very rapid induction of and emergence from anaesthesia. A pre-anaesthetic checkup which included vital parameters like NIBP, pulse rate, temperature and respiratory rate were recorded in every patient. Any significant present and past medical/ surgical history was recorded.

All routine and specific investigations required for the surgery as per hospital protocol were obtained. Informed written consent of the patients for the study, anaesthetic technique and surgical procedure were taken. On the day of surgery on arrival in the operating room, standard 5 leads electrocardiogram (ECG), heart rate, pulse oximeter (SpO2), non-invasive blood pressure (NIBP), and capnostat for end-tidal carbon dioxide (EtCO2) measurement were attached and baseline parameters were noted. Venous access was secured using an 18 G or 20 G cannula on the dorsum of the non-dominant hand. Patients were premedicated with Inj glycopyrolate 0.2 mg and inj midazolam 1 mg i.v.

There are two groups:

1. Group A (TIVA): Patients were oxygenated with 100% oxygen for 3 mins. General anaesthesia was induced with 1.5 mg/kg propofol, 2 mcg/kg fentanyl and 0.6 mg/kg rocuronium. Following tracheal intubation, anaesthesia was maintained with 0.1 to 0.2 mg/kg/min i.v. propofol administered in a variable rate infusion and 1 mcg/kg fentanyl i.v. bolus after 1 hour.
2. Group B (DES): Patients were oxygenated with 100% oxygen for 3 mins.General anaesthesia was induced with 1.5 mg/kg propofol, 2 mcg/kg fentanyl and 0.6 mg/kg rocuronium. Following tracheal intubation, anaesthesia was maintained with inhalational gas (desflurane) and 1 mcg/kg fentanyl i.v. bolus after 1 hour.

After induction, the patient's eyes were covered with a tegaderm and a thick layer of water-soluble sonography jelly was applied over the both upper eyelids. A linear array (6-13 MHz) transducer probe of the ultrasonography machine (FUJIFILM Sonosite, Inc. Bothell, Washington) was placed gently over both the right and left upper eyelids of patient exerting minimal pressure on the eyeball and was manually fixed to maintain a consistent view of ocular sonography.

The secondary outcomes that is systolic and diastolic blood pressure, heart rate, EtCO2 and SpO2 were also measured along with ONSD measurement at defined time points that is, Before anaesthesia administration (T0), 10 mins after the trendelenburg position (T1), 30 mins after the trendelenburg position (T2), 1 hour after the trendelenburg position (T3), 5 mins after resuming the supine position (T4), at post-anaesthetic care unit (T5). After the ultrasound probe was gently placed on the superolateral aspect of the orbit and slid from temporal to nasal end to locate a suitable angle for viewing the entry of the optic nerve as a hypoechoic linear structure with clear margins posteriorly to the globe in the transverse plane. The probe was further adjusted to bring the optic nerve in the center of the screen

of ultrasound for measurement of diameter. The ONSD was measured at a distance of 3 mm behind the papilla in the left globe and right globe, perpendicular to the axis of the optic nerve, once in the transverse plane of each eye. A total of 6 measurements of ONSD were performed in the same manner in each eye at defined time points. The primary outcome measure was the mean ONSD of all readings of right and left eye of group A and group B.

2.1. Statistical analysis

The collected data were analysed with SPSS, version 23 for Windows statistical software. The Categorical data were presented as numbers (percent) and were compared among groups using the Pearson's chi square test. The quantitative data were presented as mean and standard deviation and were compared by two equal sample independent t-test. In all the above statistical tools, probability was considered to be significant if p value less than 0.05.

3. Results

Both the groups were comparable with respect to male and female distribution. There was no significant difference among the groups with respect to baseline characterstics (Table 1).

Table 2 shows comparison of optic nerve sheath diameter (ONSD) of right as well as left eye among the two groups. The table shows statistical significant difference at T1, T2, T3 and T4 time intervals and statistically non-significant difference at T0 and T5 time intervals. The peak point was T3. The table also shows that mean ONSD was significantly lower in group A (TIVA) as compared to group B (DES).

There was no statistical significant difference between mean heart rate of both groups (Table 3) (p= 0.57).

There was no statistical significant difference between mean mean arterial pressure of both groups (Table 4) (p= 0.33).

There was no statistical significant difference between mean end tidal carbon dioxide (EtCO2) of both groups (Table 5) (p= 0.84).

4. Discussion

Optic nerve sheath diameter (ONSD) measurement was considered as a screening technique for patients with increased intracranial pressure (ICP).[14] There is contact between cerebrospinal fluid (CSF) in the dural sheath of the optic nerve and the CSF in the intracranial subarachnoid space. Therefore, there is direct transmission of intracranial pressure (ICP) to the CSF in the optic nerve sheath. Because of the elastic trabecular anatomy of the subarachnoid space of the optic nerve sheath, it is most distensible 3mm behind the papilla in the globe.[15] The insertion of invasive intraventricular catheter is a reliable way for intracranial pressure (ICP) measurement. However, there are several limitations for the use of this invasive method to accurately assess the intracranial pressure (ICP) that includes, the possibility of severe complications including hemorrhage, infection and equipment malfunction, and the absence of neurological operators.[16] Hence the non-invasive and uncomplicated technique is needed to evaluate intracranial pressure (ICP) during intraoperative period in such cases. Simple and non- invasive technique to monitor the rise of intracranial pressure (ICP) is optic nerve sheath diameter (ONSD) measurement using ultrasonography.[17]

In our study, SpO2 remained constant throughout surgery and there were no changes. In our study, the mean EtCO2 value was similar in both groups. There was no significant difference in EtCO2 among the both groups. EtCO2 controll was possible with both techniques. Kaur G et al[6] and Eun-Su Choi et al[18] in their study found that there was no significant difference in EtCO2 among the both groups.

In our study, there was no statistically significant difference among the group A and group B in terms of changes in heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure at all defined time points of the study. With both techniques, control of mean arterial pressure (MAP) was maintained within 20% of the pre-operative value. The study conducted by Kaur G et al.[6] also validated findings of hemodynamic parameters (HR, SBP, DBP, MAP) which were found to be comparable between two groups of our study. Ann Hee You et al[19] and Yanghyun Kim et al[20] in their study found that there was no significant difference in MAP and HR. In contrast to our study, Youn Young Lee et al[15] reported that the heart rate in group A was significantly lower as compared to group B. There was no significant difference in MAP between two groups.

In our study, the baseline optic nerve sheath diameter (ONSD, in mm) (T0) was similar in both groups. After steep trendelenburg position and CO2 pneumoperitoneum creation, optic nerve sheath diameter (ONSD) value increased from the baseline value at T1, T2, T3 and T4 time point in both group, and peak point at one hour after steep trendelenburg position and CO2 pneumoperitoneum creation (T3). It was found that mean ONSD was significantly lower in group A as compared to group B. Eun –Su Choi et al[18] concluded that optic nerve sheath diameter (ONSD) was significantly higher in desflurane group as compared to TIVA group. This findings validates our study and although in our study the rise in optic nerve sheath diameter (ONSD) in desflurane group was statistically significant, it may be considered clinically insignificant because it remained within normal diurnal range (<20 mmHg). Our results support the study of Lentschener et al[21] and Mowafi et al.[2] Mowafi et al[2] found that propofol based TIVA was better than isoflurane and sevoflurane inhalational anaesthesia, respectively, in attenuating the increase in intraocular pressure (IOP) during

Table 1: Baseline characteristics among the study groups

Group	Mean Age (in years)	SD	t test	p value
Group B (DES)	34.23	11.691	0.92	0.43
Group A (TIVA)	35.47	13.698		
	Mean Weight (Kg)	SD		
Group B (DES)	66	7.30	0.24	0.37
Group A (TIVA)	67.03	9.05		
	Mean Height (cm)	SD		
Group B (DES)	165.23	6.29	3.24	0.08
Group A (TIVA)	168.27	6.76		
		ASA Grade		
	I		II	
		%		%
Group B (DES)	26	86.67	4	13.33
Group A (TIVA)	23	76.67	7	23.33
Total	49	81.67	11	18.33
Chi Square		1.02		
p value		0.32		

Comparison of MAP (mmHg) among the groups at different intervals

Table 2: Comparison of OSND (mm) among the groups at different intervals

Group	Right Eye	T0	T1	T2	T3	T4	T5	Mean OSND
Group B	Mean	4.11	4.47	4.67	4.82	4.67	4.34	4.51
(DES)	SD	0.14	0.15	0.17	0.18	0.10	0.15	0.16
Group A	Mean	4.16	4.33	4.51	4.63	4.57	4.26	4.42
(TIVA)	SD	0.16	0.18	0.19	0.21	0.14	0.17	0.17
Mean Difference		-0.05	0.14	0.16	0.19	0.10	0.08	0.09
t test		1.31	10.62	12.87	17.07	3.48	3.72	4.31
p value		0.26	0.002*	0.001*	<0.01*	0.03*	0.06	0.04*
	Left Eye							
Group B	Mean	4.13	4.49	4.69	4.84	4.68	4.35	4.52
(DES)	SD	0.12	0.13	0.14	0.15	0.10	0.13	0.13
Group A	Mean	4.17	4.36	4.50	4.61	4.56	4.26	4.41
(TIVA)	SD	0.21	0.21	0.19	0.21	0.12	0.22	0.21
Mean Difference		-0.04	0.13	0.19	0.23	0.12	0.09	0.11
t test		0.95	9.07	18.02	23.28	3.71	3.21	5.08
p value		0.33	0.004*	<0.01*	<0.01*	0.02*	0.08	0.03*

*: statistically significant

Table 3: Comparison of Heart rate (beats/min) among the groups at different intervals

Group		T0	T1	T2	T3	T4	T5	Mean HR
Group B	Mean	79.92	86.17	85.20	86.25	84.03	90.27	85.31
(DES)	SD	5.502	6.254	5.346	4.88	5.07	5.14	4.43
Group A	Mean	78.93	85.57	84.97	86.33	83.47	88.67	84.66
(TIVA)	SD	5.502	6.361	5.385	5.14	5.35	4.87	4.35
t test		0.49	0.13	0.03	0.04	0.18	1.53	0.33
p value		0.48	0.71	0.87	0.85	0.68	0.22	0.57

Table 4: Comparison of MAP (mmHg) among the groups at different intervals

Group		T0	T1	T2	T3	T4	T5	Mean MAP
Group B (DES)	Mean	93.77	92.33	95.77	96.10	96.80	98.77	95.59
	SD	5.65	4.83	4.01	3.98	2.78	5.82	2.96
Group A (TIVA)	Mean	94.53	91.73	96.27	98.90	98.43	99.27	96.52
	SD	5.36	6.43	4.53	3.80	2.79	5.92	3.06
t test		0.30	0.17	0.21	1.82	1.36	0.92	1.44
p value		0.28	0.68	0.65	0.14	0.23	0.42	0.33

Table 5: Comparison of EtCO2 (mmHg) among the groups at different intervals

Group		T1	T2	T3	T4	Mean $EtCO_2$
Group B (DES)	Mean	39.80	39.07	39.40	39.67	39.49
	SD	3.643	1.048	.932	3.61	1.78
Group A (TIVA)	Mean	40.60	39.23	39.43	38.67	39.47
	SD	4.26	.898	.728	2.523	1.54
t test		0.61	0.44	0.04	1.54	0.08
p value		0.44	0.51	0.88	0.22	0.84

laparoscopic surgery in trendelenburg position. Kaur G et al[6] reported that IOP was significantly higher in sevoflurane group as compared to propofol based TIVA group from T2 to T6 pre-defined time point. The maximum rise in intraocular pressure (IOP) was seen at T3 (30 min after CO2 pneumoperitoneum with head-down position) as compared with baseline (T0). In contrast to our study, Sator et al[22] concluded that sevoflurane maintains the intraocular pressure (IOP) at an equally reduced level compared with propofol during open gynecological and urological surgeries. This discrepancy could be because of difference in type of surgery (laparoscopic versus open surgery).

In our study, no significant side effects were observed between the two groups. Weber et al[23] found postoperative visual loss due to a prolonged steep trendelenburg position during minimally invasive prostatectomy in their case report of two patients. Molloy et al[3] reported that intraocular pressure (IOP) increases in steep trendelenburg position.

There are certain limitations in our study. Although patients were randomly assigned into two groups by chit and box method, observer was aware to the optic nerve sheath diameter (ONSD) measurement time points. Therefore, observer bias may be seen in optic nerve sheath diameter (ONSD) measurement done at predefined time points during laparoscopic surgery. Our study was conducted on patients with ASA grade I and II with no pre-existing ophthalmic disease. Thus effect on intracranial pressure (ICP) were not evaluated in patients with pre-existing ophthalmic disease in our study.

5. Conclusion

Our result suggest that total intravenous anaesthesia (TIVA) may be a better option than inhalational anaesthesia to prevent rise in intracranial pressure in patients undergoing laparoscopic surgery. Ultrasonographic measurement of optic nerve sheath diameter (ONSD) in laparoscopic surgeries can enable timely intervention to decrease the raised intracranial pressure (ICP) and thereby preventing further complications.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare no conflict of interest.

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