Original Research Article

OPTIC NERVE SHEATH DIAMETER ASSESSMENT DURING TOTAL LAPAROSCOPIC HYSTERECTOMY: A PROSPECTIVE, OBSERVATIONAL STUDY

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ABSTRACT

Background: The primary aim of this observational study was to investigate the dynamic changes in optic nerve sheath diameter (ONSD) during total laparoscopic hysterectomy (TLH) and to evaluate these changes as a surrogate marker for intracranial pressure (ICP) variations throughout the surgical procedure.

Materials and Methods: Specifically, the study seeks to measure and correlate intraoperative fluctuations in ONSD with other key hemodynamic parameters such as mean arterial pressure (MAP) and end- tidal CO_2 (ETCO2), as well as to assess postoperative cognitive function using the Mini-Mental State Examination (MMSE). By obtaining repeated measurements at defined surgical phases— baseline, 1 hour and 2 hours after the start of surgery, and before extubation—the study aims to provide a comprehensive temporal profile of physiological stress induced by pneumoperitoneum and the steep Trendelenburg position combined.

Results: The study's findings reveal that most patients, predominantly middle-aged women. During the initial phase of surgery, the onset of pneumoperitoneum and the steep Trendelenburg position led to a significant increase in MAP to 89.25 ± 9.06 mm Hg and $ETCO_2$ to 33.60 ± 1.76 mm Hg, accompanied by an increase in ONSD to 0.5659 ± 0.05815 cm, indicating an early rise in intracranial pressure. Cognitive function, as measured by the Mini-Mental State Examination (MMSE), showed a statistically significant decline from a preoperative score of 30.00 to a postoperative score of 29.46 ± 1.587. Additionally, the study demonstrated that the incidence of postoperative nausea and vomiting (PONV) was relatively low at 13.3%, with 86.7% of patients remaining free of such symptoms, and delayed recovery in 30.5% patients at the time of extubation.

Conclusion: The results of this study emphasize the need for tailored perioperative management strategies that consider both systemic and cerebral responses to the stresses imposed by laparoscopic surgery, ultimately aiming to minimize potential neurological sequelae and improve overall patient outcomes.

Keywords: Optic Nerve Sheath Diameter (ONSD), Total Laparoscopic Hysterectomy (TLH), Pneumoperitoneum (PP), Trendelenburg Position (TP).

INTRODUCTION

The laparoscopic approach being minimally invasive has become a standard of care for many types of modern surgical practices over the recent years, mainly including gynecology, general surgery, and urology. Pneumoperitoneum, which is induced by gas insufflation, leads to increased intra-abdominal pressure. This has several systemic physiological effects, including decreased venous return, cardiac output, increased heart rate, mean arterial pressure, and systemic vascular resistance. Additionally, the absorption of carbon dioxide (CO_2) across the peritoneal surface can lead to hypercapnia and respiratory acidosis.

In gynecological laparoscopic surgeries, achieving proper surgical exposure often requires placing the patient in a steep Trendelenburg position (TP). This position helps in facilitating the procedure and maintaining adequate visualization. However, it leads to significant changes in respiratory mechanics, such as a reduction in pulmonary compliance and increased peak airway pressures, as well as increased venous return and pulmonary capillary wedge pressure. The effects of pneumoperitoneum (PP) and Trendelenburg position (TP) on intracranial pressure (ICP) are not well documented, but increasing evidence suggests a positive correlation between intra-abdominal pressure and ICP.

Raised intracranial pressure (ICP) can cause secondary brain ischemia, exacerbating conditions like traumatic brain injury, stroke, and intracranial hemorrhages. This can result in serious complications such as visual impairment, reversible or permanent neurological deficits, seizures, stroke, and even death.Several non-invasive methods for assessing ICP have been explored, including transcranial ultrasonography and optic nerve sheath diameter (ONSD).

Given the potential consequences of raised ICP, it is crucial to monitor these changes in patients undergoing gynecological laparoscopic surgeries. The aim of this study is to evaluate the extent of increased ICP resulting from CO_2 pneumoperitoneum and steep Trendelenburg positioning using ultrasonographic measurement of ONSD. Early diagnosis and prompt treatment of intracranial hypertension (ICH) are critical to improving patient outcomes.

Therefore, the purpose of this study is to assess the extent of increased intracranial pressure (ICP) resulting from CO_2 pneumoperitoneum and steep Trendelenburg positioning using ultrasonographic measurement of optic nerve sheath diameter in patients undergoing total laparoscopic hysterectomy as early diagnosis and prompt treatment of intracranial hypertension is critical to ensuring timely and appropriate management and can improve patient risk stratification and outcome.

MATERIALS AND METHODS

Study design: Prospective, Observational work to evaluate any change in ONSD

Sample Size: 128 participants

Duration of study: One calendar year 12 months.

Study Location: Department of Anaesthesiology, Apollomedics super speciality hospital, Lucknow, Uttar Pradesh, India.

Study Population: Patients planned for total laparoscopic hysterectomy.

Inclusion Criteria

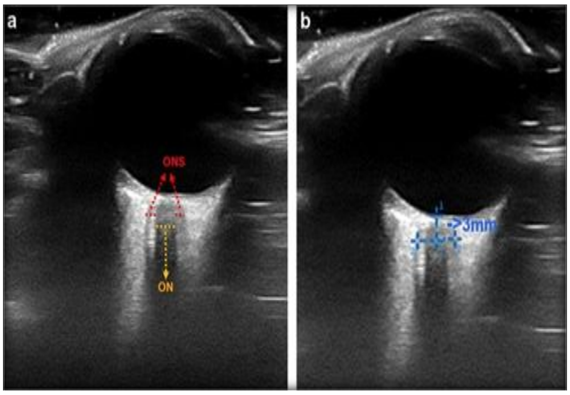
- Women between range of 18 to 60 years age.
- Patient under ASA (American Society of Anaesthesiologists) grade I and II.
- Patients scheduled for total laparoscopic hysterectomy (TLH)
- Willingness and ability to provide informed, written consent.
- Patient’s ability to understand Mini mental scoring chart.

Exclusion Criteria

- Patient refusal to participate in the study.
- ASA grading > II
- Severe obesity (Body mass index >35 kg/m2).
- History of pre-existing ophthalmic diseases (e.g., glaucoma, retinal disorders) or prior ophthalmic surgery.
- Known neurological disorders (e.g., epilepsy, stroke, or brain injury)

Methodology: On arrival in the surgical suite, standard monitoring would be applied. Anaesthesia was be maintained at 1–1.5 minimal alveolar concentration (MAC) of Sevoflurane in 50% oxygen + Air. The head-down TP would be achieved by tilting the table to an angle range of 15 to 25 degrees (visually assessed), adjusted for surgical exposure and laparoscopic accessibility. Carbon dioxide PP would be established using an intra-abdominal pressure between12 and 15 mm Hg. Ultrasonographic measurements of optic nerve sheath diameter (ONSD) would be conducted by a single trained investigator. A Mini Mental Status examination (MMSE) would be performed preoperatively and postoperatively to assess any cognitive status change.

Study Parameters the primary parameter of the study was the measurement of optic nerve sheath diameter (ONSD) using a non-invasive ultrasonic technique. Ultrasonographic measurements were taken at multiple time points during the surgery, including baseline (before induction of anaesthesia), 1 hour, 2 hours, after pneumoperitoneum and Trendelenburg position, and at the end of the procedure, 10 minutes after returning to a neutral position.



a. Transorbital ultrasound visualization of ONSD. The optic nerve (ON) appears hypoechogenic and is surrounded by the hyperechogenic optic nerve sheath (ONS). b ONSD measurement is performed 3 mm behind optic nerve papilla in-between the borders of ONS

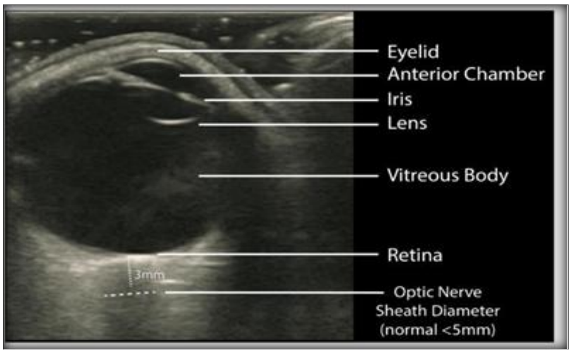


Figure: USG image showing parts of the eye and optic nerve sheath

RESULTS

The study population primarily consists of middle-aged women with BMI values within the overweight category, which may have implications for perioperative care and surgical outcomes. There was a statistically significant decrease in MAP from baseline to the first intraoperative measurement. A significant increase in MAP was observed postoperatively (MAP2 - MAPE, P = 0.000), which may be attributed to the reversal of pneumoperitoneum and the patient's return to a supine position.

The correlation analysis between mean arterial pressure (MAP) and optic nerve sheath diameter (ONSD) at different surgical phases revealed statistically significant positive correlations across all time points. The MAP however was within the limits of cerebral autoregulation (MAP of 60 to 150 mm Hg) which confers that the changes in ONSD might be attributed to changes in ICP due to physiological stress, reduced cranial compliance and surgical factors like Pneumoperitoneum and Trendelenburg position. The mean of the difference between preoperative (ONSDB) and postoperative (ONSDE) and incidence of PONV was statistically significant (p value < 0.05) indicating it as a contributing factor to the incidence of PONV. Whereas the other values at different time points showed slight to no statistical significance with a p value >0.05 throughout.

The relationship between mean optic nerve sheath diameter (ONSD) in patients who had incidence of delayed recovery and patients who had good recovery at different time points. The mean values of ONSD in patients with delayed recovery was slightly higher compared to those who had good recovery post anesthesia, across all time points. The mean of the difference between preoperative (ONSDB) and postoperative (ONSDE) values of ONSD and incidence of delayed recovery was statistically significant (p value < 0.05) indicating it as a contributing factor to the incidence of PONV. Whereas the other values at different time points showed slight to no statistical significance with a p value >0.05 throughout.

Statistical Analysis: Data collection involved systematic recording of the primary and secondary outcome variables. Ultrasonographic measurements of optic nerve sheath diameter (ONSD) were obtained at multiple time points during the procedure and postoperatively. Cognitive function was assessed using the Mini Mental State Examination (MMSE) before surgery and 1 hour after recovery.

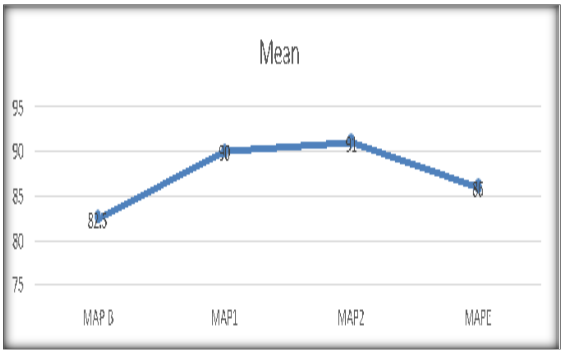


Figure 3: ?

Table 1: Descriptive statistics of patients

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
AGE	128	30	60	45.41	6.612
BMI	128	19.40	34.9	26.7628	3.23498

Table 2: Mean of map at different time points

	MAP_B	MAP_1	MAP_2	MAP_E
Mean	82.5	90	91	86

Table 3: Changes in optic nerve sheath diameter (ONSD) during TLH

		Mean	Standard Deviation	t	df	p value
Pair 1	ONSDB – ONSD1	-0.04461	0.02391	-21.112	127	0.000
Pair 2	ONSD1– ONSD2	-0.01867	0.01820	-11.606	127	0.000

Table 4: Correlation between mean arterial pressure (map) and optic nerve sheath diameter (ONSD)

		ONSDB	ONSD1	ONSD2	ONSDE
MAPB	Pearson Correlation	0.174*	0.262**	0.283**	0.276**
	Sig. (2-tailed)	0.049	0.003	0.001	0.002
MAP1	Pearson Correlation	0.235**	0.285**	0.338**	0.349**
	Sig. (2-tailed)	0.008	0.001	0.000	0.000
MAP2	Pearson Correlation	0.255**	0.310**	0.342**	0.346**
	Sig. (2-tailed)	0.004	0.000	0.000	0.000
MAPE	Pearson Correlation	0.245**	0.302**	0.358**	0.356**
	Sig. (2-tailed)	0.005	0.001	0.000	0.000

Table 5: Association between mean arterial pressure (MAP) and postoperative nausea and vomiting (PONV)

	PONV	N	Mean	Standard Deviation	P value
MAP B	Yes	17	87.24	10.171	0.869
	No	111	81.76	10.052	
MAP1	Yes	17	90.88	7.381	0.200
	No	111	89.00	9.294	
MAP2	Yes	17	92.29	12.118	0.103
	No	111	89.68	9.053	
MAPE	Yes	17	90.71	7.671	0.327
	No	111	84.91	9.451	

Table 6: Association between ONSD and PONV

	PONV	N	Mean	Std. Deviation	P value
ONSDB	Yes	17	0.5312	0.06421	0.670
	No	111	0.5198	0.05266	
ONSD 1	Yes	17	0.5829	0.06223	0.974
	No	111	0.5633	0.05736	
ONSD 2	Yes	17	0.6082	0.05294	0.457
	No	111	0.5810	0.05721	
ONSDE	Yes	17	0.6012	0.05134	0.548
	No	111	0.5719	0.05564	
ONSDE-ONSDB	Yes	17	0.0700	0.03674	0.023
	No	111	0.0522	0.02606	

Table 7: Association between ONSD and recovery status

	Recovery status	N	Mean	Std. Deviation	P value
ONSDB	Good recovery	89	0.5149	0.05159	0.669
	Delayed recovery	39	0.5359	0.05775	
ONSD1	Good recovery	89	0.5533	0.05353	0.619
	Delayed recovery	39	0.5949	0.05857	
ONSD2	Good recovery	89	0.5699	0.05295	0.711
	Delayed recovery	39	0.6182	0.05276	
ONSDE	Good recovery	89	0.5612	0.05187	0.772
	Delayed recovery	39	0.6090	0.05046	
ONSDE-ONSDB	Good recovery	89	0.0464	0.02196	0.045
	Delayed recovery	39	0.0731	0.03213	

DISCUSSION

The significance of this study lies in its potential to enhance the safety and quality of care in minimally invasive gynecological surgery. TLH is increasingly performed due to its benefits over open procedures; however, the associated physiological changes, particularly the increase in intracranial pressure, have raised concerns regarding neurological outcomes and recovery. Employing non-invasive

ONSD measurement offers clinicians a practical, real-time tool for monitoring ICP changes, enabling early detection and intervention if adverse trends are noted. Understanding the relationship between systemic hemodynamics and intracranial dynamics can help to refine anesthetic management and surgical protocols, potentially reducing postoperative complications such as delayed recovery, postoperative nausea, vomiting, headache, and cognitive dysfunction. Ultimately, the insights gained from this study could inform the development of targeted strategies to minimize the negative impact of procedural stress, thereby improving patient outcomes and contributing to the evolving standards of care in laparoscopic surgery.

In our study, the relative homogeneity of these demographic variables likely contributed to the controlled baseline hemodynamic parameters, such as a MAP of 82.48 ± 10.20 mm Hg and an ONSD of 0.5213 ± 0.05419 cm, which in turn may have facilitated the reliable assessment of intraoperative changes. By comparing our data with existing literature, it is evident that our population is representative of the typical patient requiring TLH. Future studies might explore whether specific subgroups based on BMI or age exhibit differential responses to pneumoperitoneum or altered intracranial dynamics, thereby further refining patient selection and management strategies.

In the postoperative period, our study observed partial normalization of systemic parameters alongside a persistent elevation in the optic nerve sheath diameter (ONSD). Dip et al reported that ONSD returned close to baseline values after surgery, although some residual elevation was noted immediately postoperatively. Similarly, Yilmaz et al documented that although ONSD decreased after the release of pneumoperitoneum, it remained statistically higher than the preoperative baseline, correlating with increased incidences of postoperative headache and nausea.

The cognitive function table, assessed via the Mini-Mental State Examination (MMSE), shows a notable yet modest postoperative decline. Three patients however had a MMSE score of < 25 on evaluation, 2 showing mild and one showing moderate cognitive impairment which is a notable concern given the ASA status of the patients. Likewise, Patel et al highlighted that the choice of anesthetic technique, with total intravenous anesthesia (TIVA) resulting in less pronounced ONSD changes, was associated with better cognitive outcomes compared to inhalational agents. Although our study shows only a minor decline in MMSE scores, it aligns with the concept that even short-term increases in ICP may contribute to transient postoperative cognitive dysfunction.

Yilmaz et al found that increases in optic nerve sheath diameter (ONSD) during laparoscopic hysterectomy were associated with PONV and headache, although the direct link with MAP was not as pronounced. Furthermore, Patel et al demonstrated that anesthetic technique plays a critical role in the occurrence of PONV, with TIVA showing a lower incidence compared to inhalational anesthesia. In our study, the relatively controlled hemodynamic response, with MAP values returning toward baseline postoperatively (85.68 ± 9.417 mm Hg), may have contributed to the low PONV rate. The multifactorial nature of PONV encompassing anesthetic agents, individual susceptibility, and surgical stress complicates its prediction solely based on hemodynamic parameters.

The recovery status table illustrates that out of 128 patients, 89 (69.5%) experienced a good recovery while 39 (30.5%) exhibited delayed recovery. Blecha et al documented that patients undergoing robotic-assisted procedures maintained elevated ONSD values throughout surgery, which could potentially contribute to a slower recovery profile. Additionally, Kim et al noted that prolonged intraoperative stress and sustained increases in intracranial pressure might be linked to delayed postoperative recovery, despite effective intraoperative management.

Even when the MAP is within limits of cerebral autoregulation, pneumoperitoneum may lead to decrease venous drainage leading to rise in ICP. Similarly, Trendelenburg position may lead to venous congestion further leading to raised ICP. When compared to previous studies, our results are consistent with findings by Dip et al, who observed a median ONSD increase of 0.6 mm at 15 minutes and 1.0 mm at 30 minutes post-pneumoperitoneum. Similarly, Kim et al. (2017) reported significant increases in ONSD during both early and late periods of laparoscopic surgery, with mean differences ranging from 0.46 mm to 0.67 mm.

Kim et al observed that fluctuations in MAP during laparoscopic procedures were significantly associated with changes in ONSD, reflecting the impact of hemodynamic stress on intracranial dynamics. Additionally, studies by Blecha et al and Patel et al have similarly demonstrated that intraoperative MAP variations can be predictive of ONSD changes, underscoring the potential clinical utility of this correlation in managing intracranial hypertension. The consistency of our correlation data across different surgical phases highlights the interdependence of systemic and intracranial physiology during TLH. Clinically, this correlation reinforces the importance of continuous, non-invasive monitoring of both MAP and ONSD to anticipate and mitigate potential neurological complications.

Kumar et al found that increased ONSD was significantly associated with elevated ICP, which in turn correlated with delayed recovery from anesthesia. Another study by Schneider et al highlighted that patients with higher ONSD experienced longer recovery times and more significant cognitive deficits postoperatively.

Nakagawa K et al in his work on evaluation and management of increased ICP states that elevated ICP reduces cerebral perfusion pressure, which can impair the brain's ability to receive adequate oxygen and nutrients. This reduction in cerebral blood flow can result in cognitive dysfunction and altered mental status, which may persist into the postoperative period. Therefore, collaboration between anesthesiologists, surgeon and critical care specialists is essential for managing patients.

CONCLUSION

Detailed analysis of hemodynamic and ONSD changes revealed significant paired differences and robust positive correlations between MAP and ONSD at various surgical stages, underscoring the direct relationship between systemic blood pressure fluctuations and intracranial pressure dynamics. These findings collectively highlight the importance of incorporating continuous and non-invasive monitoring techniques, such as ONSD measurement, alongside traditional hemodynamic monitoring, to promptly detect and address intraoperative physiological disturbances. By shedding light on the intricate balance between cardiovascular stability and intracranial dynamics during TLH, this study provides a compelling rationale for future investigations into optimized surgical techniques, anaesthetic protocols, and postoperative care pathways. Such efforts will be instrumental in further refining patient safety and enhancing the quality of care in minimally invasive gynaecological surgery, while also informing the development of targeted interventions to mitigate the transient yet significant physiological perturbations observed during these procedures.

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