

ORIGINAL RESEARCH

MEASUREMENT OF OPTIC NERVE SHEATH DIAMETER AS A NON-INVASIVE TOOL FOR MONITORING OF INTRACRANIAL PRESSURE DURING PRE-OPERATIVE AND POST-OPERATIVE PERIOD IN PATIENTS WITH SUPRATENTORIAL INTRACRANIAL SPACE OCCUPYING LESIONS

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ABSTRACT

Aim: To measure optic nerve sheath diameter as a non-invasive tool for monitoring of intracranial pressure during pre-operative, intra-operative and post-operative period in patients with supratentorial intracranial space occupying lesions.

Material and methods: The present prospective nonrandomised observational study was conducted in the Department of Neurosurgery, Bangur Institute of Neurosciences & SSKM hospital, IPGME & R, Kolkata from February 2020 to February 2022. Adult patients undergoing operation for supratentorial intracranial space occupying lesions during the time period were included in the study. A total of 50 cases were recruited during the study period. We measured the ONSD in the preoperative, intraoperative and postoperative period. Clinical findings suggestive of raised ICP, Cranial computed tomography or magnetic resonance imaging finding of shift, edema, mass effect, collapse of ventricles, compression of cisterns or effacement suggestive of elevated intracranial pressure was used to evaluate optic nerve sheath diameter accuracy.

Results: Most common symptom among the study subjects was headache (84%) followed by vomiting (66%). There was decrease in ONSD among the study subjects in right and left eye after the surgery as compared to baseline with statistical significant difference. No significant difference was found between USG and CT technique w.r.t. ONSD before and after surgery among the study subjects.

Conclusion: In patients with supratentorial intracranial space occupying lesions undergoing surgery, we found a significant reduction in the ONSD diameters measured by USG and CT scan after the surgery. We suggest that bedside USG is a valuable tool for detecting the ONSD during surgery, which may minimize the exposure to radiation.

Keywords: ONSD, Intracranial Pressure, Supratentorial Intracranial Space Occupying Lesions**INTRODUCTION**

The optic nerve sheath is contiguous with the dura mater, and its contents are contiguous with the subarachnoid space. Thus, raised intracranial pressure (ICP) leads to an increase in the optic nerve sheath diameter^{1,2}. Early detection and treatment of intracranial hypertension, defined as an ICP greater than or equal to 20 mm Hg, plays a significant role in the avoidance of secondary brain injury. If increased intracranial pressure is severe enough, herniation of portions of the brain from their normal location into other compartments over the dural membranes may occur, leading to compression of adjacent brain structures, giving rise to uncal, central, transtentorial, and downward herniation syndromes with catastrophic consequences³⁻⁵.

The diagnosis of ICP is very important because prompt treatment is essential for limiting neuronal injury, but physical examination has its limitations⁶. Methods including lumbar puncture, ventriculostomy, magnetic resonance imaging (MRI), or computed tomography (CT) may be used in ICP diagnosis; however, these options are invasive, time-consuming, expensive, and often not feasible⁷. Assessment of ICP and its monitoring with radiological imaging modalities requires transportation, which increases the risk and endangers the lives of critically ill patients.

In recent years, monitoring of intracranial pressure (ICP) by noninvasive methods are being practiced with the use of bedside ocular sonography. In severe head injury, intracranial bleeding and idiopathic intracranial hypertension, several studies showed close association between optic nerve sheath diameter (ONSD) and raised ICP⁸. Raised ICP can be detected with an increase in ONSD due to the presence of continuity of meninges and subarachnoid space around the optic nerve⁹.

Ultrasound is a cost effective treatment modality which does not require transportation of the patient. It is helpful bedside noninvasive method in measuring ONSD. It can be repeated at regular intervals which help in close monitoring of ICP as well⁹. Also, this technique was used to evaluate the elevated ICP caused by severe traumatic brain injury and few studies reported the cases that prompt this technique could dynamically assess the efficacy of management of elevated ICP. We observed the patients with supratentorial intracranial space occupying lesions with elevated ICP whom we assessed for ONSD and ICP before and after treatment to investigate the potential of the ultrasonic ONSD technique to dynamically assess ICP changes and evaluate treatment efficacy. The objectives of the study are as follows:

1. To evaluate efficacy of optic nerve sheath diameter (ONSD) measurement by ultrasound for detection of raised intracranial pressure (ICP) in neurosurgical patients undergoing operation for intracranial space occupying lesions.
2. To evaluate whether ultrasonographic measurement of optic nerve sheath diameter can correlate with the computed tomography or MRI findings of elevated intracranial pressure in adult patients during the preoperative, intraoperative and postoperative period.

MATERIAL AND METHODS

Ethical clearance to carry out the study was obtained from the ethical committee of the institute. The study protocol was explained to the patient/guardian and a written informed consent was obtained from each subject to be enrolled in the study. The present prospective nonrandomised observational study was conducted in the Department of Neurosurgery, Bangur Institute of Neurosciences & SSKM hospital, IPGME & R, Kolkata from February 2020 to February 2022. Adult patients undergoing operation for supratentorial intracranial space occupying lesions during the time period were included in the study. A total of 50 cases were recruited during the study period. Subjects with age >18 years, solid intracranial supratentorial space occupying lesions on MRI, lesion is amenable to surgical excision and patient willing to give consent were included in the study. Patients having cystic or mixed intracranial lesions, infratentorial lesions, lesion not amenable to surgical resection or patient unfit for surgery, enucleation of eyeball, massive facial fracture and skin infection over eyelid were excluded from the study.

STUDY TOOLS

1. History and clinical examination records, pre and postoperative imaging investigation reports (MRI/CT), ONSD using USG pre, intra and postoperative period.
2. Using a 10 MHz ultrasonographic probe on the closed eyelids, three optic nerve sheath diameter was measured 3 mm behind the globe in each eye.
3. A mean binocular optic nerve sheath diameter greater than 5.0 mm was considered abnormal.
4. We measured the ONSD in the preoperative, intraoperative and postoperative period. Clinical findings suggestive of raised ICP, Cranial computed tomography or magnetic resonance imaging finding of shift, edema, mass effect, collapse of ventricles, compression of cisterns or effacement suggestive of elevated intracranial pressure was used to evaluate optic nerve sheath diameter accuracy.

INVESTIGATION

1. Routine hematological and biochemical tests
2. Radiological
 - a. NCCT head
 - b. MRI of brain plain plus contrast with spectroscopy.
 1. Size of tumour.
 2. Intensity in T1W1 and T2W2.
 3. Enhancement
 4. Cyst
 5. Calcification
 6. Peritumoral edema
 7. Intratumoral hemorrhage

Data was collected and subjected to statistical analysis.

STATISTICAL ANALYSIS

Data so collected was tabulated in an excel sheet, under the guidance of statistician. The means and standard deviations of the measurements per group were used for statistical analysis (SPSS 22.00 for windows; SPSS inc, Chicago, USA). Difference between two groups was determined using student t-test and the level of significance was set at $p < 0.05$.

RESULTS

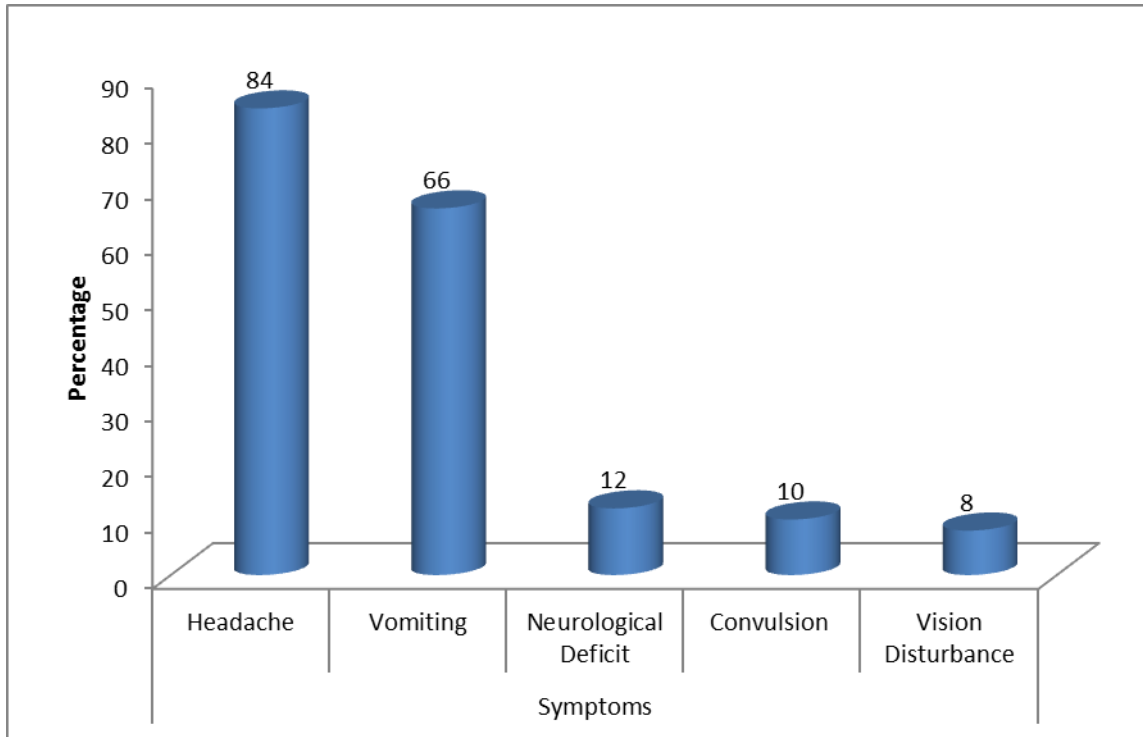
Out of 50 patients, 34 (68%) were males and 16 (32%) were females. Hence there was male dominance in our study. Mean age among the study subjects was 41.59 ± 12.42 years with minimum and maximum of 28 and 57 years respectively (table 1).

Table 1: Gender and age distribution among the study subjects

Gender	N	%
Male	34	68
Female	16	32
Total	50	100
Age Group (in years)	Value	
Mean	41.59	
SD	12.42	
Minimum	28	
Maximum	57	

Co-morbidities viz. hypertension, dyslipidemia and diabetes mellitus was reported among 52%, 34% and 28% of the subjects respectively. Most common symptom among the study subjects was headache (84%) followed by vomiting (66%). Neurological deficit, convulsion and vision disturbance was revealed in 12%, 10% and 8% of the subjects respectively (graph 1).

Graph 1: Symptoms among the study subjects



In our study, mean GCS among the study subjects was 13.27 ± 2.84 . Mean right and left pupil size among the study subjects was 2.80 and 2.78 respectively. There was decrease in ONSD among the study subjects in right and left eye after the surgery as compared to baseline. When ONSD was compared before and after the surgery using t test, significant difference was found (table 2).

Table 2: Comparison of ONSD measurement using USG before and after surgery

ONSD	Before Surgery		After Surgery		t test	p value
	Mean	SD	Mean	SD		
Right Eye	5.73	0.76	4.45	0.71	6.91	<0.01*
Left Eye	5.71	0.72	4.49	0.74	6.74	<0.01*
Overall	5.72	0.74	4.47	0.72	6.90	<0.01*

*: statistically significant

There was decrease in ONSD among the study subjects in right and left eye after the surgery as compared to baseline. When ONSD was compared before and after the surgery using t test, significant difference was found (table 3).

Table 3: Comparison of ONSD measurement using CT before and after surgery

ONSD	Before Surgery		After Surgery		t test	p value
	Mean	SD	Mean	SD		
Right Eye	5.69	0.73	4.42	0.70	6.93	<0.01*
Left Eye	5.66	0.69	4.40	0.73	6.81	<0.01*
Overall	5.68	0.71	4.41	0.71	6.96	<0.01*

*: statistically significant

Table 4 shows the comparison of ONSD measurement using USG and CT before and after surgery. No significant difference was found between USG and CT technique w.r.t. ONSD before and after surgery among the study subjects.

Table 4: Comparison of ONSD measurement using USG and CT before and after surgery

ONSD	Before Surgery		After Surgery	
	Mean	SD	Mean	SD
USG	5.72	0.74	4.47	0.72
CT	5.68	0.71	4.41	0.71
t test	0.14		0.21	
p value	0.89		0.82	

According to Pearson correlation analysis, statistically significant correlation was found between USG and CT before ($r=0.89$, $p<0.01^*$) and after surgery ($r=0.85$, $p<0.01^*$) w.r.t ONSD measurement (table 5).

Table 5: Correlation between USG and CT before and after surgery w.r.t ONSD measurement

ONSD	Before Surgery	After Surgery
r value	0.89	0.85
p value	<0.01*	<0.01*

*: statistically significant

DISCUSSION

Optic nerve sheath diameter (ONSD) might be an interesting bedside tool for evaluation of these critically ill patients. Several studies investigated the utility of measurements of the ONSD as an indicator for ICP measurement and management. Changes in the ONSD can be visualized using images from ultrasound, MRI and CT scans. Several studies have demonstrated a strong association between increase in ICP and distension of ONSD. The suggested cut-off values in these studies range between 4.1-5.9 mm and the definition of increased ICP also varies considerably, between 14.7 and 30 mmHg. ONSD measurement has been described as a useful screening method to detect clinically suspected raised ICP, especially where invasive monitoring is not readily available.

Mean age among the study subjects was 41.59 ± 12.42 years with minimum and maximum of 28 and 57 years respectively. Out of 50 patients, 34 (68%) were males and 16 (32%) were females. Hence there was male dominance in our study. Jalayondeja T et al¹⁰ in their study reported similar gender distribution, however mean age was higher as compared to our study. Bhandari D et al¹¹ in their study revealed that males were comparatively more as compared to females. Mean age among the study subjects was 40.68 ± 13.36 years. These findings are similar to our study.

Co-morbidities viz. hypertension, dyslipidemia and diabetes mellitus was reported among 52%, 34% and 28% of the subjects respectively in this study. Jalayondeja T et al¹⁰ in their study found hypertension, dyslipidemia and diabetes mellitus among 49%, 28.4% and 20.1% of the subjects respectively. These findings are approximately similar to our study.

ONSD measurement using USG during pre-operative interval among the subjects in right and left eye was 5.73 ± 0.76 and 5.71 ± 0.72 respectively. Overall ONSD measurement in both the eyes was 5.72 ± 0.74 . During surgery mean ONSD measurement in both the eyes was 5.66 ± 0.69 . ONSD measurement using USG after surgery among the subjects in right and left eye was 4.45 ± 0.71 and 4.49 ± 0.74 respectively. Overall ONSD measurement in both the eyes was 4.47 ± 0.72 . Hence there was significant decrease in ONSD after surgery among the study subjects as $p < 0.05$ in the present study. This shows that after a successfully performed surgical intervention there would be a significant reduction in ONSD, which could be used as a surrogate marker of ICP. A study conducted by Zaididet al¹², showed that the ONSD measurement could also detect VP shunt obstruction. In a study by Choi et al¹³, they found immediate reduction in ONSD after VP shunt surgeries. According to a study by Bhandari D et al¹¹, in adult patients (11 to 60 years), pre-operatively and postoperatively the average ONSD measurement by USG was found to be 5.80 ± 0.63 mm and 4.52 ± 0.72 ($p < 0.001$). These findings are similar to our study.

ONSD measurement using CT during pre-operative interval among the subjects in right and left eye was 5.69 ± 0.73 and 5.66 ± 0.69 respectively. Overall ONSD measurement in both the eyes was 5.68 ± 0.71 . ONSD measurement using CT after surgery among the subjects in right and left eye was 4.42 ± 0.70 and 4.40 ± 0.73 respectively. Overall ONSD measurement in both the eyes was 4.41 ± 0.71 . Hence there was significant decrease in ONSD after surgery among the study subjects in the present study. Similarly Jalayondeja T et al¹⁰ in their study showed that CT that was performed at 27 days (SD 14.70 days) postoperatively, showed that the ONSD had decreased significantly to within the normal range (4.17 mm [SD 0.60 mm]; $t_{79} = 8.673$, $p < 0.001$). Therefore, the ONSD could be used to follow patients' outcomes. According to a study by Bhandari D et al¹¹, in adult patients (11 to 60 years), pre-operatively and postoperatively the average ONSD measurement by CT was 5.77 ± 0.83 mm and 4.49 ± 0.76 mm ($p < 0.001$) respectively.

No significant difference was found between USG and CT technique w.r.t. ONSD before and after surgery among the study subjects. According to Pearson correlation analysis, statistically significant correlation was found between USG and CT before ($r = 0.89$, $p < 0.01^*$) and after surgery ($r = 0.85$, $p < 0.01^*$) w.r.t ONSD measurement in the present study.

Ohle R et al² in their study stated that bedside ultrasonographic measurement of ONSD to detect raised ICP is gaining popularity as it is a point of care technology and faster than CT scan or MRI. Its use has been studied in multiple cases like TBI, hydrocephalus, shunt malformation etc. As compared to CT scan, USG guided ONSD measurement shows good accuracy for detecting raised intracranial pressure with high sensitivity and specificity. Similarly Bhandari D et al¹¹ in their study found a strong correlation between the ONSD measured by USG and CT scan. ($r = 0.95$, $p < 0.001$). A high degree of reliability was found between ONSD measured by USG when compared to CT scan. Average interclass correlation between ONSD by USG and CT was 0.97 ($p < 0.001$) suggesting a strong agreement between them. In a prospective trial by Shirodkharet al⁹ showed a strong correlation between ONSD measured by USG and MRI in patients with meningoencephalitis. Similarly ONSD measurement by CT and MRI has been demonstrated to have a strong correlation¹¹.

In patients undergoing supratentorial intracranial space occupying lesion surgeries, the standard investigation tool for evaluation of the position of shunt tube and function is CT scan, which requires patients to be shifted. Whereas, USG is a quick and an easy bedside investigation, which can be repeated easily if required. Our results suggest that along with clinical parameters, ONSD measurement before and after surgery could be used to monitor shunt function and clinical improvement after surgery. Once further studies demonstrate reduction of ONSD with reduction in ICP, ONSD measurement can be used to monitor ICP after surgery.

LIMITATIONS

We noted ONSD and clinical parameters of raised ICP before and after surgery. We found a significant reduction in ONSD along with improvement in clinical signs and symptoms. However, we could not correlate ONSD with clinical signs and symptoms because of the diversity of clinical signs and symptoms. We also did not measure the opening pressure of CSF flow through ventricular end of shunt tube and correlate it with ONSD.

CONCLUSION

In patients with supratentorial intracranial space occupying lesions undergoing surgery, we found a significant reduction in the ONSD diameters measured by USG and CT scan after the surgery. We also found a strong correlation between the ONSD measured by USG and CT scan. We suggest that bedside USG is a valuable tool for detecting the ONSD during surgery, which may minimize the exposure to radiation.

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