Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 3 (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

The Relationship Between USG-Based Optic Nerve Sheath Diameter and Manifestations of Increased Intracranial Pressure in Patients with Non-Traumatic Intracranial Lesions in Dr. Soetomo Surabaya Hospital

Andika Perdani Somawi[1], Hamzah[2], Dhania A. Santosa[3], Prananda Surya Airlangga[4], Prihatma Kriswidyatomo[5], Atika[6]

[1]Department of Anesthesiology and Reanimation, Faculty of Medicine, Universitas Airlangga, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia

Email ID: andika.perdani@gmail.com

[2-5]Department of Anesthesiology and Reanimation, Faculty of Medicine, Universitas Airlangga, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia

[6]Department of Public Health Sciences Preventive Medicine, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia

Cite this paper as: Somawi, A. P., Hamzah, Dhania A. Santosa, Prananda Surya Airlangga, Prihatma Kriswidyatomo, Atika, (2025) The Relationship Between USG-Based Optic Nerve Sheath Diameter and Manifestations of Increased Intracranial Pressure in Patients with Non-Traumatic Intracranial Lesions in Dr. Soetomo Surabaya Hospital. *Journal of Neonatal Surgery*, 14 (3), 154-161.

ABSTRACT

The incidence of non-traumatic increased intracranial pressure (ICP) associated with intracranial lesions is increasing. These patients exhibit increased morbidity and mortality rates. Immediate identification and timely intervention can reduce the death rate by around 50%. The Optic Nerve Sheath Diameter (ONSD) measurement is a recently developed non-invasive method for measuring intracranial pressure (ICP). It has been shown to be a dependable method. The purpose of this study was to analyze the relationship between ONSD measured by ultrasonography and clinical manifestations such as headache, projectile vomiting, seizures, decreased consciousness, Cushing's triad, and pupillary diameter in patients with non-traumatic intracranial lesions at Dr. Soetomo Hospital Surabaya. This study is a cross sectional conducted in the emergency room of RSUD Dr. Soetomo from February to April 2023. Patients aged 18-60 with non-traumatic intracranial lesions who underwent a CT scan were selected using consecutive sampling. The optic nerve sheath diameter (ONSD) was evaluated using an ultrasonography in both eyes. The contigency coefficient test was used to determine the association between ONSD and clinical manifestations. The study included 41 subjects, with an average age of 45.66 years. The ONSD diameter was higher than the cut-off point (≥ 5.70 mm) in patients with space occupying lesions, strokes, and central nervous system infections (60%, 47.8%, and 37.5%, respectively). We found a statistically significant association between ONSD of the right and left eye and headache ($p<0.05$), seizures ($p<0.05$), Cushing's triad ($p<0.05$), and pupillary diameter ($p<0.05$). In conclusion, there is a significant association between ONSD and clinical manifestations of increased intracranial pressure including headache, seizure, decreased consciousness, Cushing's triad, and pupillary diameter.

Keywords: *ONSD, space occupying lesion, stroke, CNS infections, intracranial pressure, ultrasonography.*

1. INTRODUCTION

Increased Intracranial Pressure (ICP) is a common neurological complication in critically ill patients characterized by clinical symptoms of elevated intracranial pressure exceeding 20 mmHg caused by a combination of factors including increased brain volume, brain mass (tumor), and cerebrospinal fluid [1].

The incidence of increased ICP is associated with intracranial lesions, reaching 60-80% in patients with brain tumor and 10-24% in patients with intracerebral hemorrhage.[2] Rudiharto et al. reported increased prevalence of ICP associated with

intracranial lesions, specifically 52.6% for intracranial tumors, 25% for hemorrhage, 33.3% for cerebral edema, 37.5% for infections, and 30.8% for hydrocephalus.[3]

The incidence of increased ICP is associated with intracranial lesions, reaching 60-80% in patients with brain tumor and 10-24% in patients with intracerebral hemorrhage.[2] Rudiharto et al. reported increased prevalence of ICP associated with intracranial lesions, specifically 52.6% for intracranial tumors, 25% for hemorrhage, 33.3% for cerebral edema, 37.5% for infections, and 30.8% for hydrocephalus.[3]

Measurement of optic nerve sheath diameter (ONSD) using ultrasonography (USG) on the eye is one non-invasive method used to estimate intracranial pressure. However, measuring ONSD via USG requires skill and specific expertise from the operator (operator dependent).[4] One meta-analysis related to the use of USG as a measurement tool for ONSD indicates that this examination has good diagnostic accuracy with a pooled sensitivity value of 0.90 (95% CI 0.80 - 0.95) in detecting increased ICP. In terms of clinical decision-making, this technique can assist physicians in determining further steps.[5] The optimal cut-off value for ONSD in identifying increased ICP is 5.7 mm. ONSD measured via ocular USG can be a viable method for detecting and monitoring increased ICP in critically ill patients.[6]

Therefore, this study was conducted to determine the association between the diameter of USG-based ONSD and clinical manifestations of increased ICP in patients with non-traumatic intracranial lesions.

2. METHODS

Study Design and Sample Collection

This cross-sectional study was conducted from February to April 2023 at the Emergency Department of Dr. Soetomo Hospital in Surabaya. Sample collection was conducted using the consecutive sampling method with a minimum of 33 subjects. Samples consisted of patients with non-traumatic intracranial lesions diagnosed through medical history, physical examinations, and additional workups, who were admitted to the Emergency Department of Dr. Soetomo Hospital. Inclusion criteria for this study included patients aged 18-65 years with non-traumatic intracranial lesions who had undergone a head CT scan and provided consent to participate by signing an informed consent form. Patients with a history of prior eye pathology, optic nerve atrophy, receiving treatment for managing increased intracranial pressure (such as mannitol, dexamethasone, lactated sodium solution), or having metabolic encephalopathy were excluded from the study.

This study has been approved by the Research Ethics Committee of Dr. Soetomo Hospital, Surabaya, with the reference number 0613/KEPK/III/2023.

Variables and Study Procedure

The Optic Nerve Sheath Diameter (ONSD) was measured using the GE Vivid S70N ultrasound machine in axial sections parallel to the axis of the optic nerve, at a distance of 3 mm behind the posterior margin. This measurement was performed by covering both eyes of the patient with a sterile eye cover. Subsequently, the ultrasound probe was placed over the closed eyelid of the patient without applying pressure, and the optic nerve diameter was measured using ultrasound three times in each eye. Afterwards, the researcher calculated the average ONSD value for each eye.

Manifestations of increased intracranial pressure assessed included headache, projectile vomiting, seizures, decreased consciousness, Cushing's triad, and pupil diameter. These manifestations were evaluated through medical history and physical examination. Pupil diameter measurements were categorized as isocoric (both sizes equal) and Anisocoric (difference in size between both pupils ≥2 mm).

Statistical Analysis

Data analysis was conducted using the computer program Statistical Product and Science Service (SPSS) Windows version 22.0. Univariate analysis was conducted to determine data distribution. The association between ONSD and manifestations of increased intracranial pressure was conducted with the contingency coefficient test.

3. RESULTS

A total of 41 subjects from February-April 2023 were included in this study. The mean age of the subjects was 45.66±14.9 years, with a mean ONSD of the right eye at 5.61±0.82 mm and a mean ONSD of the left eye at 5.71±0.83 mm. Table 1 presents the characteristics of the study subjects.

Table 2 below shows the distribution of ONSD in non-traumatic intracranial lesions. ONSD values were grouped into two categories: ≥ 5.70 mm, used as the cutoff value predicting increased ICP, and < 5.70 mm, considered as normal.

Table 3 displays the distribution of characteristics related to increased ICP manifestations in the subjects. Most subjects exhibited symptoms such as headache (51.2%), followed by decreased consciousness (48.8%). Based on the classification of decreased consciousness, most subjects experienced a soporific state of consciousness (22.0%).

Based on the analysis of the relationship between ONSD and various clinical manifestations, our study indicated that subjects with ONSD values ≥ 5.7 mm in both the right and left eyes had a statistically significant association with manifestations of headache (p 0.003), seizures (p 0.015 right eye, p 0.032 left eye), Cushing's triad (p <0.001), and pupil diameter (p <0.001 right eye, p 0.002 left eye). Furthermore, based on the classification of decreased consciousness, there was a statistically significant association with ONSD ≥ 5.7 (p 0.001). Table 4 below presents the results of the analysis of the relationship between ONSD and various clinical manifestations of increased ICP.

Table 1. Characteristics of the subjects.

Characteristics	**Mean±SD***	**n (41)**	**Percentage (%)**
Age (year)	45.66±14,9	41	
Gender			
Man		17	41,5
Woman		24	58,5
ONSD right eye	5,61±0,82 mm (4,30-7,60) mm**		
≥ 5,70 mm		21	51,2
< 5,70 mm		20	48,8
ONSD left eye	5,71±0,83 mm (4,00-7,60) mm**		
≥ 5,70 mm		22	53,7
< 5,70 mm		19	46,3
Non-traumatic intracranial lesions			
Space Occupying Lesion			
A. Meningioma		8	19,5
B Wound Dehiscence postoperative		2	4,8
Stroke			
A. Infarction		10	24,4
B. ICH		13	31,7
Central nervous system infection			
A. Meningoencephalitis			
B. Tuberculoma		7	17,1
		1	2,4

*Data presented in mean and standard deviation (normally distributed).

** Minimum and maximum values.

Notes: ONSD: Optic Nerve Sheath Diameter; ICH: intracerebral hemorrhage.

Table 2. Characteristics of the ONSD.

Non-traumatic intracranial lesion ONSD	**Mean±SD (mm)***
Space Occupying lesion (n=10)	
a. ONSD right eye	5,69±0,59

b. ONSD left eye	5,73±0,65
Stroke (n=23)	
a. ONSD right eye	5,51±0,84
b. ONSD left eye	5,67±0,90
CNS infection (n=8)	
a. ONSD right eye	5,82±1,03
b. ONSD left eye	5,82±0,93

*Data presented in mean and standard deviation (normally distributed).

Notes: ONSD: *Optic Nerve Sheath Diameter;* CNS: central nervous system.

Table 3. Characteristics of increased ICP manifestations.

Manifestations	**Total (n)**	**Percentage (%)**
Headache		
a. Yes	**21**	**51,2**
b. No	20	48,8
Vomiting		
a. Yes	**7**	**17,1**
b. No	34	80,5
Seizure		
a. Yes	**8**	**19,5**
b. No	33	80,5
Decreased consciousness		
a. Yes	**20**	**48,8**
b. No		
(Compos Mentis)	21	51,2
Cushing's triad		
a. Yes	**12**	**29,3**
b. No	29	70,7
Pupillary diameter		
a. Isocoric	32	78
b. Anisocoric	**9**	**22**

Notes: ICP: Intracranial pressure.

Table 4. The association between ONSD and clinical manifestations of increased ICP.

ONSD	**Headache**		**C**	**p value**
	Yes	**No**		
Right				

a. ≥ 5,70 mm	15 (75%)	5 (25%)	0.42	0.003
b. < 5,70 mm	6 (28,6%)	15 (71,4%)		
Left				
a. ≥ 5,70 mm	16 (72,7%)	6 (27,3%)	0.42	0.003
b. < 5,70 mm	5 (26,3%)	14 (73,7%)		
	Vomiting			
	Yes	**No**		
Right				
a. ≥ 5,70 mm	5 (25%)	15 (75%)	0.20	0.188
b. < 5,70 mm	2 (9,5%)	19 (90,5%)		
Left				
a. ≥ 5,70 mm	5 (22,7%)	17 (77,3%)	0.16	0.301
b. < 5,70 mm	2 (10,5%)	17 (89,5%)		
	Seizure			
	Yes	**No**		
Right				
a. ≥ 5,70 mm	7 (35%)	13 (65%)	0.35	0.015
b. < 5,70 mm	1 (4,8%)	20 (95,2%)		
Left				
a. ≥ 5,70 mm	7 (31,8%)	15 (68,2%)	0.31	0.032
b. < 5,70 mm	1 (5,3%)	18 (94,7%)		
	Cushing's triad			
	Yes	**No**		
Right				
a. ≥ 5,70 mm	11 (55,0%)	9 (45%)	0.483	<0.001
b. < 5,70 mm	1 (4,8%)	20 (95,2%)		
Left				
a. ≥ 5,70 mm	12 (54,5%)	10 (45,5%)	0.513	<0.001
b. < 5,70 mm	0 (0%)	19 (100%)		
	Pupillary diameter			
	Anisocoric	**Isocoric**		
Right				
a. ≥ 5,70 mm	12 (54,5%)	10 (45,5%)	0.513	<0.001
b. < 5,70 mm	0 (0%)	19 (100%)		
Left				

a. ≥ 5,70 mm	9 (40,9%)	13 (59,1%)	0.442	0.002
b. < 5,70 mm	0 (0%)	19 (100%)		

In this study, a total of 41 subjects with non-traumatic intracranial lesions, receiving treatment at the Emergency Department of Dr. Soetomo Hospital from February to April 2023, met the inclusion criteria, were included. Increased ONSD has been known to correlate with elevated intracranial pressure.[7–12] The highest accuracy was observed with an ONSD cutoff value >0.58 cm, which positively correlated with findings from head CT scans. The sensitivity of ONSD cutoff value ≥5.8 mm was 94% (95% CI: 84.05% - 98.79%), with a specificity of 96.08% (95% CI, 86.7% - 99.52%). The positive predictive value was 92.08% (95% CI: 86.28% - 98.96%), and the negative predictive value was 94.23% (95% CI: 84.47% - 98.00%).[11] Therefore, in this study, a cutoff value of ≥5.70mm was used. ONSD has proven to differentiate between normal and high ICP and can serve as a useful screening tool in settings with limited resources.[7]

Increased ICP can lead to headaches through various mechanisms, including mechanical pressure, blood flow disruption, pain receptor stimulation, and trigeminal nerve activation.[13] Additionally, increased intracranial pressure results in compression of brain tissue, subsequently compressing the reticular formation leading to decreased consciousness.[14] In this study, the majority of subjects exhibited clinical manifestations such as headaches (51.2%), followed by decreased consciousness, Cushing's triad, Anisocoric pupil, seizures, and projectile vomiting. A study conducted by Allan et al. reported that clinical manifestations in patients with intracranial lesions experiencing an increase in ONSD diameter mainly included headaches (55.5%), followed by vomiting, seizures, decreased consciousness, Anisocoric pupils, and papilledema.[15] Similarly, a study by Rudiharto et al. concerning manifestations of increased intracranial pressure reported that the predominant manifestations were headaches and projectile vomiting.[3]

In this study, the percentage of headaches indicating increased intracranial pressure based on an ONSD value ≥ 5.70 mm was found to be higher compared to headaches in cases with ONSD < 5.70 mm. Findings from this study are relevant to a study conducted by Allan et al., which noted a moderate correlation between headache symptoms and ONSD values.[15] Consistent with these results, a study by Sulistyani et al. showed that analyzing ONSD values in patients experiencing headaches and in normal respondents resulted in a p-value of 0.001, indicating a significant difference in ONSD values between the two groups.[16] The study highlights that increased intracranial pressure in patients experiencing headaches can be detected early through ONSD examinations, with a headache percentage ranging from 34.8% to 85.7%, significantly associated with increased ONSD values ($p < 0.05$).[16] An increase in diameter observed in ONSD examinations correlates with headaches and serves as valuable guidance in selecting the appropriate treatment methods.[17]

The percentage of projectile vomiting in subjects with increased intracranial pressure based on an ONSD value ≥ 5.70 mm in this study was found to be higher compared to projectile vomiting in cases with ONSD < 5.70 mm. However, the contingency coefficient test showed that there was no significant correlation between ONSD and projectile vomiting ($p>0.05$). The findings from this study align with previous studies conducted by Lee et al. and Rudiharto et al., which reported no association between ONSD dilation and projectile vomiting.[3,18]

Regarding the clinical manifestation of seizures, our study indicated a statistically significant positive correlation between ONSD and seizures ($p<0.05$) with a weak correlation strength. These findings are consistent with previous research conducted by Datta et al. and Allan et al., reporting seizure manifestations ranging from 27.7% to 33.3%.[15,19] The study by Allan et al. also noted a correlation between ONSD values and seizures in intracranial lesions, where an ONSD value ≥ 5.8 mm had a positive likelihood ratio of 4 - 8, interpreted as an indicator of increased ICP.[15]

In the manifestation of decreased consciousness, our study showed a significant positive correlation between ONSD and decreased consciousness ($p<0.05$) with a moderate correlation strength. These findings demonstrate a higher percentage compared to the results reported by Datta et al., with a percentage of approximately 24%.[19] This finding aligns with the correlation test conducted by Allan et al., reporting a significant correlation between ONSD values and decreased consciousness in patients with intracranial lesions ($p < 0.05$) in 2016.[15] Additionally, Colak et al. also found a significant correlation between ONSD and decreased consciousness in stroke patients ($p < 0.001$).[20] Thicker optic nerve sheath diameter correlates with lower Glasgow Coma Scale (GCS) values and the quality of subject consciousness. Low GCS scores are associated with higher mortality rates, and this scale can be used to predict clinical prognosis. These findings are consistent with studies indicating that patients with lower GCS scores have higher ONSD values.[21]

Based on Cushing's triad, our study indicated a significant positive correlation between ONSD and Cushing's triad ($p<0.05$) with a moderate correlation strength. A study by Sadoughi et al. stated that hypertension with or without bradycardia, along with Cushing's triad (hypertension, bradycardia, and irregular respiration), are part of the signs of increased ICP. However, it is important to note that symptoms and signs of increased ICP are not entirely specific; for example, Cushing's triad can occur in brainstem herniation without significant increased ICP. Nevertheless, these symptoms can aid in clinical

management by directing towards a prompt diagnosis and treatment approach.[22]

In terms of pupil diameter measurements, our study showed a significant positive correlation between ONSD and anisocoric pupil diameter ($p<0.05$) with a moderate correlation strength. In this study, the percentage of anisocoric pupils was slightly lower compared to previous research conducted by Allan et al., which reported findings of clinical manifestations of increased ICP in patients with intracranial lesions experiencing increased ONSD diameter, including anisocoric pupils, at 66.67%.[15] These findings reflect variations in the percentage of neuro-ophthalmic symptoms related to increased ICP among different studies.

This study has several limitations, including that the authors did not conduct periodic ultrasound measurements of ONSD to assess the response of ICP to therapy and further observation related to ONSD concerning the clinical outcomes of patients. Additionally, not all research subjects underwent surgery to determine the ICP value measured by ONSD, representing the condition of increased intracranial pressure in patients.

4. CONCLUSION

In conclusion, there is a significant association between ONSD and clinical manifestations of increased intracranial pressure including headache, seizure, decreased consciousness, Cushing's triad, and pupillary diameter.

REFERENCES

[1] Rangel-Castilla L, Gasco J, Nauta HJW, Okonkwo DO, Robertson CS. Cerebral pressure autoregulation in traumatic brain injury. Neurosurg Focus. 2008;25(4):E7.

[2] Rigi M, Almarzouqi SJ, Morgan ML, Lee AG. Papilledema: epidemiology, etiology, and clinical management. Eye Brain. 2015;7:47–57.

[3] Rudiharto T, Murtala B, Asriyani S, Muis M, Kaelan C, Bahar B. Hubungan antara Diameter Optic Nerve Sheath pada Grey Scale Ultrasound dengan Peningkatan Tekanan Intrakranial pada Pasien dengan Lesi Intrakranial. Majalah Sainstekes. 2019;6(1).

[4] Yogipranata RM, Sukmani H. Korelasi Diameter Selubung Nervus Optik dan Marshall CT Score dengan Skala Koma Glasgow pada Cedera Kepala. Majalah Kedokteran Neurosains Perhimpunan Dokter Spesialis Saraf Indonesia. 2018;35(3).

[5] Dubourg J, Javouhey E, Geeraerts T, Messerer M, Kassai B. Ultrasonography of optic nerve sheath diameter for detection of raised intracranial pressure: a systematic review and meta-analysis. Intensive Care Med. 2011;37(7):1059–68.

[6] Bhide M, Singh O, Juneja D, Goel A. Bedside ultrasonography of optic nerve sheath diameter for detection of raised intracranial pressure in nontraumatic neuro-critically ill patients. World J Crit Care Med. 2023;12(1):10–7.

[7] Aduayi OS, Asaleye CM, Adetiloye VA, Komolafe EO, Aduayi VA. Optic nerve sonography: A noninvasive means of detecting raised intracranial pressure in a resource-limited setting. J Neurosci Rural Pract. 2015;6(4):563–7.

[8] Ali MA, Hashmi M, Shamim S, Salam B, Siraj S, Salim B. Correlation of Optic Nerve Sheath Diameter with Direct Measurement of Intracranial Pressure through an External Ventricular Drain. Cureus. 2019;11(9):e5777.

[9] 9. Du Toit GJ, Hurter D, Nel M. How accurate is ultrasound of the optic nerve sheath diameter performed by inexperienced operators to exclude raised intracranial pressure? South African Journal of Radiology. 2015;19(1):5.

[10] Montorfano L, Yu Q, Bordes SJ, Sivanushanthan S, Rosenthal RJ, Montorfano M. Mean value of B-mode optic nerve sheath diameter as an indicator of increased intracranial pressure: a systematic review and meta-analysis. Ultrasound J. 2021;13(1):35.

[11] Munawar K, Khan MT, Hussain SW, Qadeer A, Shad ZS, Bano S, et al. Optic Nerve Sheath Diameter Correlation with Elevated Intracranial Pressure Determined via Ultrasound. Cureus. 2019;11(2):e4145.

[12] Nabeta HW, Bahr NC, Rhein J, Fossland N, Kiragga AN, Meya DB, et al. Accuracy of noninvasive intraocular pressure or optic nerve sheath diameter measurements for predicting elevated intracranial pressure in cryptococcal meningitis. Open Forum Infect Dis. 2014;1(3):ofu093.

[13] Sharma S, Hashmi MF, Kumar A. Intracranial Hypertension. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2023.

[14] Jang SH, Kim OL, Kim SH, Kim JB. The Relation Between Loss of Consciousness, Severity of Traumatic

Brain Injury, and Injury of Ascending Reticular Activating System in Patients With Traumatic Brain Injury. Am J Phys Med Rehabil. 2019;98(12):1067–71.

[15] Allan JS. Diagnostic Utility and Accuracy of Optic Nerve Sheath Diameter (ONSD) in detecting raised Intracranial Tension [Internet] [masters]. Christian Medical College, Vellore; 2016. Available from: Available at: http://repository-tnmgrmu.ac.in/id/eprint/10485.

[16] Sulistyani S, Danuaji R. Perbedaan Optic Nerve Sheath Diameter (ONSD) pada Responden Normal dan Nyeri Kepala. Biomedika. 2019;11(2):96–104.

[17] Karadag MK, Akyuz ME, Sahin MH. The role of ONSD in the assessment of headache associated with Chiari malformation type 1. Front Neurol. 2023;14:1127279.

[18] Lee SU, Jeon JP, Lee H, Han JH, Seo M, Byoun HS, et al. Optic nerve sheath diameter threshold by ocular ultrasonography for detection of increased intracranial pressure in Korean adult patients with brain lesions. Medicine (Baltimore). 2016;95(41):e5061.

[19] Datta P, Sutradhar S, Khan M, Hossain M, Mahamud Sumon S, Hasan I, et al. Clinical Pattern of Intra-cranial space occupying lesion in Tertiary Level Hospital. Journal of Dhaka Medical College. 2020 Mar 3;28:17–22.

[20] Çolak T, Tekten B, Celik K. Prognostic value of the optic nerve sheath thickness as an indicator of intracranial pressure among acute stroke patients. Experimental Biomedical Research. 2020;3:157–66.

[21] Komut E, Kozacı N, Sönmez BM, Yılmaz F, Komut S, Yıldırım ZN, et al. Bedside sonographic measurement of optic nerve sheath diameter as a predictor of intracranial pressure in ED. Am J Emerg Med. 2016;34(6):963–7.

[22] Sadoughi A, Rybinnik I, Cohen R. Measurement and Management of Increased Intracranial Pressure. The Open Critical Care Medicine Journal. 2013;6(1):56–65.