Original Research Article

Indian Journal of Emergency Medicine
Volume 6 Number 1, January – March 2020
DOI: http://dx.doi.org/10.21088/ijem.2395.311X.6120.4

Can Optic Nerve Sheath Diameter Diagnose Raised Intracranial Pressure Before Neuroimaging Results in Cerebrovascular Accidents?

BS Gopala Krishna[1], Manikanta Chaitanya L[2], K Raghu[3], Ahammad Basha SK[4], Pranay Krishna[5], Ravi Sankar[6], Dhiran Showri B[7]

Author's Affiliation:
[1]Assistant Professor [2]Post graduate, [3]Head of Clinical Services [5]Assistant Professor [6]Assistant Professor [7]Postgraduate, Department of Emergency Medicine, [4]Assistant Professor, Department of Community Medicine, Narayana Medical College and Hospital, Chintareddypalem, Nellore, Andhra Pradesh 524003, India.

Corresponding Author:
Manikanta Chaitanya L, Post graduate, Department of Emergency Medicine, Narayana Medical College and Hospital, Chintareddypalem, Nellore, Andhra Pradesh 524003, India.

E-mail: drmani.posti@gmail.com

Received on 19.12.2019
Accepted on 28.01.2020

Abstract

Introduction: Stroke is the primary cause of morbidity and mortality in India. Stroke management depends on neuroimaging and time management in the emergency department. The main aim of the present study is to determine whether Optic Nerve Sheath Diameter (ONSD) could be an early predictor of raised Intracranial Pressure (ICP) before neuroimaging results. *Methodology:* Computed Tomography (CT) scan was considered to be positive for raised ICP if the findings as cerebral edema, midline shift, mass effect, the collapse of ventricles, and compression of cisterns were present. Modified Rankin Score (mRS), Glasgow Coma Scale (GCS) and National Institute of Health Stroke Scale (NIHSS) were recorded. *Results:* A total of 66 patients were included with the Mean ± SD age of 62.62 ± 12.29 [Range: 35–85] years. The mean binocular ONSD was significantly higher in raised ICP than without raised ICP on CT imaging ($p < 0.0001$). The mean of mRS and NIHSS were significantly higher in raised ONSD than normal ONSD ($p < 0.0001$). The mean binocular ONSD was significantly higher with ventilator support than without ventilator support ($p < 0.0001$). The mean binocular ONSD had a very strong positive correlation with NIHSS ($r = 0.781$, $p < 0.0001$) and a very strong negative correlation with GCS ($r = -0.751$, $p < 0.0001$). It was also observed that there was a very strong negative correlation between NIHSS and GCS ($r = -0.898$, $p < 0.0001$). The Area Under Curve (AUC) showed that mean ONSD had the highest sensitivity level (100%) than NIHSS (95.83%) and mRS (79.71%) for raised ICP ($p < 0.0001$). *Conclusion:* ONSD can be used in the early diagnosis and management of cerebrovascular accident cases and it could be an early indicator of raised Intracranial Pressure (ICP) before neuroimaging results.

Keywords: Optic nerve sheath diameter; Intracranial pressure; Glasgow Coma Scale; National institute of health stroke scale score; Modified Rankin Score; Computed tomography.

How to cite this article:
BS Gopala Krishna, Manikanta Chaitanya L, K Raghu, et al. Can Optic Nerve Sheath Diameter Diagnose Raised Intracranial Pressure Before Neuroimaging Results in Cerebrovascular Accidents? Indian J Emerg Med. 2020;6(1):23–29.

Introduction

In India, Stroke is the main cause of morbidity and mortality. The WHO was defined as stroke as rapidly developing clinical signs of focal disturbances of cerebral function with symptoms lasting 24 hours or prolonged with vascular origin as a cause.[1] This study was conducted at a tertiary care hospital with a duration of three months and registered all stroke cases in the Department of Emergency. Timely treatment and supportive care for stroke patients in the Emergency Department is crucial for patient outcomes.[12] Optic nerve sheath is an anatomical extension of diameter, along with subarachnoid space encircling the optic nerve. As optic nerve forms a continuum with intracranial compartment any change in ICP reflects changes in optic nerve sheath.[2] CT imaging done for diagnosis of CVA is highly cost procedure, risk of radiation exposure, and can't be performed on bedside, whereas ONSD measured by ultrasound is reliable, cost-effective, no radiation risks, easily done on bedside, easy to repeat, if there is a decrease in sensorium of patient. And also early detection of raised ICP by ultrasonography, facilitates the use of measures to reduce ICP like the elevation of the head end of the bed, anti-edema measures like Mannitol and 3% saline. Ischemic stroke and hemorrhagic stroke are the two major types of stroke.[3] Ischemic stroke occurs when a blood vessel supplying to the brain is occluded, a hemorrhagic stroke occurs when a weakened blood vessel ruptures. Management strategies are different for these two-stroke categories. In ischemic stroke, we do thrombolysis if a patient presents to us in a window period of 4.5 hours. NIHSS (National Institute of Health Stroke Scale) is used to assess stroke severity which includes detailed neurological examination.[4] Endovascular therapy, mechanical clot disruption with retrieval with a stent may be given within six hours of the onset of symptoms but better outcomes are associated with shorter time to treatment.[5] In hemorrhagic stroke we look to control the blood pressure, look for signs of raised ICP, and look for the cause of hemorrhage like A-V malformations, aneurysmal bleed CT scan imaging result was considered as positive for raised ICP if the findings, suggestive of elevated ICP such as significant cerebral edema, midline shift, mass effect, the collapse of ventricles, compression of cisterns.[6,17] The aim of the study is to check for the effectiveness of ONSD in diagnosing raised ICP as demonstrated by clinical and neuroimaging findings.

Materials and Methods

A prospective observational study was done at a tertiary care hospital with a period of three months and registered all stroke cases in the Department of Emergency. All patients were resuscitated as per ACLS protocols and neuroimaging done. ONSD was measured for all patients in both eyes and binocular ONSD was calculated with 5–13 MHz probes, 3 mm from the posterior aspect of globe.[7] The patient's demographic data, NIHSS score, GCS score, and the patient transferred to the stroke unit were collected. The optic nerve sheath with a diameter of more than 5 mm (0.5 cm) was considered as elevated ICP.[8,9,17]

Inclusion criteria

- All patients who presented in the Emergency Department with signs and symptoms of a stroke.
- The patient's age was above 18.

Exclusion criteria

- The patient's age was less than 18.
- Recurrent stroke, vascular dementia, trauma, optic neuritis.

Statistical Analysis

The data values have been entered into MS-Excel and statistical analysis has been done by using IBM SPSS Version 24.0 (IBM SPSS Inc., USA). For categorical variables, the values were expressed as number and percentages and to test the association between the groups, the chi-square test was used. For continuous variables, the values were expressed as mean ± standard deviation and to test the mean difference between the two groups, the student's *t*-test was used. Pearson's correlation coefficient was used to test the correlation between the groups. The ROC curve analysis was used to determine the area under curve values along with cut-off values and to obtain sensitivity and specificity values to diagnosing the variables for raised ICP. All the *p*-values are having less than 0.05 are considered statistically significant.

Results

Out of 66 cases, 47 (71.2%) were males and 19 (28.8%) were females, 41 (62.1%) were infarct state, 25 (37.9%) were hemorrhage. Among the site of infarct cases, 29 were MCA infarcts, 5 were PCA infarcts, and 2 were site infarcts and among the site of hemorrhagic stroke cases, 14 cases were capsule ganglionic bleeds and 6 cases were thalamic bleeds. Only 16 (24.2%) patients were having a window period of ≤ 4.5 hours for a time from symptomonset. 17 (25.8%) patients were required ventilator support. Among the risk factors, 50 (75.8%) patients were in hypertension, 21 (31.8%) patients were smokers, for each of 18 (27.3%) patients had diabetes and alcoholic, 7 (10.6%) patients have IHD, and 5 (7.6%) patients have CKD. 17 (25.8%) patients were in the group of ONSD ≥ 0.5, 10 (15.2%) patients were having GCS score ≤ 8. These results were shown in Tables 1 and 2.

Table 1: Demographic and patient characteristics of the present study

	Number (*n* = 66)	Percentage (%)
Sex		
Males	47	71.2
Females	19	28.8
Type of CVA		
Infarct state	41	62.1
Hemorrhage	25	37.9
Time from symptom onset		
≤ 4.5 hours	16	24.2
> 4.5 hours	50	75.8
Ventilator support		
Yes	17	25.8
No	49	74.2
Raised ICP on imaging		
Yes	24	36.4
No	42	63.6
ONSD		
≥ 0.5 cm	17	25.8
< 0.5 cm	49	74.2
GCS		
≤ 8	10	15.2
> 8	56	84.8

Table 2: Symptoms and risk factors and in the present study (*n* = 66)

	Number	Percentage (%)
Symptoms		
Hemiplegia & Paresis	50	71.2
Speech abnormal	29	43.9
Alt. Sensorium	25	37.9
Headache	8	12.1
Seizures	7	10.6
Cerebellar signs	6	37.9
Risk Factors		
HTN	50	75.8
Smokers	21	31.8
DM	18	27.3
Alcoholic	18	27.3
IHD	7	10.6
CKD	5	7.6

Table 3 shows that the Mean ± SD age of the infarct patients (64.56 ± 11.85 years) was higher than hemorrhage patients (59.44 ± 12.57 years).

The Mean ± SD of the modified Rankin score (4.04 ± 1.34) was significantly higher in hemorrhagic stroke patients than infarct patients (2.95 ± 1.38) [$p = 0.002$]. The Mean ± SD of NIHSS for hemorrhagic stroke patients (18.68 ± 10.94) was significantly higher than in infarct patients (11.63 ± 8.26) [$p = 0.008$].

The Mean ± SD of GCS for infarct patients (13.15 ± 2.39) was significantly higher than hemorrhagic stroke patients (10.16 ± 4.08) [$p = 0.002$]. The Mean ± SD of platelet count for infarct patients (285887.50 ± 73479.94) was significantly higher than the hemorrhagic stroke patients (212772 ± 68565.36) [$p < 0.0001$]. The Mean ± SD of binocular ONSD for raised ICP (0.519 ± 0.029) was significantly higher than without any raised ICP (0.432 ± 0.028) on CT imaging ($p < 0.0001$).

Table 3: Comparison of mean values for different variables with infarct and hemorrhage patients

Variables	Mean ± SD		p-value
	Infarct (n = 41)	Hemorrhage (n = 25)	
Age	64.56 ± 11.85	59.44 ± 12.57	0.101
Modified Rankin Score (mRS)	2.95 ± 1.38	4.04 ± 1.34	0.002*
NIHSS	11.63 ± 8.26	18.68 ± 10.94	0.008*
GCS	13.15 ± 2.39	10.16 ± 4.08	0.002*
Platelet count	285887.50 ± 73479.94	212772.0 ± 68565.36	< 0.0001**

* $p < 0.05$ – Statistically significant, ** $p < 0.0001$ – Very high significant

Table 4 showed that the Mean ± SD of the modified Rankin score for ONSD of ≥ 0.5 cm (4.76 ± 0.44) was significantly higher than ONSD of < 0.5 cm (2.88 ± 1.364) [$p < 0.0001$]. The Mean ± SD of NIHSS for ONSD of ≥ 0.5 cm (24.76 ± 5.41) was significantly higher than <0.5 cm (10.67 ± 8.41) [$p < 0.0001$]. However, It was observed that the Mean ± SD of binocular ONSD for ventilator support patients (0.520 ± 0.026) was significantly higher than without ventilator support patients (0.445 ± 0.042) [$p < 0.0001$].

Table 4: Comparison of mean values of mRS, GCS, and NIHSS for mean ONSD

Variables	Mean ± SD		p-value
	ONSD (< 0.5 cm) (n = 49)	ONSD (≥ 0.5 cm) (n = 17)	
Modified Rankin Score (mRS)	2.88 ± 1.36	4.76 ± 0.44	< 0.0001*
NIHSS	10.67 ± 8.41	24.76 ± 5.41	< 0.0001*
GCS	13.35 ± 2.44	8.18 ± 3.01	< 0.0001*

*$p < 0.0001$ – Very high significant

Table 5 showed that there was a significant very strong negative correlation for GCS with binocular ONSD (r value = –0.751, $p < 0.0001$) and there was a very strong significant positive correlation for NIHSS with binocular ONSD (r value = 0.781, $p < 0.0001$) and it was also observed that there was a very strong significant negative correlation between NIHSS and GCS score (r value = –0.898, $p < 0.0001$) and these were reflected in scatter plot which is shown in Fig. 1.

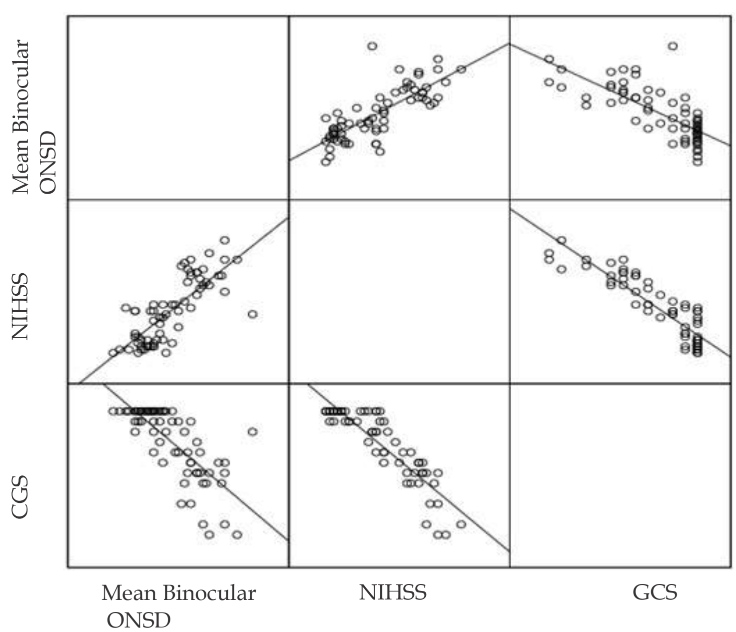

Fig. 1: Scatter plot for mean binocular ONSD, NIHSS, and GCS

Table 5: Relationships between mean ONSD, NIHSS and GCS

Variables	Number of patients	Correlation coefficient (r-value)	p-value
NIHSS	66	0.781	< 0.0001*
GCS	66	–0.751	< 0.0001*

*$p < 0.0001$ – Very high significant

Table 6 showed that the Receiver Operator Characteristics (ROC) curve analysis, the mean ONSD of Area Under Curve (AUC) value with 95% CI was 0.993 (0.933–1.0) and a cut-off value of more than 0.475 mm (Sensitivity [95% Confidence Interval (CI)]: 100.0% (85.8–100.0)], specificity [95% C.I.]: 95.24% [83.8–99.4]) was obtained. The NIHSS of Area under curve (AUC) value with 95% CI was 0.988 (0.923–1.0) and a cut-off value of more than 17 (Sensitivity [95% Confidence interval (CI)]: 95.83% (78.9–99.9)], specificity [95% CI]: 100% [91.6–100.0]). The mRS of Area under Curve (AUC) value with 95% CI was 0.968 (0.892–0.996) and a cut-off value of more than 4 (Sensitivity [95% Confidence Interval (CI)]: 79.17% (57.8–92.9)], specificity [95% CI]: 100% [91.6–100.0]). Mean ONSD, NIHSS, and mRS were also obtained significantly better AUC values. It was observed that the Mean ONSD was shown a 100% sensitivity level than NIHSS and mRS. Hence, the mean binocular ONSD was the best-predicted variable for raised ICP. These are shown in Table 6 and Fig. 2.

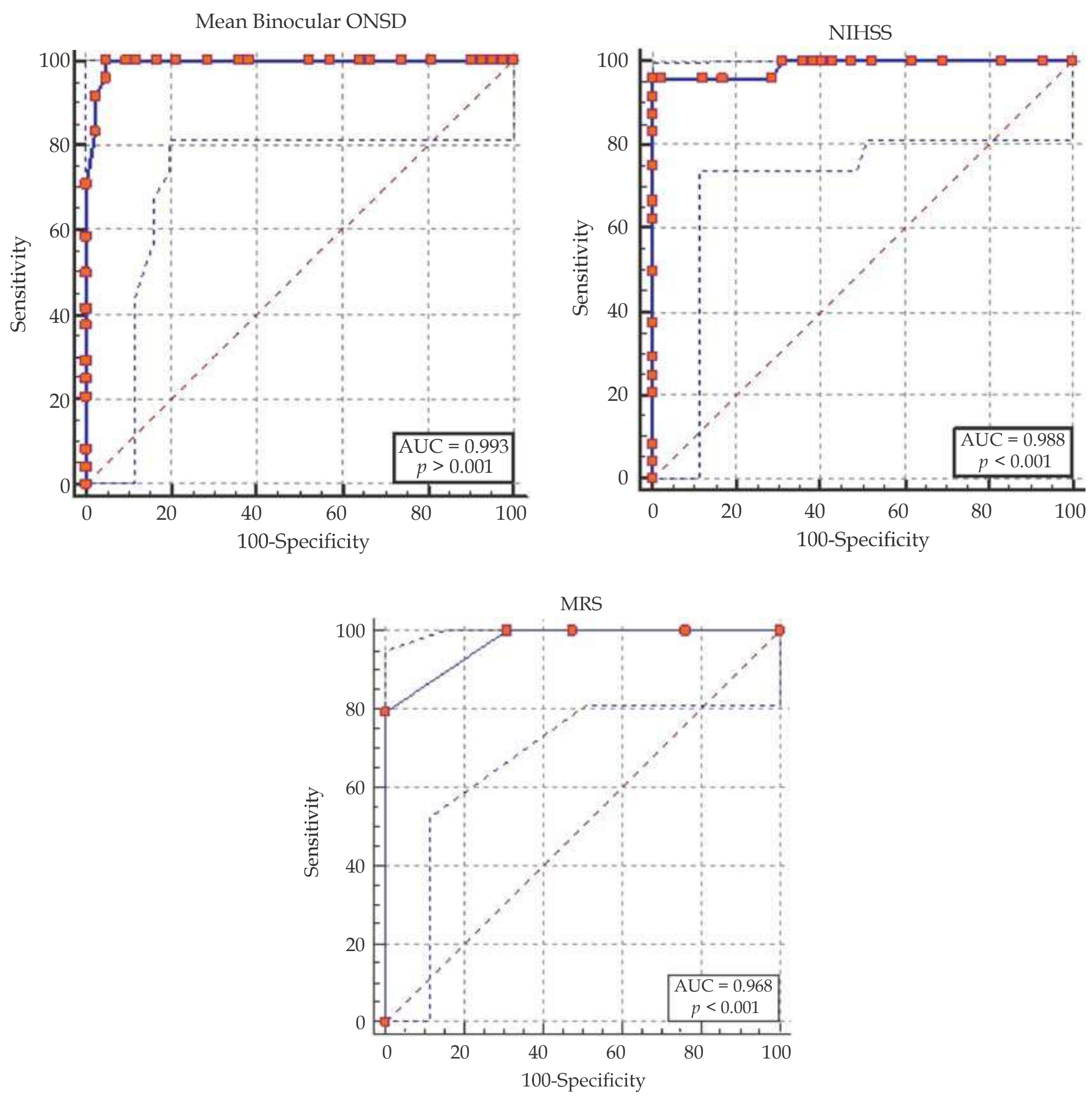

Fig. 2: Receiving Operating Characteristic (ROC) curves with 95% CI of mean ONSD, NIHSS, and mRS for detection of raised ICP.

Table 6: Diagnostic accuracy of mean ONSD, NIHSS and GCS for the prediction of raised ICP

Variables	AUC (95% CI)	Std. Error	Sensitivity (95% CI)	Specificity (95% CI)	*p*-value*
Mean ONSD	0.993 (0.933–1.00)	0.0062	100.0 (85.8–100.0)	95.24 (83.8–99.4)	< 0.0001
NIHSS	0.988 (0.923–1.0)	0.0127	95.83 (78.9–99.9)	100.0 (91.6–100.0)	< 0.0001
mRS	0.968 (0.892–0.996)	0.0151	79.17 (57.8–92.9)	100.0 (91.6–100.0)	< 0.0001

*$p < 0.05$ – Statistically significant.

Discussion

In the present study of 66 cases, 47 are males and 19 are females showing male preponderance. 41 cases are ischemic stroke and 25 cases are a hemorrhagic stroke. 17 cases required ventilator support, 17 patients have ONSD ≥ 0.5 cm. The predominant presenting complaint is hemiplegia/ hemiparesis followed by speech abnormalities and altered sensorium. Only 16 cases presented within a window period of 4.5 hours.

Several studies proved that the mean of binocular ONSD with raised ICP features on imaging is significantly higher than the mean of binocular ONSD without raised ICP on CT imaging.[10–12] This study was also proved in the above contradiction.

NIHSS scores have been reported to be effective in showing the general status of patients and mortality rates.Yüzbaşioğlu et al.[12] showed that there was a weak positive correlation between the NIHSS and the ONSD. But the current study showed that there was a very strong significant correlation between NIHSS and ONSD.

In this study, there is a strong negative correlation between GCS and the mean of binocular ONSD and also NIHSS is a significantly very high negative correlation with the GCS. This is in accordance with the studies of Amini et al.[13] and Dusenbury et al.[14]

In the current study, we showed that the mean platelet count with ischemic stroke was significantly higher than the hemorrhagic stroke, the mean GCS had significantly higher in ischemic stroke patients when compared with hemorrhagic stroke patients and also the mean of NIHSS for the infarct group is significantly lower than the mean of NIHSS for the hemorrhage group. These result statements are coinciding with the previous studies.[15–18]

In the Receiver Operator Characteristics (ROC) curve analysis, the mean ONSD of Area Under Curve (AUC) value with 95% CI was 0.993 (0.933–1.0) with a cut-off value of 0.475 mm, the NIHSS of Area Under Curve (AUC) value with 95% CI was 0.988 (0.923–1.0) and a cut-off value of 17 and the mRS of Area Under Curve (AUC) value with 95% CI was 0.968 (0.892–0.996) and a cut-off value of more than 4. It was concluded that the mean binocular ONSD was a better predictor for raised ICP. Several studies are also reported that the mean binocular ONSD was the best-predicted variable for raised ICP in literature.[6,9–13] The main strength of the study is that we focused on to determine the cut-off values of mean ONSD, NIHSS and mRS values by using the ROC curve analysis along with sensitivity analysis for predicting raised ICP.

The main limitations of the study are the lack of size of the sample and more possible chances of error may occur. We didn't perform ophthalmic examinations to see the presence of papilledema. Whether papilledema was present, it didn't influence the correlation between ICP and ONSD changes, not on the day of the cerebrovascular event. We didn't have any follow-up in our strategy to find changes in correlation in time in the same patient.

Conclusion

Bedside ocular ultrasonographic measurement of ONSD is a simple, easily measured and low-cost procedure in patient monitoring and it can be considered as a predictor of raised ICP with neuroimaging findings. Because of its ease in administration, repeatability and no risks of radiation, measures to reduce ICP can be administered at the earliest before the neuroimaging findings were obtained.

Source of support: Nil.

Conflict of interest: None declared.

References

1. Coupland A. P., Thapar A., Qureshi M. I., et al. The definition of stroke. Journal of the Royal Society of Medicine 2017;110(1):9–12.
2. Chacko J. Optic nerve sheath diameter: An ultrasonographic window to view raised intracranial pressure? Indian J Crit Care Med 2014 Nov;18(11):707–08.

3. Types of Stroke. Available onwww.stroke association.org
4. Rost NS, Bottle A, Lee JM, et al. Global Comparators Stroke GOAL collaborators. Stroke severity is a crucial predictor of outcome: An international prospective validation study. Journal of the American Heart Association 2016;5(1):e002433.
5. American Heart Association. Highlights of the 2015 American Heart Association guidelines update for CPR and ECC. Dallas, USA: American Heart Association 2015.
6. Aduayi OS, Asaleye CM, Adetiloye VA, et al. Optic nerve sonography: A non-invasive means of detecting raised intracranial pressure in a resource-limited setting. J Neurosci Rural Pract 2015 Oct-Dec;6(4):563–67.
7. Srikar R Adhikari. Available at: https://www.acep.org/sonoguide/smparts_ocular.html
8. Golshani K. Diagnostic accuracy of Optic Nerve Ultrasonography and Ophthalmoscopy in the prediction of elevated intracranial pressure. Emergency 2015 Spring;3(2):54–58.
9. Dubourg J, Javouhey E, Geeraerts T, et al. Ultrasonography of optic nerve sheath diameter for detection of raised intracranial pressure: a systematic review and meta-analysis. Intensive Care Medicine 2011;37(7):1059–68.
10. Shirodkar CG, Rao SM, Mutkule DP, et al. Optic nerve sheath diameter as a marker for evaluation and prognostication of intracranial pressure in Indian patients: An observational study. Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine. 2014;18(11):728–34.
11. Blaivas M, Theodoro D, Sierzenski PR. Elevated intracranial pressure detected by bedside emergency ultrasonography of the optic nerve sheath. Academic Emergency Medicine 2003;10(4):376–81.
12. Yüzbaşioğlu Y, Yüzbaşioğlu S, Coşkun S, et al. Bedside measurement of the optic nerve sheath diameter with ultrasound in cerebrovascular disorders. Turkish Journal of Medical Sciences 2018;48(1):93–9.
13. Amini A, Eghtesadi R, Feizi AM, et al. Sonographic Optic Nerve Sheath Diameter as a Screening Tool for Detection of Elevated Intracranial Pressure. Emergency 2013;1(1):15–19.
14. Dusenbury W, Tsivgoulis G, Brewer BB, et al. Abstract WP456: Validation of the NIH Stroke Scale Score for Clinical Assessment of Intracerebral Hemorrhage. Stroke 2019 Feb;50(Suppl_1):AWP456.
15. Mayda-Domaç F, Mısırlı H, Yılmaz M. Prognostic role of mean platelet volume and platelet count in ischemic and hemorrhagic stroke. Journal of Stroke and Cerebrovascular Diseases 2010;19(1):66–72.
16. Ojaghihaghighi S, Vahdati SS, Mikaeilpour A, Ramouz A. Comparison of neurological clinical manifestation in patients with hemorrhagic and ischemic stroke. World J Emerg Med 2017;8(1):34–38.
17. Major R, Girling S, Boyle A. Ultrasound measurement of optic nerve sheath diameter in patients with a clinical suspicion of raised intracranial pressure. Emergency Medicine Journal 2011;28(8):679–81.
18. Chiu D, Peterson L, Elkind MS, et al. Comparison of outcomes after intracerebral hemorrhage and ischemic stroke. Journal of Stroke and Cerebrovascular Diseases 2010;19(3):225–9.