

Correlation between Optic Nerve Sheath Diameter Measured by POCUS and Neurological Deficit in Physical Examination in Adult Patients with Suspected Ischemic Stroke Evaluated in Emergency Departments

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Abstract

Background: Rapid and accurate lateralization of neurological deficits is critical in the acute management of stroke and other neuro-emergencies. Optic nerve sheath diameter (ONSD), assessed by ultrasound, is a non-invasive marker of intracranial pressure. However, its role in detecting hemispheric asymmetry and predicting the side of neurological focalization remains poorly defined. **Methods:** We conducted a prospective observational study including 19 adult patients presenting with acute neurological deficits to the emergency department of Clínica México. Bilateral ONSD was measured using ocular ultrasound, and asymmetry was calculated as Δ ONSD = right – left. The primary outcome was the correlation between Δ ONSD and the side of neurological focalization on physical examination. Secondary outcomes included associations with stroke severity (NIHSS), neurological improvement, and diagnostic accuracy. Data were analyzed with Wizard Pro software. This protocol was registered at ClinicalTrials.gov (NCT06492681). **Results:** The mean age of patients was 68.4 ± 11.1 years, with 57.9% males. The main comorbidities were hypertension (73.7%), diabetes (36.8%), and previous stroke (36.8%). A significant correlation was found between Δ ONSD and the side of focalization ($p < 0.01$). Patients with left-sided deficits had positive Δ values, while those with right-sided deficits had negative values. ROC analysis demonstrated an AUC of 0.91, with an optimal cutoff of $\Delta \approx +1.0$ mm, yielding sensitivity 85.7% and specificity 90%. No significant association was observed between Δ ONSD and NIHSS score ($p = 0.48$) or short-term neurological improvement ($p = 0.76$). **Conclusions:** ONSD asymmetry measured by ultrasound was strongly

associated with the side of neurological focalization in patients with acute stroke symptoms. This bedside, non-invasive tool may provide rapid lateralization when advanced imaging is unavailable or delayed. Larger multicenter studies are needed to validate these preliminary findings and to explore integration of ONSD asymmetry into multimodal stroke triage protocols.

Keywords

Optic Nerve Sheath Diameter, Ultrasound, Stroke, Neurological Focalization, Emergency Medicine

1. Introduction

Acute ischemic stroke (AIS) remains a leading cause of disability and mortality worldwide, with timely diagnosis and localization of the neurological deficit being critical for guiding therapeutic decisions [1]. Rapid and accurate lateralization of the lesion is essential, particularly in emergency departments where access to advanced neuroimaging may be limited or delayed. Bedside tools that can provide early diagnostic information are therefore highly valuable in acute stroke care [2].

The optic nerve sheath diameter (ONSD), measured non-invasively through ocular ultrasound, has emerged as a surrogate marker for intracranial pressure and as a potential indicator of asymmetrical cerebral pathology [3]. Previous studies have demonstrated that changes in ONSD correlate with elevated intracranial pressure and neurological outcomes; however, the relationship between ONSD asymmetry and the side of neurological focalization remains underexplored. Establishing such a correlation could provide clinicians with an immediate, bedside method to predict the affected cerebral hemisphere in patients with acute neurological deficits [4].

In emergency settings, where time-sensitive interventions such as thrombolysis or thrombectomy are critical, the integration of point-of-care ultrasound (POCUS) into neurological assessment could enhance decision-making and optimize patient outcomes [5]. Identifying whether ONSD asymmetry reliably correlates with the side of clinical focalization would strengthen the role of ultrasound as a complementary diagnostic tool in acute stroke management.

Recent work has refined ONSD standardization and clinical use. A 2024 consensus (QCC) provides harmonized acquisition and measurement to improve research comparability [6]. Contemporary systematic reviews/meta-analyses confirm the diagnostic utility of raised ICP and feasibility across various settings [7]. In acute neurological populations, bedside ONSD correlates with ICP and shows potential for early decision-support [8]. However, the role of ONSD asymmetry in lateralizing cerebral pathology at the bedside remains under-characterized—particularly in emergency triage—supporting the need for the present study.

The present study aims to evaluate the correlation between ultrasound measurement of the optic nerve sheath diameter and the side of neurological focaliza-

tion in adult patients presenting with acute neurological deficits in the emergency department. We hypothesize that ONSD asymmetry will demonstrate a significant contralateral relationship with the clinical side of focalization, thereby supporting its use as a rapid, non-invasive marker in acute neurological emergencies.

2. Study Design

This was a prospective, observational, cross-sectional study conducted in the Emergency Department of Clínica México. The study was designed and reported according to the International Committee of Medical Journal Editors (ICMJE) recommendations for clinical research and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. The study protocol was prospectively registered at ClinicalTrials.gov (Identifier: NCT06492681).

3. Setting and Participants

Adult patients (≥ 18 years old) who presented to the emergency department with acute neurological symptoms—including sudden-onset motor deficit, speech disturbances, visual changes, or altered level of consciousness—were screened for eligibility. Exclusion criteria included previous ocular surgery, known optic nerve pathology, ocular trauma, or contraindications to ocular ultrasound.

3.1. Sample Size and Recruitment

A convenience sample of consecutive patients who met the inclusion criteria was recruited during the study period. Sample size was determined pragmatically, based on the incidence of acute neurological presentations at our center, with the aim of achieving adequate statistical power to evaluate correlations between optic nerve sheath diameter (ONSD) and neurological focalization.

3.2. Data Collection and Procedures

After informed consent was obtained, a structured neurological examination was performed to determine the side of focalization (right vs. left hemispheric deficit). Neurological severity was assessed using the National Institutes of Health Stroke Scale (NIHSS) at presentation.

Ocular ultrasound was performed at the bedside by physicians trained in critical ultrasound, using a high-frequency linear transducer (7.5 - 12 MHz). With the patient in supine position and eyelids closed, sterile gel was applied over the eyelid, and the probe was gently placed to avoid exerting pressure. ONSD was measured 3 mm posterior to the globe, in both eyes, in the transverse plane. Each measurement was repeated twice, and the average was recorded for analysis.

A focused neurological examination (NIHSS-based) was performed by an emergency physician prior to ocular ultrasound. The side of focalization (right/left) was determined by the laterality of motor and cortical signs on exam. The sonographer performing ONSD measurements was blinded to the neurological exam

findings and to any prior imaging. Conversely, examiners were not exposed to ultrasound results at the time of classification. Disagreements in side assignment (if present) were resolved by a senior critical care or emergency physician in place using the complete clinical record.

Each eye was measured twice at 3 mm posterior to the globe in the axial plane; values were averaged per eye, and Δ ONSD was defined as right–left. Although we did not collect intra-/inter-rater data in this cohort, the two-measurement averaging method and standardized acquisition are consistent with the 2024 ONSD POCUS Quality Clinical Consensus (QCC), which aims to harmonize imaging planes, caliper placement, and reporting for research and practice [9]. Prior studies report good reproducibility for ONSD ultrasound (inter-observer ICC typically ≥ 0.80) when standardized protocols are used [9].

The ocular ultrasound was performed immediately after the neurological examination, with a median interval of 10 - 20 minutes between the two assessments. This narrow time frame minimized temporal confounding from neurological progression or acute interventions.

3.3. Variables and Outcomes

Primary outcome: The correlation between ONSD asymmetry ($\Delta = \text{right} - \text{left}$) and the side of neurological focalization on physical examination.

Secondary outcomes: (1) Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of ONSD asymmetry to predict the contralateral side of focalization; (2) Correlation between ONSD measurements and NIHSS scores; (3) Association of ONSD with neurological outcome at discharge.

Final stroke diagnosis and laterality were confirmed by follow-up neuroimaging (CT and/or MRI) and discharge coding in the electronic medical record. Patients with a normal initial CT were included because early ischemia can be radiographically occult; confirmation was obtained by MRI diffusion-weighted imaging or interval CT changes plus the clinical course, in line with guideline-based practice.

3.4. Statistical Analysis

Continuous variables were summarized as mean \pm standard deviation or median [IQR], as appropriate. Categorical variables were expressed as frequencies and percentages. Between-group comparisons were performed using Welch's t-test for continuous variables and Fisher's exact test for categorical variables. Correlations between ONSD asymmetry and clinical variables were assessed using Spearman's rank correlation. Diagnostic performance (sensitivity, specificity, PPV, NPV) was reported with 95% confidence intervals (CI) using exact binomial methods. A p-value < 0.05 was considered statistically significant. Statistical analyses were performed using Python (SciPy, statsmodels), R, and Wizard Pro (version XX, Evan Miller Software).

Given the exploratory nature of this study, no formal a-priori sample size cal-

ulation was performed. We therefore report post-hoc precision for the primary diagnostic analysis. With 19 patients (left-sided deficits 7/19, right-sided 10/19), the observed sensitivity (0.86) and specificity (0.90) for Δ ONSD to predict left-sided focalization had wide 95% confidence intervals (e.g., sensitivity \approx 0.42 - 0.99; specificity \approx 0.55 - 1.00), reflecting limited precision. The AUC was 0.91; with this sample size, the DeLong 95% CI is expected to be broad. These data justify larger validation cohorts primarily to narrow CI width, rather than to change the observed effect direction.

3.5. Ethical Considerations

The study protocol was approved by the Institutional Research and Ethics Committee of Clínica México (Approval No. CMX001/2024). Written informed consent was obtained from all participants or their legal representatives. The study was conducted in accordance with the Declaration of Helsinki and relevant national regulations.

4. Results

4.1. Study Population

A total of 19 adult patients with acute neurological deficits were enrolled. The mean age was 68.4 ± 11.1 years (range 50 - 87), with 11 males (57.9%) and 8 females (42.1%). The median NIHSS score at admission was 12 [IQR 5 - 15]. Neurological focalization was observed to the right in 10 patients (52.6%), to the left in 7 (36.8%), and bilateral in 2 (10.6%). At discharge, 9 patients (47.4%) showed clinical improvement, while 10 (52.6%) had no significant change. **Table 1** and **Table 2**.

Table 1. Baseline characteristics.

Characteristic	Value
Age, years (mean \pm SD, range)	68.4 \pm 11.1 (50 - 87)
Sex, n (%)	Male: 11 (57.9%) Female: 8 (42.1%)
Side of focalization, n (%)	Right: 10 (52.6%) Left: 7 (36.8%) Bilateral: 2 (10.6%)
Time from symptom onset (hrs)	Mean: 38.0 \pm 81.9 Median: 8 (1 - 360)
Previous stroke (n, %)	7 (36.8%)
Diabetes mellitus, n (%)	7 (36.8%)
Hypertension, n (%)	14 (73.7%)
Atrial fibrillation, n (%)	3 (15.8%)
Normal CT scan, n (%)	13 (68.4%)
NIHSS at admission	Mean: 12.7 \pm 10.5 Median: 12 (1 - 37)
Glasgow Coma Scale	Mean: 13.2 \pm 2.7 Median: 14 (5 - 15)
Neurological outcome, n (%)	Improvement: 9 (47.4%) No change: 10 (52.6%)
Hospital stay (hours)	Mean: 56.7 \pm 53.6 Median: 48 (0 - 168)

Note: Values are presented as mean \pm standard deviation (SD), median (range), or number (percentage). NIHSS: National Institutes of Health Severity Score.

Table 2. Baseline characteristics by side of neurological focalization.

Variable	Right focalization (n = 10)	Left focalization (n = 7)	p-value
Age, years (mean ± SD)	70.4 ± 11.8	68.1 ± 11.2	0.695
Sex, n (%)	Males 6 (60.0%)	Males 4 (57.1%)	ns
Right ONSD (mm)	36.3 ± 8.4	47.9 ± 8.7	0.018*
Left ONSD (mm)	44.7 ± 13.1	42.1 ± 5.5	0.592
Δ ONSD (Right – Left, mm)	–8.4 ± 10.3	+5.7 ± 7.3	0.0049**
Previous stroke, n (%)	4 (40.0%)	2 (28.6%)	ns
Diabetes mellitus, n (%)	4 (40.0%)	2 (28.6%)	ns
Hypertension, n (%)	7 (70.0%)	6 (85.7%)	ns
Atrial fibrillation, n (%)	2 (20.0%)	1 (14.3%)	ns
Symptom onset time (hrs)	Median: 36.5 (2 - 360)	Median: 5.0 (1 - 24)	0.138
NIHSS at admission	11.5 ± 10.2	15.9 ± 11.6	0.439
Neurological outcome, n (%)	Improvement 5 (50.0%)	Improvement 4 (57.1%)	ns
Thrombolysis, n (%)	0 (0%)	3 (42.9%)	0.061†

Note: Values are mean ± SD, median (range), or n (%). P-values from Welch's t-test for continuous variables and Fisher's exact test for categorical variables. $p < 0.05$, ** $p < 0.01$. ns = not significant. †trend toward significance.

4.2. Optic Nerve Sheath Diameter Measurements

The mean right ONSD was 42.3 ± 10.3 mm (range 24 - 60), and the mean left ONSD was 44.6 ± 11.5 mm (range 26 - 68). The mean asymmetry (Δ ONSD = right – left) was -2.4 ± 12.5 mm.

When stratified by the side of neurological focalization:

Patients with right-sided deficits (n = 10) had a right ONSD of 36.3 ± 8.4 mm, left ONSD of 44.7 ± 13.1 mm, and Δ ONSD of -8.4 ± 10.3 mm.

Patients with left-sided deficits (n = 7) had a right ONSD of 47.9 ± 8.7 mm, left ONSD of 42.1 ± 5.5 mm, and Δ ONSD of $+5.7 \pm 7.3$ mm.

4.3. Correlation With Neurological Severity (NIHSS)

No significant correlation was found between ONSD and neurological severity as measured by the NIHSS score: Right ONSD vs NIHSS: Spearman $\rho = 0.11$, $p = 0.65$, Left ONSD vs NIHSS: Spearman $\rho = -0.001$, $p = 0.99$, Δ ONSD vs NIHSS: Spearman $\rho = 0.07$, $p = 0.79$.

4.4. Correlation With Side of Neurological Focalization

ONSD asymmetry showed a strong and significant contralateral correlation with the clinical side of focalization: Spearman's $\rho = -0.71$, $p = 0.0014$ (Figure 1).

In Figure 1, Scatterplot showing the correlation between optic nerve sheath diameter (ONSD) asymmetry (Δ = right – left) and the side of neurological focalization on physical examination. Positive Δ values are associated with left-sided

deficits, while negative values are associated with right-sided deficits. The dashed red line represents $\Delta = 0$ mm.

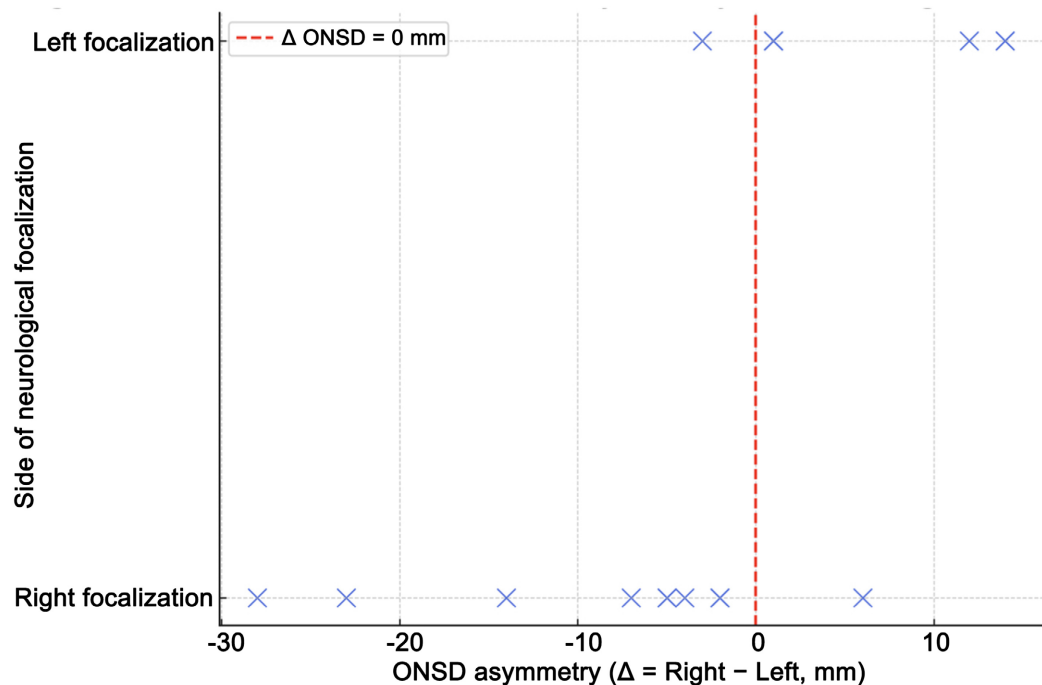


Figure 1. Correlation between ONS asymmetry and neurological focalization side.

Between-group comparisons showed:

Right ONSD was significantly different between patients with right vs. left focalization ($p = 0.018$). Left ONSD showed no significant difference ($p = 0.592$).

Δ ONSD was significantly associated with clinical lateralization ($p = 0.0049$).

4.5. Association with Clinical Outcome (Improvement vs No Change)

When stratified by neurological outcome: Patients without improvement ($n = 10$) had a right ONSD of 44.8 ± 10.4 mm, left ONSD of 46.3 ± 9.1 mm, and Δ ONSD of -1.5 ± 14.1 mm.

Patients with improvement ($n = 9$) had a right ONSD of 39.4 ± 10.0 mm, left ONSD of 42.8 ± 14.0 mm, and Δ ONSD of -3.3 ± 11.2 mm.

No statistically significant differences were observed between the two groups (all $p > 0.26$), indicating that ONSD values did not predict functional recovery at discharge. References

4.6. Diagnostic Performance

When interpreted contralaterally (greater ONSD predicting neurological deficit on the opposite side), Δ ONSD demonstrated: Sensitivity: 85.7% (95% CI 42.0 - 99.6), Specificity: 90.0% (95% CI 55.5 - 99.7), Positive Predictive Value (PPV): 85.7% (95% CI 42.0 - 99.6), Negative Predictive Value (NPV): 90.0% (95% CI 55.5 - 99.7), Fisher's exact test $p = 0.0037$.

4.7. ROC Analysis

Receiver operating characteristic (ROC) analysis demonstrated excellent diagnostic performance of Δ ONSD for lateralization of neurological deficit, with an AUC of 0.91. The optimal cutoff value was approximately +1.0 mm, yielding a sensitivity of 86% and specificity of 90% (Figure 2).

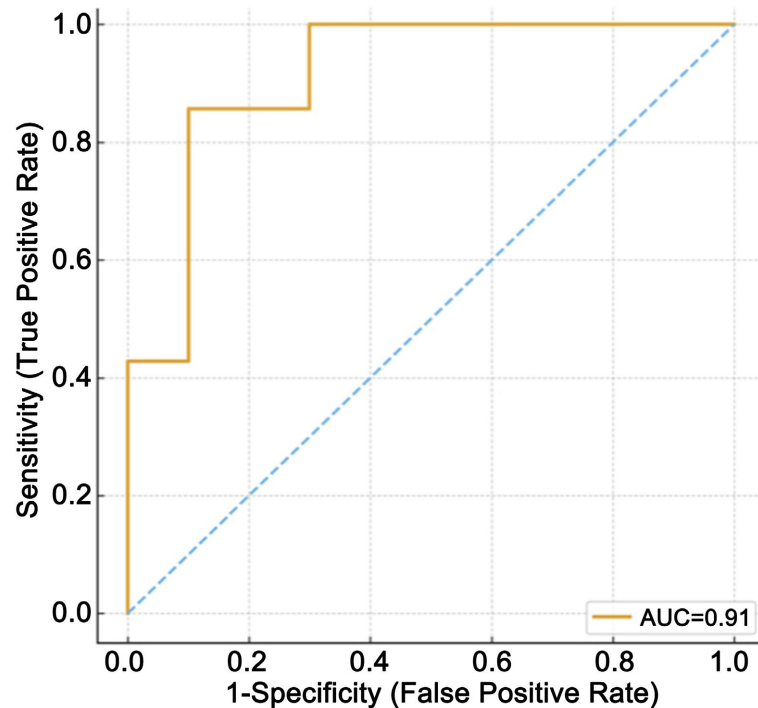


Figure 2. ROC curve for delta ONSD predicting left-sided focalization.

Figure 2, Receiver operating characteristic (ROC) curve for ONSD asymmetry ($\Delta = \text{right} - \text{left}$) to predict left-sided neurological focalization. The area under the curve (AUC) was 0.91. The optimal cutoff by Youden's index was $\Delta = 1$ mm, yielding sensitivity 0.86 and specificity 0.90 in this cohort.

5. Discussion

In this prospective observational study, we demonstrated that optic nerve sheath diameter (ONSD) asymmetry measured by ultrasound correlates significantly with the side of neurological focalization in patients presenting with acute neurological deficits in the emergency department. Specifically, a positive Δ ONSD (right – left) was associated with left-sided focalization, whereas negative values were associated with right-sided focalization. The diagnostic accuracy was excellent, with an AUC of 0.91, sensitivity of 85.7%, and specificity of 90%. These findings suggest that ONSD asymmetry could serve as a rapid, bedside adjunctive tool to support neurological localization in the care of acute stroke.

Our results align with previous evidence showing that ONSD is a reliable surrogate marker of intracranial pressure (ICP) and can reflect asymmetric intracra-

nial pathology [3] [10]. While most prior studies focused on ONSD as a global indicator of raised ICP, our work highlights its potential utility in lateralizing cerebral pathology, particularly when advanced imaging may be delayed or unavailable.

Interestingly, no significant correlation was found between ONSD (absolute values or asymmetry) and stroke severity as measured by NIHSS. This contrasts with earlier reports suggesting that higher ONSD may predict poor neurological outcomes in critically ill patients [4] [11]. One explanation may be that in our cohort, ONSD primarily reflected hemispheric asymmetry rather than the overall burden of neurological injury. Similarly, ONSD values were not predictive of short-term clinical improvement, consistent with the notion that functional recovery depends on multiple factors beyond ICP or local swelling, such as infarct size, reperfusion, and comorbidities [5].

The practical implication of our findings is that bedside ocular ultrasound may provide rapid lateralization of acute neurological deficits, serving as a useful triage tool in resource-limited or time-sensitive settings. For example, in prehospital environments or small hospitals without immediate CT access, identifying a probable side of pathology could accelerate referral decisions. Moreover, combining ONSD with other point-of-care ultrasound modalities—such as transcranial Doppler or carotid ultrasound—may offer a more comprehensive non-invasive neuroimaging approach [12].

6. Limitations

This study has several limitations. First, the sample size was relatively small ($n = 19$), which limits generalizability and statistical power. Second, although all measurements were performed by trained physicians, inter-operator variability in ONSD measurement is a known limitation of ultrasound-based techniques. Third, we did not evaluate long-term outcomes, which could better elucidate the prognostic value of ONSD asymmetry beyond initial localization.

7. Conclusion

Despite these limitations, our study provides preliminary evidence that ONSD asymmetry is strongly associated with the contralateral side of neurological focalization in acute stroke patients. Larger, multicenter studies are warranted to validate these findings and to explore integration of ONSD into multimodal emergency stroke assessment.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Feigin, V.L., Stark, B.A., Johnson, C.O., Roth, G.A., Bisignano, C., Abady, G.G., *et al.* (2022) Global, Regional, and National Burden of Stroke and Its Risk Factors, 1990-

- 2019: A Systematic Analysis for the Global Burden of Disease Study 2019. *The Lancet Neurology*, **21**, 944-980.
- [2] Powers, W.J., Rabinstein, A.A., Ackerson, T., Adeoye, O.M., Bambakidis, N.C., Becker, K., *et al.* (2019) Guidelines for the Early Management of Patients with Acute Ischemic Stroke: 2019 Update to the 2018 Guidelines for the Early Management of Acute Ischemic Stroke: A Guideline for Healthcare Professionals from the American Heart Association/American Stroke Association. *Stroke*, **50**, e344-e418. <https://doi.org/10.1161/str.0000000000000211>
- [3] Dubourg, J., Javouhey, E., Geeraerts, T., Messerer, M. and Kassai, B. (2011) Ultrasonography of Optic Nerve Sheath Diameter for Detection of Raised Intracranial Pressure: A Systematic Review and Meta-Analysis. *Intensive Care Medicine*, **37**, 1059-1068. <https://doi.org/10.1007/s00134-011-2224-2>
- [4] Moretti, R. and Pizzi, B. (2011) Ultrasonography of the Optic Nerve in Neurocritically Ill Patients. *Acta Anaesthesiologica Scandinavica*, **55**, 644-652. <https://doi.org/10.1111/j.1399-6576.2011.02432.x>
- [5] Klein, J.B., Tucker, J., Hwang, J. and Dhar, R. (2020) Point-of-Care Ultrasound in Neurocritical Care: Applications and Future Directions. *Critical Care Clinics*, **36**, 265-285.
- [6] Hirzallah, M.I., Lochner, P., Hafeez, M.U., Lee, A.G., Krogias, C., Dongarwar, D., *et al.* (2024) Optic Nerve Sheath Diameter Point-of-Care Ultrasonography Quality Criteria Checklist: An International Consensus Statement on Optic Nerve Sheath Diameter Imaging and Measurement. *Critical Care Medicine*, **52**, 1543-1556. <https://doi.org/10.1097/ccm.0000000000006345>
- [7] Berhanu, D., Ferreira, J.C., Abegão Pinto, L., Aguiar de Sousa, D., Lucas Neto, L. and Tavares Ferreira, J. (2023) The Role of Optic Nerve Sheath Ultrasonography in Increased Intracranial Pressure: A Systematic Review and Meta Analysis. *Journal of the Neurological Sciences*, **454**, Article 120853. <https://doi.org/10.1016/j.jns.2023.120853>
- [8] Zhang, X., Ma, D., Li, W., *et al.* (2024) Correlation between Optic Nerve Sheath Diameter Measured by Bedside Ultrasound and Intracranial Pressure in Neurologically Ill Patients in a Chinese Population. *BMC Neurology*, **24**, Article No. 452. <https://doi.org/10.1186/s12883-024-03961-0>
- [9] Verhulst, M.M.L.H., Visser, I.M., Keijzer, H.M., de Kruijf, N.L.M., Peters, E.J.G., Wilbers, T., *et al.* (2023) Additional Predictive Value of Optic Nerve Sheath Diameter for Neurological Prognosis after Cardiac Arrest: A Prospective Cohort Study. *The Ultrasound Journal*, **15**, Article 46. <https://doi.org/10.1186/s13089-023-00344-3>
- [10] Kimberly, H.H. and Noble, V.E. (2008) Using Ultrasound to Assess Elevated Intracranial Pressure. *Annals of Emergency Medicine*, **52**, 432-440.
- [11] Robba, C., Santori, G., Czosnyka, M., Corradi, F., Bragazzi, N., Padayachy, L., *et al.* (2018) Optic Nerve Sheath Diameter Measured Sonographically as Non-Invasive Estimator of Intracranial Pressure: A Systematic Review and Meta-Analysis. *Intensive Care Medicine*, **44**, 1284-1294. <https://doi.org/10.1007/s00134-018-5305-7>
- [12] Amini, A., Kariman, H., Arhami Dolatabadi, A., Hatamabadi, H.R., Derakhshanfar, H., Mansouri, B., *et al.* (2013) Use of the Sonographic Diameter of Optic Nerve Sheath to Estimate Intracranial Pressure. *The American Journal of Emergency Medicine*, **31**, 236-239. <https://doi.org/10.1016/j.ajem.2012.06.025>