Turkish Journal of Geriatrics
2025; 28(4):449–456

DOI: 10.29400/tjgeri.2025.462

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Received : Oct 22, 2025
Accepted: Dec 01, 2025

Cite this article as:
Aslanoğlu B, Aydın K, Gunara SO et al. The Effect of Optic Nerve Sheath Diameter on Prognosis and Its Perioperative Evaluation in Geriatric Ischemic Cerebrovascular Patients. Turkish Journal of Geriatrics 2025; 28(4):449–456.doi:10.29400/tjgeri.2025.462

ORIGINAL ARTICLE

THE EFFECT OF OPTIC NERVE SHEATH DIAMETER ON PROGNOSIS AND ITS PERIOPERATIVE EVALUATION IN GERIATRIC ISCHEMIC CEREBROVASCULAR PATIENTS

Abstract

Introduction: This study evaluates the prognostic value of optic nerve sheath diameter measurement as a noninvasive indicator of elevated intracranial pressure and its potential role in guiding decompressive surgical decision-making in elderly patients with ischemic stroke.

Materials and Method: This multicenter retrospective observational study included patients over 65 years of age who were hospitalized with middle cerebral artery infarction between 2023 and 2025. Patients with intracranial mass lesions, hydrocephalus, orbital pathology, or a history of head trauma were excluded. Preoperative and postoperative optic nerve sheath diameter measurements were obtained using computed tomography at a distance of 3 mm posterior to the optic disc. Clinical and radiological parameters, including Glasgow Coma Scale, Glasgow Outcome Scale, infarct volume, and degree of midline shift, were systematically analyzed.

Results: A total of 97 patients were included (57.7% female; mean age 75.3 ± 8.5 years). The mean preoperative optic nerve sheath diameter was 4.21 ± 0.81 mm. Increased preoperative optic nerve sheath diameter, larger infarct volume, and greater midline shift were significantly associated with lower Glasgow Outcome Scale scores ($p = 0.035$). An optic nerve sheath diameter threshold above 4.4 mm predicted poorer outcomes, while postoperative optic nerve sheath diameter variation showed no significant correlation with prognosis

Conclusion: Preoperative optic nerve sheath diameter measurement may serve as a rapid, noninvasive, and reliable parameter for prognostication and for supporting early surgical decision-making in elderly patients with ischemic stroke. However, individualized multidisciplinary evaluation remains crucial given the complex clinical profile of this population.

Keywords: Ischemic Stroke; Intracranial Pressure; Decompressive Craniectomy; Prognosis.

INTRODUCTION

Stroke is defined as a neurological dysfunction lasting longer than 24 hours that develops due to causes other than vascular pathologies, and it is reported to be the second most common cause of death among non-communicable diseases, following cardiovascular diseases (1). Clinically, stroke is classified into two main groups: ischemic and hemorrhagic. In the literature, approximately 65.3% of strokes are reported to be ischemic and 34.7% hemorrhagic in origin (1).

In the geriatric population, the high prevalence of comorbidities and polypharmacy presents significant challenges in stroke management. Epidemiological data indicate that 30–65% of elderly individuals use five or more medications concurrently (2). In geriatric patients, drug–drug and drug–disease interactions resulting from comorbidities, the increased prevalence of concomitant diseases, the need for additional treatments targeting these conditions, and prolonged rehabilitation processes all contribute to added clinical management challenges and increased healthcare costs. Indeed, the global costs associated with stroke were estimated at USD 891 billion in 2017 and are projected to reach USD 2.31 trillion by 2050 (1). This highlights that geriatric stroke is not only a clinical concern but also a major public health issue with substantial economic and social implications. Therefore, preventing stroke in the geriatric population, identifying risk factors at an early stage, and implementing timely and appropriate treatment strategies are of critical importance in reducing morbidity and mortality.

Stroke may lead to increased intracranial pressure (ICP), which can result in secondary brain injury in addition to primary damage and fatal outcomes through cerebral herniation (3). Hence, the measurement of intracranial pressure is crucial for both mortality and morbidity outcomes. In recent years, stroke management protocols have emphasized the "time is brain" approach, underscoring the decisive role of early intervention in determining prognosis (4). Therefore, noninvasive and rapid assessment of intracranial pressure offers a vital advantage in clinical management. While transcranial Doppler ultrasonography can be used for intracranial pressure evaluation, the measurement of optic nerve sheath diameter (ONSD) has gained increasing attention as an indirect indicator of intracranial pressure in recent years (5).

Axonal loss, glial proliferation, and reduced microvascular perfusion associated with aging form the primary mechanisms predisposing to optic nerve atrophy. Furthermore, the increased prevalence of systemic vascular diseases such as hypertension, diabetes mellitus, and atherosclerosis in elderly individuals adversely affects optic nerve perfusion and accelerates the atrophic process (6). As a result of these structural changes, the optic nerve sheath diameter may show relatively lower values in older populations. Therefore, consideration of age-related anatomical and pathological changes when assessing optic nerve sheath diameter is clinically important to avoid false-positive results (7).

Although various parameters are used to determine the indications for decompressive craniectomy, predicting treatment outcomes in patients over 65 years of age with comorbidities can help both to reduce mortality and morbidity through timely surgical intervention and to prevent complications associated with unnecessary invasive procedures. Since there are no studies in the literature examining the efficacy of optic nerve sheath diameter measurements in guiding decompressive surgical decisions in elderly individuals, this study aims to evaluate whether measuring the optic nerve sheath diameter in patients treated for cerebrovascular events can serve as an additional marker in determining the indications for decompressive surgery.

MATERIALS AND METHOD

The study was approved by the Non-Interventional Clinical Research Ethics Committee of Diyarbakır Gazi Yaşargil Training and Research Hospital

(Approval No: 527, dated 27/06/2025). The study was conducted in accordance with the principles of the Declaration of Helsinki from its design stage through to completion. This was a multicenter, observational, retrospective study.

Patients who presented with ischemic stroke between 2023 and 2025 at Diyarbakır Gazi Yaşargil Training and Research Hospital and Gaziantep Şehitkamil State Hospital were included in the study. Patients over the age of 65 were involved in the study. Patients with intracranial space-occupying lesions, hydrocephalus, orbital pathologies that could affect optic nerve sheath diameter, transient ischemic attack, or conditions such as head trauma that could cause cerebral edema or increase intracranial pressure and thus affect ONSD, and patients with other identified causes that could affect ONSD measurements were excluded from the study. Only patients with middle cerebral artery infarction were included to achieve standardization by eliminating the potential prognostic variability related to lesion location.

The variables included in the study were patients' age, sex, development of hemorrhagic infarction or performance of thrombectomy, three-dimensional measurement of the ischemic area, surgical history, lesion side, Glasgow Coma Scale (GCS), Glasgow Outcome Scale (GOS), degree of shift, and ONSD. In operated patients, postoperative ONSD was also measured.

All preoperative and postoperative computed tomography (CT) scans were performed using a 128-slice Philips (Incisive) CT scanner available at our hospital. In operated patients, postoperative ONSD measurements were obtained from brain CT images taken within the first 24 hours after surgery.

In our study as well, the ONSD measurement was performed 3 mm behind the disc, which is the most preferred location, since an increase of up to 60% occurs at a distance of 3 mm from the disc (8). The ONSD was measured manually in the section where the optic nerve and its sheath were clearly visualized, in a mediolateral oblique plane. All measurements were performed using the same window settings (WW 50, WL 250) and identical brightness and contrast levels.

All data were evaluated separately by two researchers and then included in the study. Clinical findings of the patients were added afterward to ensure a blinded study design.

Statistical Analysis

Data were analyzed using IBM SPSS V20 (Chicago, USA). In the study, descriptive statistics were presented as numbers and percentages for categorical variables, and as arithmetic mean and standard deviation for continuous variables. Pearson's Chi-square test was used to assess categorical data. The conformity of the data to a normal distribution across groups was examined using the Kolmogorov–Smirnov/Shapiro–Wilk test. The results of the analyses were expressed as mean ± standard deviation for continuous variables. ROC analysis was performed to determine the cut-off value. A p-value of less than 0.05 was considered significant.

RESULTS

A total of 97 patients who were followed up due to ischemic stroke, including both operated and non-operated patients, were included in the study. Of these, 57.7% were female and 42.3% were male. The mean age of the patients was 75.28 ± 8.46 years (range: 65–100 years). Hypertension was present in 61.9% of the patients, diabetes mellitus in 15.5%, and coronary artery disease in 41.2%. Various additional comorbidities (chronic renal failure, pneumonia, and liver disorders) were identified in 16.5% of the patients.

Occlusion was located in the right middle cerebral artery in 47.4% of patients and in the left middle cerebral artery in 52.6%. Hemorrhagic infarction was detected in 37.1% of the patients, and 40.2%

Table 1. Evaluation of outcomes based on patient data

GOS	1 (n=46)	2 (n=12)	3 (n=13)	4 (n=17)	5 (n=9)	p
Age	74,11±8,37	76,42±9,84	77,23±7,91	78,76±8,4	70,44±5,29	0,104
GCS	5,21±1,98	6,83±1,4	9,31±1,8	11,53±1,18	13,11±0,6	0,000
Volume	5222±2151	4923±1822	4068±1377	3209±1959	1978±492	0,000
Shift	8,11±6,18	4,42±3,03	3,92±3,57	2,16±4,16	0	0,000
The Mean Preop ONSD	4,4±0,83	4,27±0,79	4,33±0,79	3,8±0,68	3,73±0,66	0,035
	n=15	n=3	n=2	n=2	n=0	
The Mean Postop ONSD	4,34±0,50	3,71±1,05	4,65±0.2	2,5±3,54	0	0,111

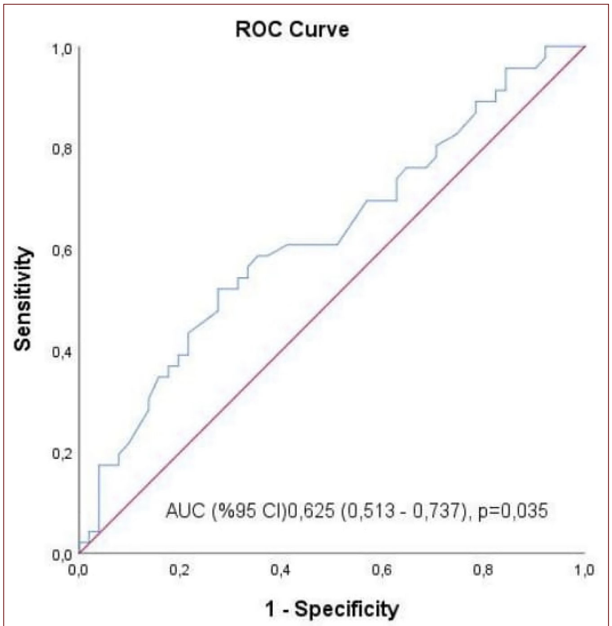

Figure 1. ROC analysis of preoperative ONSD and GOS

underwent thrombectomy. Decompressive surgery was performed in 21.6% of the cases. The mean infarct volume was measured as 4377.10 ± 2149.47 mm^2 (range: 294–11130).

The GCS scores of the patients ranged from 3 to 14, with a mean of 7.80 ± 3.38. The degree of midline shift measured on brain CT ranged from 0 to 19 mm, with a mean of 5.30 ± 5.65 mm. The GOS scores ranged from 1 to 5, with a mean of 2.28 ±1.44.

The mean preoperative ONSD was measured as 4.21 ± 0.81 mm, while in operated patients the mean postoperative ONSD was 4.11 ± 1.10 mm.

According to GOS results, a lower admission GCS, larger infarct volume, greater degree of midline shift, and higher preoperative ONSD were all associated with lower GOS scores (Table 1– GOS). However, no significant relationship was found between postoperative ONSD measurements and GOS outcomes.

Upon comparison of preoperative ONSD measurements with GOS outcomes, an ONSD value greater than 4.4 mm was found to be statistically associated with lower GOS scores (AUC [95% CI] = 0.625 [0.513–0.737], p = 0.035) (Figure 1).

When admission GCS was evaluated, it was observed that as the volume and the degree of midline shift increased, GCS decreased (p = 0.000). As GCS increased, both the admission ONSD and postoperative ONSD values decreased (p = 0.004 and p = 0.001, respectively).

Hemorrhage developed in 41.5% of male patients and 33.9% of female patients. When the occurrence of hemorrhage was evaluated in relation to comorbidities, it was found to be significantly less frequent in patients with coronary artery disease (p = 0.010). Although GOS scores were lower in patients who developed hemorrhage, this difference was not statistically significant (p = 0.525). Among patients who developed hemorrhage, both the admission and postoperative ONSD values were higher compared with those without hemorrhage; however, only the change in admission ONSD was statistically significant (p = 0.07 / 0.132).

DISCUSSION

Stroke is characterized by neurological dysfunction lasting longer than 24 hours due to non-vascular pathologies and is one of the leading causes of mortality and morbidity worldwide. Clinically, it is classified into two main types: ischemic and hemorrhagic. In the literature, approximately 65.3% of all stroke cases are reported to be ischemic, while 34.7% are hemorrhagic (1).The majority of ischemic strokes (85%) are acute in nature, and when the etiological distribution is examined, it has been reported that 51% of cases are due to middle cerebral artery occlusion, 13% to lacunar artery occlusion, 11% to vertebrobasilar system occlusion, 7% to posterior cerebral artery occlusion, and 5% to anterior cerebral artery occlusion (9). Hemorrhagic strokes most commonly (50%) occur in the basal ganglia, while 10–20% occur in the cerebral lobes, 15% in the thalamus, 10–20% in the pons and brainstem, and 10% in the cerebellum (10). Stroke leads not only to acute complications but also to significant long-term neurological, cognitive, and functional impairments. Common post-stroke sequelae include motor deficits, spasticity, aphasia, dysphagia, depression, epileptic seizures, cognitive decline, and dementia (11). Furthermore, prolonged immobilization and neurological dysfunction increase the risk of developing secondary complications such as pneumonia, deep vein thrombosis, pulmonary embolism, and infections (12). These factors contribute to higher mortality rates and markedly reduced quality of life in stroke patients.

In our study, only ischemic strokes caused by middle cerebral artery occlusion were evaluated, with occlusion detected in the right middle cerebral artery in 47.4% of patients and in the left middle cerebral artery in 52.6%.

Epidemiological data indicate that 52.6% of strokes occur in men and 47.4% in women, with the mean age at first stroke being 72.9 years for women and 68.6 years for men (13). Moreover, the risk of stroke approximately doubles after the age of 55, and the overall prevalence of stroke in populations aged 65 years and older has been reported to be 7.4% (14). In line with these findings, the fact that nearly three-quarters of all strokes occur in individuals over 65 years of age demonstrates that age is one of the most significant independent risk factors for stroke development (15).

According to data from the World Health Organization (WHO) and the World Stroke Organization (WSO), approximately 12 million new stroke cases occur annually, and around 7 million people die due to stroke each year. The WHO estimates that by 2050, the number of individuals who have experienced a stroke will exceed 1.5 billion (16). Furthermore, stroke-related mortality rates are expected to increase by 50%, while morbidity rates are projected to rise by 31% (1). Considering that 47% of strokes occur in individuals aged 70 years and older, and that 67% of stroke-related deaths occur within this age group (17), it is evident that stroke represents a major public health concern in the geriatric population, not only in terms of clinical outcomes but also due to its economic and social implications. Therefore, in this age group, stroke prevention, early identification of risk factors, and prompt implementation of appropriate treatment strategies are of critical importance.

Sex differences are also regarded as an important determinant in stroke epidemiology and clinical outcomes. Although the literature generally reports a higher incidence of stroke in men, in our study, 57.7% of the patients were female and 42.3% were male. This finding can be explained by the inclusion of only individuals aged 65 years and older and the longer life expectancy observed in women. Similarly, WHO data indicate that in older age groups, the prevalence of stroke is higher in women compared to men (17).

When stroke types were examined, it was revealed that 63.9% of cases were ischemic and 37.1% were hemorrhagic, ratios largely consistent with those reported in the literature (9). Although hemorrhagic strokes occur less frequently, they are generally associated with more severe clinical courses and higher mortality rates (18). In our study, GOS scores were lower in the hemorrhagic stroke group, though the difference was not statistically significant.

Nevertheless, the higher prevalence of hemorrhagic stroke among men was consistent with literature findings. Interestingly, a lower rate of hemorrhagic stroke was observed in patients with concomitant coronary artery disease, possibly suggesting the influence of cardiovascular protective treatments (e.g., antiplatelet or statin use).

In stroke management, decompressive craniectomy is recommended as a life-saving option, particularly in cases with high ICP, malignant cerebral edema, or hemorrhages exerting mass effect (>30–50 mm² cross-sectional area) (19). However, the effectiveness of surgery in elderly patients remains a controversial issue. The DESTINY II study demonstrated that surgery significantly reduced mortality but provided limited functional improvement in the elderly population (20). Similarly, a large-scale meta-analysis involving 1,657 patients reported that decompressive surgery reduced mortality across all age groups; however, mortality rates rose significantly after the age of 60 (21). These findings underscore that age and comorbidities are major factors influencing surgical outcomes. In our study, 61.9% of patients had hypertension, 15.5% had diabetes mellitus, 41.2% had coronary artery disease, and 16.5% had other comorbidities (chronic renal failure, pneumonia, liver disorders).

The timing of surgery is also critically important for prognosis. It has been emphasized that decompressive hemicraniectomy performed within the first 48 hours is highly effective in reducing mortality and improving functional outcomes (20). Randomized controlled trials have shown significant benefits when surgery is performed within the first 48 hours after symptom onset, whereas exceeding this period limits the effect on mortality and functional recovery (22). Thus, the "48-hour rule" underscores the urgency of surgical decision-making, especially in patients with malignant middle cerebral artery infarction. However, it has been reported that invasive ICP monitoring may increase the risk of complications in elderly or comorbid patients (23). At this point, non-invasive ONSD measurement emerges as a safe and rapid alternative.

In our study, higher admission ONSD values were found to be associated with poor clinical course and lower GOS scores. The relationship between ONSD and ICP has been validated in idiopathic intracranial hypertension, head trauma, and animal studies, with values above 4.8–5.2 mm generally considered pathological (24). Given that most literature data have been obtained from young and middle-aged populations, these threshold values may correspond to relatively lower measurements in the elderly. In the study by Avcı et al., it was reported that ONSD decreases in populations aged 65 and above (25). In our series, ONSD values above 4.4 mm were found to be significantly associated with lower GOS scores.

The observation that admission ONSD values were higher, particularly in the hemorrhagic stroke group, suggests that this measurement may be valuable in predicting prognosis and surgical need. Conversely, no significant relationship was found between postoperative ONSD changes and clinical outcomes. The lack of correlation between postoperative ONSD and GOS may be explained by the multifactorial nature of post-surgical pressure regulation. In patients with comorbidities, surgical stress and additional treatment requirements may influence GOS, suggesting that postoperative ONSD measurements have limited prognostic value.

Our study demonstrates that ONSD, particularly at the time of admission, may serve as a non-invasive, rapid, and reliable prognostic marker. The more pronounced increase in ONSD observed in hemorrhagic strokes suggests that early ONSD measurements may support surgical indication in this patient group. However, it was concluded that using postoperative ONSD alone as a risk determinant in geriatric patients is not appropriate. Given the prevalence of comorbidities and polypharmacy in the elderly population, it is evident that surgical decision-making should be approached in a multidisciplinary manner.

CONCLUSION

In our study, the relationship between ONSD and the effectiveness of decompressive surgical decisions in stroke patients aged 65 and older was evaluated. Our findings showed that preoperative ONSD values above 4.4 mm were significantly associated with lower GOS scores. This result suggests that ONSD may serve as a non-invasive, rapid, and reliable indicator to guide early surgical decision-making.

Although increased ONSD values at admission may indicate that early decompression, before clinical deterioration and infarct expansion, could be associated with better GOS outcomes, multidisciplinary assessment should not be neglected due to comorbidities.

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