



## Prognostic value of optic nerve sheath thickness in patients with central and peripheral vertigo

Tamer Colak · Kaan Celik

Department of Emergency Medicine, Bolu Abant Izzet Baysal University, Faculty of Medicine, Bolu, Turkey

### ABSTRACT

**Aim:** To evaluate the role of the diameter of the optic nerve sheath (ONSD) in the differential diagnosis of the central and peripheral vertigo in patients, who had applied with the complaints of vertigo.

**Method:** Our study had a prospective design and 113 vertigo patients were included in the study. The demographic characteristics, vital signs, symptoms accompanying vertigo and findings of the imaging examinations were evaluated.

**Results:** The median age of our patients was 43 years (IQR: 17) and 44.2 % of them were males. 19.5 % of the patients were diagnosed with central and 80.5 % with peripheral vertigo. In our study, the median ONSD was 4.88 mm (IQR=0.86) in patients with central vertigo and 4.65 mm (IQR=0.20) in patients with peripheral vertigo. The median value of ONSD in patients with central vertigo was significantly higher ( $p=0.030$ ). In our study, the area under the curve was 0.654 (95 % CI=0.498-0.810) and the sensitivity and specificity for the cut-off value of 4.65 mm were 68.2 % and 61.5 % respectively.

**Conclusion:** We determined that ONSD was larger in patients with central vertigo. Further studies with larger subject size are needed on this topic.

**Keywords:** Central vertigo, peripheral vertigo, emergency, optic nerve sheath thickness.

© 2020 [experimentalbiomedicalresearch.com](http://www.experimentalbiomedicalresearch.com)

✉ Dr. Tamer Colak

Department of Emergency Medicine, Bolu Abant Izzet Baysal University, Faculty of Medicine, Bolu, Turkey

E-mail: [drtamercolak@gmail.com](mailto:drtamercolak@gmail.com)

Received: 2020-04-01 / Revisions: 2020-05-20

Accepted: 2020-05-30 / Publication Date: 2020-10-01

### Introduction

Vertigo is in the top 10 among the admissions to the emergency units. Vertigo is a dizzying sensation of being in tilting or spinning surroundings. The rate of the lifetime and yearly prevalence of vertigo are 7.4 % and 4.9 % respectively [1].

40-60 % of all vertigo cases are caused by the peripheral vestibular dysfunction, 10-20 % by the central causes, 1-2 % by the medication, and 15 % by the psychiatric disorders. 10 % of the cases are caused by unknown pathological conditions [2,3].

It was determined that one-third of the patients, who were discharged from the emergency units with the diagnosis of peripheral vertigo, had posterior ischemia. The rate of the morbidity and mortality increase in patients with the wrong diagnosis due to the lack of an appropriate treatment [4]. It has been

demonstrated that the brain perfusion is impaired and the intracranial pressure is increased in several cerebrovascular disorders, which may cause vertigo [4].

Hayreh had shown in 1978 that the optic nerve sheath diameter (ONSD) was dilated in patients with increased intracranial pressure (ICP). Following this study, the physicians started to focus on the determination of the ICP with non-invasive methods [5]. In the recent studies, the importance of ONSD in the diagnosis of ICP was evaluated in the disorders (e.g. cranial trauma, stroke, intracranial mass lesion, infection etc.) accompanied by the increased ICP and encouraging results were obtained [6-9]. There are no publications in the literature regarding the ONSD in the differential diagnosis of the central and peripheral vertigo. In our study, our objective was to evaluate the role of ONSD in the differential diagnosis of central and peripheral vertigo in patients, who applied with the complaint of vertigo.

### Materials and Methods

Following the approval of the Ethics Committee of the Medical Faculty at Bolu Abant Izzet Baysal University (Date: 08/02/2018; Decision number: 2018/13), 113 volunteered patients, who had applied to our emergency clinic between 01.02.2018-31.07.2018 and had isolated vertigo, were investigated in a prospective design. All procedures performed in studies involving human participants were in accordance with the ethical standards of the Institutional Research Ethics Committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent was obtained from all participants prior to being included in the study. We established a standardized form for data collection. The demographic characteristics

(age, gender), vital signs (systolic and diastolic blood pressure and heart rate at admission) and symptoms of the patients, who were enrolled into the study, were recorded. In the patients with central vertigo, cranial tomography (CT) was performed and we also examined the images of the diffusion magnetic resonance imaging (DW-MRI) if we did not observe any pathological finding in CT. In our study, exclusion criteria are shown in Table 1.

**Table 1.** Exclusion criteria.

1	Not give his/her informed consent
2	Not want to share medical information due to any reason
3	Previous cerebrovascular event (CVE) or trans-ischemic attack (TIA)
4	Below the age of 18 years
5	Hypertensive encephalopathy
6	Vascular dementia
7	Liver insufficiency
8	Chronic kidney failure
9	Pregnant or breastfeeding
10	Trauma
11	Optic nerve trauma
12	Optic neuritis
13	Optic nerve arachnoid cyst and mass lesion in the orbita/cavernous sinus

A trained emergency medicine specialist carried out 7.5 MHz linear probe measurement, after the application of a thin layer of a gel on both eyes of the patients, who were in the supine position. The diameter of the optic nerve sheath was evaluated with transverse and sagittal measurements at the 3 mm beyond the posterior of the eye globe. The mean value of the ONSD was calculated as the mean value of the transverse and sagittal ONSD measurements. All images were confirmed by a blinded emergency medicine specialist and the groups were compared.

**Table 2.** The comparison of demographic characteristics of patients and the control group.

Parameters		Central (n=22)	Peripheral (n=91)	<i>p</i>
Age (year), Median (IQR)		60.5 (35)	43 (15)	0.001*
Gender, n (%)	Male	11 (50)	39 (42.9)	0.545**
	Female	11 (50)	52 (57.1)	
Duration (hours), Median (IQR)		16 (19)	4 (6)	<0.001*
Vertigo attack in the medical history, n (%)		3 (13.6)	19 (20.6)	0.559***
Symptoms, n (%)	Headache	8 (36.4)	14 (15.4)	0.036***
	Sudden Onset	11 (50.0)	77 (84.6)	0.001***
	Nausea/vomiting	13 (59.1)	62 (68.1)	0.421**
	Hearing impairment	4 (18.2)	30 (33.0)	0.175**
	The feeling of fullness in the ear	0	25 (27.5)	0.003**
	Tinnitus	2 (9.1)	38 (41.8)	0.004**
	Balance disorder	10 (45.5)	21 (23.1)	0.035**
Nystagmus, n (%)	None	7 (31.8)	41 (45.1)	<0.001*
	Horizontal	6 (27.3)	50 (54.9)	
	Vertical/rotatory	9 (40.9)		
Imaging, n (%)	Restriction in D-MRI	8 (36.4)		
	Cerebellar infarction in CT	5 (22.7)		
	Lacunar infarction in CT	2 (9.1)		
	Bleeding in CT	1 (4.5)		
	No special finding in CT and MRI	6 (27.3)		
Vital Signs, Median (IQR)	Systolic blood pressure (mmHg)	134.5 (19)	133 (38)	0.488*
	Diastolic blood pressure (mmHg)	81 (12)	81 (16)	0.881*
	Pulse (beats/min)	82.5 (17)	75 (22)	0.189*
Comorbidity, n (%)	Comorbidity	13 (59.1)	33 (36.3)	0.050**
	Hypertension	6 (27.3)	17 (18.7)	0.384***
	Diabetes mellitus	3 (13.6)	14 (15.4)	0.837***
	Previous CerebroVascularAccident	3 (13.6)	8 (8.8)	0.491**
	Other	4 (18.2)	4 (4.4)	0.045***

\* Mann-Whitney U, \*\* Pearson's Chi-square test, \*\*\* Fisher's Exact test, n: number of patients, CT: cranial tomography, MRI: magnetic resonance imaging, D-MRI: diffusion magnetic resonance imaging.

### Statistical analysis

The data were uploaded to a computer and analyzed with SPSS (Statistical Package for Social Sciences) Windows v22.0 software package. The descriptive statistics were expressed in numbers (n) and in percentages. The distribution of the continuous data was analyzed with the Kolmogorov-Smirnov test. Median and interquartile range (IQR) were used for the evaluation of the quantitative data. Mann-Whitney U test was used for the comparison of the continuous data and Chi-square test and Fisher's Exact test were used for the comparison of the categorical data. ROC curves were drawn in order to test the role of ONSD in the differential diagnosis of central and peripheral vertigo. The sensitivity and specificity were calculated for central vertigo. The results were evaluated in a confidence interval of 95 % and at a significance level of  $p < 0.05$ .

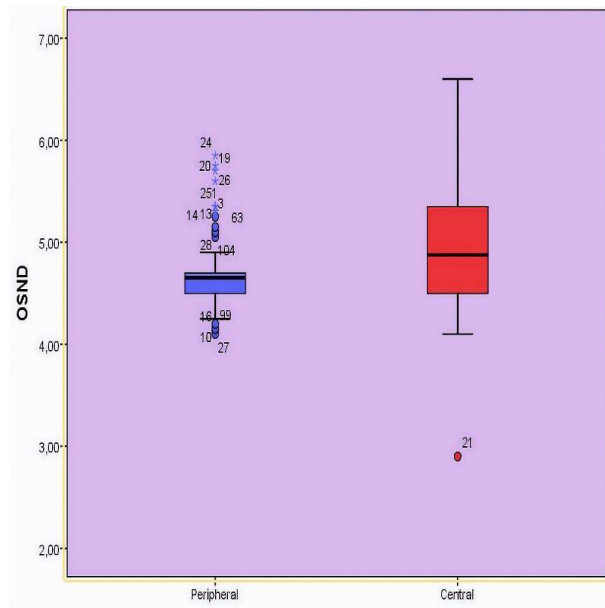
### Results

The median age of our patients was 43 years (IQR: 17) and 44.2 % of them were males. 22 patients (19.5%) had central and 91 patients (80.5%) peripheral vertigo. The mean age of the patients with central vertigo was higher and the duration of vertigo was longer compared to the patients with peripheral vertigo ( $p < 0.05$ ).

The frequency of vertigo attacks was comparable between the genders and the groups ( $p > 0.05$ ). Although headache and balance problems were more common in the central vertigo group, sudden onset, feeling of fullness in the ear and tinnitus were the prominent characteristics of peripheral vertigo ( $p < 0.05$ ). 57.5% of the patients had nystagmus and vertical/rotatory nystagmus was significantly more common in the central vertigo group ( $p < 0.05$ ). Regarding the imaging examination of the central vertigo patients, the restriction

was most commonly encountered in the D-MRI examination (36.4 %). There was no difference between the groups in terms of vital parameters and comorbidity ( $p > 0.05$ ) (Table 2).

In our study, the median ONSD was 4.88 mm (IQR=0.86) in patients with central vertigo and 4.65 mm (IQR=0.20) in patients with peripheral vertigo. The median of ONSD in patients with central vertigo was significantly higher ( $p = 0.030$ ) (Figure 1).

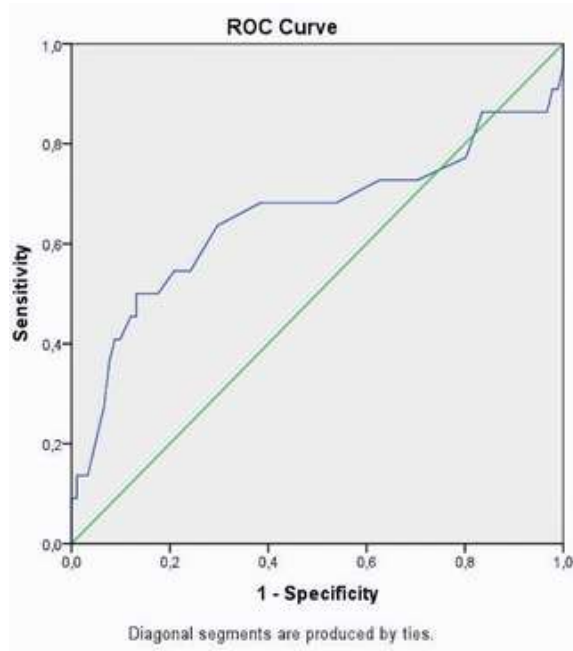


**Figure 1.** The comparison of the groups for ONSD.

ROC curves were drawn in order to test the role of ONSD in the differential diagnosis of central and peripheral vertigo. The area under the curve was 0.654 (95 % CI=0.498-0.810) and the sensitivity and specificity for the cut-off value of 4.65 mm were 68.2 % and 61.5 % respectively (Figure 2).

### Discussion

We found no study in the literature focused on the ONSD measurements for the differential diagnosis of the central and peripheral vertigo. Nevertheless, it has been demonstrated that ONSD was increased in strokes and traumatic



**Figure 2.** Diagnostic ROC for ONSD.

hemorrhages [6, 10-12]. The impairment of the cerebral blood perfusion due to the hypoxia, bleeding and edema and the increase of ICP due to the impairment in the CSF circulation may lead to the dilatation of ONSD [13,14]. In our study, the ONSD was significantly larger in the patients with central vertigo. We believe that this finding depended on the increase of ICP due to the emergence of edema and the deterioration of the CSF circulation.

Batur reported in his thesis study that the sensitivity and specificity of the US in ICP was 95.7 % and 100 % respectively [15]. In patients with ischemia, the sensitivity and specificity were 76-80 % and 84-86 % respectively [6,16]. In the patients with intracranial bleeding, the sensitivity and specificity were 74-100 % and 72.7-100 % respectively [17,18]. In our study, regarding central vertigo, for a cut-off value of 4.65 mm, the sensitivity and specificity were 68.2 % and 61.5 % respectively. The specificity and sensitivity levels were lower than the previous studies and it might be related that the present disorders like ischemia/bleeding did not

severely affect the CSF circulation. In addition, certain disorders, which did not increase ICP (vestibular migraine, multiple sclerosis, epileptic migraine etc.) but cause central vertigo, might decrease the sensitivity. The misdiagnosis of some central vertigo as peripheral vertigo might be the most important reason for the low level of the specificity.

The optic nerve is considered as an extension of the brain tissue, as it originates directly from the brain tissue, is protected by the same sheaths (dura mater, arachnoid and pia mater) as the brain and has Schwann's sheath in its structure [19]. ICP, which is common in the intracranial events, increases the mortality and morbidity in addition to the secondary injuries [17,20]. Xue et al. suggested that 17 % of all vertigo cases depended on central causes [3]. However, Hain and Yacovino stated that the rate of the central vertigo is below 5 % [21]. Branch and Barton reported that the rate of central vertigo was 10 % and added that the rate of central vertigo might increase up to 20 % with aging [2]. In our study, the rate of central vertigo was 19.5 %, which was higher than the reported rates in the literature. The relatively older patient population of our study may be the main reason for this result.

Tinetti et al. [22] and Lin et al. [23] reported that the rate of dizziness might be increased up to 38 % in the elderly patients. Gönüllü and Aygün reported in their study that vertigo was more common in women and central vertigo was more common in elderly patients [24]. They stated that this might be a result of the impairment of the nerve structures, of the increase in depression, and cardiovascular disease rates and of the side effects of the medication. It has also been reported that elderly patients are more likely to apply with central vertigo [2]. In our study, we determined that central vertigo was more common in older

male patients. This finding might be related to the comorbidities, which were increased with aging; to the impaired metabolism and to the decline of the ischemic events in women due to the estrogen. We also believe that the previous strokes have a special place in the etiology of central vertigo.

Nystagmus depends on the continuous stimuli to the optic nerve, which emerge to preserve the accommodation with the help of the chemical and electrical mediators, which were released in the brain as a response to the new condition caused by the dizziness [18]. Studies have demonstrated that sudden onset, horizontal nystagmus and hearing symptoms are prominent in peripheral vertigo and slow onset, vertical/rotatory nystagmus, headache and balance disorders are at the forefront in central vertigo [25,26]. In our study, we determined that slow onset, headache, balance problems and vertical/rotatory nystagmus were more common in the patients with central vertigo and sudden onset, feeling of fullness in the ear, and tinnitus and horizontal nystagmus were more common in patients with peripheral vertigo. We believe that in central vertigo, central events (cerebellar infarction, vestibular migraine, intracranial hemorrhage etc.) cause headache and balance problems due to the emergence of the irritation and the impact on the balance system. On the other hand, symptoms related to the ear are more common in peripheral vertigo, as it is mainly caused by the vestibular dysfunction. It may be suggested that the symptoms progress slowly depending on the penumbra, which enlarges with time in the ischemic events.

Xue et al. investigated 2481 patients with central vertigo and reported that central vertigo emerged due to the cerebrovascular disorders (59 %), vestibular migraine (21.6 %), vestibular paroxysmia (13.5 %), degenerative disorders (3

%), sensorineural hearing loss (2 %) and multiple sclerosis/optic neuromyelitis (0.9 %) [3]. Riberio et al. stated that besides ischemia and bleeding, central vertigo was also caused by certain conditions like tumors, infections and anatomical disorders [27]. In our study, the most common finding was infarction and we did not observe any pathological finding in 27.3 % of the patients. We believe that the most common cause of the central vertigo is ischemia, which was also a finding in our study. In addition, we also believe that 27.3 % of the patients remained undiagnosed, as some ischemia and small bleeding areas could not be detected with the imaging methods and other imaging methods were needed for certain diagnosis except CT and DW-MRI.

Berkiten et al. reported in their study that high blood pressure might provoke vertigo [25]. In some studies, it was demonstrated that in certain comorbidities, in which stroke was common, the rate of the stroke-related vertigo was increased [13,14,28]. It is also known that some drugs trigger vertigo [2,3]. In our study, we did not detect any correlation between the comorbidities and the vital parameters. We believe that this finding depended on the fact that the factors related to the comorbidities were found in both central and peripheral vertigo. We also believe that it was increased due to itself in central vertigo and due to the elevated stress in peripheral vertigo and therefore there was no difference between the groups.

The most important limitation of our study is a single center study, and it was carried out on a small population. Our results must be supported by multi-center studies.

### **Conclusion**

We conclude that the ONSD measurement may be used to support the differential diagnosis of the central and peripheral vertigo. Further

studies with larger subject size are needed on this topic.

**Funding:** *There is no financial support and sponsorship*

**Conflict of Interest:** *The authors declare that they have no conflict of interest.*

**Ethical statement:** *The study was conducted in accordance with the ethical approval of the University Ethics Committee (Date: 08/02/2018; Decision number: 2018/13).*

### **ORCID iD of the author(s)**

Tamer Colak / 0000-0003-3844-4785

Kaan Celik / 0000-0002-9664-6732

### **References**

- [1] Bayır A. Vertigolu Hastaya Acil Yaklaşım. *Türkiye Klinikleri Journal of Emergency Medicine-Special Topics*. 2017; 3(3):238-43.
- [2] Kroenke K, Lucas CA, Rosenberg ML, et al. Causes of persistent dizziness. A prospective study of 100 patients in ambulatory care. *Ann Intern Med*. 1992;117(11):898-904.
- [3] Xue H, Chong Y, Jiang ZD, et al. Etiological analysis on patients with vertigo or dizziness. *Zhonghua yi xue za zhi*. 2018; 98(16):1227-230.
- [4] Newman-Toker DE, Curthoys IS, Halmagyi GM. Diagnosing Stroke in Acute Vertigo: The HINTS Family of Eye Movement Tests and the Future of the "Eye ECG". *Semin Neurol*. 2015;35(5):506-21.
- [5] Hayreh SS. Fluids in the anterior part of the optic nerve in health and disease. *Surv Ophthalmol*. 1978; 23(1):1-25.
- [6] Komut E, Kozaci N, Sonmez BM, et al. Bedside sonographic measurement of optic nerve sheath diameter as a predictor of intracranial pressure in ED. *The Am J Emerg Med*. 2016; 34(6):963-67.
- [7] Frumin E, Schlang J, Wiechmann W, et al. Prospective analysis of single operator sonographic optic nerve sheath diameter measurement for diagnosis of elevated intracranial pressure. *The West J Emerg Med*. 2014; 15(2):217-20.
- [8] Amini A, Kariman H, Dolatabadi AA, et al. Use of the sonographic diameter of optic nerve sheath to estimate intracranial pressure. *The Am J Emerg Med*. 2013; 31(1):236-39.
- [9] Şafak KY, Türkoğlu Ö, Şencan BD, et al. Optic nerve sheath diameter: comparison between ultrasonography and magnetic resonance imaging. *Okmeydanı Tıp Derg*. 2015; 31(2):71-74.
- [10] Školoudík D, Herzig R, Fadrná T, et al. Distal enlargement of the optic nerve sheath in the hyperacute stage of intracerebral haemorrhage. *Br J Ophthalmol*. 2011; 95(2):217-21.
- [11] Hansen HC, Lagreze W, Krueger O, et al. Dependence of the optic nerve sheath diameter on acutely applied subarachnoidal pressure - an experimental ultrasound study. *Acta Ophthalmol*. 2011; 89(6):528-32.
- [12] Soliman I, Johnson G, Gillman LM, et al. New Optic Nerve Sonography Quality Criteria in the Diagnostic Evaluation of Traumatic Brain Injury. *Crit Care Res Pract*. 2018; 2018:3589762.
- [13] Andersen KK, Olsen TS, Dehlendorff C, et al. Hemorrhagic and ischemic strokes compared: stroke severity, mortality, and risk factors. *Stroke*. 2009; 40(6):2068-72.
- [14] O'Donnell MJ, Xavier D, Liu L, et al. Risk factors for ischaemic and intracerebral haemorrhagic stroke in 22 countries (the interstroke study): a case-control study. *The Lancet*. 2010; 376(9735):112-23.
- [15] Batur A. The diagnostic value of optic nerve sheath diameter measurements by

- ultrasonography in elevated intracranial pressure in stroke patients. (MedicineThesis). Ankara 2015. <http://hdl.handle.net/11655/3503>
- [16] Gokcen E, Caltekin I, Savrun A, et al. Alterations in optic nerve sheath diameter according to cerebrovascular disease subgroups. *The Am J Emerg Med.* 2017; 35(11):1607-11.
- [17] Soldatos T, Karakitsos D, Chatzimichail K, et al. Optic nerve sonography in the diagnostic evaluation of adult brain injury. *Crit Care.* 2008; 12(3):R67.
- [18] Sahoo SS, Agrawal D. Correlation of optic nerve sheath diameter with intracranial pressure monitoring in patients with severe traumatic brain injury. *The Ind J Neurot.* 2013; 10(1):9-12.
- [19] Güngör K, Bekir NA. Optik atrofi. *Gaziantep Tıp Derg.* 1999; 1(2):42-45.
- [20] Shirodkar CG, Munta K, Rao SM, et al. Correlation of measurement of optic nerve sheath diameter using ultrasound with magnetic resonance imaging. *Ind J Cri Care Med.* 2015; 19(8):466-70.
- [21] Hain TC, Yacovino D. Pharmacologic treatment of persons with dizziness. *Neuro Clin.* 2005; 23(3):831-53.
- [22] Tinetti ME, Williams CS, Gill TM. Dizziness among older adults: a possible geriatric syndrome. *Ann Int Med.* 2000; 132(5):337-44.
- [23] Lin HW, Bhattacharyya N. Balance disorders in the elderly: epidemiology and functional impact. *The Laryngoscope.* 2012; 122(8):1858-61.
- [24] Gönüllü H, Aygün D. Differential diagnosis of vertigo in the emergency department. *J Exp Cli Med.* 2012; 29(4):290-94.
- [25] Berkiten G, Tolgar L, Uyar Y. Vertigolu Hastaya Yaklaşım. *Klinik Gelişim.* 2012; 25(2) :73-77.
- [26] Baloh RW. Differentiating between peripheral and central causes of vertigo. *Otolaryngol H Neck Surg.* 1998; 119(1):55-59.
- [27] Ribeiro BNF, Correia RS, Antunes LO, et al. The diagnostic challenge of dizziness: computed tomography and magnetic resonance imaging findings. *Rad Brasil.* 2017; 50(5):328-34.
- [28] Jeng J-S, Huang S-J, Tang S-C, et al. Predictors of survival and functional outcome in acute stroke patients admitted to the stroke intensive care unit. *J Neuroscience.* 2008; 270(1-2):60-66.