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Effect of scuba-diving on optic nerve and sheath diameters

Masoud Mehrpour[1], Narges Sadat Shams-Hosseini[2], Saeed Rezaali[3]

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Abstract

Background: There is not any data available about the effect of high bar pressure condition on intracranial pressure. In this study, the effect of diving on the optic nerve and sheath diameters as non-invasive markers of intracranial pressure has been investigated.

Methods: Twenty professional male divers from twenty one volunteers were chosen for this cross-sectional study. Only one person who had a history of barotraumas was excluded. Each diver then completed a questionnaire on demographic data, medical and diving history. Nineteen other volunteers were selected to represent a control group. A 10-MHz linear ultrasonic probe was used to measure the optic nerve sheath diameters of both eyes in closed and supine position and its relationship with diving history of divers was determined.

Results: It was found that divers have a higher mean optic nerve sheath diameter compared to the normal population as previously reported by other studies. The mean diameter of the left and right optic nerve sheaths were 6.4±0.7, 6.5±0.9 mm respectively and a significant relationship between optic nerve sheath diameter and diving history was found.

Conclusion: Results showed that divers have a higher optic nerve diameter than the general population. However, our result cannot yet be considered as a marker of intracranial pressure in divers as it was conducted on an limited number of subjects and so a bigger study should be undertaken for this purpose.

Keyword: Optic nerve, Ultrasound, Diving, Pressure.

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Introduction

The underwater environment produces some pathophysiological problems due to the fast changing of its bounded pressure which may cause various illnesses that might be difficult to detect and treat.

Our nervous system is an organ which is very sensitive to underwater pressure changes, and a damaged nervous system can lead to hazardous disorders. One of the most important disorders caused by hyperbaric environment is cerebral ischemic event. Hyperbaric condition can be considered as a risk factor for cerebral ischemic events and strokes in divers (1-4). The trembling of hands, postural instability, gastrointestinal problems, somnolence and cognitive dysfunction are some of the diving related disorders developed by a hyperbaric condition called High Pressure Neurological Syndrome (HPNS) (5).

Clinical symptoms of nitrogen narcosis are similar to alcohol intoxication which leads to a temporary dysfunction of neuromuscular and intellectual activity and the disturbance of behavior and personality. This condition generally occurs in depths of deeper than 30 meters (100 ft). Nitrogen narcosis leads to hallucinations, unconsciousness and even death at a depth of 90 to 100 meters (5).

Zeba et al showed that the cases of diving CNS barotraumas are rare but its symptoms are diverse and include dysesthesias, com-

1. MD, MPH, Associate Professor (Neurologist), Department of Neurology, Iran University of Medical Sciences, Tehran, Iran. m-mehrpour@tums.ac.ir
2. (**Corresponding author**) MD, Occupational medicine resident, Department of Occupational and Environmental Medicine, Center Research of Occupational Disease, Firoozgar Clinical Research Developmental Center, Tehran University of Medical Sciences, Tehran, Iran. shams1361@yahoo.com
3. General practitioner (MD), Islamic Azad University, Tehran Medical Branch, Tehran, Iran. saeedrezaali@yahoo.com

plete quadriplegia and encephalopathy (6).

Moreover, long term diving may cause various problems, the most common of them being the lack of concentration and numbness of hands and feet (7). Although there is much evidence emphasizing neurological effect of barotraumas in divers, there is not any data about the effect of high pressure condition on intracranial pressure. In some studies ultrasound (US) has been called as a noninvasive technique to detect increased intracranial pressure (ICP) (8) in conditions such as hydrocephalus (9, 10) and trauma (11, 12). However, in this study we investigated the effect of long term diving practice upon optic nerve and sheath diameters as a non-invasive indicator of intracranial pressure changes in professional divers.

Methods

Population Study

This cross sectional study was performed from June 2012 to October 2012. An informed consent was taken from all of the participants, and the study was approved by the Tehran University Medical Sciences' (TUMS) Ethics Committee.

The study group consisted of 21 professional male scuba divers between 26 and 66 years of age having totally 42 eyes, and the control group consisted of 19 non-diving healthy male patients having 38 eyes. However, one of the divers who had history of barotraumas was excluded.

All of the participants had at least 2 years of scuba diving history without any previous history of eye disease or abnormal vision, head trauma or brain disorders. All divers had normal visual acuity and visual fields. The diving depths were about 25 to 50 meters which was varied for different individuals.

Control group subjects were selected from healthy individuals with the following criteria: 1) Not having any history of diving, working or living in very low or high atmospheric pressure conditions, 2) Not having any history of eye or brain injuries or diseases, 3) not having any history of blurred vision, eye pain, and low visual acuity.

All divers and the control group cases completed a questionnaire including demographic data, medical and diving history.

Sonographic examinations were conducted using a 10-MHz linear ultrasonic probe. All patients were examined in the supine position.

Statistical analysis

Descriptive analysis of quantitative and qualitative variables were performed and presented in a table. Possible association between ONSD and scuba diving was examined by Mann-Whitney U-test. Then, the relationship between qualitative data such as education and marriage, and quantitative data such as age and experience was determined using chi2 test and spearman correlation test, and after this, comparison of ONSD and diving experience was made by linear regression model.

Results

Average age of the divers was 43 years. Only one of them was a smoker. Their average experience was 27 years (ranging from 2 to 39 years). All of them dived in 50 meter depths frequently. All worked 14 days per month. Most of them worked far from their place of residence, (13; 86.6%). Four divers suffered from hypertension. More details about demographic factors of participants are given in Table 1. In the control group, no hypertension was found.

The mean diameter of the two optic nerve sheaths was observed to be higher than 5.7 mm in thirty five divers. The mean of the left optic nerve and sheath diameters was significantly higher than the right ones in the diver group ($p=0.001$,). No difference was found between right and left ONSD in the control group ($p>0.05$); but age of divers had influence on the right ONSD ($p=0.01$; $r=0.6$).

Thus a significant difference was witnessed in the optic nerve diameters of diver group and control group ($p= 0.01$, $p=0.05$). (Table1).

Table1. The mean and quartiles of both optic nerve and sheath diameters and their comparison between diver group and control group.

Variables	Diver group	Control group	p
Age(year) (Mean ± SD)	42.45 ± 10.64	45.20± 13.02	0.62
Experience of diving (year)(Median)	27	-	
BMI (Kg/m^2) (Mean ±SD)	27.24± 3.17	25.24± 4.72	0.30
Education			0.30
Lower than diploma	6 (30%)	11(50%)	
Diploma	9 (45%)	9(45%)	
Higher than diploma	5(25%)	1(5%)	
Marital status			0.50
Married	17(85.0%)	16(80%)	
Smoking			0.10
Yes	0(0%)	3(15.8%)	
Place of residence			0.48
Tehran	15(75%)	18(90%)	
Right optic nerve sheath diameter (mm) Mean (SD)	6.42 (0.87)	4.87(0.57)	0.0001
Right optic nerve diameter (mm) Mean (SD)	3.50(0.66)	3.00(0.37)	0.01
Left optic nerve sheath diameter (mm) Mean (SD)	6.52(0.63)	4.95(0.52)	0.0001
Left optic nerve diameter (mm) Mean (SD)	3.45(0.55)	3.12(0.40)	0.05

Mean diameter of left and right optic nerve sheaths in diver group was

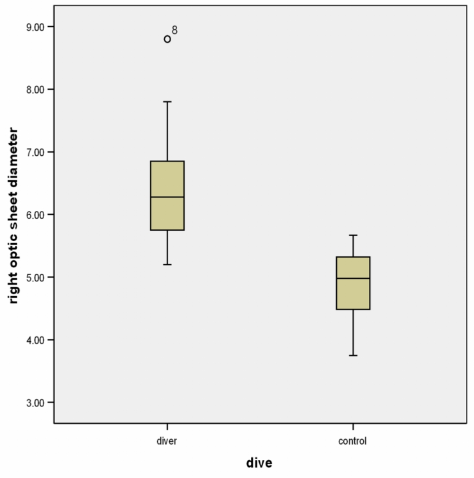

Fig.1. Comparison of right optic nerve sheath diameters of the diver and control group.

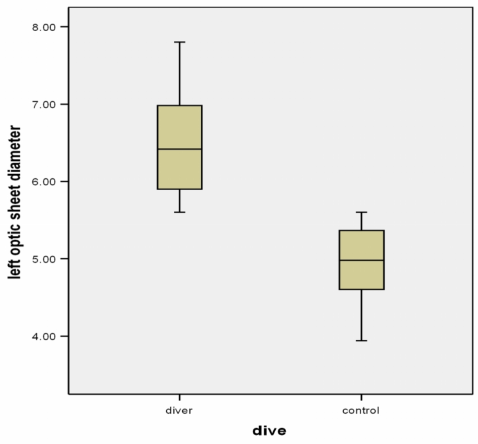

Fig. 2. Comparison of left optic nerve sheath diameters of diver and control group.

6.42±0.87, 6.52±0.63 respectively. It was significantly higher than the mean of the left and right optic nerve sheaths in control group which was 4.87 ±0.57 and 4.95± 0.59, respectively (p=0.001, p= 0.001).(see in Figs. 1 &2)

No relationship was found between optic nerve sheath and optic nerve diameters and BMI, but a significant relationship was noticed between both optic nerve sheath diameter and the diving, after age adjustment which is shown in Table 2.

Discussion

Effect of hyperbaric condition on brain and nervous systems was already known to some extent. However, the result of this study gives evidence that divers have a higher ONSD than that of the general population reported by related studies (13-17).

The ultrasound-based evaluation of the optic nerve sheath diameter is a highly suggestive method for the determination of increasing intracranial pressure especially in a critical situations. Sensitivity and specificity of this method is estimated to be higher than 90%, whereas, that of Tayal et al study was reported to be only 63% (11)

Our research has also assessed the effect of atmosphere on ONSD. ONSD might be considered as a predictor of intracranial pressure increase (13). ONSD increase was

Table 2. Relationship between, optic nerve and sheath diameters and diving, before and after age adjustment

	Before age adjustment				After age adjustment					
	Diving group		R^2	P	Age		Diving group		R^2	P
	B	P			B	P				
Right optic nerve sheath diameter (mm)	1.52	0.0001	0.51	0.0001	0.01	0.06	1.57	0.0001	0.55	0.0001
Right optic nerve diameter (mm)	0.44	0.01	0.12	0.01	-0.006	0.42	0.42	0.02	0.11	0.04
Left optic nerve sheath diameter (mm)	1.55	0.0001	0.65	0.0001	1.58	0.0001	0.01	0.11	0.66	0.0001
Left optic nerve diameter (mm)	0.30	0.05	0.07	0.05	-0.002	0.77	0.30	0.05	0.05	0.14

seen at high altitudes, and so it is assumed that ONSD increase may be associated with severe symptoms of acute mountain syndrome (AMS) and may be related to intracranial pressure(18). However, this claim could not be proved in a separate study undertaken for this purpose. It was shown that the development or amelioration of mild high altitude headache (HAH) has no association with intracranial pressure (19). Therefore, there is a controversy over the claim that atmospheric pressure variations have affect on the optic nerve sheath diameter.

In comparison to the normal range of OSND of normal population which is estimated to be below 5.7 mm (11, 16, 20), our study showed a higher OSND in divers.

Little research has been done on the effect of bar pressure or barotraumas on optic nerve; and peripheral neuropathy after decompression sickness is a rare event. The mechanism of injury is assumed to be a manifestation of decompression illness with a gas bubble causing blood flow obstruction and an ischemic infarct (21). In one case-report, sixth nerve palsy and sensory loss and ataxia was reported after decompression sickness (22). High effect of age on ONSD was not shown in other studies.

Thus the two possible mechanisms are: 1) High pressure conditions may cause temporary increase of intracranial pressure, and then increase of ONSD; 2) A blood flow obstruction or/and the effect of bar pressure on the performance of some enzymatic systems such as carbonic anhydrides enzyme, which may cause ONSD increase.

Even though no study investigated the effect of age on ONSD, a relationship was noticed between diving history and the optic nerve diameter even after making adjustments for age in our study.

According to previous studies, increase of ONSD is an indicator of severe increase of intracranial pressure and so in emergency cases it can be used for diagnosis in place of invasive methods. Hence, on the basis of the results of this study, the effects of bar pressure on ONSD increase can be used for the diagnosis of intracranial pressure increase.

This study had some limitations too, such as intracranial pressure could not be measured by invasive method in healthy individuals, because invasive evaluation of normal population is unethical. Another limitation was the low number of participants, as only a few divers had agreed to participate in this study.

There was also one advantage by this study which is the origin of a new idea. However, more investigations are suggested for considering optic nerve and sheath diameters increase as a sure marker of intracranial pressure increase, especially in divers.

Conclusion

In this study, we showed divers have a higher optic nerve diameter than that of the general population reported by other studies. Although high optic nerve sheath diameter was previously seen in emergency situation caused by high intracranial pressure, we found that optic nerve sheath in normal divers is higher than the normal control group. Mechanism of this finding is unknown yet. However, our result cannot yet be considered as a marker of intracranial pressure in divers as it was conducted on an insufficient number of subjects and so a bigger study should be undertaken for this purpose.

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