Choroidal thickness variation in highly myopic eyes during the water drinking test

Variação da espessura de coroide em olhos alto míopes durante o teste de sobrecarga hídrica

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ABSTRACT

Purpose: To evaluate variations in choroidal thickness (CT) during the water drinking test (WDT) in emmetropic eyes (EE) and highly myopic eyes (ME) using spectral-domain optical coherence tomography (SD-OCT).

Methods: Clinical trial performed at a tertiary care hospital comprising 30 randomly selected eyes. The WDT and SD-OCT macular scans were performed 10 and 45 min after water ingestion in 15 myopic and 15 EE of 15 healthy patients in each group. Primary study outcomes were average macular CT measured by SD-OCT and intraocular pressure (IOP) during the WDT.

Results: The mean spherical equivalent refraction was 0.15 ± 0.24 D in emmetropic and -7.1 ± 1.75 D in ME (p=0.001). No statistical differences between EE and ME were observed during the WDT response. EE had higher CT compared with ME at the fovea (361.4 ± 55.4 vs 257.9 ± 95.3; p=0.001), 3 mm nasal to the fovea (158.0 ± 71.8 vs 122.5 ± 54.5; p=0.047), and 3 mm temporally to the fovea (310.6 ± 52.4 vs 247.6 ± 90.1; p=0.05). Regarding CT variation, significant differences in foveal CT at 10 min after water ingestion were observed in both EE and ME, with no statistically significant difference observed between groups. A moderate correlation between IOP peak during the WDT and CT was demonstrated in ME (r=0.52; p=0.04).

Conclusions: No statistically significant differences in CT variation during the WDT were observed between EE and ME, indicating similar behavior of the choroidal bed during the WDT in both groups. Further, CT was thinner in highly ME, with CT variation unable to explain elevations in IOP observed during the WDT.

Keywords: Myopia; Choroid; Tomography; Optical coherence; Axial length; Eye; intraocular pressure; Water; drinking; Osmosis

RESUMO

Objetivo: Avaliar a espessura de coroide (EC) e sua variação durante o teste de sobrecarga hídrica (TSH) em olhos emétropes (EE) e míopes (ME) utilizando a tomografia de coerência óptica Spectral-Domain (SD-OCT).

Métodos: Estudo clínico realizado em um hospital terciário. 30 olhos selecionados aleatoriamente, 15 míopes e 15 emétropes de 15 pacientes em cada grupo foram submetidos ao TSH e scans maculares com SD-OCT realizados 10 e 45 minutos após a ingestão de água. Os principais resultados avaliados foram média da EC na região macular pelo SD-OCT e pressão intraocular (PIO) durante o TSH.

Resultados: O equivalente esférico médio foi de 0.15 ± 0.24 diptorias em emétropes e -7.1 ± 1.75 diptorias nos olhos miopes (p<0.001). Não foram encontradas diferenças estatísticas durante a resposta ao TSH entre EE e ME. EE apresentaram maior EC em comparação com ME, tanto na região foveal (361.4 ± 55.5 vs 257.9 ± 95.3; p<0.001), 3 milímetros nasal à fovea (158.0 ± 71.8 vs 122.5 ± 54.5; p=0.047) e 3 milímetros temporal à fovea (310.6 ± 52.4 vs 247.6 ± 90.1; p=0.05). Em relação à variação da EC, diferenças estatisticamente significativas foram demonstradas na região foveal, 10 minutos após a ingestão de água em ambos EE e ME, sem diferenças entre os grupos. Moderada correlação entre pico de PIO durante o TSH e EC foi demonstrada em ME (r=0.52, p=0.04).

Conclusão: A diferença na variação da EC provocada pelo TSH não foi estatisticamente diferente entre olhos emétropes e míopes, o que sugere um comportamento semelhante da coroide nestes dois grupos quando submetidos ao TSH. Além disso, a EC é mais fina nos olhos alto miopes e a variação na EC não explica o aumento da PIO durante o TSH.

Descritores: Miopia; Coroide; Tomografia de coerência óptica; Comprimento axial do olho; Pressão intraocular; Água; Ingestão de líquidos; Osmose

INTRODUCTION

Myopia is typically classified into two groups: low-to-moderate myopia (-0.5 to -5.0 D) and high or pathological myopia (greater than -5.0 D)(1). Pathological myopia is associated with several vision-threatening fundus complications such as macular atrophy, posterior staphyloma, lacquer cracks, choroidal neovascularization, macular hole, stretched vessels, patchy atrophy, tilting of the optic disc, and retinal detachment.(2,3). Such complications are typically caused by excessive stretching of the eyeball, which may also cause decreased choroidal perfusion, and possible operator-dependent variability.(6,7). The development of newer technologies such as spectral-domain optical coherence tomography (SD-OCT) has improved imaging visualization of deeper intraocular structures. However, effective measurement of OCT has only been possible since the development of enhanced depth imaging (EDI) technology by Spaide et al.(8) using the Heidelberg Spectralis (Heidelberg Engineering, Heidelberg, Germany) OCT instrument, with OCT measurements of the choroid shown to be reproducible(9).

Previously, the water drinking test (WDT) has predominantly been used as a diagnostic tool for glaucoma. However, the WDT was abandoned due to its poor diagnostic value(10,11) Recently, the WDT was revived as a tool to evaluate the outflow facility reserve of the eye(12). The results of the WDT have been shown to correlate well with intraocular pressure (IOP) peaks occurring during daytime(13). A correlation between WDT results and progression of glaucoma has also been demonstrated(14,15). The choroid has been studied due to its potential role in the development of glaucoma(16). OCT measurements of the choroid show good correlation between WDT results and progression of glaucoma(17). De Moraes et al.(21) described an increase in CT during the WDT in a group of eyes.
glaucomatous patients, which may partly explain observed increases in IOP following water ingestion. However, Arora et al.22 found a significant increase in CT and a decrease in anterior chamber depth after WDT in angle closure eyes but not open angle eyes, indicating different behavior of the choroidal bed in these two conditions.

To the best of our knowledge, no previous studies have compared CT variation in response to the WDT between highly myopic eyes (ME) and EE. The purpose of the present study was to evaluate CT variation during the WDT in patients with ME compared with a control group of EE.

METHODS

All procedures of the present study followed the tenets of the Declaration of Helsinki and were approved by the Institutional Review Board/Committee of Ethics.

A total of 30 non-glaucomatous patients were recruited from the Department of Ophthalmology of the University of Sao Paulo School of Medicine and divided into the following two groups: 15 eyes chosen randomly from 15 consecutive patients with high myopia (>−5.0 D) and a control group of 15 eyes chosen randomly from 15 consecutive patients without myopia, with a spherical equivalent higher than 0.0 D and lower than +1.0 D. One eye per patient was included in the present study to avoid high intereye correlation in the analysis, as this has been known to falsely increase observed differences between groups24,25. Further, one eye per patient was randomly chosen for statistical analysis to avoid selection bias24,25. Each participant provided signed informed consent for participation in the present study.

To be included in the present study, all patients were required to have a normal optic disc appearance on fundus biomicroscopy and IOP lower than 21 mmHg on at least two measurements performed at two different days by the same examiner and with the same calibrated Goldmann tonometer (R900, Haag-Streit, Koeniz, Switzerland).

Exclusion criteria included conditions that may affect choroidal morphology and IOP outflow such as presence of any type of glaucoma, eyes with a history of retinal detachment, pars plana vitrectomy, diabetes, systemic arterial hypertension, use of any kind of eye drops, photodynamic therapy, foveoschisis, posterior uveitis, or macular hole.

Patients underwent refraction tests for classification into each of the two groups. Biometry was performed using an IOL Master 500 (Carl Zeiss Meditec Inc., Dublin, CA, USA), with a minimum of two measurements formed until two reliable consecutive measurements of axial length performed until two reliable measurements were acquired with a signal-to-noise ratio greater than 2.0 = 0.05).

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Changes in IOP are therefore thought to depend on outflow facility(12). The nasal quadrant was thinner than the foveal and the temporal quadrant, which is in agreement with a previous study(26). However, the mean subfoveal CT in ME was 257.9 ± 95.3 μm, thicker than the average thickness measured in other studies. Fujiwara et al.(26) reported a subfoveal CT of 93.2 μm (±62.5 μm) using the Spectralis with EDI, the same instrument used in the present study. Further, Flores-Moreno et al.(27) reported a mean subfoveal CT of 166 ± 88.7 μm (13.5-486.5) using the Topcon 3-D-2000 OCT in a pattern that facilitates the visualization of deeper ocular structures, similar to the EDI in Spectralis. There may be at least two possible reasons for this difference. First, the mean age of the myopic group was 23.1 ± 2.4 years (20-27), significantly younger age compared with that in other studies(26,27). Second, the mean spherical equivalent refraction was -7.1 ± 1.75 D in the myopic group, a smaller value than the -12.05 ± 5.02 D value reported by Flores-Moreno et al.(27) and -11.9 D (± 3.7 D) value reported by Fujiwara et al.(26). CT is known to decrease with increasing age and degree of myopia. The results of a previously reported regression analysis indicated subfoveal CT decreases by 12.7 μm for each decade of life and by 8.7 μm for each diopter of myopia(26).

The exact mechanisms underlying the IOP elevation in response to the ingestion of 1 L of water are not completely understood(26). This increase has been posited to be caused by an increase in aqueous humor production or a reduction in aqueous humor outflow. Bruculeri et al.(28) tested the hypothesis that elevated IOP was determined by increased aqueous production resulting from a blood-ocular osmotic pressure gradient in 16 healthy volunteers. No variation in hematocrit, total plasma osmolality, or plasma colloid osmotic pressure was observed in this study, and the authors therefore concluded that neither vitreous hydration nor increased aqueous ultrafiltration was responsible for the increase in IOP. However, previous studies have indicated osmotic mechanisms may influence IOP during the ingestion of water(29,30). Campbell et al.(31) analyzed blood sodium and diuresis in glaucomatous and nonglaucomatous patients and reported an initial fall in blood sodium after ingestion of water, which coinciding with the maximum rise in IOP but without a proportional relationship being observed. Spaeth(32) performed 234 WDT and demonstrated that osmotic changes contribute to the observed changes in IOP during the WDT but are unable to fully explain the rise in IOP following the ingestion of water.

In contrast, Brubaker(12) posited that the WDT may be a marker of the outflow facility of the eye. After drinking any hypotonic fluid such as water, there is an influx of volume into body tissues including the eye, thereby changing the episcleral venous pressure. Elevation of episcleral venous pressure may alter IOP by two mechanisms: increased resistance to aqueous outflow and engorgement of the choroidal vasculature and alteration of the trabecular outflow(33). Thus, variations in the outflow facility of the eye may explain the variation in IOP during the WDT.

Previous studies have attempted to determine the correlation between the WDT and CT variation. De Moraes et al.(34) measured changes in CT after the WDT in a group of glaucomatous patients using ultrasonography. They reported a significant increase in CT after the WDT, associated with an IOP increase of 3.5 mmHg and a peak IOP at 30 min. They also demonstrated a moderate correlation between the CT peak and the ocular pulse amplitude peak, which preceded the IOP peak by 15 min. They concluded that acute water intake leads to a transient decrease in blood colloid osmotic pressure, which transfers fluid from the systemic circulation to the choroidal space due to the osmotic gradient, thereby increasing choroidal volume. This, in turn, would be transmitted to the anterior segment, causing fluid to exit in an amount dependent on outflow facility. Changes in IOP are therefore thought to depend on outflow facility(34).

Two recent studies evaluated CT changes during the WDT using OCT. Arora et al.(35) studied CT changes in a group of patients with open-angle and angle-closure glaucoma, where Mansouri et al.(36) evaluated CT changes after the WDT in healthy individuals. The first group(35) described a significant increase in CT and a decrease in anterior chamber depth after WDT only in angle closure eyes. According
to these authors, IOP increases without a commensurate CT increase in patients with open-angle glaucoma support the hypothesis that increased outflow resistance is the major mechanism underlying IOP elevations in response to WDT.

Mansouri et al. demonstrated a statistically significant increase in macular CT after the WDT of a smaller magnitude, with an maximum increase of 4.3%. They observed no association between increased IOP and CT and concluded that choroidal changes did not fully explain WDT-related rises in IOP. We attempted to further investigate the findings of Mansouri et al. by also evaluating healthy individuals without glaucoma. We divided individuals into two groups: highly ME and a control group of EE. As myopia is a risk factor for glaucoma development, and it is known that CT differs between EE and ME, we used macular OCT to evaluate the effects of the WDT over the choroid in these two groups of patients. The results of the present study corroborate the findings of Mansouri et al. We also found no statistically significant difference in mean central corneal thickness between the two groups, which may otherwise have interfered with IOP measurements.

Bonomi et al. studied the outflow facility of 137 anisometric subjects with unilateral high myopia and concluded that the outflow facility was higher on the myopic side, as the scleral rigidity was found to be lower as well. In the present study, considering that the WDT is a surrogate of the outflow facility, we were unable to demonstrate this difference. However, the present study was not designed to evaluate the outflow facility directly. It may be possible that, even with the outflow facility difference reported by Bonomi et al., the magnitude of such difference was not enough to be detected by the WDT.

Thinner CT is associated with poorer visual acuity in highly ME as shown by Flores-Moreno et al. They demonstrated that subfoveal CT, mean macular CT, and outer foveal thickness are the most important predictors of visual acuity in highly ME without macular pathology.

The present study has some limitations. CT was measured using EDI in spectral domain OCT, and the demarcation of CT was manually performed by the operator, which may have increased measurement variability. The same operator performed all CT demarcation in both ME and EE groups. However, the examiner was not blinded to measurement results.

We believe the present study to be the first in the literature designed to evaluate differences in CT elicited by the WDT between the EE and highly ME, which may reflect differences in the physiologic behavior of the choroid layer in both conditions. We observed greater CT in EE compared with ME. The identification of different choroidal responses to the WDT broadens our understanding of the mechanisms underlying increases in IOP during the WDT and the physiopathology of glaucoma development in ME. The importance of CT in higher myopics and its association with fundus changes in these eyes merits further investigation.

We were unable to find any statistical difference between these two groups of eyes during the WDT, indicating similar behavior of the choroidal bed in these two groups. Additionally, we observed a small increase in CT after water ingestion, indicating that CT variation alone is not enough to explain IOP elevations during the WDT.

REFERENCES