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Evaluation Of Ocular Parameters In Patients Receiving Hemodialysis Treatment

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Abstract

Background: Changes in retrobulbar blood flow during hemodialysis (HD) may result in ocular changes. It may have effects especially on the choroid, which is the area with high blood flow, and therefore the retina. This study aims to compare choroidal and retinal changes before and after a single HD session.

Methods: In this prospective study, patients receiving HD treatment in the dialysis unit between October 2022 and February 2023 were included. The patients were divided into two groups: diabetes mellitus (DM) and non-DM. Measurements were made before and after dialysis treatment using optical coherence tomography. Using computerized segmentation, macular retinal layer volumes of the eye (total retinal volume and ganglion cell layer from outside to inside, inner plexiform layer) were measured. The enhanced depth imaging system of optical coherence tomography was used to measure choroidal thickness.

Results: A total of 28 patients (18 women and 10 men) participated the study. All patients underwent in-depth eye examination. After HD session, a statistically significant decrease in choroidal thickness was observed in the macula temporal, subfoveal region, macula nasal and optic disc nasal in both the DM and non-DM groups. According to the measurements made on the retinal layers before and after HD, it was observed that there was no change in the macular thickness of the ganglion cell layer and inner plexiform layer.

Conclusion: The lack of change in the macular thickness of the ganglion cell layer and inner plexiform layer suggested that HD did not have any effect on the neural tissue. Thinning was observed in the choroidal layer after hemodialysis. It was observed that HD affected choroidal blood flow and caused changes in the vascular layer of the eye. Changes in the choroidal tissue in the optic disc nasal and posterior pole regions also suggest that HD affects the vascular layer of the eye globally.

Keywords: Ganglion cell layer, hemodialysis, inner plexiform layer, choroid thickness

INTRODUCTION

The incidence of end-stage renal disease (ESRD) is progressively rising due to the demographic shift towards an aging population, making it a burgeoning global public health concern. Hemodialysis (HD) is a therapy modality that incurs significant costs and has been associated with a decline in quality of life (1). HD is a process utilized to eliminate metabolic wastes and excess fluid from extracorporeal blood. Simultaneously, renal replacement fluid therapy is employed to uphold electrolyte and acid-base balance (2).

Metabolic alterations manifest during hemodialysis, and scientific data suggests that these changes can impact ocular health, as well as various other human tissues and organs (3,4).

Hemodialysis can lead to alterations in retrobulbar blood flow, which can subsequently cause modifications in ocular physiology. The potential impact of this phenomenon is particularly notable in the choroid, a region characterized by its abundant blood supply, and consequently, the retina. Optical coherence tomography (OCT) is a non-invasive imaging modality utilized for the assessment of retinal tomography and retinal histopathology. This technique operates on the idea of analyzing the characteristics of reflections from tissues with distinct optical properties, achieved by directing

infrared light towards the retina (6).

The choroid supplies blood to both the retinal pigment epithelium (RPE) and the retina. The regulatory capacity of the choroidal arteries is limited, rendering them susceptible to systemic alterations (6,7). Additionally, it has been observed that this particular phenomenon can lead to RPE and retinal malfunction, ischemia, and potentially result in the demise of photoreceptor cells (6).

In addition to the immediate alterations observed in ophthalmological observations prior to and following a solitary hemodialysis session, this investigation seeks to assess the variations in peripapillary and macular regions, as well as choroidal and retinal regions. Furthermore, we hope to examine the associations between these alterations and systemic parameters.

The aim of this study was to evaluate changes in the thickness of the choroid, both within and outside the macula, in patients with ESRD who are having HD treatment.

METHODS

The present cross-sectional study was conducted at the Ophthalmology and Nephrology clinics of Gebze Fatih State Hospital from October 2022 to February 2023. For this study, ethics committee approval numbered 2022/83 was received from the Health Sciences University Ethics Committee on 13.10.2022 and study was conducted in accordance with the principles of the Declaration of Helsinki. All participants provided written informed consent.

Patients receiving hemodialysis treatment at Gebze Fatih State Hospital Nephrology Clinic were included in the study. The study population consisted of individuals diagnosed with ESRD, who were then categorized into two groups based on the presence or absence of diabetes mellitus (DM). The study comprised individuals who had a best-corrected visual acuity greater than 20/200 and eyes with an ocular axis length (AL) ranging from 22.1 to 25.9 mm. This study excluded patients who had a medical history of retinal vein occlusion, glaucoma, age-related macular degeneration (AMD), or uveitis, and who had experienced anterior or posterior segment disease that hindered the ability to conduct precise examination, ocular surgery, or retinal laser treatments within a period of 3 months prior to the commencement of the study. The study did not include patients who were undergoing active ophthalmological treatment for diabetic retinopathy.

In the present study, all participants had hemodialysis treatments three times per week, each session lasting four hours, for a minimum duration of three months. The study employed the usage of the Fresenius Medical Care 4008s (TR-TR 1A. 2014) and Gambro ak98 (program version2.xx, Gambro Lundia AB PO Box 10101 SE 22010 Lund Sweeden) dialysis machines in conjunction with the polynephron synthetic hollow fiber dialyzer and low molecular weight heparin as an anticoagulant. The patient was subjected to bicarbonate dialysis, utilizing a dialysate flow rate of 500 ml/min and a blood flow rate ranging from 300 to 350 ml/min. The body weight and blood pressure of each patient were assessed both prior to and following the dialysis procedure.

Each individual underwent a comprehensive ophthalmological evaluation, including dilated fundus ophthalmoscopy and structural spectral-domain optical coherence tomography (SD-OCT). The exclusion criteria encompassed glaucoma, vitreoretinal and retinal vascular illnesses, ocular media opacity, any prior laser photocoagulation therapy or ocular surgery in the study eye, as well as macular dystrophies and diseases.

The ophthalmologist obtained OCT readings both prior to and following the initial hemodialysis session of the week, which took place on either Monday or Tuesday. In order to mitigate the influence of circadian rhythm on choroidal thickness, measurements were conducted during the early morning hours, without the use of pupil dilation. Measurements using OCT were conducted both prior to and following the administration of dialysis treatment. Once the patient was positioned in the correct manner, measurements of the retinal layer of the eye were obtained.

The OCT scans were obtained by a single operator utilizing an eye-tracking device (Automated Real-Time system). The identical regions were scanned both prior to and subsequent to the HD.

The imaging procedure involves the utilization of a high-speed, high-resolution SD-OCT device (Spectralis® OCT, Heidelberg Engineering, Heidelberg, Germany) to focus on the macula and optic disc. The superluminescent diode (SLD) is utilized to generate an infrared beam with an average wavelength of 870 nm for the intended application. To mitigate the potential influence of movement artifacts caused by tiny eye movements during the examination, a advenced eye tracking system was integrated into the SD-OCT device.

The volumes of the macular retina layer in both eyes were quantified using digital segmentation. The aforementioned volumes encompassed the aggregate retinal volume, along with the volumes of the ganglion cell layer (GCL) and inner plexiform layers (IPL).

The measurement of choroidal thicknesses was conducted using the enhanced depth imaging (EDI) technology of OCT. An integrated device was used to measure the choroid-sclera border at the fovea and optic disc. The device was positioned vertically from the outer margin of the retinal pigment epithelium (Figure

Table 1. The clinical and laboratory of th participants and the comparison of thw two groups

	DM (n=13)	Non DM (n=15)
Age (years)	66.61 ± 9.69	58.50 ± 16.40
Dialysis duration (years)	3.22 ± 2.31	3.25 ±2.20
DM duration (years)	11.39 ± 5.54	-
Weight before HD (kg)	82.60 ± 17.85	73.70 ± 15.03
Weight after HD (kg)	79.86 ± 17.35	70.74 ± 14.99
Systolic Blood Pressure before HD (mmHg)	130.56 ± 27.96	135.63 ±21.28
Systolic Blood Pressure after HD (mmHg)	118.33 ± 26.62	125.00 ± 17.88

DM; diabetes mellitus; HD; hemodialysis

1). Retinal and choroidal thickness measurements were taken in both the macula region and areas outside of it. The measurement of retinal and choroidal thickness in the macula revealed a consistent value of 1.5 mm at the central region of the fovea, both towards the temporal and nasal directions leading to the center of the fovea. Measurements of the thickness of the retina and choroid were conducted in the nasal region, namely at a distance of 3.5 mm from the edge of the optic disc, excluding the macula.

STATISTICAL ANALYSIS

The statistical analysis was conducted using the SPSS Ver. 22.0 software (SPSS Chicago, Illinois, USA). A p value below 0.05 was deemed statistically significant. The Shapiro-Wilk test was employed to ascertain the presence of a normal distribution. The study assessed the disparities between pre- and post-hemodialysis measures using the dependent groups T test for variables that followed a normal distribution, and the Wilcoxon signed ranks test for variables that did not follow a normal distribution.

RESULTS

The demographic characteristics of each group are shown in **Table 1**. The DM group comprised 13 patients, while the non-DM had 15 patients. In the DM group (n=13), the estimated duration of DM was 11.39±5.54 years. Hemodialysis duration was 3.22±2.31 years in the DM group and 3.25±2.20 years in the non-DM group. The times did not differ significantly between the two groups (p=0.959). After hemodialysis, the mean body weight decreased from 82.60±17.85 kg to 79.86±17.35 kg (p<0.001) in the DM group and from 73.70±15.03 to 70.74±14.99 kg (p<0.001) in the Non-DM group.

After hemodialysis; it was observed that systolic blood pressure (SBP) decreased from 130.56±27.96 to 118.33±26.62 mmHg (p<0.054) in the DM group and from 135.63±21.28 to 125.00±17.88 mmHg (p<0.059) in the non-DM group.

The mean central macular thickness before the start of hemodialysis was 258.38±36.31µm and 253.46±22.35 µm (p=0.327) in the DM and non-DM groups, respectively. After completion of dialysis, the values were 250.69±40.35 µm and 247.60±25.79 µm (p= 0.114) in the DM and non-DM groups, respectively.

According to the measurements made in the retinal layers before and after HD, it was observed that there was no change in GCL and IPL macular thickness. **Table 2** shows GCL and IPL measurement details.

Table 2. GCL and IPL layer volume analysis in DM and non-DM groups before and after HD obtained by SD-OCT in end-stage renal disease patients.

	DM(n=13)				Non DM (n=15)			
	Before HD		After HD		Before HD		After HD	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
GCL								
Makula Temporal	29.31	6.52	30.15	7.04	29.47	7.10	32.33	6.01
Subfoveal	15.38	6.39	16.76	7.32	11.93	4.62	12.66	5.19
Macula Nasal	31.31	5.31	30.61	9.91	35.67	6.81	36.20	7.58
Optic Disc Nasal	21.15	5.85	23.30	3.27	22.73	5.70	30.13	2.99
IPL								
Makula Temporal	28.15	4.12	29.30	3.79	30.07	4.30	30.13	2.99
Subfoveal	20.38	5.05	19.76	6.15	17.40	3.75	17.73	4.14
Macula Nasal	25.00	4.63	25.46	4.19	27.73	4.59	29.20	4.91
Optic Disc Nasal	21.54	5.15	23.23	4.14	22.13	7.38	21.60	7.62

DM; diabetes mellitus; HD; hemodialysis; GCL; ganglion cell layer; IPL; inner plexus layer, SD-OCT; spectral domain optic cohorens tomography; SD; standart deviation

Table 3. The variations in choroidal layer thickness in both diabetic and non-diabetic groups prior to and following hemodialysis. These measurements were acquired using enhanced depth imaging optical coherence tomography (EDI-OCT) in patients with ESRD.

	DM			Non-DM		
Choroidal Thickness	**Before HD**	**After HD**	**p**	**Before HD**	**After HD**	**p**
Macula Temporal	259.23±48.67	212.92 ± 48.33	<0.001	259.23±48.67	224.92±48.32	<0.001
Subfoveal	296.15±62.71	230±62.83	<0.001	296.15±62.71	251.46±62.82	<0.001
Macula Nasal	214.38±90.35	187.92±78.11	<0.001	255.38±90.34	209.92±78.11	<0.001
Optic Disc Nasal	190.92±73.10	150.46±66.36	<0.001	202.92±73.10	166.46±66.36	<0.001

DM; diabetes mellitus; HD; hemodialysis;

In the DM group, choroidal thickness was 259.23± 48.67µm at the temporal macula before hemodialysis; subfoveal 296.15±62.71µm; 214.38±90.35µm at macula nasal; The optic disc was 190.92±73.10µm nasally. In the measurement made after HD, it was 212.92 ± 48.33µm at the temporal macula; subfoveal 230±62.83µm; 187.92±78.11µm at macula nasal; 150.46±66.36µm was measured nasal to the optic disc. An observable reduction in choroidal thickness was found to be statistically significant following HD (p value was <0.001, 0.003, 0.001, 0.002 for macula temporal, subfoveal, and macula nasal, respectively).

In the non-DM group, choroidal thickness was 259.23±48.67µm at the temporal macula before hemodialysis; subfoveal 296.15±62.71µm; 255.38±90.34µm at macula nasal; The optic disc was 202.92±73.10µm nasally. In the measurement made after HD, it was 224.92±48.32µm in the temporal macula; subfoveal 251.46±62.82µm; 209.92±78.11µm at macula nasal; 166.46 ±66.36 µm was measured nasal to the optic disc. According to the values given in the Table 3, a statistically significant decrease was detected in choroidal thickness after hemodialysis (p<0.001 for macula temporal, subfoveal, macula nasal) (p=0.008 for OD nasal) (**Table 3**).

The mean difference in choroidal thickness in the macular region, assessed at the foveal center and 1.5 mm to the right of the foveal center, was higher in the group of individuals with DM (44.69; 34.30 µm) compared to the group non-DM (35.73; 29.00 µm). The statistical significance of the results are indicated by a p-value of less than 0.001, as shown in **Table 4**. The mean difference in choroidal thickness outside the macula in the group of individuals with DM (macula nasal 45.46; optic disc nasal 36.46 µm) was likewise substantially distinct (p<0.001) from that in the group non-DM (macula nasal 34.13; optic disc nasal 18.56 µm). The information is presented in **Table 4**.

DISCUSSION

In the present study, it was shown that HD had no discernible impact on the ganglion cell layer and inner plexiform layer, both of which constitute the neuronal layers of the retina. However, noteworthy alterations were observed in the choroid tissue.

Patients with chronic renal disease who are receiving HD may have exacerbation of corneal and conjunctival ocular abnormalities, leading to the development and progression of dry eye and red eye symptoms [8]. Renal failure and renal immunity can lead to HD, which in turn may result in ocular alterations or exacerbation of pre-existing ocular conditions (9). The presence of a choroidal tissue that is both structurally and functionally intact is essential for the proper functioning of the retina. The presence of abnormal choroidal blood flow has been identified as a potential factor contributing to photoreceptor malfunction and subsequent cell death (6,10).

Two intradialytic pressures, ultrafiltration and solute clearance, have an impact on ocular structures. It is important to mention that a major element that causes changes in eye measurements during HD is the movement of fluids and molecules between the blood and the fluids inside the eye, such as the aqueous humor, vitreous, and choroidal interstitium (8). During HD, the process of ultrafiltration leads to a progressive reduction in the volume of fluid inside the extracellular fluid compartment. This finally results in an elevation of the oncotic pressure within the extracellular space, leading to the withdrawal of fluid from the adjacent tissues. Fluid transport from the eye to the plasma is facilitated by the elevation of plasma colloid osmotic pressure

Table 4. The comparison of thickness differences in the eye measurements before and after hemodialysis in the DM and non-DM groups (p values for the comparison of each parameter <0.05)

		Macular Temporal Choroidal Thickness Difference	Subfoveal Choroidal Thickness Difference	Macular Nasal Choroidal Thickness Difference	Optic Disc Nasal Choroidal Thickness Difference
DM	Median	12.0(-18.0 - 159.0)	19.0(-4.0 - 103.0)	33.0(-5.0 - 95.0)	10.0(-28.0 - 57.0)
Non-DM	Median	21.0(2.0 - 96.0)	38.0(0 - 159.0)	31.0(2.0 - 117.0)	33.0(-14.0 -126.0)

(11). The aforementioned modifications may potentially result in a reduction in choroidal thickness, as indicated by previous studies (11-13). Hence, it is postulated that the occurrence of choroidal thinning can be attributed to hypovolemia resulting from ultrafiltration and the subsequent elevation in plasma colloid osmotic pressure. Numerous investigations have demonstrated a reduction in choroidal thickness and retinal edema subsequent to HD, therefore aligning with this perspective (14-17.

A study was conducted to examine the impact of HD on peripapillary choroidal thickness in patients with ESRD. The study utilized swept source OCT and other ophthalmological parameters. The results revealed a notable association between changes in PCT and subfoveal choroidal thickness. In our study, we demonstrated the decrease in subfoveal choroidal thickness. Differently, we did not measure the peripapillary choroidal thickness, which may be a limitation of our study. We measured the choroidal thickness in the nasal region of the optic disc. HD can affect the optic nerve head and surrounding structures.

In a study conducted by Chang et al., it was found that patients undergoing HD saw a reduction in choroidal thickness, body weight, serum osmolarity, and SBP (18). In parallel with our study, mean choroidal thickness changes were greater in the DM group than in the non-DM group. In that study, overall changes in peripapillary retinal nerve fiber layer thickness were not statistically significant.

Following the process of HD, a notable reduction in choroidal layer thickness was noted in both the groups with DM and non-DM. However, no discernible alterations were detected in the layers of the neural retina. In this study, we aimed to assess the temporal macula, macula, nasal macula, and optic disc utilizing OCT within a comparatively expansive region in comparison to prior research efforts. The observed correlation in the nasal optic disc led us to consider the comprehensive impact of hemodialysis on the choroid layer, particularly in the DM group.

There are certain limitations inherent in our investigation. Initially, it is worth noting that the study sample size was rather limited. Consequently, it is imperative to conduct additional research using a larger sample in order to establish conclusive findings on alterations in choroidal thickness and GCL. Furthermore, all parameters were recorded 30 minutes prior to and 30 minutes subsequent to HD. Conducting additional OCT examinations over time intervals when the body has had sufficient opportunity to attain complete equilibrium and fluid balance may yield varied outcomes.

The fluctuations in body weight and blood pressure that occur during HD have the potential to impact the thickness of the choroid, both within and outside the macula. Additional research is required to assess the potential alterations that can arise in different ocular pathological states following hemodialysis in individuals with ESRD.

CONCLUSION

This study showed us that the lack of change in GCL and IPL macular thickness suggested that HD did not have any effect on neural tissue. Thinning was observed in the choroidal layer after hemodialysis. It was observed that HD affected choroidal blood flow and caused changes in the vascular layer of the eye. Changes in the choroidal tissue in the optic disc nasal and posterior pole regions also suggest that HD affects the vascular layer of the eye globally.

DECLERATIONS

Informed consent was obtained from all individual participants included in the study. Informed consent was obtained from patients regarding publishing their data and photographs. Ethics committee approval numbered 2022/83 was received from the Kocaeli Derince Training Hospital on 13.10.2022

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Conflict of interest: None

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

This study has not been published anywhere.

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