Impact of Hemodialysis on Visual Parameters in Patients With End-stage Renal Disease

Hassan Ghasemi,[1] Reza Afshar,[2,3] Nikan Zerafatjou,[4] Saeid Abdi,[5] Ali Davati,[6] Mani Khorsand Askari,[4] Hoda Shabpiray[4]

[1]Department of Ophthalmology, Shahed University, Tehran, Iran
[2]Division of Nephrology, Department of Medicine, Shahed University, Tehran, Iran
[3]Division of Nephrology, Nephrology Research Center, Tehran University of Medical Sciences, Tehran, Iran
[4]Shahed University, Tehran, Iran
[5]Shahid Beheshti University of Medical Sciences, Tehran Iran
[6]Department of Epidemiology, Shahed University, Tehran, Iran

Keywords. hemodialysis, retinopathy, refractive errors, visual acuity

Introduction. Patients with end-stage renal disease who receive hemodialysis are prone to visual disturbances. The aim of this study was to evaluate the effects of metabolic changes on visual parameters during hemodialysis sessions.

Materials and Methods. Demographic information including history of underlying diseases, wearing eyeglasses, any ocular diseases or surgeries, and hemodialysis duration and frequency were recorded in 65 hemodialysis patients. The best corrected visual acuity (BCVA) in logarithm of the minimum angle of resolution and spherical equivalent (SE) per diopter were measured before and after hemodialysis. Other systemic and metabolic parameters including systolic blood pressure, body weight, KT/V, and blood levels of glucose, urea, and sodium were recorded.

Results. A total of 130 eyes of 38 men and 27 women with ages ranged from 24 to 90 years (mean, 60.3 ± 16.7 years) were enrolled. The mean BCVA changed significantly after hemodialysis (0.29 ± 0.48 increased to 0.31 ± 0.49; $P < .001$). The mean SE changes were significant as well (-0.33 ± 0.31 D decreased to -0.40 ± 0.12 D; $P < .001$). There was a weakly positive correlation between the BCVA and blood glucose changes ($P = .05$, $r = 0.166$). There were significant associations between diabetic retinopathy and wearing of eyeglasses with BCVA and SE ($P < .001$ for both).

Conclusions. Hemodialysis could influence on visual parameters such as BCVA and refractive status by means of changes in blood glucose or possibly other systemic parameters.

IJKD 2012;6:457-63
www.ijkd.org

Original Paper

INTRODUCTION

Hemodialysis patients, especially the elderly, have visual acuity (VA) levels much lower than their age-matched counterparts, and low vision rehabilitation may be useful in these patients. Decreased VA is associated with reduction in quality of life, interference with daily activities, increased sudden fall, and difficulties in performing personal tasks. Hemodialysis patients are usually old and fragile and encounter many problems in their life, including sleep disorders and depression.[1-5] Some important ocular effects of hemodialysis are, alterations in lacrimal secretion and fundus changes including paleness, arteriolar narrowing, and significantly decreased retinal blood flow.[6]

Short-term changes in VA are frequently seen due to rapid shifts of body fluid, abrupt changes of glycemic control and retraction of macular edema. Long-term deterioration of visual acuity results from both uncontrolled hypertension and poor glycemic control.[7] Several studies have reported sudden and severe decrease in VA or even blindness during the hemodialysis.[8-10] In one study, changes in refractive state was observed in hyperopic mean, before and after hemodialysis.[11] In diabetics, rapid reduction of hyperglycemia caused a reduction in refractive indexes of intraocular tissues, especially the crystaline lens.[12] In the study of Somnez and coworkers, a considerable number of diabetic patients became more hyperopic by intensive glycemic control.[13]

Ocular blood flow, volume, and osmolality are important factors affecting the refractive states of the eyes. The ocular pulse amplitude and the magnitude of pulsatile ocular blood flow significantly decrease with increasing ocular axial length. Also, a significant close relationship has been reported between the ocular pulse amplitude and pulsatile ocular blood flow and the refractive state of the eye.[14] In highly myopic patients, the axial length and refractive error correlated moderately with the ocular pulse and with the resistance index of the central retinal artery.[15] In fact, myopic refractive errors and longer axial length are associated with narrower retinal arterioles and venules.[16]

During hemodialysis, numerous metabolic parameters including blood urea, sodium, potassium, and sugar will be changed.[17-21] These fluctuations result in osmotic changes in blood and extracellular fluids, including aqueous and vitreous. Any changes in osmotic pressure of these fluids could affect the refractive status.[22-24] We conducted this study to evaluate the effect of these metabolic variables on the best corrected visual acuity (BCVA) changes as well as refractive status during hemodialysis session.

MATERIALS AND METHODS

In this before-after semi-experimental study, 65 hemodialysis patients (130 eyes) were selected using random numbers method. All the patients were under maintenance conventional intermittent hemodialysis for at least 3 months in Mustafa Khomeini Hospital, Tehran, Iran. All the available patients during their last hemodialysis sessions in this hospital were included in the study. The sample size was estimated based on the number of patients in previous similar studies. All of the patients were under regular hemodialysis by low-flux dialysis membranes (PS13 LF, PS13 LF, and PES13 LF, Meditechsys Co, Tehran, Iran). The mean dialysis solution flow rate was 500 mL/min and blood flow rates were between 200 mL/min and 250 mL/min. The study protocol was approved by ethics committee of Shahed University and was complied with the principles outlined in the Declaration of Helsinki were followed. Informed consent was obtained from the patients. Patients who with blindness, one eye, and glaucoma and those who were unable to participate or did not give informed consent were excluded.

Demographic information, including age, gender, underling diseases, history of wearing eyeglasses, ocular diseases and surgeries, and hemodialysis duration and frequencies per week, were recorded. Factors that were deemed to influence visual parameters and were affected by hemodialysis, such as the levels of blood sugar, blood urea, serum sodium, blood pressure, and body weight, were recorded before and after hemodialysis. In addition, the KT/V values as a marker for dialysis adequacy based on urea kinetic modeling were measured after the dialysis sessions. Venous blood samples were obtained just before and 30 and 60 seconds after hemodialysis, and the laboratory measurements were done promptly and the results were recorded. In addition, the patients' BCVA and spherical equivalent (SE), as the representative of refractive status, were measured by an expert optometrist using an automated refractometer (AR-800, Nidek, Japan), subjective refractions, red green test, and Snellen chart (distance per feet) and then converted to logarithm of the minimum angle of resolution (logMAR) for statistical purposes. In the cases of patients' inability to diagnose the largest E letter of Snellen chart, VA was measured using hand motion and light perception methods. Because of independent visual parameters and blood circulation of each eye, analyses of all data were taken in to consideration as 130 eyes of 65 patients instead of 65 left eyes and 65 right eyes.

The collected data were analyzed using the SPSS software (Statistical Package for the Social Sciences, version 17.0, SPSS Inc, Chicago, Ill, USA). Changes in BCVA and their relationship with other variables were evaluated using chi-square test, paired *t* test, Spearman rank correlation, and Mann-Whitney U test. *P* values less than .05 were considered significant.

RESULTS

Sixty-five patients with the ages ranged from 24 to 90 years (mean, 60.3 ± 16.7 years) were evaluated. Among these patients, 38 (58.5%) were male (mean age of 57.02 ± 16.9 years) and 27 (41.5%) were female (mean age, 64.9 ± 15.5 years). Forty-one patients (63.1%) were younger than 70 years (15 females and 26 males) and 24 (36.9%) were older than 70 years (12 females and 12 males). Among the patients, 19 (29.2%) were diabetic and 46 (70.77%) were nonediabetic. Frequencies of hemodialysis per week were less than 3 times in 14 patients (21.5%; 3 males and 11 females) and were 3 times or more in 51 (78.5%).

There were no significant differences between the left and right eyes in BCVA and refractive status before and after hemodialysis. The mean BCVA (LogMAR) was significantly different ($P < .001$) before and after hemodialysis (0.29 ± 0.48 and 0.31 ± 0.49, respectively; Table). Changes in BCVA were not significant in 93 (71.5%) of the 130 eyes, but 37 eyes (28.5%) showed significant changes after hemodialysis, which had one or two lines drop in their vision. Also the mean BCVA before hemodialysis in patients aged under 70 years were significantly higher than in patients aged 70 years or older (0.21 ± 0.23 versus 0.45 ± 0.35; $P < .001$). The mean BCVA before hemodialysis in nondiabetic patients was significantly higher than in diabetic patients (0.22 ± 0.27 versus 0.50 ± 0.42; $P < .001$).

The mean SE (sum of sphere plus astigmatisms levels divided by two) were changed in 109 (83.8%) of the 130 eyes, of which 65 eyes (50%) showed myopic shift and 44 (33.8%) showed hyperopic shift. Overall, the mean SE was significantly different between pre- and posthemodialysis sessions (-0.33 ± 0.31 D versus -0.40 ± 0.12 D; $P < .001$). Before hemodialysis, the mean SE in nondiabetic and diabetic patients was not statistically different (-0.39 ± 0.19 D versus -0.21 ± 0.20 D). After hemodiaysis, the mean SE changes in diabetics (-0.35 ± 0.15) were significant ($P = .02$) but in nondiabetics (-0.41 ± 0.22 D), those were nonsignificant ($P = .26$).

Although the mean blood glucose levels were significantly different between diabetics and nondiabetics before (190.68 mg/dL and 129.50 mg/dL, respectively) and after (174.68 mg/dL and 137.78 mg/dL, respectively) hemodialysis ($P < .001$ and $P < .001$, respectively), these differences were not significant in each independent group ($P = .07$ and $P = .10$, respectively). The mean blood glucose levels increased in nondiabetics, while decreased in diabetics after hemodialysis. The mean systolic blood pressure, serum sodium, blood urea and weight (equals to ultrafiltration volume) levels were not significantly different in women and men before and after hemodialysis; however, as a whole, they were significantly different before (131.92 ± 18.87 mm Hg, 138.75 ± 3.35 mEq/L, 163.83 ± 46.21 mg/dL, and 64.82 ± 13.88 kg, respectively) and after (128.07 ± 20.95 mm Hg, 141.12±2.57 mEq/dL, 77.58±25.54 mg/dL, and 62.00 ±13.57 kg, respectively) hemodialysis sections ($P = .01$, $P < .001$, $P < .001$, and $P < .001$, respectively; Table).

Despite these significant changes, there were no significant relationships between these parameters and BCVA or refractive status. Also, there were no significant relationships between hemodialysis programs (duration or frequency) and BCVA or refractive status. History of retinopathy was positive in 30 eyes and negative in 100 eyes. Wearing eyeglasses observed in 54 eyes and were not seen in 76 eyes. There were significant associations between history of retinopathy and wearing of eyeglasses and changes in BCVA and SE before and after hemodialysis ($P < .001$ for all items). Generally, there were weakly positive correlations

Visual and Biochemical Parameters Before and After Hemodialysis*

Parameter	Before Dialysis	After Dialysis	*P*
BCVA, LogMAR	0.29 ± 0.48	0.31 ± 0.49	< .001
Spherical equivalent, D	-0.33 ± 0.31	-0.40 ± 0.12	< .001
Blood glucose, mg/dL			
Diabetics	129.50 ± 67.67	137.78 ± 40.88	.07
Nondiabetics	190.68 ± 78.86	174.68 ± 39.50	.10
Systolic BP, mm Hg	131.92 ± 18.87	128.07 ± 20.95	.01
Serum sodium, mEq/L	138.75 ± 3.35	141.12 ± 2.57	< .001
Blood urea, mg/dL	163.83 ± 46.21	77.58 ± 25.54	< .001
Weight changes, kg	64.82 ± 13.88	62.00 ± 13.57	< .001

*BCVA indicates best corrected visual acuity and BP, blood pressure.

between BCVA and blood glucose changes after hemodialysis ($P = .05$, r = 0.166). On the other hand, there were no significant correlation between SE and blood glucose changes ($P > .05$, r = 0.153). The ranges of KT/V were between 1 and 1.2, and there were no significant relationship between various KT/Vs and BCVA or SE after hemodialysis. There were no missing values during the study period because of the enclosed spaces that the study process was performed.

DISCUSSION

In ESRD patients, pathologic changes could be found in many tissues and organs including the eyes. Regular and more frequent ocular examinations have been suggested in these patients.[25] Many patients on maintenance hemodialysis suffer from chronic eye diseases induced by both dialysis procedure and the uremic milieu.[26] Findings of this study revealed that overall mean SE was significantly different before and after hemodialysis sessions and there were a weakly positive correlation between BCVA changes and blood glucose changes after hemodialysis. Also there were significant association between history of retinopathy and wearing of eyeglasses and changes in BCVA and SE before and after hemodialysis. Serum sodium, blood pressure, blood urea, and body weight were significantly changed by hemodialysis. Also, there were no significant relationships between serum sodium, blood urea, body weight, various hemodialysis programs (duration/frequencies), and KT/V with BCVA or SE changes.

In the study of Chiu and associates on 159 hemodialysis patients, older adults had higher frequency of visual impairment.[1] This is in parallel with the findings of present study. In the study of Tomazzoli and colleagues, conducted on 18 hemodialysis patients, changes in refraction and SE were seen after hemodialysis in 64% and 83.5% of the examined eyes, respectively.[11] Also, in the present study, a high percentage (83.8%) of the subjects had changes in their SE after hemodialysis.

Macula and fovea play critical roles in central vision. Severe visual loss and blindness usually are the results of retinal vascular leakage or ischemia in diabetics. Hypertension is a further risk factor for diabetic retinopathy. In older diabetic patients visual impairment is more common and less readily corrected than in younger diabetics.[27] Diabetic patients are prone to visual disturbances such as decrease VA and even blindness due to retinopathy. These effects are more common in diabetic hemodialysis patients.[28, 29] In this study mean BCVA before hemodialysis in diabetic patients was significantly lower than in nondiabetic patients. Transient refractive changes are common during periods of hyperglycemia in diabetic patients.[30] Osmotic changes induced by hyperglycemia before the start of intensive insulin therapy, play an important role in lens over hydration by sorbitol accumulation in the lens. The lens membrane permeability to glucose is much more than to its alcoholic metabolites such as sorbitol. Depending on the osmotic gradient across the lens membrane, either swelling or dehydration of the lens may occur.[31,32] Okamoto and colleagues, Tie and colleagues, and Saito and colleagues studied groups of poorly controlled diabetic patients that underwent intensive glycemic control encountered transitory hyperglycemia. They reported that unlike other refractive parameters such as corneal keratometric parameters, anterior chamber depth, lens curvature/thickness or axial length, the alteration in refractive index of the lens is responsible for the refractive changes of the eye.[12,33,34]

Furushima and coworkers proposed another hypothesis after glucose load in healthy volunteers. They suggested that increased plasma osmosis, caused a series of happenings including ocular hypotension, decrease in zonular tension, shallowing of the anterior chamber, thickening of the lens and finally a myopic shift in refractive power of the eye. Hyperopia ensures by the reversal of the myopia after normalization of plasma glucose levels.[35] On the other hand, Wiemer and colleagues reported that in diabetic eyes, using aberrometry and Scheimpflug imaging, no significant correlations were found between changes in blood glucose levels and refractive states and geometric parameters including shape of the cornea and lens.[36] In this study mean blood glucose levels increased in non-diabetics and decreased in diabetics after hemodialysis. The reason refers to the dialysis solution glucose level that was higher than the mean blood glucose levels in nondiabetics and lower than it in diabetics. In our study, although after hemodialysis sections, mean blood glucose levels alterations in diabetics (decreased) and non-diabetics (increased) were not significant, but mean SE changes (toward myopic shift) were significant only in diabetics. This finding seems in contrast with those hypotheses that support the effects of serum osmolality on refractive status of the eye. Decreased in macular thickness during hemodialysis have been shown by optical coherence tomography in some recent studies.[37,38] Considering that each 50 μm changes in retinal thickness, caused 0.15 D changes in refractive error,[39] this difference may explain by first, possible decreased in retinal thickness induced during hemodialysis sessions and second, insignificant decreased in blood glucose levels in diabetic patients. Changes in macular thickness in diabetics under hemodialysis may be affected by previous retina laser photocoagulation.[40] Although in healthy subjects, acute hyperglycemia did not cause changes in the refractive properties and retinal thickness of the eyes,[23,39] but in diabetics, increased macular thickness due to changes in osmolar conditions differs from healthy subjects that may effect on BCVA.[41] In the present study, other variables affecting on BCVA during hemodialysis sections were history of retinopathy and wearing of eyeglasses. Meanwhile, BCVA in elder patients and diabetics were lower in contrast to younger and nondiabetics. Also blood glucose changes in hemodialysis patients were correlated to BCVA changes.

This experience showed that blood glucose increased in nondiabetic and decreased in diabetic hemodialysis patients. This is due to different blood glucose levels and constant dialysate glucose levels. Dialysis solution glucose levels are usually higher than blood glucose of non-diabetic patients and lower than blood glucose of diabetic patients which results in blood glucose levels changes and simultaneous possible effects on visual system. To prevent sudden changes in blood glucose and the resultant ocular and systemic effects, use of Dialysates with glucose levels closer to the patients blood glucose may be of helpful.

Arterial and venous retinal blood flow velocities increased in patients with early diabetes mellitus before the development of structural changes.[42] With the development of retinopathy flow velocities significantly decreased in the retinal arterioles and venules.[43] Retinal blood flow, BP and vascular diameters alone or in concert with, may influence on refractive status or VA in hemodialysis patients that needs more investigations. Some studies confirm the association between myopia and attenuation of retinal vessels.[44] There are few studies concerning correlations between blood pressure and refractive status during hemodialysis.[15,16] Although any changes in systolic blood pressure and blood flow influence on central retinal artery and vein diameter or resistance,[45-47] to explain how the systolic blood pressure changes can affect refractive status still remained obscure. In this study we did not find any significant relationship between changes in blood pressure and BCVA or refractive status.

CONCLUSIONS

Findings of this study showed that hemodialysis is effective on BCVA and refractive status. History of diabetic retinopathy and wearing of eyeglasses are associated with the changes of BCVA in hemodialysis sessions. Increased blood glucose in nondiabetics and changes of blood glucose in diabetics can cause BCVA changes in hemodialysis patients.

ACKNOWLEDGMENTS

We would like to thank all the patients, personnel of hemodialysis department of Mustafa Khomeini Hospital and Shahed University for their kind cooperation.

CONFLICT OF INTEREST

None declared.

REFERENCES

1. Chiu E, Markowitz SN, Cook WL, Jassal SV. Visual impairment in elderly patients receiving long-term hemodialysis. Am J Kidney Dis. 2008;52:1131-8.
2. Haba-Rubio J, de Seigneux S, Heinzer R. [Sleep disorders in chronic renal failure]. Nephrol Ther. 2012; 8:74-80. French.
3. Hedayati SS, Yalamanchili V, Finkelstein FO. A practical approach to the treatment of depression in patients with chronic kidney disease and end-stage renal disease. Kidney Int. 2012;81:247-55.
4. Rai M, Rustagi T, Rustagi S, Kohli R. Depression, insomnia and sleep apnea in patients on maintenance hemodialysis. Indian J Nephrol. 2011;21:223-9.
5. Theofilou P. Quality of life in patients undergoing hemodialysis or peritoneal dialysis treatment. J Clin Med Res. 2011;3:132-8.
6. Ignat F, Davidescu L, Mota E, Godeanu L. [The ocular changes in patients on chronic dialysis]. Oftalmologia. 1999;46:23-30.
7. Watanabe Y, Yuzawa Y, Mizumoto D, et al. Long-term follow-up study of 268 diabetic patients undergoing

haemodialysis, with special attention to visual acuity and heterogeneity. Nephrol Dial Transplant. 1993;8:725-34.

8. Keynan Y, Yanir Y, Shupak A. Hyperbaric therapy for bilateral visual loss during hemodialysis. Clin Exp Nephrol. 2006;10:82-4.
9. Stoffelns BM, Richard G. Is buckle surgery still the state of the art for retinal detachments due to retinal dialysis? J Pediatr Ophthalmol Strabismus. 2010;47:281-7.
10. Winkelmayer WC, Eigner M, Berger O, Grisold W, Leithner C. Optic neuropathy in uremia: an interdisciplinary emergency. Am J Kidney Dis. 2001;37:E23.
11. Tomazzoli L, De NR, Lupo A, Parolini B. Visual acuity disturbances in chronic renal failure. Ophthalmologica. 2000;214:403-5.
12. Okamoto F, Sone H, Nonoyama T, Hommura S. Refractive changes in diabetic patients during intensive glycaemic control. Br J Ophthalmol. 2000;84:1097-102.
13. Sonmez B, Bozkurt B, Atmaca A, Irkec M, Orhan M, Aslan U. Effect of glycemic control on refractive changes in diabetic patients with hyperglycemia. Cornea 2005;24:531-7.
14. James CB, Trew DR, Clark K, Smith SE. Factors influencing the ocular pulse--axial length. Graefes Arch Clin Exp Ophthalmol. 1991;229:341-4.
15. avente-Perez A, Hosking SL, Logan NS, Broadway DC. Ocular blood flow measurements in healthy human myopic eyes. Graefes Arch Clin Exp Ophthalmol. 2010;248:1587-94.
16. Lim LS, Cheung CY, Lin X, Mitchell P, Wong TY, Mei-Saw S. Influence of refractive error and axial length on retinal vessel geometric characteristics. Invest Ophthalmol Vis Sci. 2011;52:669-78.
17. Ramirez G, Bercaw BL, Butcher DE, Mathis HL, Brueggemeyer C, Newton JL. The role of glucose in hemodialysis: the effects of glucose-free dialysate. Am J Kidney Dis. 1986;7:413-20.
18. Kotyk P, Lopot F, Blaha J. Study on sodium and potassium balance during hemodialysis. Artif Organs. 1995;19:185-8.
19. Stefanidis I, Stiller S, Ikonomov V, Mann H. Sodium and body fluid homeostasis in profiling hemodialysis treatment. Int J Artif Organs. 2002;25:421-8.
20. Charra B, Chazot C, Jean G et al. Role of sodium in dialysis. Minerva Urol Nefrol. 2004;56:205-13.
21. Gotch FA, Panlilio FM, Buyaki RA, Wang EX, Folden TI, Levin NW. Mechanisms determining the ratio of conductivity clearance to urea clearance. Kidney Int Suppl. 2004;:S3-24.
22. Lin SF, Lin PK, Chang FL, Tsai RK. Transient hyperopia after intensive treatment of hyperglycemia in newly diagnosed diabetes. Ophthalmologica. 2009;223:68-71.
23. Wiemer NG, Eekhoff EM, Simsek S et al. Refractive properties of the healthy human eye during acute hyperglycemia. Graefes Arch Clin Exp Ophthalmol. 2008;246:993-8.
24. Seko Y, Shimokawa H, Pang J, Tokoro T. Disturbance of electrolyte balance in vitreous of chicks with form-deprivation myopia. Jpn J Ophthalmol. 2000;44:15-9.
25. Vrabec R, Vatavuk Z, Pavlovic D et al. Ocular findings in patients with chronic renal failure undergoing haemodialysis. Coll Antropol. 2005;29 Suppl 1:95-8.
26. Evans RD, Rosner M. Ocular abnormalities associated with advanced kidney disease and hemodialysis. Semin Dial. 2005;18:252-7.
27. Bloomgarden ZT. Screening for and managing diabetic retinopathy: current approaches. Am J Health Syst Pharm. 2007;64:S8-14.
28. Clark A, Morgan WH, Kain S et al. Diabetic retinopathy and the major causes of vision loss in Aboriginals from remote Western Australia. Clin Experiment Ophthalmol. 2010;38:475-82.
29. de Fine ON, Siersma V, Almind GJ, Nielsen NV. Prevalence and progression of visual impairment in patients newly diagnosed with clinical type 2 diabetes: a 6-year follow up study. BMC Public Health. 2011;11:80.
30. Ebeigbe JA, Osaiyuwu AB. Transient refractive changes in a newly diagnosed diabetic-a case report. J Nig Optom Asso. 2009;15:28-32.
31. Dickey JB, Daily MJ. Transient posterior subcapsular lens opacities in diabetes mellitus. Am J Ophthalmol. 1993;115:234-8.
32. Giusti C. Transient hyperopic refractive changes in newly diagnosed juvenile diabetes. Swiss Med Wkly. 2003;133:200-5.
33. Tai MC, Lin SY, Chen JT, Liang CM, Chou PI, Lu DW. Sweet hyperopia: refractive changes in acute hyperglycemia. Eur J Ophthalmol. 2006;16:663-6.
34. Saito Y, Ohmi G, Kinoshita S et al. Transient hyperopia with lens swelling at initial therapy in diabetes. Br J Ophthalmol. 1993;77:145-8.
35. Furushima M, Imaizumi M, Nakatsuka K. Changes in refraction caused by induction of acute hyperglycemia in healthy volunteers. Jpn J Ophthalmol. 1999;43:398-403.
36. Wiemer NG, Dubbelman M, Ringens PJ, Polak BC. Measuring the refractive properties of the diabetic eye during blurred vision and hyperglycaemia using aberrometry and Scheimpflug imaging. Acta Ophthalmol. 2009;87:176-82.
37. Theodossiadis PG, Theodoropoulou S, Neamonitou G, et al. Hemodialysis-induced alterations in macular thickness measured by optical coherence tomography in diabetic patients with end-stage renal disease. Ophthalmologica. 2012;227:90-4.
38. Auyanet I, Rodriguez LJ, Bosch E, et al. Measurement of foveal thickness by optical coherence tomography in adult haemodialysis patients with diabetic nephropathy. Nefrologia. 2011;31:66-9.
39. Wiemer NG, Eekhoff EM, Simsek S et al. The effect of acute hyperglycemia on retinal thickness and ocular refraction in healthy subjects. Graefes Arch Clin Exp Ophthalmol. 2008;246:703-8.
40. Yoshimoto M, Matsumoto S. [Changes in diabetic retinopathy and visual acuity in patients with end-stage diabetic nephropathy after the introduction of hemodialysis]. Nihon Ganka Gakkai Zasshi. 2006;110:271-5.
41. Thornit DN, Vinten CM, Sander B, Lund-Andersen H, la CM. Blood-retinal barrier glycerol permeability in diabetic

macular edema and healthy eyes: estimations from macular volume changes after peroral glycerol. Invest Ophthalmol Vis Sci. 2010;51:2827-34.

42. Burgansky-Eliash Z, Barak A, Barash H, et al. Increased retinal blood flow velocity in patients with early diabetes mellitus. Retina. 2012;32:112-9.
43. Burgansky-Eliash Z, Nelson DA, Bar-Tal OP, Lowenstein A, Grinvald A, Barak A. Reduced retinal blood flow velocity in diabetic retinopathy. Retina. 2010;30:765-73.
44. Li H, Mitchell P, Rochtchina E, Burlutsky G, Wong Y, Wang JJ. Retinal vessel caliber and myopic retinopathy: the blue mountains eye study. Ophthalmic Epidemiol. 2011;18:275-80.
45. Lehmann MV, Schmieder RE. Remodeling of retinal small arteries in hypertension. Am J Hypertens. 2011;24:1267-73.
46. Cheung CY, Tay WT, Mitchell P et al. Quantitative and qualitative retinal microvascular characteristics and blood pressure. J Hypertens. 2011;29:1380-91.
47. Li LJ, Cheung CY, Liu Y et al. Influence of blood pressure on retinal vascular caliber in young children. Ophthalmology. 2011;118:1459-65.

Correspondence to:
Hoda Shabpiray, MD
Shahed University, School of Medicine, Tehran 14155-7435, Iran
Tel: +98 21 8896 3122
Fax: +98 21 8896 3122
E-mail: parsa465@yahoo.com

Received February 2012
Revised June 2012
Accepted July 2012