Effect of hemodialysis on intraocular pressure in Palestine: a single-center study*

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ABSTRACT

Ocular complications are common in patients with end-stage renal disease treated with hemodialysis. Disability due to visual impairment in these patients represents a global public health problem. The study aimed to estimate the hemodialysis effect on intraocular pressure (IOP) fluctuation and related factors. A cross-sectional study of 60 patients with hemodialysis (120 eyes) from the hemodialysis unit at a major tertiary teaching hospital in Palestine. Clinical tests were carried out using the Goldman application tonometry and the volk 90d non-contact slit lamp lens. Participant's mean age was 55.5±12.6 years. Thirty-two of them were males (53.3%), and 22 (36.7%) were diabetic. IOP changed significantly after hemodialysis compared to pre hemodialysis level; (14.28±2.68mmHg before versus 12.39±2.24 after hemodialysis) ($P<0.001$). This change was more significant among females ($P<0.001$) and patients with diabetes ($P=0.001$) and correlated significantly with baseline systolic blood pressure ($P=0.002$), serum sodium ($P<0.001$), chloride ($P=0.034$), BUN ($P=0.01$), and osmolarity ($P<0.001$). In conclusion, hemodialysis treatment affects IOP and several other laboratory parameters significantly. It likely causes underestimation of IOP and corneal morphometry changes, and these changes may be necessary when planning corneal or lenticular surgeries in hemodialysis patients.

Keywords: Chronic kidney disease, Hemodialysis, Intraocular Pressure, Palestine.

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INTRODUCTION

Chronic kidney disease (CKD) is prevalent worldwide, with approximately 11% to 13%. [1]. It is often progressive, leading to irreversible loss of kidney function known as an end-stage renal disease (ESRD). The only treatment options for patients with ESRD are dialysis, hemodialysis or peritoneal dialysis, and kidney transplantation [2, 3]. The prevalence of ESRD in Palestine reached 240.3 per million in 2010, which is comparatively lower than in other countries in the Middle East and other regions of the world [4]. However, the number of ESRD patients on hemodialysis rose from 666 in 2011 to 1014 in 2015 [5].

In end-stage renal disease patients undergoing hemodialysis, multiple ocular anomalies may occur because of their uremic condition and dialysis procedure [6, 7]. These abnormalities include the decreased density of corneal endothelium cells, refractive changes, conjunctival calcium deposits, ischemic optic neuropathy, symptoms and signs of ocular surface disease, and intraocular pressure (IOP) changes. Several metabolic parameters, including sodium, potassium, glucose, and blood urea, can fluctuate during hemodialysis. Osmotic changes in the blood, aqueous and vitreous humor, and other extracellular fluids occur from these fluctuations. This puts the patient at a high risk of ocular complications such as IOP changes, band keratopathy, conjunctival, corneal calcium deposits, exudative retinal detachment, and cataract [8].

Increased IOP is a well-known risk factor for glaucoma development and progression [9, 10], as are IOP fluctuations [11]. Various techniques (Goldmann, Perkins, Schiotz, pneumotonometer, air tonometer) measure intraocular pressure. Goldmann applanation tonometry technology is already considered the gold standard in the evaluation of IOPs [12].

The relationship between chronic hemodialysis and IOP has been thoroughly studied in the past. However, the findings of studies previously published tend to be inconsistent [13–15]. This can be attributed to methodological differences, such as different exclusion requirements, other tonometry techniques, and variable sample size. These are likely due to significant technological advancements in the hemodialysis process over the years [16]. Several studies show an increase in IOP during hemodialysis sessions. Other studies have shown the contrary effect, while some studies did not show IOP change during hemodialysis.

Identifying patient-related factors susceptible to significant intra-ocular fluctuations in hemodialysis can help identify patients at high risk of visual effects in the earliest steps. It can help avoid any related visual impacts or disabilities by detecting them.

The purpose of this study was, therefore, to test IOP changes after hemodialysis sessions. The aim is to show the possible correlation between IOP change and baseline systolic blood pressure (SBP), diastolic blood pressure (DBP), body weight, and other laboratory parameters.

METHODS

Study Design and population

This prospective observational correlation study of 60 patients (120 eyes) with ESRD was carried out at a major tertiary teaching hospital dialysis Unit in Palestine between January and March 2017. This unit is the largest dialysis center in the region, with more than 350 patients receiving hemodialysis and peritoneal dialysis therapy.

All patients were on regular hemodialysis (three times weekly, 4 hours per session) from both genders. We excluded patients with an ocular disorder that may interfere with retinal and intraocular pressure measurements, such as active infection, prior eye surgery, or any irregular corneal opacity and glaucoma.

The study was carried out with the Institutional Review Board (IRB) approval of the An-Najah National University. After receiving oral and written information on the study's intent and the potential implications for clinical practice, all patients gave informed oral and written consent to participate in the study.

Measurements

We conducted eye examinations, including Snellen visual acuity, Slit-lamp fundoscopy (Haag-Streit BM 900), and Goldman tonometry applanation (Haag-Streit, AT 900), on both eyes after taking clinical history. IOP measurements were taken within 30 minutes before and after hemodialysis. Ultrafiltration during dialysis was recorded. Pre-and post-hemodialysis blood samples for osmolarity analysis were obtained.

Demographic and clinical information were derived from medical records (age, gender, and hemodialysis period in years and diabetic status) using a data abstraction sheet. Factors affected by hemodialysis include systolic and diastolic and diastolic blood pressure, body weight, hemoglobin, hematocrit, serum sodium, serum potassium, serum chloride, glucose level, Blood Urea Nitrogen (BUN), and albumin, were assessed twice before and after hemodialysis.

The IOP of the patient sitting upright at the slit-lamp microscope was measured (average of two readings) using the same calibrated Goldman applanation tonometer for the entire study duration. One investigator (YS) conducted all the measurements to remove the intra-observer bias. Measures of IOP intradialytic have not been reported. Many studies have shown that IOP changes follow a linear pattern with maximum changes occurring at the end of hemodialysis [17, 18].

Statistical Analysis

Statistical Package for Social Sciences (SPSS) was used to analyze data. The mean ± SD of each parameter for the whole group was calculated. These values were also separately determined in different groups. The data were explored for normality and found to derive from a normal distribution. The paired sample t-test determined the significance of the change in IOP after Hemodialysis. We used an independent t-test to assess IOP change concerning age, sex, and diabetes status. The Pearson coefficient test was used to determine the correlation between IOP change and baseline serum albumin levels, sodium levels, SBP, DBP, weight, potassium, chloride, BUN, and osmolarity. We set the significance level at <0.05.

RESULTS

Sixty patients (120 eyes) participated in this study. The mean age was 55.5 ± 12.6 years. Thirty-two of the patients were males (53.3%), and 22 (36.7%), 14 males and eight females, were diabetic. Their mean duration of hemodialysis was 3.9 ± 3.4 years. The participants' average body weight was 77.9 ± 15.4 kg, and their mean SBP was 135 ± 19.5 (Table 1).

Table (1): Background and clinical characteristics of the participants (n=60).

Characteristic	Number (%)	Mean ± SD
Age (years)		55.5±12.6
< 60 years	34 (56.7%)	
≥ 60 years	26 (43.3%)	
Sex		
Male	32(53.3%)	
Female	28(46.7%)	
Diabetes status		
Yes	22 (36.7%)	
No	36 (63.3%)	
Duration on hemodialysis (years)		3.9±3.4
SBP* (mmHg)		135±19.5
Bodyweight* (kg)		77.9 ±15.4

Before dialysis, **SBP: systolic blood pressure*

Comparing IOP before and after hemodialysis, it was noted that it decreased significantly by 1.89 mmHg (P<0.001). While the IOP decreased, its value remained within the normal range (11-21 mmHg). The SBP and DBP significantly decreased by 10.01mmHg and 8.40mmHg (P<0.001). The body weight reduced considerably (P<0.001) after hemodialysis by 2.94Kg and blood glucose and sodium levels increased significantly by 14.3 mg/dL (P=0.004) and 4.7 mmol/L (P<0.001) respectively. On the other hand, serum potassium and BUN levels significantly decreased after the hemodialysis session by 1.3mol/L and 32.2mg/dL, respectively (P<0.001), and the albumin levels increased considerably by 0.56g/dL (P<0.001). Serum osmolarity and chloride didn't show significant change after the hemodialysis session (P=<0.05).

Table (2): Effect of hemodialysis on IOP and systematic parameters.

Variables	**Before Hemodialysis**	**After Hemodialysis**	**Mean difference (95% CI)**	**% change**	**P-value***
IOP, *mmHg*	14.28±2.676	12.4±2.3	-1.89(-2.41--1.37)	13.2%	<0.001
SBP, *mmHg*	135.4±19.6	125.4±22.8	-10.1 (-13.8 --6.6)	08.0%	<0.001
DBP, *mmHg*	78.9±15.4	70.5±14.014	-8.40 (-11.3- -5.4)	10.7%	<0.001
Body Weight,*kg*	77.9±15.4	75.0±15.3	-2.94 (-3.1 - -2.8)	03.8%	<0.001
Glucose, *mg/dL*	127.8±59.2	142.1±49.	14.3 (0.48-23.8)	11.2%	0.004
Sodium, *mmol/L*	139.5±3.5	144.2±2.3	4.70 (4.2 - 5.2)	03.4%	<0.001
Potassium, *mol/L*	4.89±0.89	3.6±0.42	-1.29(-1.43--1.15)	26.4%	<0.001
BUN, *mg/dL*	53.9±16.9	21.7±9.3	-32.2(-34.2--30.2)	59.7%	<.001
Albumin, *g/dL*	4.1±2.2	4.7±2.5	0.56 (0.47-067)	13.7%	<0.001
Chloride, *mmol/L*	98.3±4.18	98.6±3.49	0.25 (-0.32-0.81)	01.0%	0.391
Osmolarity, *mOsm*	305.3±9.1	304.0±4.4	-1.3 (-2.7- 0.07)	0.04%	0.062

CI: *confidence interval***,** ***IOP:*** *intraocular pressure,* ***SBP:*** *systolic blood pressure,* ***DBP:*** *diastolic blood pressure,* ***BUN:*** *blood urea nitrogen*

The correlation between the changes in the IOP and the different measured variables was investigated. No significant difference in IOP between patients ≥60 years of age and patients under 60 years of age. On the other hand, IOP change was more marked among females (P<0.001) and patients with diabetes (P=0.001) (Table 3).

Table (3): Intraocular pressure change with gender and sex.

Characteristic	**IOP***Mean (±SD)*	P-value*
Age		
< 60 years	-2.3 (±2.8)	0.103
≥ 60 years	-1.4 (±2.9)	
Sex		
Male	-1.0 (±2.8)	<0.001
Female	-2.9 (±2.7)	
Diabetes status		
Yes	-3.0 (±2.4)	0.001
No	-1.3 (±2.9)	

** Independent t-test*

The analysis was conducted to assess if hemodialysis-induced IOP changes were correlated with baseline serum albumin levels, sodium levels, SBP, DBP, weight, potassium, chloride, BUN, and osmolarity. Spearman's correlation found that changes in IOP were significantly correlated with baseline in SBP (P=0.002) serum sodium (P<0.001), chloride (P=0.034), BUN (P=0.01), and osmolarity (P<0.001) (Tables 4).

Table (4): Correlation between changes in the IOP and other variables.

Variables	IOP change	
	r	*P-value**
Bodyweight, Kg	0.117	0.203
SBP, mmHg	0.274	0.002
DBP, mmHg	0.131	0.152
Serum Sodium, mmol/L	-0.351	<0.001
Potassium,mmol/L	-0.070	0.450
Chloride, mmol/L	-0.193	0.034
BUN, mg/dL	-0.235	0.01
Glucose, mg/dL	-0.086	0.353
Albumin, g/dL	-0.044	0.635
Osmolarity, mOsm	-0.394	<0.001

** Spearman's test, IOP: intraocular pressure, SBP: systolic blood pressure, DBP: diastolic blood pressure, BUN: blood urea nitrogen*

DISCUSSION

from end-stage renal disease (ESRD),

Intra-ocular pressure is the eye's fluid pressure created by the equilibrium between aqueous humor production and drainage [19]. The study's objective was to examine the impact of hemodialysis on IOP in ESRD patients and address its related risk factors. The study showed a significant decrease in IOP after hemodialysis in 78% of the patients with a mean change of -1.89 mmHg.

The change that occurs in variables after hemodialysis has been expected. The body weight substantially decreased by around 3 kg, reflecting the dialysis-removing fluid that lowers systolic and diastolic blood pressure. The increase in serum sodium levels is due to the dilution effect of excess water in the body before dialysis and the high sodium concentration in the dialysis system. BUN dropped considerably because urea is removed from the body during dialysis. Serum osmolarity has not changed significantly.

Correlation between IOP change and other baseline variables revealed that serum osmolality, serum sodium, serum chloride, and SBP significantly correlated with the IOP change.

Our study's results are supported by findings of other studies, which reported that IOP significantly decreases after the hemodialysis session [13, 20, 21]. Further studies showed the opposite results and claimed that hemodialysis would raise IOP values [22]. Samsudin *et al*. investigated the impact of hemodialysis on IOP and did not find significant change [14]. Nowadays, improved renal dialysis techniques such as high-flux hemodialysis maintain better osmolar balance and prevent a marked IOP elevation. Another explanation that illustrates the IOP decrease is attributed to the change in the SBP, which is significantly correlated with the IOP [23]. Thus, more decline in the SBP will cause the IOP to decrease more.

Fluid removal during the hemodialysis process allows water to be transferred from plasma to the dialysate, leaving behind large proteins such as albumin and globulin as they cannot cross the membrane. As a result, plasma protein concentration increases, and a colloid gradient between plasma and interstitial fluid is formed, so water transfers through capillary endothelia from interstitial and aqueous humor to plasma fluid IOP decreases [24].

Significant associations have been observed in other studies between serum osmolarity and IOP changes during hemodialysis. These studies indicated that ocular fluid difference and plasma osmolarity might cause the IOP to change [16, 25]. In patients with obstructed aqueous outflow, this increased IOP is even more pronounced [26].

This study has some limitations that should be taken into consideration when interpreting its results. The fact that the sample was conveniently selected and included a relatively small sample size and that a single ophthalmologist was performing the patient assessment could limit its generalizability. The anterior chamber, which would have given some outflow facility results, was not evaluated; patients described as having obstructed outflow pathways may have had findings that differed from those of other patients during hemodialysis. Another limitation of the current research is not measuring plasma colloid osmotic pressure, probably the primary mechanism responsible for decreasing IOP. The lack of central corneal thickness assessment is another limitation of the current research, as measured IOPs have been shown to differ based on central corneal thickness. IOP is not a constant value but varies considerably due to a number of factors working over periods ranging from seconds to minutes or hours; some are acting over more extended periods [27]. Regular IOP variations are expected, and countervailing measures are in place to protect the tissues' integrity. However, in the case of abnormal IOP elevations, or where normal counterbalancing mechanisms are defective, damage may be more likely to occur [27].

Conclusions and Recommendations

In conclusion, we observed that hemodialysis treatment affects IOP and several other laboratory parameters significantly. Hemodialysis likely causes underestimation of IOP and corneal morphometry changes, and these changes may be necessary when planning corneal or lenticular surgeries in hemodialysis patients.

Findings from this study showed that while total blood osmolarity decreased after hemodialysis when this change is smaller, osmolarity is still higher and more fluid is transferred to blood with a higher drop in IOP compared to a more significant change. This indicates that osmolarity decreased by higher values, and thus less fluid would transit to blood, leaving IOP at a high level.

Even though hemodialysis decreases the IOP, which reduces the risk of optic nerve damage, it's recommended to follow up with all patients for a routine ophthalmic checkup, especially those patients with DM who is already risky for retinopathy.

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COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper.

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