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Effect of Hemodialysis on Intraocular Pressure (IOP) and Ocular Perfusion Pressure (OPP)

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ABSTRACT

Hemodialysis is a routine procedure in patients on renal replacement therapy. It carries risk of intraocular pressure and ocular perfusion pressure derangement. With proper monitoring of IOP and blood pressure, visual impairment can be minimized. **Objective:** To study the effect of hemodialysis on intraocular pressure (IOP) and ocular perfusion pressure (OPP). **Methods:** Cross sectional observational study after getting ethical approval was carried out in a Tertiary Care Hospital Rawalpindi from Aug 2021 to Apr 2022. Sixty patients with CKD on HD were included. A pneumotonometer was used to measure IOP twice at every time point. IOP was measured Pre-HD, during HD, and Post-HD. After measuring IOP and BP the value of OPP, MAP, SOPP and DOPP were calculated. Statistical analysis was done using SPSS version 21.0. **Results:** The value of IOP at pre-HD was 18.82 ± 0.57, during HD was 20.73 ± 0.55 and post-HD was 21.55 ± 0.60. Similarly, the value of MAP at pre-HD was 93.48 ± 4.26, during HD was 88.25 ± 4.71 and post-HD was 84.63 ± 5.20. The value of OPP at pre-HD was 74.70 ± 4.23, during HD was 67.50 ± 4.80 and post-HD was 63.13 ± 5.19. Pre-HD to post-HD the value of IOP increased significantly to 2.73 mmHg, MAP decreased significantly to -8.85 mmHg and OPP decreased significantly to -11.57 mmHg. **Conclusion:** During HD, there is a significant rise in IOP and reduction in OPP, both of which enhance the risk of glaucoma progression and development. Even when IOP is effectively managed, clinicians must evaluate HD history in patients with glaucoma progression.

INTRODUCTION

Patients with CKD "chronic kidney disease" are typically treated with hemodialysis (HD) i.e. blood-filtration technique. Numerous metabolic markers, such as glucose levels, potassium, sodium and blood urea, might vary during HD. Osmotic shifts in blood, vitreous and aqueous humour, and other extracellular fluids come from these fluctuations [1]. During or after dialysis, however, few patients can develop symptoms like headache, eye discomfort and blurred vision. The question of whether high intraocular pressure caused by the long-term dialysis causes glaucoma or visual problems in the patients on hemodialysis has piqued ophthalmologists' interest, prompting more investigation [2]. It can also impact intraocular pressure (IOP), visual acuity and retinal thickness [3]. Patients with CKD and renal replacement treatment may experience visual loss because of the original disease, such as diabetic retinopathy and hypertension, or because of dialysis-related complications [4]. Ocular complications include endogenous endophthalmitis, occipital lobe blindness, ischaemic optic neuropathy and reduced cell density of corneal endothelium. In literature during or after the HD changes in

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IOP have been reported widely. Glaucoma is caused by an increased IOP and decreased ocular perfusion pressure (OPP)[5]. In the USA, 871 000 patients got therapy for ESRD, with 26.0 % of which patients being over "60. years old", as per NIH "National Institutes of Health". As Age increases the chances for developing glaucoma. Older patients on hemodialysis who have end-stage renal illness are more probable to develop glaucoma [6, 7]. IOP is main risk' factor in the progression & development of glaucoma. Transitory elevations in Intra Ocular Pressure have been documented while HD in the patients without or with glaucoma. However, the effect of large but brief rise in IOP during HD sessions, its relations to the progression of glaucomatous illness, is not understood [8]. Maintenance of the OPP via system adjustment of blood pressure' and general control of IOP is required for adequate oxygenation of ocular tissues. Vascular dysregulation is thought to cause irregular perfusion of eyes leading to ischaemic damage of optic nerve, which is thought to be the underlying cause of glaucoma [9]. Researchers discovered that hypoxia of optic nerve develops when the IOP rises beyond 40 mmHg or OPP falls under 50 mmHg, indicating that autoregulation is no longer able to adjust. However, it was found by Stefánsson et al that "optic nerve" may withstand "OPP" over 50 mmHg, but hypoxia resulted when OPP went below 30 mmHg in variety of human and animal trials [10]. Low OPP has been linked to OAG "open angle glaucoma" in humans, according to multiple population-based epidemiologic studies [11]. According to the findings of the Early Manifest Glaucoma Trial, low baseline pressure of systolic perfusion elevated hazard ratio for development of glaucomatous illness was the up to 1.42. Every such epidemiologically studied research mentioned low OPPs that were stable and constant throughout time; HD may only cause a transitory alteration in OPP [12]. Significant IOP rise or OPP decrease that goes unnoticed during HD may lead to glaucomatous optic nerve injury and vision loss. The link between variations in IOP and HD has been studied for over 50 years. CKD patients have inadequate general blood supply to eyes [13, 14], and hemodialysis-induced changes in the IOP can worsen this state or potentially cause irreparable ischemia and hypoxic damage to retina and optic nerve. As a result, to safeguard visual function in hemodialysis patients, it is vital to examine variations in IOP during hemodialysis and research associated causes.

Patients undergoing hemodialysis experience significant physiological fluctuations, yet its impact on ocular parameters such as intraocular pressure (IOP) and ocular perfusion pressure (OPP) remains underrecognized in routine clinical practice. Although previous studies have explored IOP changes during hemodialysis, findings remain inconsistent, and limited data are available regarding simultaneous changes in OPP and their potential role in glaucomatous risk, particularly in local or regional populations. Moreover, the transient but repeated hemodialysis-related ocular hemodynamic changes and their cumulative effect on optic nerve health are not well established. This study aims to evaluate the effect of hemodialysis on IOP and OPP and to determine their potential role in increasing the risk of glaucoma progression among CKD patients.

METHODS

After getting approval of the ethical review approval, under letter ID A/28/EC/447/20, a cross-sectional prospective study was carried out as at Tertiary Care Hospital Rawalpindi from Aug 21 to Apr 22. Informed written consent was also obtained from each patient. Using convenience sampling technique, according to WHO sample calculator sixty (60) patients with CKD who were on HD were included. Dialysis was done three times a week for three to five hours each time. Patients who had a previous Corneal defect, past corneal intervention /surgery, topical anesthetics drugs allergies and having present eye illness /infection were excluded for study. A pneumotonometer was used to measure IOP twice at every time point. Two observations were averaged into single reading with a variation of <0.5 mmHg. At each of following time intervals, IOP was measured with patient seated: Pre-HD, around 20 minutes before commencing HD; During HD, roughly 2 hours after the starting HD; and Post-HD, around 20 minutes after terminating HD. For calculating the "Mean Arterial Pressure" MAP, at each time following formula was used:

MAP = diastolic B.P + 1/3 (systolic B.P – diastolic B.P).

By using automated sphygmomanometer BP was checked in terms of SBP and DBP with patient sitting in upright position around brachial artery. The OPP, DOPP, SOPP and MOPP were calculated using following equations:

O.P.P = MAP – I.O.P

S.OPP = Systolic B.P – I.O.P

D.OPP = Diastolic B.P – I.O.P

MOPP = 2/3 (MAP – I.O.P)

Descriptive statistics were used to describe quantitative and qualitative variables. Comparisons among mean O.P.P, MAP & I.O.P before, during and after HD were made using the paired samples. For analyzing the data, SPSS "statistical package for social sciences" version 22.0 was used and 'p< 0.05' was taken as statistically significant.

RESULTS

In this study, 60 patients were enrolled after fulfilling the selection criteria. The mean age of patients in our study was 51.57 ± 12.04 years with 33(55.0%) patients were male and 27(45.0%) patients were female. Of 60 patients, 25(41.7%) had urban residential status and 35(58.3%) had rural residential status. The causes of ESRD in our study

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were diabetes mellitus (26.7%), hypertension (25.0%), focal segmental glomerulosclerosis (8.3%) and others (40.0%).

Table 1: Baseline Results of Parameters of Study Patients

Parameters	Results
Age (Years)	51. 57 ± 12.04
Sex	
Male	33 (55.0 %)
Female	27 (45.01 %)
Residential Status	
Urban	25 (41.7 %)
Rural	35 (58.3 %)
Causes of CKD	
DM	16 (26.7 %)
HTN	15 (25.0 %)
FSGS	05 (8.3 %)
Others	24 (40. %)

The pre and post results of weight, plasma osmotic pressure and blood pressure were given in table 2. Also, no patient was observed any adverse event.

Table 2: The Hemodialysis Effect on Weight, BP and Plasma Osmotic Pressure

Different Variables	N	Mean ± SD
Pre-Hemodialysis Weight (kg)	60.00	68.05 ± 4.76
Post-HD Weight (kg)	60.00	66.05 ± 4.78
Pre-HD Plasma Osmotic Pressure (mOsm/kgH_2O)	60.00	277.27 ± 4.51
Post-HD Plasma Osmotic Pressure (mOsm/kgH_2O)	60.00	264.62 ± 3.23
Pre-HD SBP	60.00	136.52 ± 10.83
Pre-HD SBP	60.00	72.00 ± 2.90
During HD SBP	60.00	122.37 ± 10.26
During HD SBP	60.00	71.10 ± 5.19
Post-HD SBP	60.00	117.75 ± 11.02
Post-HD SBP	60.00	68.10 ± 4.82

In this study, the value of IOP at pre-HD was 18.82 ± 0.57, during HD was 20.73 ± 0.55 and post-HD was 21.55 ± 0.60. Similarly, the value of MAP at pre-HD was 93.48 ± 4.26, during HD was 88.25 ± 4.71and post-HD was 84.63 ± 5.20. The value of OPP at pre-HD was 74.70 ± 4.23, during HD was 67.50 ± 4.80 and post-HD was 63.13 ± 5.19. The mean values of IOP, OPP and MAP were significantly changed in the session of HD. From pre-HD to post-HD the value of IOP increased significantly 2.73 mmHg (p<0.001), MAP decreased significantly -8.85 mmHg (p<0.001) and OPP decreased significantly -11.57 mmHg (p<0.001). Others pressure of perfusion was also decreased significantly from baseline values. Independent T-test was applied. p<0.05 is considered significant. These results are given in Table 3.

Table 3: Measurement of Pressure and Calculation in Hemodialysis

Measurement (mmHg)	Mean ± SD			Change From					
	Before-HD	While-HD	After-HD	Before HD to During HD		While HD to Post-HD		Pre- to post-HD	
				Mean + SD	p-value	Mean + SD	p-value	Mean + SD	p-value
IOP	18.82 ± 0.57	20.73 ± 0.55	21.55 ± 0.60	1.91 ± 0.76	<0.001	0.82 ± 0.81	<0.001	2.73 ± 0.86	<0.001
MAP	93.48 ± 4.26	88.25 ± 4.71	84.63 ± 5.20	-5.23 ± 5.77	<0.001	-3.62 ± 7.85	0.007	-8.85 ± 7.01	<0.001
OPP	74.70 ± 4.23	67.50 ± 4.80	63.13 ± 5.19	-7.20 ± 5.73	<0.001	-4.37 ± 7.95	0.001	-11.57 ± 6.98	<0.001
SOPP	117.69 ± 10.79	101.64 ± 10.34	96.20 ± 10.93	-16.06 ± 15.32	<0.001	-5.43 ± 15.86	0.010	-21.49 ± 15.42	<0.001
DOPP	53.17 ± 2.87	50.37 ± 5.18	46.55 ± 4.85	-2.81 ± 5.90	0.005	-3.82 ± 8.34	0.008	-6.62 ± 5.56	<0.001
MOPP	49.80 ± 2.82	45.00 ± 3.20	42.09 ± 3.46	-4.80 ± 3.82	<0.001	-2.91 ± 5.30	0.001	-7.71 ± 4.65	<0.001

*DOPP "diastolic ocular perfusion pressure (OPP)"; I.O.P "intraocular pressure"; MAP "mean arterial pressure"; MOPP "mean OPP" SOPP "systolic OPP"

DISCUSSION

Impact of Hemodialysis on the OPP is not thoroughly investigated. The impact of HD on IOP, on the other hand, has been thoroughly researched, but the findings are mixed, and no definitive solution has evolved. Findings of current study show a notably increased Intra Ocular Pressure and reduction in almost all the parameters of perfusion pressure. The OPP has risen to levels that increased the chances of developing glaucomatous illness and its progression. Most of the early research looking at the impact of HD on the IOP found increase in the "IOP", which was accredited to a quick drop in the Osmolarity of plasma along with relative increase in the intra-cellular urea concentration in comparison to the extra-cellular urea concentration. A pressure difference is formed between' the eye and the plasma compartments as consequence of rapid change, causing extracellular fluid to migrate from blood to anterior chamber [6,15]. Recent research has shown that during HD, IOP does not alter or decreases, and OPP does not change [13,16]. These results contradict present findings, which demonstrated a large rise in IOP and a considerable reduction in OPP during HD. Current HD approach was not sufficiently different from that employed in this other research to account for the disparities in outcomes. As previously stated, a drop in the plasma osmolarity can cause a rise in the Intra-Ocular Pressure, whereas a rise in the colloid osmotic, pressure

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causes a decrease in IOP. So, it is evidenced that Instability in BP & IOP are related to glaucoma. Therefore, Ocular Perfusion Pressure alterations owing to I.O.P or B.P variations can play a significant part in illness progression. Two observations back the concept. First, individuals with generally proper controlled IOP but increasing POAG "primary open angle glaucoma" or general tension glaucoma experienced a substantial drop in the SBP throughout 24-hour duration. 2^{nd} was in comparison with the well persons. People with the POAG showed significantly less MOPP as well as larger diurnal MOPP changes [17]. Also, more investigations revealed, changes in MOPP within 24-hour duration can be risk in progression and normal-tension glaucoma development [18]. These investigations suggest that individuals with glaucoma show more variation in 'passive' OPP than in well individuals. Present investigation indicated oscillations in 'OPP' throughout the HD, which is known to be associated with BP alterations related to shifting of fluids. Consequently, Hemodialysis patients could be having greater active changes in 'IOP' and/or 'OPP' during repeated hemodialysis sessions, which can ultimately enhance their chances for the progression and glaucomatous illness development. Wang *et al.*, [2] investigate how the influence of hemodialysis on intra-ocular pressure changes with anatomy of the anterior eye chamber, similar to other findings [6]. They find that an increase in intra-ocular pressure in individuals with highly narrow angles is linked with alterations in anterior chamber anatomy. After a single hemodialysis session, a study found that ophthalmological observations, including IOP was consistent and significant in patients undergoing this therapy owing to ESRD. During ophthalmologic checkup of patients receiving hemodialysis, keep in mind that there may be dry eye findings than in the general population, and the condition may worsen after hemodialysis session. The low values of IOP after hemodialysis suggest that a thorough eye examination should be performed the same day. It seems that evaluating IOP before or after hemodialysis is more suitable for these individuals. Furthermore, since axial length fluctuates with hemodialysis, be cautious while measuring it [19]. A prospective, observational, comparative 24-hour trial was performed on consecutive subjects with normal IOP undergoing maintenance HD 3 days a week between 13:00 and 17:00 hours in an academic setting. Trial suggests that HD significantly impacts 24-hour IOP characteristics in normotensive eyes. The long-term significance of these findings requires further elucidation in normotensive patients and, predominantly, in patients with glaucoma undergoing HD [20]. Current research includes strengths and drawbacks. The key strength of present research is that this is the first study that was undertaken in current circumstances. The initial limitations of the current investigation are limited number of the patients. Second, while OPP and IOP were evaluated in single session, it is uncertain if observed higher Intra Ocular pressure & lower Ocular Perfusion Pressure are repeatable for every patient over additional sessions of Hemodialysis. In the future, investigations with large size of the sample that including repeated measurements throughout numerous Hemodialysis sessions is required in corroboration with present findings. Third, the function of this temporary rises in Intraocular Pressure and reductions in Ocular Perfusion Pressure is uncertain. Thus, alterations in the OPP identified in current investigation, happening throughout span of 5 hours, thrice weekly, can be inconsequential regarding chance of glaucoma development. Prospective research related specifically to the chance of glaucoma development following Hemodialysis with 'examination of visual fields' abnormalities will adequately answer the query.

This study is limited by its relatively small sample size and single-center design, which may affect generalizability of findings. The use of a single hemodialysis session for measurement also limits assessment of long-term or cumulative ocular effects. Future studies should include larger, multicenter cohorts with repeated measurements across multiple dialysis sessions to better evaluate consistency of IOP and OPP changes. Additionally, longitudinal studies incorporating visual field analysis and optic nerve assessment are recommended to establish a clearer causal relationship with glaucoma development.

CONCLUSIONS

It is concluded that during HD, there is a significant rise in IOP and a reduction in OPP, both of which enhance risk of glaucoma progression and development. Even when IOP is effectively managed, clinicians must evaluate the history of hemodialysis in the patients with glaucoma aggravation. During HD sessions, such individuals can benefit from monitoring of IOP and as well as BP to reduce OPP alterations caused by spikes in IOP spikes and/or reduced BP.

Authors' Contribution

Conceptualization: MO, MI
Methodology: SM, KM
Formal analysis: MA[1]
Writing and Drafting: JM, MA[2]
Review and Editing: JM, MA[2], MO, MI

All authors approved the final manuscript and take responsibility for the integrity of the work

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Conflicts of Interest

All the authors declare no conflict of interest.

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