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INTRAOCULAR PRESSURE CHANGES IN PATIENTS UNDERGOING HEMODIALYSIS

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ABSTRACT **Objective:** To determine changes in intraocular pressure (IOP), axial length (AxL), central corneal thickness (CCT), retinal nerve fiber layer (RNFL) thickness, and central macular thickness (CMT) in patients undergoing a single session of hemodialysis. **Methods:** This cross-sectional study included 30 patients with chronic kidney disease (CKD) undergoing hemodialysis (HD) at our institute. Patients underwent a comprehensive ophthalmic evaluation before and half an hour after a single session of HD. IOP readings before HD (T1) were compared with IOP 2 hours after starting HD (T2) and 15-30 mins after completion of HD (T3) using tailed T-test. The pre-HD values of CCT, AxL, RNFL thickness and CMT were compared with post-HD values using paired t-test. **Results:** The mean pre-HD IOP was 13.4 mmHg ± 2.3 mmHg in the right eye and 13.6 mmHg ± 2.2 mmHg in the left eye respectively. The mean IOP at T2 was 11.8 mmHg ± 2.4 mmHg in the right eye and 11.7 mmHg ± 2.7 mmHg in the left eye, while at T3 was 13.4 mmHg ± 2.3 mmHg in the right eye and 13.6 mmHg ± 2.4 mmHg in the left eye. The IOP decreased by 1.6 mmHg ± 2.1 mmHg (p-0.0001) in right eye and 1.9 mmHg ± 2.3 mmHg (p-0.00003) in left eye during HD and returned to pre-HD values after completion of HD. This decrease in IOP was statistically significant. There were no significant alterations in CCT, AxL, RNFL thickness and CMT after a session of HD. **Conclusion:** IOP significantly decreased during HD in our study. However, there were no significant alterations in the other ocular parameters after a single session of HD.

KEYWORDS : Intraocular Pressure (IOP); Hemodialysis (HD); Chronic Kidney Disease (CKD).

INTRODUCTION

Patients on HD exhibit a broad range of ocular manifestations, including red, dry and irritated eye, ocular pain, changes in visual acuity (VA), intraocular pressure (IOP), refractive errors (REs), elevated tear osmolarity, band keratopathy, conjunctival calcium deposits, corneal endothelium changes and lenticular opacity.[1,2]

HD induces osmotic changes in blood and extracellular fluids leading to alterations in multiple metabolic parameters such as urea, sodium, potassium and glucose level.[3]

The effect of HD on IOP has been extensively studied over the years, but the results are conflicting, and no concrete answer has emerged.

The earliest studies[4-7] examining this effect predominantly reported a rise in IOP, owing to rapid decrease in plasma osmolarity, resulting in a gradient and shift of extracellular fluid from blood to anterior chamber, similar to "dialysis disequilibrium syndrome".

Few studies[8-10] reported no correlation between serum osmolarity and IOP. Other studies demonstrated no significant change in IOP with hemodialysis or a decrease in IOP.[3,11-13]

SUBJECT AND METHODS

This was a cross-sectional study where 30 patients with End-stage kidney disease undergoing hemodialysis treatment in Nephrology hemodialysis unit in Bapuji and Chigateri hospitals were taken up.

The study was conducted in the Department of Ophthalmology at J.J.M. Medical College, Davangere from April 2023 to April 2025.

Inclusion Criteria:

- Patients of either gender with End-stage kidney disease undergoing HD.
- Patients who were ambulatory and cooperative enough to undergo complete ophthalmological examination on hemodialysis free day and post HD.

Exclusion Criteria:

- Patients who have been diagnosed with glaucoma.
- Patients with media opacities precluding the analysis of posterior segment.
- Patients with current eye infections.
- Patients who are allergic to topical anesthetics.
- Patients with corneal abnormalities.
- Patients who are not willing or consenting for the study.

Method of Collection of Data:

All the patients who satisfied the inclusion and exclusion criteria were taken for the study and the demographic data with detailed history was noted.

After obtaining written informed consent, all the patients underwent a comprehensive ophthalmic examination which included -

- External ocular examination.
- Visual acuity for distance using Snellen's chart and near vision using Jaeger's chart.
- Best corrected visual acuity (BCVA) assessment
- Slit lamp biomicroscopic examination of the anterior segment.
- Intraocular pressure measurement with rebound tonometer – Icare IC100 was done. An average of 6 readings was taken for each eye and baseline IOP of the patients was noted down as pre-HD IOP. On the day of the scheduled HD, for each patient IOP was recorded 15 minutes prior to HD (T1), 2 hours after starting HD (T2) and 15-30 minutes after the completion of HD (T3) using a rebound tonometer. IOP changes between these time frames was then assessed.
- Gonioscopy using four-mirror lens.
- Slit lamp fundus bio microscopy using +90D lens –
- Specular microscopy using Specular Microscope Tomey EM-3000 for Central Corneal Thickness (CCT).
- Ultrasonography A-scan using PacScan+ model: 300A for axial length measurement.
- Optical coherence tomography using Carl Zeiss Cirrus HD-OCT model 500 for RNFL thickness and Central Macular Thickness.

Statistical Analysis

- Statistical analysis was done by IBM SPSS (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp).
- Paired t test was used for comparison of pre-HD and post-HD values of other ocular parameters, while tailed t test was used for IOP.
- Mean and SD were used to summarize the data. A 'P' value of <0.05 was considered as statistically significant difference.

RESULTS

The pre-HD IOP, CCT, AxL, RNFL thickness and CMT were recorded and compared with the post-HD values and the following observations were made:

Demographic Data

The demographic data of the study participants is as depicted in table 1.

Table 1: Demographic Data

Data	Number	Percentage (%)
Age-wise distribution		
21-30	3	10
31-40	8	27
41-50	9	30
>51	10	33

Total	30	100
Gender distribution		
Male	20	66.7
Female	10	33.3
Cause of CKD		
HTN	23	76.67
DM + HTN	6	20
APCKD	1	3.33
Duration since HD		
<1 year	5	16.66
1-5 years	20	66.67
>5 years	5	16.67
Frequency of HD		
1 session/week	1	3.33
2 sessions/week	16	53.33
3 sessions/week	13	43.33
4 sessions/week	0	0

In this study it was found that out of 30 participants maximum belonged to the age group of >51 years i.e. 10 (33%) and minimum i.e. 3 (10%) belonged to the age group of 21 to 30 years. The mean age of the participants was 42.1 years with a standard deviation of 11.7. (Table 1)

This study had 30 participants, majority of whom were male i.e. 20 (66.7%) and 10 (33.3%) were female. The ratio among M:F is 2.1 and it is depicted in table 1.

Ocular Findings in Study Participants

Table 2: Ocular Changes in Study Subjects

Parameter		Number	Percentage (%)
Best corrected visual acuity (BCVA)			
<6/60	RE	0	0
	LE	0	0
6/60-6/18	RE	0	0
	LE	1	3.33
6/12-6/6	RE	30	100
	LE	29	96.67
Anterior segment changes			
Conjunctival/Corneal calcifications		2	6.67
Xanthelasma		1	3.33
Dry eye		3	10
Cataract		15	50
Posterior segment changes			
Diabetic retinopathy		7	23.33
Hypertensive retinopathy		17	56.67
Macular edema		0	0
Disc edema		0	0

BCVA

Only 1 patient (3.33%) had BCVA between 6/60-6/18 in the LE. All 30 patients had BCVA between 6/12-6/6 (100%). 29 patients (96.67%) had similar BCVA in the LE.

Anterior Segment Changes

Out of 30 patients, 2 patients (6.67%) had conjunctival calcifications, 1 patient (3.33%) had xanthelasma, and 3 patients had dry eye (10%). 15 patients had cataract (50%).

Posterior Segment Changes

Out of 30 patients, 7 patients showed diabetic retinopathy changes (23.33%) and 17 patients showed hypertensive retinopathy changes (56.67%). 4 of these 24 patients showed both (16.66%).

Intraocular Pressure

The IOP data of the study patients is depicted in Table 3

The average IOP measured at T1 was 13.4 mmHg ± 2.3 mmHg in the right eye and 13.6 mmHg ± 2.2 mmHg in the left eye. At T2, it was 11.8 mmHg ± 2.4 mmHg in the right eye and 11.7 mmHg ± 2.7 mmHg in the left eye. At T3 it was 13.4 mmHg ± 2.3 mmHg in the right eye and 13.6 mmHg ± 2.4 mmHg in the left eye.

In the right eye, we observed that the IOP decreased by a mean of 1.6 mmHg ± 2.1 mmHg 2 hours into the HD session (T2) from pre-HD IOP values (T1) which was statistically significant (p-value 0.0001).

The IOP then increased to reach near-baseline values within 30 minutes post the HD session. The difference in the IOP between T2 and T3 was a mean of +1.6 mmHg ± 2.5 mmHg, which was also statistically significant (p-value 0.000003).

However, the change between T1 and T3 was not statistically significant (p-value 0.8).

Similarly in the left eye, we observed a statistically significant decrease in IOP 2 hours into the HD session when compared to pre-HD levels i.e. a mean change of -1.9 mmHg ± 2.3 mmHg (p-value 0.00003).

The difference in the IOP between T2 and T3 was a mean of +1.9 mmHg ± 2.7 mmHg. This was statistically significant (p-value 0.000006). Like in the right eye, mean IOP change between T1 and T3 was not significant (p-value 0.9).

Table 3: Effect of Hemodialysis on Intraocular Pressureocular Parameter Changes in Study Participants

IOP	Mean (SD) mmHg			Change from					
	T1 - average pre-HD IOP	T2 - average IOP 2 hours after HD start	T3 - average IOP 15-30mins after HD	T1 to T2 Mean change (SD)	P-Value	T2 to T3 Mean change (SD)	P- Value	T1 to T3 Mean change (SD)	P-Value
RE	13.4 (2.3)	11.8 (2.4)	13.4 (2.3)	-1.6 (2.1)	0.0001	1.6 (2.5)	0.000003	0 (2.3)	0.8
LE	13.6 (2.2)	11.7 (2.7)	13.6 (2.4)	-1.9 (2.3)	0.00003	1.9 (2.7)	0.000006	0 (2.2)	0.9

The pre-HD and post-HD values of CCT, AxL, RNFL thickness, CMT, CSFT and CAT were compared.

Central Corneal Thickness

The average pre-HD CCT in RE was 520.1 um ± 31.5 um and in the LE was 520.9 um ± 31.6 um.

The CCT values post HD in RE was 520.3 um ± 31.7 um and LE was 518.4 um ± 33.4 um. The difference in the pre-HD and post-HD values did not reach statistical significance (p-value RE 0.79 and LE 0.17).

Axial length

The average AxL pre-HD was 22.9 mm ± 0.5 mm and 23 mm ± 0.5 mm in the right and left eyes respectively. Post-HD, the average AxL in RE was 23 mm ± 0.5 mm and LE was 23.1 mm ± 0.5 mm. The difference, however, was not statistically significant (p-value RE 0.28; LE 0.92).

Retinal Nerve Fiber Layer Thickness

The average pre-HD RNFL thickness in the RE was 91.2 um ± 14.9 um and LE was 90.3 um ± 13.7 um. Post-HD it was 90.8 um ± 0.9 um in RE and 89.3 um ± 12.1 um in LE. Although there was a slight decrease, it was not statistically significant in both eyes (p-value RE 0.37; LE 0.18).

Central Macular Thickness

The average CMT in the RE pre-HD was 263.2 um ± 18.1 um and in LE was 261.2 um ± 16 um. Post-HD, the CMT was 264.3 um ± 18 um in RE and 261.1 um ± 15.6 um in LE. There was no significant change. (p-value RE 0.42; LE 0.92).

The central sub-foveal thickness pre-HD in RE was 261.2 um ± 17.9 um and LE was 261.1 um ± 16.3 um. Post-HD values of CSFT were 262.3 um ± 18 um in RE and 262.3 um ± 18 um in LE. There was no statistically significant change. (p-value RE 0.41; LE 0.91).

The cube average thickness (CAT) pre-HD in RE was 279.6 um ± 20.2 um and LE was 275.3 um ± 20.8 um while post-HD it was 279.5 um ± 21.1 um in RE and 276.3 um ± 19.7 um in LE. Thus, there was no statistically significant change (p-value RE 0.94; LE 0.56).

DISCUSSION

Demographic profile

In this study the mean age of participants was found to be 42.1 ± 11.7 years.

The gender ratio is similar to other studies. For instance, Chen H et al.'s study[14] had a 3:2 male-female ratio and Barbosa CP et al's study[12] had 65.7% males and 34.3% females. In our study, majority were male i.e.

20 (66.7%) and 10 (33.3%) were female. The ratio among M:F is 2.1.

Intraocular Pressure

In the present study, it was found that IOP, on average, decreased in both eyes 2 hours after initiating dialysis, when compared to pre-HD levels. This fall in IOP then recovered to pre-HD levels 15-30 mins post HD.

The mean and standard deviation of IOP in the right eye at T1 (pre-HD), T2 (2 hours of HD) and T3 (post-HD) was 13.4 mmHg ± 2.3 mmHg, 11.8 mmHg ± 2.4 mmHg and 13.4 mmHg ± 2.3 mmHg respectively. At 2 hours of HD, a statistically significant decrease was noted, with a mean change of -1.6 mmHg (SD 2.1) (p-value 0.0001) compared to T1.

Additionally, IOP post-HD displayed a statistically significant increase, with mean change being +1.6 mmHg (SD 2.5) (p-value 0.000003), thus matching the pre-HD levels (p-value 0.8).

Similarly, the left eye had a mean and standard deviation at T1, T2 and T3 of 13.6 mmHg ± 2.2 mmHg, 11.7 mmHg ± 2.7 mmHg and 13.6 mm Hg ± 2.4 mmHg respectively. A statistically significant decrease was noted from T1 to T2 and an increase from T2 to T3 i.e. -1.9 mmHg (SD 2.3) and +1.9 mmHg (SD 2.7) (p-value 0.00003 and 0.000006) respectively, finally returning to pre-HD levels 15-30 mins after HD (p-value 0.9).

These findings correlate with other studies.

A French study conducted by Chelala E et al.[3] on CKD patients undergoing HD found that significant reduction in IOP which correlated with serum albumin levels and weight changes. They attributed the cause of this decrease in IOP to ultrafiltration. Gradual extracellular fluid reduction is caused by ultrafiltration. This produces a colloid gradient between plasma and interstitial fluid since the larger proteins like Albumin and globulin would be unable to cross the membranes. The water is forced into the plasma, from the interstitial area and aqueous.

The findings of this study support this hypothesis. Additionally, the return of IOP to pre-HD levels might be the result of compensatory increase in aqueous production in response to reduction of plasma osmotic pressure as postulated by Wang F et al.[15]

Axial length

There was no significant difference in the axial length of patients pre- and post-HD in this study (p-value 0.28).

Kalayci M et al.[16] noted a statistically significant change in axial length. They found a significant decrease in axial length which correlated with IOP, which they attributed to fluid loss as well as decreased volume of anterior chamber and central corneal thickness.

Wang L et al.[17] discovered a statistically significant increase in vitreous axial length caused by lens expansion and its forward displacement. They, however, did not consider total axial diameter.

Central Corneal Thickness

In our study, we found no statistically significant changes in CCT post-HD.

Kalayci M et al.[16] noticed a significant decrease in central corneal thickness (CCT) as well as IOP, which they attributed to fluid loss. Similarly, Erdem S et al.[13] found that the CCT and IOP reduced significantly post hemodialysis in addition to mean body volume and weight. They postulated that the possible reasons could be the correction of the extra accumulated and wrongly dispersed fluid in the body, or a rise in plasma colloid osmotic pressure (COP) which causes the liquid to flow to the plasma from the aqueous humor.

Retinal Nerve Fiber Layer Thickness

In this study, no statistically significant difference was noted in average retinal nerve fiber layer thickness.

Dinc U.A et al.'s study[8] also found no significant alterations in retinal nerve fiber layer thickness (RNFLT) parameters.

Chen H et al.[14] noted an increase in average retinal thickness including RNFL thickness in their study. They theorized that HD reduces the plasma crystal osmotic pressure such that the liquid goes into the retinal layers along the concentration gradient, thus thickening the retina and leading to edema.

Macular Thickness

In this study, no significant change was noted in CMT, CSFT or CAT.

Suryakanth S et al.[18] and Panagiotis G. Theodossiadis et al.[19] both conducted a study of macular thickness changes and found a significant reduction in central subfield macular thickness and maximum macular thickness respectively. However, it was performed on diabetic patients who are prone to macular edema. The fluid loss caused by HD can alleviate the edema thus producing a significant reduction in macular volume.

Chelala E et al.[3] and Yang SJ et al.[1] found no changes in macular volume. However, the latter found that the average choroidal thickness was significantly reduced.

Clinical Implications of the Study

The consistency of posterior segment stability across multiple studies, including ours, is clinically reassuring. It indicates that routine short-term HD sessions are unlikely to cause structural damage to the retina or cornea in patients without underlying ocular conditions. However, the evidence from prior research suggests that specific ocular features—such as narrow anterior chamber angles, pre-existing glaucoma, and vascular fragility—may predispose certain patients to HD-induced changes, particularly in IOP and choroidal circulation.

Future studies should integrate these parameters to provide a more holistic understanding.

Limitations

There are several limitations in our study that warrant mention.

First, the relatively small sample size (n=30) may have limited the statistical power to detect small but clinically relevant changes.

Second, we did not assess parameters such as anterior chamber angle configuration or choroidal thickness, which have shown to be affected by HD in other studies.

Finally, only a single HD session was evaluated, so long-term cumulative effects remain unassessed.

CONCLUSION

- Our patients experienced a reduction in intraocular pressure during dialysis, which returned to baseline levels after dialysis.
- Although the HD induced changes in ocular parameters did not reach statistical significance, it is important to monitor the ocular parameters of these patients since they may be affected due to their systemic co-morbidities.

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