Kidney Medicine

Increased Intraocular Pressure During Hemodialysis: Ocular Dialysis Disequilibrium

Ayodele K. Maja, Chad Y. Lewis, Eric Steffen, Michael E. Zegans, and Martha L. Graber

A man in his early 70s presented with a 1-month history of headache, left-sided photophobia, periorbital pain, and redness occurring during hemodialysis. He had a history of ESKD secondary to diabetic nephropathy and of proliferative diabetic retinopathy. We observed elevated intraocular pressure during dialysis. A diagnosis of neovascular glaucoma with a compromised iridocorneal angle was made. Medical management of glaucoma and modifications to the hemodialysis regimen were initiated but were insufficient. The resolution of symptoms required surgical management, including cataract extraction with intraocular lens placement, pars plana vitrectomy, and peripheral retina endolaser, and placement of an Ahmed glaucoma drainage valve. This case illustrates the importance of attention to intraocular pressure and risk factors for glaucoma in patients treated with hemodialysis. Clinicians caring for patients treated by hemodialysis should consider hemodialysis-related elevation in intraocular pressure as a possible etiology for headache, visual changes, or ocular symptoms during dialysis and should pursue ophthalmic evaluation.

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INTRODUCTION

Chronic kidney disease affects more than 1 in 7 Americans, including 1 in 3 with diabetes, at an annual cost to Medicare of over $81.8 billion in 2018 alone.[1,2] In 2016, close to 125,000 Americans began treatment for kidney failure and over 726,000 individuals required dialysis and/or had received a kidney transplant.[3] Glaucoma, a common condition of elevated intraocular pressure, is the second leading cause of blindness worldwide and affects nearly 3 million Americans.[4] Diabetes mellitus with proliferative retinopathy is an important predictor of glaucoma. Hemodialysis may result in transiently elevated intraocular pressure, a phenomenon termed ocular dialysis disequilibrium by Lippold et al.[5] The probable mechanism is dyssynchronous reduction in osmolality between the blood and the eye during hemodialysis, leading the aqueous humor to become hypertonic relative to the blood, producing increased intraocular pressure in individuals with a reduced aqueous outflow capacity due to an impaired or closed iridocorneal angle. Elevation of intraocular pressure during hemodialysis may damage vision and may be asymptomatic or present as headache, ocular discomfort, photophobia, visual change, or visual loss.[5]

CASE REPORT

A man in his 70s presented with a 1-month history of headache, left-sided photophobia, periorbital pain, and redness occurring during intermittent hemodialysis. He had a history of proliferative diabetic retinopathy and kidney failure secondary to diabetic nephropathy, which had been treated by hemodialysis 3 times a week for the previous 3 years. Shortly after starting a home hemodialysis regimen, he developed headache with continuous 3 out of 10 pain. The pain increased during dialysis to 8 out of 10 and was associated with photophobia and left-sided periorbital pain and redness. He was evaluated in the ophthalmology clinic and was found to have elevated intraocular pressure of 36-43 mm Hg in the left eye, while normal intraocular pressure is less than 22 mm Hg. The intraocular pressure and anatomy of the iridocorneal angle of the right eye were normal (Fig 1). Neovascular glaucoma related to diabetic nephropathy was diagnosed. Topical therapy was initiated, including eye drops with brimonidine tartrate at 0.1% and 0.15%, dorzolamide at 2%, and timolol maleate at 0.5%. Intravitreal bevacizumab was given to promote regression of diabetic retinopathy and iris neovascularization. The outpatient intraocular pressure returned to normal. However, the patient continued to experience intermittent intraocular pressure increases and symptoms during dialysis. Oral acetazolamide was added to the regimen. We modified the dialysis prescription with the goal of reducing the rate and magnitude of change in plasma osmolality due to removal of urea and other small solutes. The dialysate sodium concentration was increased to 145 mEq/l, and blood and dialysate flow rates were decreased. After implementation of these changes, intraocular pressure was measured in both eyes at the outpatient dialysis unit before and during dialysis using the Medtronic TonopenXL. Despite oral, topical, and intraocular glaucoma therapy and the above modifications to the dialysis regimen, there was a persistent increase in intraocular pressure during dialysis in the left eye (Table 1). There was no significant increase in intraocular pressure in the right eye, which had normal anatomy of the iridocorneal angle. To address the glaucoma, cataract, and proliferative diabetic retinopathy, the patient underwent cataract extraction with intraocular lens placement, pars plana vitrectomy, peripheral retina endolaser, and placement of an Ahmed glaucoma drainage valve. The intraocular pressure stabilized and the ocular symptoms during dialysis resolved.

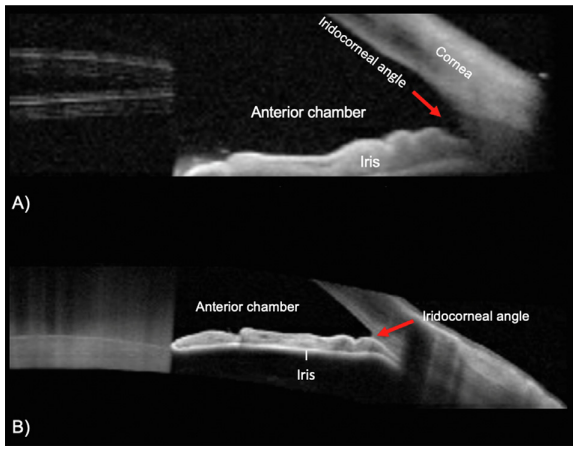

Figure 1. Optical coherence tomography (OCT) of the iridocorneal angles at baseline. Anterior-chamber OCT images obtained before treatment demonstrate an open angle on the right eye and a closed angle on the left. OCT images were obtained using a Heidelberg HRA+OCT Spectralist device with an anterior segment lens and additionally installed software for anterior segment imaging. Modes were set to cornea, sclera, and angle.

DISCUSSION

Pathological increases in intraocular pressure may be asymptomatic or may present with pain, periorbital redness, headache, or visual changes. Prolonged untreated increases in intraocular pressure result in retinal ischemia, visual loss, and eventual blindness. The changes in intraocular pressure during hemodialysis have been studied by previous investigators, demonstrating increases, decreases, or no changes in intraocular pressure, with significant interindividual variability (Table 2).[6-11]

Osmotically active molecules with large volumes of distribution, such as urea, are removed from the plasma during dialysis, reducing plasma osmolality. Sitprija et al[9] have shown that increases in intraocular pressure during hemodialysis correlate with decreases in plasma osmolality. This suggests that the decrease in osmolality of the aqueous humor lags behind that of the plasma, rendering the aqueous humor hypertonic to the plasma, resulting in movement of water from the vascular space to the aqueous space. Lippold et al[5] proposed the term ocular dialysis disequilibrium to describe this phenomenon. We suggest that the reported variability in the response of intraocular pressure to hemodialysis in prior studies is due primarily to variations in the anatomy and functional capacity of the iridocorneal angle. In individuals with normal anatomy, the flow of fluid from the aqueous humor via the canal of Schlemm to the periorbital lymphatics increases to compensate for dialysis disequilibrium, restoring baseline intraocular pressure. In persons with narrow-angle glaucoma, the rate of egress of fluid may be insufficient to overcome the increased volume of aqueous humor, resulting in increased intraocular pressure. Other factors that may influence the gradient between the plasma and the eye include the initial plasma urea concentration, the rate of small solute diffusion across the dialysis membrane, and the urea reduction ratio. As in our patient, who had diabetic proliferative retinopathy involving the iridocorneal angle, hemodialysis may unmask glaucoma when intraocular pressure increases into the pathological range during hemodialysis.

We modified the dialysis regimen by increasing the dialysate sodium concentration above the plasma sodium

Table 2. Hemodialysis-Associated Changes in Intraocular Pressure

Authors	No. of Patients	Change in Intraocular Pressure
Olawoye et al[6]	1	Increased
Song et al[7]	1	Increased
Chelala et al[8]	49	Decreased
Sitprija et al[9]	83 6	Increase No significant change
Levy et al[10]	6 3 7	Increased Decreased No significant change
Saaverda-Fuentes et al[11]	15	No significant change

Table 1. Intraocular Pressure Values at Presentation and Following Medical and Surgical Intervention

Time Point	Predialysis Intraocular Pressure, Left Eye/Right Eye, mm Hg	During Dialysis, at 3 h	Change During Dialysis	Percent Change, %
At presentation	9/12	12/25	+3/+13	+33/+108
With medical and dialysis interventions	12/25	16/33	+4/+8	+33/+32
Postoperative	13/12	15/16	+2/+4	+15/+33

Note: Intraocular pressure was measured before and during dialysis using the Medtronic TonopenXL.

concentration to reduce the rate of decrease of plasma osmolality and by decreasing blood and dialysate flow to reduce the rate of change. Previous authors have suggested additional strategies that we did not employ, including administration of mannitol or hyperosmolar glucose during dialysis, pure ultrafiltration to increase plasma colloid oncotic pressure, and a modality change to peritoneal dialysis. [12-16] In our patient, alterations to the dialysis prescription, together with maximal medical management, were insufficient to stabilize intraocular pressure. He required surgery, including placement of a mechanical valve to drain the aqueous humor.

This case illustrates that attention to intraocular pressure and risk factors for glaucoma are important for the diagnosis and prevention of secondary ocular disease and visual loss in patients treated with hemodialysis. Clinicians should encourage regular ophthalmologic assessments for patients treated with hemodialysis that are at risk, particularly those over the age of 40, with diabetes, or with a history of previous eye disease. Providers should have heightened suspicion for conditions with the potential to limit aqueous outflow, including diabetic proliferative retinopathy, and central retinal vein occlusion. Complaints of visual changes, ocular pain, or headache during dialysis warrant urgent referral for ophthalmic investigation, bearing in mind that intraocular pressure measured when the patient is not undergoing dialysis may be normal. In our experience, the portable tonometer is simple to use in the outpatient dialysis setting and requires minimal training. This device may prove to be a useful future tool for research and for investigation and management of these complex patients.

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