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Marked Decrease in Intraocular Pressure in a Neovascular Glaucoma Patient During Hemodialysis

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Abstract: While the relationship between intraocular pressure and plasma osmolarity has been investigated during hemodialysis, no research has been published concerning the relationship between intraocular pressure and plasma colloid osmotic pressure during hemodialysis. We describe a patient with neovascular glaucoma who demonstrated a marked decrease in intraocular pressure during hemodialysis. The patient's intraocular pressure, plasma osmolarity, plasma colloid osmotic pressure, and body weight were evaluated every 30 minutes during hemodialysis lasting 4.5 hours. Plasma osmolarity was almost constant during hemodialysis (beginning: 295 mOsm/L; ending: 305 mOsm/L), and plasma colloid osmotic pressure increased (beginning: 23.0 mm Hg; peak: 27.2 mm Hg). Weight loss was 5.7 kg. Intraocular pressure decreased markedly during hemodialysis (beginning: 53 mm Hg; ending: 14 mm Hg). This sharp decrease in intraocular pressure and the increase in plasma colloid osmotic pressure, indicate a relationship between plasma colloid osmotic pressure and the change in intraocular pressure during hemodialysis. **Jpn J Ophthalmol 1997;41:101–103** © 1997 Japanese Ophthalmological Society

Key Words: Hemodialysis, intraocular pressure, plasma colloid osmotic pressure, plasma osmolarity.

Introduction

The relationship between intraocular pressure (IOP) and plasma osmolarity during hemodialysis (HD) is of interest because of plasma osmolarity changes that usually occur during HD. A rapid decrease in plasma osmolarity during HD induces a change in IOP with the movement of water between the plasma and the aqueous humor.[1] Although this movement is also influenced by plasma colloid osmotic pressure, no studies have examined the relationship between IOP and plasma colloid osmotic pressure during HD. We describe an elderly man with neovascular glaucoma who demonstrated a marked decrease in IOP during HD. His plasma osmolarity remained almost constant, but the plasma colloid osmotic pressure increased during HD.

Case Report

A 62-year-old Japanese man came to our outpatient clinic reporting progressive loss of vision in the left eye. Diabetes mellitus had been diagnosed in 1967; he developed diabetic retinopathy, which was treated in 1983 with bilateral panretinal photocoagulation. In 1988, HD was begun for treatment of end-stage renal disease. He had an extracapsular cataract extraction in the left eye in 1990 and in the right eye in 1991. Corrected visual acuity was 20/100 in the right eye, but limited to hand motion in the left. IOP was 10 mm Hg bilaterally. Ocular examination revealed proliferative diabetic retinopathy in the right eye. The fundus of the left eye was not visible because of vitreous hemorrhage. Although the patient had had a vitrectomy for persistent vitreous hemorrhage of the left eye in 1992, neovascular glaucoma was diagnosed soon afterward. Because we noticed that the IOP in the left eye decreased markedly after HD, we measured the IOP just before and just after HD on each of 16 of his treatment days at our outpatient clinic. The IOP of the left eye, > 40 mm Hg be-

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Table 1. Intraocular Pressure of the Left Eye Before and After Hemodialysis

	Intraocular Pressure (mm Hg)	
	Mean ± SD*	*P* Value†
Before hemodialysis	45.1 ± 9.9	*P* = 0.0004
After hemodialysis	16.0 ± 5.6	

*Mean ± SD of 16 measurements of intraocular pressure.
†Wilcoxon signed-rank test.

fore HD, decreased markedly after HD. Measurements are shown in Table 1. We therefore developed a study to evaluate the mechanism of the decrease.

Subject and Methods

Written, informed consent was obtained from the patient. We measured his IOP, plasma osmolarity, plasma colloid osmotic pressure and body weight every 30 minutes during the HD procedure that lasted 4.5 hours. The patient received no osmotic agents, such as mannitol, during HD. Bilateral IOP was measured with the Alcon Applanation Pneumatonograph (Alcon, Fort Worth, TX, USA) while the patient was in a supine position. Plasma osmolarity was measured by freezing-point depression. Plasma colloid osmotic pressure was calculated using the following formula:[2]

plasma colloid osmotic pressure = 5.5 (plasma albumin concentration) + 1.4 (plasma globulin concentration)

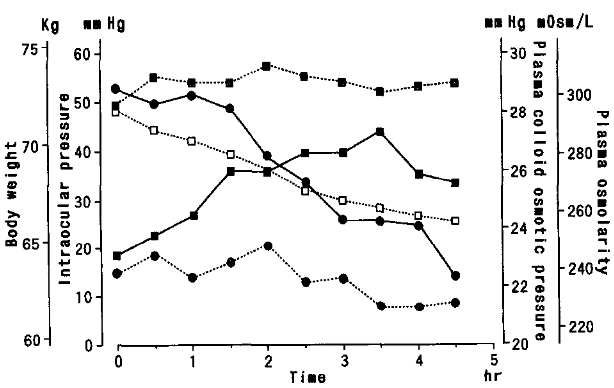

Figure 1. Changes in intraocular pressure, plasma osmolarity, plasma colloid osmotic pressure and body weight (circle cross hatch: intraocular pressure of the right eye, ●: intraocular pressure of the left eye, square cross hatch: plasma osmolarity, ■: plasma colloid osmotic pressure, □: body weight).

We used the Wilcoxon signed-rank test for statistical analysis.

Results

The IOP of the left eye, initially 53 mm Hg, decreased to 14 mm Hg at the end of HD. IOP of the right eye, initially 15 mm Hg, decreased to 9 mm Hg at the end of HD. Beginning plasma osmolarity was 295, increasing by 12 mOsm/L within the first 30 minutes of HD. Thereafter it remained almost constant; ending plasma osmolarity was 305 mOsm/L. Plasma colloid osmotic pressure increased from an initial 23.0 mm Hg to a peak of 27.2 mm Hg after 3.5 hours of HD; final pressure was 25.5 mm Hg. Body weight, 71.6 kg at the start, decreased to 65.9 kg during HD because of fluid removal of 5700 mL during the procedure (Figure 1). Initial blood pressure was 158/82 mm Hg and decreased to an ending of 74/37 mm Hg.

Discussion

Sitprija et al[1,3,4] reported that a marked increase in IOP is associated with a rapid decrease in plasma osmolarity during HD. This increase was attributed to the movement of water from the plasma into the aqueous humor due to an osmotic disequilibrium between the two compartments from the rapid decrease in plasma osmolarity. Although many researchers have since investigated the change in IOP during HD, most of the reports describe the relationship between IOP and plasma osmolarity.[5–10]

Fauchald[11] demonstrated that the accumulation of excessive volumes of fluid in the interstitial compartment occurring before HD is corrected without a

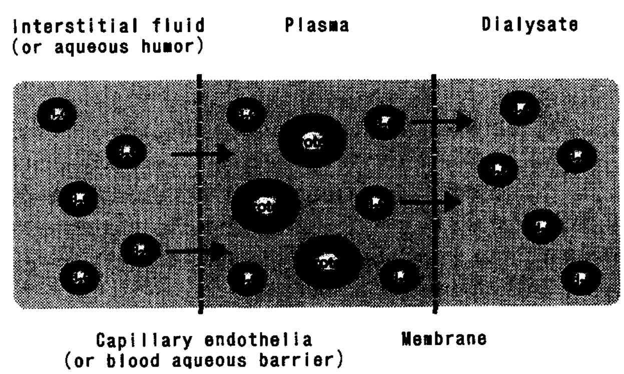

Figure 2. Schematic diagram illustrating movement of water during hemodialysis. The mechanism for correction of massive accumulation of fluid in the interstitial compartment, and for reduction in IOP is illustrated.

marked decrease in plasma volume, due to the plasma colloid osmotic pressure, which is instrumental in shifting water between the plasma and interstitial fluid. The following mechanism is proposed (Figure 2): Plasma is separated from the interstitial fluid by the capillary endothelia and from the dialysate by the membrane. As the plasma volume decreases in response to the removal of water from plasma into the dialysate by HD, a relative increase in the concentration of plasma proteins (the increase in plasma colloid osmotic pressure) occurs because large proteins, such as albumin and globulin, cannot cross the membranes. An increase in transcapillary colloid osmotic pressure between the plasma and interstitial fluid then causes water to flow from the interstitial fluid to the plasma. The interstitial fluid accumulation was finally corrected without a decrease in plasma volume.

We attribute our subject's marked fall in IOP to the increase in plasma colloid osmotic pressure induced by the rapid fluid removal during HD. Since the aqueous humor is separated from plasma by the blood-aqueous barrier, just as interstitial fluid is separated from plasma by the capillary endothelia, the relative increase in plasma colloid osmotic pressure resulting from the fluid removal during HD may have caused water to move from the aqueous humor into the plasma, thereby decreasing the IOP (Figure 2).

Since the blood-aqueous barrier is impaired in neovascular glaucoma, our theory is valid only if the blood-aqueous barrier is maintained to some degree. Sandramouli et al[12] indicated that the concentration of aqueous humor with neovascularization of the iris was raised (345.7 ± 161.0 mg/dL; mean ± SD) compared with the control group (30.91 ± 14.95 mg/dL); however this was still significantly lower than the normal concentration of total plasma protein (7000 mg/dL).[2] The results, therefore, support our hypothesis that in neovascular glaucoma, the plasma protein penetrates the blood-aqueous barrier, but that the barrier does not completely break down.

The present study indicated that plasma colloid osmotic pressure is closely related to the decrease in IOP during HD. Thus, plasma colloid osmotic pressure as well as plasma osmolarity should be considered when evaluating the change in IOP in patients receiving hemodialysis.

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