

Could Glaucoma Be a Two-Pressure Disease?

Research on the effects of space flight on the ocular system may help reveal if cerebrospinal fluid pressure plays a role in the development of glaucoma and idiopathic intracranial hypertension.

BY JOHN P. BERDAHL, MD

Ophthalmologists have long been aware that IOP is the biggest risk factor for glaucoma. They also know, however, that IOP is not the entire story. Up to 30% of patients with glaucoma may not have an elevated IOP, whereas only a small percentage of individuals with high IOP ultimately develop glaucoma.^{1,2} Clearly, there are factors at play other than IOP. Neurodegeneration, ocular perfusion, and a lack of neurotrophic factors have all been suggested as major factors in the development of glaucoma. Recent data suggest that cerebrospinal fluid pressure (CSFp) may play an important role in the disease^{3,4} (Figure 1).

DIFFERENCES IN PRESSURE

When we clinicians measure IOP, we are really measuring the pressure difference across the cornea. We apply a force to the external cornea to flatten (applanate) the cornea so that the pressure inside the eye equals the pressure outside the eye. Although we use the term *intraocular pressure*, a more appropriate term would be *transcorneal pressure difference*, because that is actually what we are measuring. Obviously, glaucoma does not occur at the cornea but at the optic nerve head, which has led to explorations of whether the pressure difference across the optic nerve head may be the key factor in defining glaucoma.

CSF fills the subarachnoid space and bathes the optic nerve all the way to its insertion through the lamina cribrosa. The IOP is separated from the CSFp by the lamina cribrosa, which is roughly 500 μm thick but thins with glaucoma. If the IOP is high or if the CSFp is low, then a pressure differential exists across the optic nerve head, and glaucomatous damage can occur. The relatively low CSFp or relatively elevated IOP will generate a net force on the optic nerve, causing posterior bowing of the lamina cribrosa and the cupping that is characteristic in eyes with glaucoma.

Studies have shown that patients with glaucoma have a lower CSFp, whereas those with ocular hypertension have a higher and possibly protective CSFp (Figure 2). These retrospective and prospective studies suggest that glaucoma could be a two-pressure disease.³⁻⁵ Other research has demonstrated a decrease in CSFp with increasing age, consistent with the rising incidence of glaucoma with increasing age⁶ (Figure 3). If these theories prove true, they may have implications beyond glaucoma.

OF ASTRONAUTS AND PRESSURE

The National Aeronautics and Space Administration has been investigating the role of CSFp in astronauts who have engaged in long-term space flight on the international space station. It had been shown that astronauts

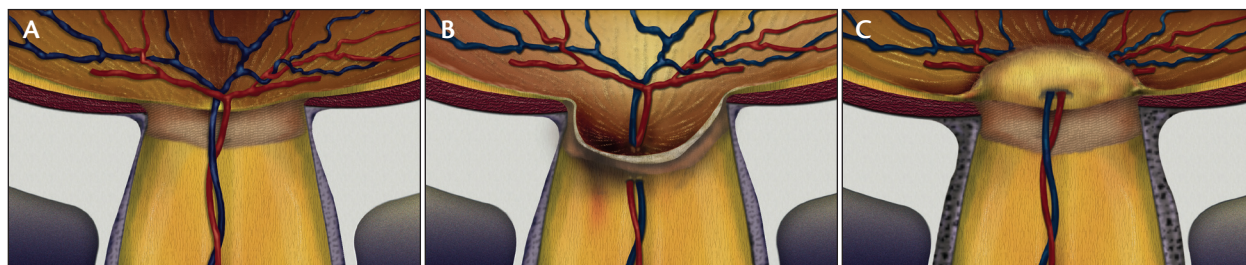


Figure 1. The relationship of IOP to intracranial pressure (ICP). Normal nerve showing a balance between IOP and ICP (A). A glaucomatous nerve with cupping resulting from an IOP that is higher than ICP (B). A swollen nerve resulting from an ICP that is higher than IOP such as in pseudotumor cerebri or ocular hypotony (C). (Note the swollen CSF space).

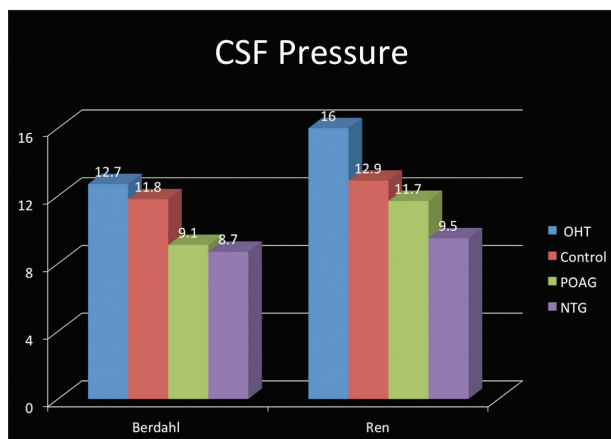


Figure 2. CSFp is lower in patients with normal-tension glaucoma and those with open-angle glaucoma but higher in patients with ocular hypertension.

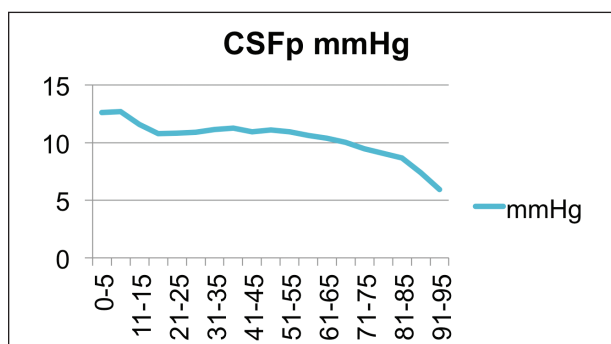


Figure 3. CSFp decreases with age.

can develop optic nerve head edema and flattening of the posterior globe, resulting in decreased vision and a hyperopic shift.⁷ The changes could be due to the lack of gravity in space, which would result in a higher-than-normal CSFp at eye level.⁸

On Earth, CSF pools in the caudal spinal column, resulting in a zero or negative CSFp at eye level (Figure 4). IOP is therefore higher than CSFp at the lamina cribrosa. The lack of gravity in space allows CSF to diffuse throughout the spinal column and intracranial space, resulting in a higher CSFp at eye level. The CSFp can thus be higher than IOP, reversing the pressure gradient at the lamina cribrosa and causing the optic nerve to bow forward and swell.

CONCLUSION

CSFp can only be accurately measured by a spinal tap. Using imaging modalities, ophthalmodynamometry, or postural changes, many companies have tried to develop a noninvasive method by which to measure ICP. Success in this area could unlock numerous possibilities for research to determine if CSFp truly plays a role in the development of glaucoma. It would also further characterize the role

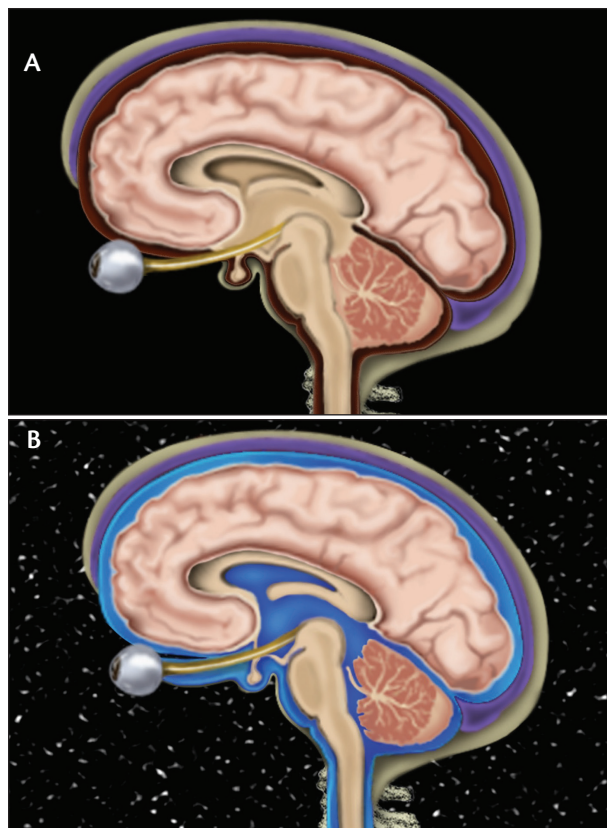


Figure 4. CSF pools in the caudal spinal column on Earth (A), whereas in space, the absence of gravity allows CSF to diffuse equally through the intracranial subarachnoid space (B), resulting in a higher CSFp at eye level.

of CSFp in space flight and help to permit further human exploration of other planets. ■

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