WHAT IS THE REAL IOP?

How laboratory glaucoma studies may help us better understand this clinical dilemma.

BY NATHAN RADCLIFFE, MD


It is not uncommon for a patient to experience glaucomatous progression despite apparently "normal" or seemingly controlled IOP. The opposite may occur as well: a patient whose IOP is higher than average never seems to develop glaucomatous optic neuropathy. Importantly, the measured IOP (eg, with a Goldmann applanation tonometer [GAT]) may not be as "true" as the eye care provider thinks. This creates concern in both the doctor and the patient. We asked three investigators three questions regarding this complex issue with the hope of better understanding "true" IOP.

In the first of this three-part series, Dr. Radcliffe addresses challenges surrounding measuring IOP. In addition, he discusses how corneal biomechanics may affect IOP and how new analyzers may help provide better glaucoma care.

—Ronald L. Fellman, MD, and Davinder S. Grover, MD, MPH, section editors

The standard for IOP measurement continues to be the GAT. Please explain how this device works and why it may not be the best way to measure IOP.

The GAT is a transcorneal IOP assessment technique that works by measuring the force required to deform the cornea and inferring the IOP from that measurement. To begin with, this is an indirect measure of the eye pressure, because it measures corneal biomechanical properties at the same time; it is therefore also subject to any assumptions we clinicians have made as a part of that measurement. We are now well aware that corneal geometry such as its thickness and curvature significantly affects the accuracy of IOP measurements.[1,2] I think it is important to stress that corneal geometry does not just influence the absolute value of the pressure measurement but also influences our ability to detect changes in those measurements.

James Brandt, MD, showed from the Ocular Hypertension Treatment Study (OHTS) that the GAT-measured efficacy of IOP-lowering medications varies based on the corneal thickness.[3] Even more troubling is that these inaccuracies have been demonstrated in a way that may be counterproductive to our treatment of glaucoma patients. For example, patients with thick corneas who are generally at low risk of disease progression will show more modest pressure reductions from a prostaglandin analogue, whereas patients with thin corneas who are at higher risk of progression will show larger pressure reductions. For me, this scenario is most common in the "tough-to-treat" ocular hypertensive (with a thick cornea) who has a normal nerve fiber layer and a full visual field but who has shown little pressure reduction from medication and has been overtreated by his or her caregiver. A better appreciation of the lack of IOP reduction seen in patients with thick corneas might have prevented the overtreatment of this patient.

We are learning that corneal biomechanics may affect IOP measurements and may be related to the risk that glaucoma will develop and progress. Can corneal hysteresis help us better understand IOP measurement and the eye's response to elevated IOP? Please explain corneal hysteresis. Will cornea-correlated IOP measured with the Ocular Response Analyzer G3 (Reichert), which takes corneal biomechanics into consideration, become the new standard for IOP measurement?

If thickness and curvature describe the geometry of the cornea, corneal hysteresis describes its behavior or response to applied forces. Hysteresis is somewhat correlated with

> **"Hysteresis values significantly affect the observed pressure reductions from topical IOP-lowering medications as well as laser trabeculoplasty."**

corneal thickness but is more of a dynamic value. Corneal hysteresis is lower when the pressure is high, and the former increases a little bit when the pressure is reduced with medication or laser therapy. At least four studies have compared corneal hysteresis to central corneal thickness and found that hysteresis is more closely associated with glaucomatous damage and progression than corneal thickness.[4-7]

Corneal hysteresis can be used to adjust IOP measurements to create a value known as cornea-compensated IOP. For example, after LASIK, the corneal hysteresis and GAT-measured IOP will both be lower. If we adjust the GAT-measured IOP value for corneal hysteresis and arrive at a cornea-compensated IOP, we will generally find a very minimal difference in IOP from before to after the LASIK procedure. Despite some value in making this adjustment, I still prefer to isolate my glaucoma risk factors and to think of IOP and corneal hysteresis separately.

It is important to note that, as with corneal thickness, hysteresis values significantly affect the observed pressure reductions from topical IOP-lowering medications as well as laser trabeculoplasty. Patients who have a low hysteresis prior to eye drop or laser therapy will demonstrate significantly greater IOP reductions from those treatments.[8,9] In my study on this topic, patients with the lowest hysteresis had a threefold greater pressure reduction from a prostaglandin analogue than those with the highest level of hysteresis. It is true that, on average, patients with thick corneas and at least an average or high corneal hysteresis will usually have a lower cornea-compensated IOP than their GAT reading. Bringing these averages down to the level of the individual patient can be a challenge. We all have patients with thick corneas and low IOPs whose glaucoma continues to progress, for example.

Until we have the best way to measure IOP, how do we obtain the most accurate IOP?

In my clinical practice, it is clear that we must take IOP measurements with a grain of salt and that we must appreciate that there are more powerful risk factors for glaucomatous progression than just elevated IOP. Dr. Brandt wrote a great essay on this topic called "The myth of clinical precision."[10] Corneal thickness, corneal hysteresis, peripapillary atrophy, optic nerve damage, and the presence of an optic nerve hemorrhage are also strong risk factors, along with elevated IOP. Hanging our hat on a single variable in the treatment of a multifactorial disease exposes our patients and us to the many problems of transcorneal IOP measurement. ■

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