DETECTING DISEASE PROGRESSION


Studies assessed whether deep learning models and IOP fluctuation could provide clues that glaucoma would rapidly become more severe.

BY JULIUS T. OATTS, MD, AND YING HAN, MD, PHD

FORECASTING RISK OF FUTURE RAPID GLAUCOMA WORSENING USING EARLY VISUAL FIELD, OCT, AND CLINICAL DATA

Herbert P, Hou K, Bradley C, et al[1]
Industry support for this study: None

ABSTRACT SUMMARY

This retrospective cohort study assessed whether future rapid visual field (VF) worsening could be predicted with the use of deep learning models (DLMs). A total of 4,536 eyes from 2,962 patients monitored for glaucoma or suspected glaucoma were evaluated. Eight DLMs were trained on baseline clinical data, including age, sex, BCVA, and IOP; OCT data; and VFs, including reliability data and mean deviation.

The main outcome measure was the area under the curve (AUC) of DLMs when forecasting rapidly worsening glaucoma, which was defined as a median deviation slope worse (more negative) than -1 dB/y across all VFs. Patients were randomly divided into training, validation, and test sets with the same ratio of rapid and nonrapid progressors in each group.

Overall, 263 (5.8%) eyes experienced rapid VF progression. A moderate to high model predictive performance was found. The worst model had an AUC of 0.74 (95% CI, 0.62–0.86) and included only baseline VF data. The best model had an AUC of 0.87 (95% CI, 0.77–0.97) and included baseline clinical and OCT data in addition to three longitudinal VFs.

DISCUSSION

Is DL ready for the clinic?

DL is a rapidly evolving field with an increasing number of clinical applications. DL has been used to diagnose glaucoma based on OCT and VFs, but this is the first study to use DL to forecast rapid disease progression based on baseline data.[2,3] One can imagine a world in which a patient undergoes longitudinal VF testing for the 12 months following a new diagnosis of glaucoma, at which point a DLM analyzes their chart for data and produces a predictive score that can inform patient education and clinical decision-making. A concern with this scenario is the black box nature of DL. Clinicians are trained to understand how things work. With the specific DLMs used in this study, there are no feature importance values, which makes how the predictions were determined even less clear.

Studies of AI-assisted diagnosis are hot in medicine. Further improvements of AI technology and more research into its application are necessary before DL is ready for the clinic.

What are some drawbacks of DL for glaucoma?

AI can inadvertently learn and perpetuate biases present in training data, potentially leading to disparities in care for underrepresented populations.[4] Additionally, training requires large, high-quality datasets, which can be challenging to find in ophthalmology, where such data are not always standardized. The rapid evolution of DL techniques, moreover, may outpace researchers' ability to validate new iterations, raising concerns about reliability and generalizability.

STUDY IN BRIEF

- A retrospective cohort study assessed whether future rapid visual field worsening could be predicted with the use of deep learning models (DLMs). The DLMs were able to forecast future rapid glaucomatous progression relatively well when trained using data from early in the disease course. The DLMs' performance improved with additional baseline data. The best-performing DLM received clinical and OCT data and had a high area under the curve for predicting rapid disease progression.

WHY IT MATTERS

Many patients with glaucoma experience slow or no disease progression. Identifying the small subset of patients whose disease progresses rapidly is crucial to preventing irreversible vision loss. Physicians gather a lot of clinical and diagnostic information on patients with glaucoma, and DLMs can gather and summarize large amounts of data rapidly. Harnessing these DLMs to evaluate clinical data efficiently could improve clinicians' ability to diagnose glaucoma and anticipate its progression.

RELATIONSHIP BETWEEN INTRAOCULAR PRESSURE FLUCTUATION AND VISUAL FIELD PROGRESSION RATES IN THE UNITED KINGDOM GLAUCOMA TREATMENT STUDY

Rabiolo A, Montesano G, Crabb DP; United Kingdom Glaucoma Treatment Study Investigators[5]

Industry support for this study: Principal funding (Pfizer)

ABSTRACT SUMMARY

The randomized, double-masked, placebo-controlled, multicenter United Kingdom Glaucoma Treatment Study (UKGTS) was designed to assess whether treatment with a topical prostaglandin analogue (latanoprost) reduced the frequency of VF deterioration events in patients newly diagnosed with open-angle glaucoma by 50% over a 2-year period.[6] This planned secondary analysis of the UKGTS investigated whether IOP fluctuation was associated independently with the rate of VF progression.[5] At least five VFs were available for all participants (213 in the placebo arm and 217 in the treatment arm). Patients had an IOP of less than 35 mm Hg on two consecutive occasions in either eye and a mean (two visits) baseline IOP of less than 30 mm Hg. IOP was measured with Goldmann applanation tonometry, and investigators obtained several other IOP metrics, including peak IOP (highest ever recorded during the study), diurnal IOP fluctuation (standard deviation of baseline diurnal IOP measurements), long-term IOP fluctuation (standard deviation of all IOP readings), and ocular pulse amplitude (OPA), as measured with the Pascal Dynamic Contour Tonometer System (Ziemer Group).

As expected, postrandomization IOP metrics differed significantly between groups and were lower in the treatment arm. IOP fluctuation was assessed on the level of seconds (OPA), hours (diurnal fluctuation), and multiple visits (long-term fluctuation). Overall, the only type of IOP fluctuation associated with a faster rate of glaucomatous progression was OPA in the placebo arm (-1.23 ±0.46 dB/y for a 1-unit increase).

STUDY IN BRIEF

▶ A planned secondary analysis of the United Kingdom Glaucoma Treatment Study (UKGTS) sought to determine whether IOP fluctuation was independently associated with the rate of visual field progression. Diurnal and long-term IOP fluctuations were not independently associated with glaucomatous progression, but ocular pulse amplitude–a measure of very short-term IOP fluctuation–was.

WHY IT MATTERS

IOP is currently the only modifiable risk factor for glaucoma treatment. Several IOP characteristics, including peak IOP, mean IOP, and degree of IOP fluctuation, have been implicated in disease progression, but the exact role of IOP fluctuation in glaucoma remains unclear. Understanding whether IOP fluctuation has a clinically meaningful impact on glaucomatous progression could inform which dynamic aspects of IOP to focus on in future diagnostic and therapeutic studies.

DISCUSSION

What are some issues with IOP measurements?

In the clinic, a single point-in-time IOP measurement is often used to represent a dynamic ocular vital sign. Factors such as the measurement modality, patient positioning, the time of day, and cardiovascular comorbidities can affect the IOP reading. Although IOP is important to the diagnosis, monitoring, and treatment of patients with glaucoma, how this parameter is measured could be improved. As technology advances to permit more frequent IOP monitoring, understanding how to interpret the additional information becomes crucial.

Is the OPA worth considering?

The UKGTS defined OPA as the range of the IOP pulse wave contour on Pascal Dynamic Contour tonometry. The idea was that a dynamic view of IOP could assess fluctuation over a short period of time—about the length of the cardiac cycle. Traditionally, IOP fluctuation is thought of on a larger scale. The UKGTS findings, however, suggest that short-term IOP fluctuation may be an important factor in rapid, long-term glaucomatous progression. As the roles of ocular biomechanics and perfusion in glaucoma's pathogenesis become clearer, the OPA may provide insight into the mechanism of disease progression. ■

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