

AI-BASED GLAUCOMA CARE



Where are we now, where are we going, and how do we translate results?

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Ophthalmology has been at the forefront of AI advances in medicine. The field generates large amounts of rich multimodal data (text, images, visual fields, etc.), enabling AI models to be trained for various tasks. Specifically, glaucoma clinicians may benefit from the ongoing innovations in transformer-based AI models (the backbone of ChatGPT [OpenAI], Bard [Google], etc.); these models offer a natural architecture for the analysis of longitudinal glaucoma patient data, which may enable more accurate AI predictions. However, several unmet needs must be addressed to translate the advances in AI research for glaucoma care. This article covers

where we are with AI in glaucoma, where we are likely headed, and the steps that must be taken to impact patient care.

PROGRESSION OF WORK

Much of the early work with deep AI models for glaucoma care focused on detecting the presence or absence of disease. This included differentiating glaucomatous from healthy eyes using large datasets of fundus photographs,¹ visual field tests,² and peripapillary OCT scans.³ Although these studies generally showed that AI models performed well in diagnosing glaucoma, the translational relevance of such work for glaucoma care is

unclear. Such algorithms may be useful in the setting of community-based screenings, where the focus is identifying the presence or absence of glaucoma. The algorithms are less relevant, however, for monitoring patients with glaucoma, when the ultimate question is whether the disease is progressing. Approximately 10% of patients observed longitudinally in a treated population experience rapid worsening of their glaucoma (based on serial visual field testing).⁴ Identifying these individuals and monitoring and/or treating them aggressively should be a key goal for glaucoma providers observing patients longitudinally.

To address this issue, our group has developed models that can identify, with relatively good performance, patients at high risk based on early visits.⁵ We have also developed models that can forecast which eyes are at the highest risk of requiring surgery for uncontrolled glaucoma.⁶ Access to such models in clinical practice could allow physicians to triage patients by predicting which have a high likelihood of requiring surgical intervention and thus should be monitored by a glaucoma specialist versus who is at less risk of requiring surgery and can be observed by a comprehensive eye care provider.

In the future, we not only aim to forecast disease risk but also predict how various treatments (medication, laser therapy, surgery) may reduce or eliminate someone's risk of worsening glaucoma. Such models could help us

AT A GLANCE

- ▶ The field of ophthalmology generates large amounts of rich multimodal data, enabling AI models to be trained for various tasks.
- ▶ Although basic research on AI models in glaucoma has advanced significantly, much work remains to translate this progress into clinical care.
- ▶ We must develop systems to display AI model results in real time to clinicians and also understand how clinicians interact with these results.
- ▶ In time, AI models could help to reduce the risk of vision loss from glaucoma by facilitating better risk forecasting and treatment selection, allow physicians to dedicate more energy to patient counseling, and help eye care providers to appropriately care for the growing number of patients.

“A BETTER UNDERSTANDING IS REQUIRED OF HOW CLINICIANS INTERACT WITH DIFFERENT RISK PREDICTION MODEL USER INTERFACE DESIGN ELEMENTS, SUCH AS THE INTERPRETABILITY OF MODEL RESULTS OR DISPLAYS OF MODEL UNCERTAINTY. INCREASING (OR DECREASING) [USER INTERFACE] INTERPRETABILITY AND UNCERTAINTY MAY ENHANCE CLINICIANS’ TRUST IN THE MODEL, THEIR PERFORMANCE IN SELECTING THE CORRECT MANAGEMENT STRATEGY, AND THEIR EFFICIENCY.”

select the treatment with the highest probability of halting vision loss in patients with glaucoma.

TRANSLATION TO CLINICAL CARE

Although basic research on AI models in glaucoma has advanced significantly, much work remains to translate this progress into clinical care. First, systems must be developed to ingest various streams of patient data (visual field tests, OCT scans, and text-based clinical examination results) so that AI risk predictions can be made in real time and displayed to the clinician. This requires the development of a secure cloud-based infrastructure where models have access to incoming data streams to perform the necessary computations. The uptake of the DICOM standard⁷ for medical imaging and visual field data by various device manufacturers may allow such a cloud-based, real-time risk prediction system to become a reality. Additionally, a better understanding is required of how clinicians interact with different risk prediction model user interface (UI) design elements, such as the interpretability of model results or displays of model

uncertainty. Increasing (or decreasing) UI interpretability and uncertainty may enhance clinicians’ trust in the model, their performance in selecting the correct management strategy, and their efficiency. Clinicians must be involved throughout the UI design process, and user studies must be conducted to identify the impact of varying UI elements. Finally, the effects of AI risk and treatment suggestion models on patient outcomes must be studied systematically. In future clinical trials, patients may be randomly assigned to AI-assisted care versus standard care, with the rates of functional and structural progression assessed in each arm.

When such AI models are deployed in clinics, they could improve patient care and the clinician experience in several ways. First, they may reduce the risk of vision loss from glaucoma by facilitating better risk forecasting and treatment selection. Next, by undertaking some of the clinicians’ most difficult mental work and decreasing the cognitive demand, AI systems may allow physicians to dedicate more energy to patient counseling. Finally, by improving clinical

efficiency, such models may help eye care providers to appropriately care for the growing number of glaucoma patients as the population ages. ■

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