Artificial Intelligence (AI) for Glaucoma Progression

Outline

- What is glaucoma
- Causes of glaucoma
- Types of glaucoma
- Who is at risk
- Global impact
- AI timeline
- AI definitions
- AI and glaucoma
- The Harvard study
- What's next?

What is Glaucoma?

A brief review

- A group of eye diseases causing optic nerve damage
- Eye pressure plays a role damaging the delicate nerve fibers
When significant number of nerve fibers are damaged, blind spots develop in the field of vision.

Once nerve damage and visual loss occur, it is permanent.

Most people don’t notice these blind areas until much of the optic nerve damage has already occurred.

Glaucoma is the number TWO leading cause of blindness after cataract, especially in elderly.

Early detection and treatment by ophthalmologist are the keys to preventing optic nerve damage and vision loss from glaucoma.

It has been proposed that the word glaucoma originates from the ancient Greek word Γλαύκος (glaucos) a noun and adjective originating from the verb Γλαύσσω (glausso), meaning "to glow" or "to shine".

This glows or shine is perhaps related to the "hot" eye with acute glaucoma.
A brief review

Exact cause is not fully understood

Involves mechanical compression and/or decreased blood flow to the optic nerve

Although high eye pressure sometime leads to glaucoma, many people can develop glaucoma with “normal” eye pressure

Early detection and treatment by ophthalmologist with help of AI are the keys to preventing permanent optic nerve damage and vision loss from glaucoma

### Types of Glaucoma

<table>
<thead>
<tr>
<th>Form of glaucoma</th>
<th>Angle (anatomic)</th>
<th>Angle (gonioscopy)</th>
<th>Outflow impairment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Open Angle Glaucoma (90%)</td>
<td>Open</td>
<td>Completely open. Structures appear normal</td>
<td>In the trabecular meshwork (open angle)</td>
</tr>
<tr>
<td>Secondary Open Angle Glaucoma (5-14%)</td>
<td>Open</td>
<td>Completely open. Trabecular meshwork and secondary outflow pathways visible</td>
<td>Trabecular meshwork, cilioretinal shunt, neovascularization</td>
</tr>
<tr>
<td>Primary Angle Closure Glaucoma (1%)</td>
<td>Closed</td>
<td>No angle structures visible</td>
<td>No intrinsic outflow</td>
</tr>
<tr>
<td>Secondary Angle Closure Glaucoma (1-4%)</td>
<td>Closed</td>
<td>No angle structures visible</td>
<td>No intrinsic outflow</td>
</tr>
<tr>
<td>Congenital and Developmental Glaucoma (1%)</td>
<td>Undifferentiated</td>
<td>Open. Occulting endothelial tissue and lack of differentiation visible</td>
<td>In the trabecular meshwork which is not fully developed or is occluded by melanotic tissue (Stafleu meshwork)</td>
</tr>
</tbody>
</table>
Warning signs?

- Most patients completely asymptomatic
- Trouble adjusting to dark rooms
- Recurrent pain in or around eyes
- Sudden hazy or blurry vision
- Red eye
- Loss of peripheral vision

Risk Factors?

- Age
- Elevated IOP
- African ancestry
- Thin corneas
- Family history
- Nearsightedness
- History of injury to eye
- Steroid use

Artificial intelligence in glaucoma
Where we started

- Hermann Von Helmholtz
  - German physician/physicist
  - Revolutionized ophthalmology with invention of ophthalmoscope in 1800s

Definitions

- Artificial intelligence
  - The field of computer science dedicated to solving cognitive problems commonly associated with human intelligence, such as learning, problem solving, and pattern recognition.
- Machine learning
  - Subset of AI techniques which use statistical methods to enable machines to improve with experience
- Deep learning
  - Subset of machine learning in which multilayer neural networks learn from vast amounts of data
How far we have come

- Tonometry
  - IOP
- Ophthalmoscopy
  - Optic disc parameters
- Gonioscopy
  - Angle parameters
- Perimetry
  - Visual field/retinal sensitivity
- Pachymetry
  - Corneal thickness
- OCT
  - RNFL thickness

Glucoma assessment is data rich

Why AI?

- The idea behind a computational approach is to utilize all this data in a more efficient way
Growing interest

AI Publications in Ophthalmology

Types of AI

SUPERVISED LEARNING

Types of AI

UNSUPERVISED LEARNING
Issue | Heavy Workloads | Varying diagnostic skill | Areas without specialists | Delayed treatment
---|---|---|---|---
Method | Octopus fundus image analysis with AI

Results | Reduce mistakes, improve safety | Ensure consistent, high quality diagnosis | Prompt diagnosis from anywhere, integrate | Early diagnosis leads to timely care, cut costs

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Glucoma

An Artificial Intelligence Approach to Detect Visual Field Progression in Glaucoma Based on Spatial Pattern Analysis

- Background
  - Visual fields can be difficult to interpret
- How to detect progression
  - Either clinical based evaluation or computer based algorithms
- Applied unsupervised AI technique
  - Identified 16 recognizable patterns
Summary
- Developed new method to detect VF progression in glaucoma by quantifying the changing of VF patterns
- Using unsupervised artificial intelligence method
- Proven to be superior than four typical existing methods of progression detection
- This model could be incorporated into clinical practice to yield more accurate diagnosis of glaucoma progression

AI and Glaucoma, What’s Next?
- AI can analyze and categorize data from VF, ON structure (OCT, photo) and a combination thereof to identify disease severity, determine disease progression, and/or recommend referral for specialized care
- Algorithms have become increasingly complex in recent years, utilizing both supervised and unsupervised methods of AI, often outperforming standard global indices and expert observers.

- There remains no clearly defined gold standard for determining the presence and severity of glaucoma, which undermines the training of these algorithms
- Future work must employ more robust definitions of disease, optimize data inputs for AI analysis, and improve methods of extracting knowledge from learned results
- Artificial intelligence has the potential to revolutionize the screening, diagnosis, and classification of glaucoma by earlier detection of new disease patterns.
References