INPLASY

The Value of Machine Learning in Glaucoma Diagnosis: A Meta-Analysis

INPLASY202460010
doi: 10.37766/inplasy2024.6.0010
Received: 04 June 2024
Published: 04 June 2024

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ADMINISTRATIVE INFORMATION

Support - "This Meta-Analysis is Unfunded".

Review Stage at time of this submission - The review has not yet started.

Conflicts of interest - None declared.

INPLASY registration number: INPLASY202460010

Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 04 June 2024 and was last updated on 04 June 2024.

INTRODUCTION

Review question / Objective This meta-analysis aims to synthesize the results of relevant literature to further explore the application value of machine learning in the diagnosis of glaucoma.

Condition being studied Glaucoma is a group of progressive optic neuropathies characterized by damage to the optic nerve and gradual loss of vision, which can ultimately lead to blindness. This damage is often associated with elevated intraocular pressure (IOP), but it can also occur within the range of normal IOP. Glaucoma is one of the leading causes of irreversible blindness worldwide.

METHODS

Participant or population Patients with glaucoma or individuals at risk for glaucoma.

Intervention Using machine learning algorithms for the diagnosis of glaucoma.

Comparator Traditional methods for diagnosing glaucoma.
These methods may include:
1、Intraocular pressure measurement (Tonometry): Assessing the risk of glaucoma by measuring the intraocular pressure.
2、Visual field testing (Perimetry): Detecting defects in the visual field through visual field examination, which is an important indicator of glaucoma progression.
3、Fundus examination (Ophthalmoscopy): Evaluating the condition of the optic nerve by directly or indirectly examining the optic nerve head with an ophthalmoscope.
4、Optical coherence tomography (OCT): Measuring the thickness of the retinal nerve fiber layer (RNFL) using high-resolution imaging technology, which is a sensitive indicator of optic nerve damage in glaucoma.

5、Corneal thickness measurement (Pachymetry): Measuring the thickness of the cornea, as corneal thickness can affect the accuracy of intraocular pressure measurements.
6、Gonioscopy: Examining the structure of the anterior chamber angle to determine the potential risk of angle-closure glaucoma.

Study designs to be included Diagnostic accuracy studies, which assess the accuracy, sensitivity, specificity, and other metrics of machine learning algorithms in the diagnosis of glaucoma.

Eligibility criteria Inclusion Criteria:
Study Population: The study should involve patients with glaucoma or individuals at risk for glaucoma.
Intervention: The study should use machine learning algorithms as a diagnostic tool.
Comparison: The study should compare with traditional methods for diagnosing glaucoma.
Outcome Measures: The study should report metrics related to diagnostic accuracy, such as sensitivity, specificity, area under the curve (AUC), etc.
Exclusion Criteria:
Irrelevant Studies: Studies unrelated to the diagnosis of glaucoma.
Non-Machine Learning Algorithms: Studies that do not use machine learning algorithms for diagnosis.
Poor Quality: Studies with poor methodological quality or inadequate reporting.
Duplicate Publications: Data that has already been included in other studies that are being included.

Information sources Information is sourced from the following major literature databases: PubMed, EMBASE, Cochrane Library, Web of Science, Scopus, and Google Scholar, among others.

Main outcome(s) Diagnostic Accuracy: (1) Sensitivity: True positive rate, which is the ability of the algorithm to correctly identify patients with glaucoma. (2) Specificity: True negative rate, which is the ability of the algorithm to correctly identify individuals without glaucoma. (3) Accuracy: The proportion of correct diagnoses, including both true positives and true negatives.
Area Under the Curve (AUC): The area under the ROC curve (Receiver Operating Characteristic curve), used to assess the algorithm's sensitivity and specificity in a combined manner.
Positive Predictive Value (PPV) and Negative Predictive Value (NPV): The probabilities that the algorithm's positive and negative predictions are correct, respectively.
Misdiagnosis and Undiagnosed Rates: The frequency of incorrect diagnoses and missed diagnoses of glaucoma by the algorithm.

Quality assessment / Risk of bias analysis We utilized the QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies) tool for the evaluation of literature quality. This tool is specifically designed for assessing the quality of diagnostic accuracy studies and encompasses four domains: patient selection, index test, reference standard, and flow and timing.

Strategy of data synthesis 1. Data Extraction: Extract relevant diagnostic performance metrics from the included studies, such as sensitivity, specificity, accuracy, positive predictive value (PPV), negative predictive value (NPV), area under the curve (AUC), etc.
2. Heterogeneity Assessment: Use statistical methods (e.g., I^2 statistic) to assess the heterogeneity among studies. If significant heterogeneity is present, a random-effects model may be needed for data pooling.
3. Effect Size Aggregation: Use appropriate statistical methods (e.g., fixed-effects model or random-effects model) to aggregate the effect sizes from individual studies. For diagnostic accuracy studies, a bivariate model or HSROC (Hierarchical Summary Receiver Operating Characteristic) model is often used to consider sensitivity and specificity simultaneously.
4. Forest Plot: Create a forest plot to visualize the effect sizes from individual studies and the pooled effect size.
5. Funnel Plot and Bias Assessment: Use a funnel plot to assess publication bias and conduct statistical tests (e.g., Egger's test) to evaluate potential small-study effects.

Subgroup analysis If data allow, perform subgroup analyses to explore differences in effect sizes among different subgroups (e.g., different types of machine learning algorithms, different types of glaucoma,etc.).

Sensitivity analysis Conduct sensitivity analyses to assess the robustness of the results, for example, by excluding low-quality studies or using different models for analysis.

Country(ies) involved China (Anqing Municipal Hospital).

Keywords Glaucoma、Machine Learning、Diagnosis、Deep Learning、Optic Nerve、

Intraocular Pressure、Visual Field、Sensitivity、Specificity.

Contributions of each author

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