The Use of Artificial Intelligence in Choroidal Neovascularisation

Mohammad Anas,[1,2] Ahmed Ellabban,[2] Muhammad Habbas,[2] Tayyab Hasan,[2] Hashaam N Choudhry,[2] Sameer Khan[2]

[1]Medical Student, Faculty of Life Sciences & Medicine, King's College London, United Kingdom;
[2]Student, Institute of Ophthalmology, University College London, United Kingdom

Commercial Disclosures: None

Background

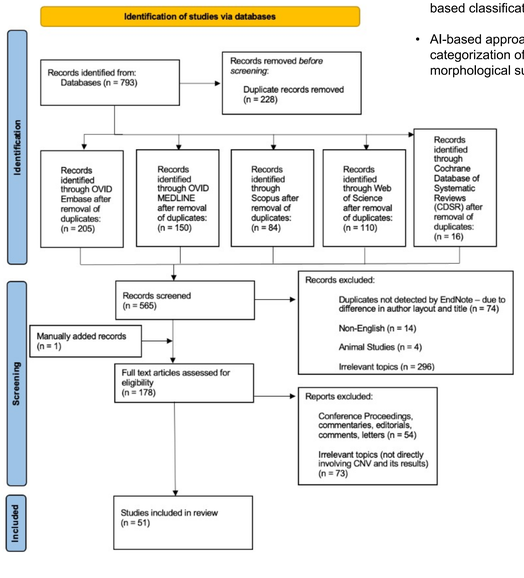
Choroidal Neovascularisation (CNV) is a pathological condition characterised by the abnormal growth of blood vessels in the sub-retinal space or sub-retinal pigment epithelium (RPE) space. It is associated with various primary diagnoses, including Age-Related Macular Degeneration (AMD) and Pathological Myopia. As the field of modern medicine shifts towards utilising Artificial intelligence (AI), in ophthalmology, it has already demonstrated significant success in diagnosing and managing ocular conditions such as AMD, diabetic retinopathy and glaucoma. [1] Given the sight-threatening nature of CNV and the importance of early diagnosis, integrating AI in CNV diagnosis, classification and segmentation has the potential to greatly improve clinical decision making and patient management.

Objectives

This literature review aims to synthesise the current state of AI applications in CNV and identify research gaps and future directions in this area. The objectives include understanding the capabilities of existing AI algorithms, exploring the datasets used in these studies and identifying any limitations in current approaches.

Methods

A comprehensive literature search of OVID Embase, OVID Medline, Scopus, Web of Science and Cochrane Database of Systematic Reviews (CDSR) was conducted, extracting relevant studies and trials for critical appraisal.



Results

- A total of 50 papers, published from 2018 to the present, were selected based on specific inclusion criteria.
- The reviewed studies showcased AI models, particularly convolutional neural networks (CNNs), which demonstrated high performances in CNV diagnosis, classification, and segmentation.

CNV Classification

- Classification of CNV lesions from normal anatomy or other conditions (Drusen and DMO) yielded consistent and accurate results, with sensitivities and specificities frequently exceeding 96%.
- CNNs and U-Net architectures, combined with multi-scale analysis, achieved mean DICE coefficients of up to 0.93, demonstrating the effectiveness of AI-based classification.
- AI-based approaches facilitated the automated categorization of CNV into activity levels and morphological subtypes.

Automated Detection & Diagnosis

- AI models, particularly Convolutional Neural Networks (CNNs), demonstrated high accuracy in identifying CNV lesions in various conditions, such as AMD, pathological myopia, and other related complications.
- Several studies achieved accuracy levels exceeding 95%, with some even achieving 100% accuracy in detecting CNV presence.

CNV Segmentation

- CNN and U-Net models demonstrated successful delineation of CNV lesion boundaries in OCT and FA images.
- Incorporating multi-scale analysis, attention blocks, and anatomical priors improved segmentation, especially for small CNV volumes.
- Failure to focus on small CNV regions in the feature map learning process by many studies indicates a challenge that should be focused on in the future.

Treatment

- Only one paper by Feng et al. which achieved high AUC, sensitivity and specificity showed the ability to predict the effectiveness of anti-VEGF injections for CNV patients, however, this was done on a relatively small dataset of 228 images. [2]
- A similar combination of OCT and response to anti-VEGF treatment was shown in AMD treatment using a random forest classifier, achieving AUCs between 0.7 and 0.8, resulting in being comparable to an expert human grader in predicting both low and high anti-VEGF treatment requirements. [3]

- These AI models often achieved accuracy statistics comparable to or even surpassing those of expert ophthalmologists.
- However, finding a lack of research regarding AI's role in guiding CNV treatment decisions and follow-up, alongside discrepancies in dataset sizes and utilisation, made it challenging to compare different deep learning models.
- Additionally, multi-modal integration was rarely explored, with many papers focusing solely on OCT images.
- Ethical considerations and transparency of models also emerged as factors for the successful clinical integration of AI for CNV.

Conclusion

The findings from this review highlight the transformative potential of AI in CNV, emphasising the importance of ongoing research and collaboration in this field. The integration holds a high promise, offering significant improvements in clinical decision-making and patient outcomes. However, several research gaps persist, including the need for standardised large datasets for external model validation and a greater focus on AI's role in guiding CNV treatment and follow-up. The findings from this review highlight the transformative potential of AI in CNV, emphasising the importance of ongoing research and collaboration in this field.

References

[1] Tufail, A., Rudisill, C., Egan, C., Kapetanakis, V.V., Salas-Vega, S., Owen, C.G., Lee, A., Louw, V., Anderson, J., Liew, G. and Bolter, L., 2017. Automated diabetic retinopathy image assessment software: diagnostic accuracy and cost-effectiveness compared with human graders. Ophthalmology, 124(3), pp.343-351.

[2] Feng, D., Chen, X., Wang, X., Mou, X., Bai, L., Zhang, S. and Zhou, Z., 2023. Predicting effectiveness of anti-VEGF injection through self-supervised learning in OCT images. Mathematical Biosciences and Engineering, 20(2), pp.2439-2458.

[3] Bogunovic H, Waldstein SM, Schlegl T, et al. Prediction of anti-VEGF treatment requirements in neovascular AMD using a machine learning approach. Invest Ophthalmol Vis Sci. 2017; 58: 3240–3248.