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Machine Learning in OCT Radiomics for Predicting Intraocular Inflammation

Neovascular age-related macular degeneration (nAMD) represents a severe form of macular degeneration characterised by the growth of abnormal blood vessels originating from the choroid, breaking into the sub-retinal pigment epithelium space. This condition is primarily mediated by vascular endothelial growth factor (VEGF), making anti-VEGF agents the cornerstone of nAMD treatment. However, a small subset of patients experiences intraocular inflammation (IOI) as an adverse reaction to these treatments. This study explores the innovative use of optical coherence tomography (OCT)-derived texture-based radiomics features to identify early biomarkers for IOI, potentially allowing clinicians to pre-emptively alter treatment strategies to avoid severe complications.

The Role of Radiomics in Early Detection

The study's primary objective was to investigate whether texture-based radiomics features from spectral-domain OCT (SD-OCT) images could be predictive biomarkers for IOI. By analysing the vitreous compartment of the eye, researchers aimed to detect subtle heterogeneities that might indicate early inflammatory changes. A comprehensive set of 481 texture-based radiomics features was initially extracted, focusing on aspects such as texture uniformity, contrast, and edge sharpness within the vitreous humour. The most discriminative features were identified using the Wilcoxon Rank Sum test, which was subsequently used to train a Random Forest (RF) classifier. This classifier was tasked with differentiating between patients who developed IOI and those who did not, both at a pre-IOI timepoint and at the event of inflammation.

Study Design and Statistical Analysis

The analysis was based on a subset of 67 patients from the phase 3 HAWK trial, which compared the efficacy of aflibercept and brolucizumab. The cohort was divided into a safety group, which included patients who experienced IOI, and a control group, matched for propensity. The RF classifier demonstrated robust predictive capabilities, achieving an AUC of 0.76 for predicting IOI at the pre-IOI timepoint and 0.81 at the event timepoint. These results were validated using an independent test set, ensuring the model's generalizability and minimising the risk of overfitting. The classifier's performance metrics, including accuracy, sensitivity, and specificity, underscored its potential utility in clinical settings for early identification of patients at risk of developing severe inflammatory reactions.

Clinical Implications and Future Directions

Identifying early IOI signals through OCT-derived radiomics has profound implications for clinical practice. Early detection could enable ophthalmologists to adjust anti-VEGF therapy, potentially preventing the progression to severe inflammatory states like retinal vasculitis or vascular occlusions. This capability is particularly valuable given the high stakes involved in treating nAMD, where the primary goal is to preserve vision and prevent further deterioration. The study's findings suggest that specific texture features within the vitreous compartment—such as those related to the Laws and Gabor filter families—indicate IOI risk. These features likely correspond to physical manifestations like hyperreflective deposits or cellular debris, which are not always visible to the naked eye but can be detected through advanced imaging techniques.

Moreover, the use of texture-based radiomics as a non-invasive biomarker aligns with the broader trend towards personalised medicine. By tailoring treatment plans based on individual risk profiles derived from detailed imaging data, clinicians can offer more precise and safer therapeutic interventions. This approach not only enhances patient outcomes but also contributes to the more efficient use of healthcare resources by potentially reducing the need for emergency interventions or additional treatments caused by unforeseen adverse reactions.

Integrating OCT-derived radiomics features into clinical practice offers a promising avenue for enhancing the management of nAMD. The ability to predict IOI before its clinical manifestation enables more informed decision-making and risk management. However, while the initial findings are promising, further research is needed to validate these biomarkers across larger, more diverse patient populations. Future studies should also explore the integration of multi-modal imaging data, such as fluorescein angiography and fundus photography, to further refine the predictive

models.

Source: **Cell Heliyon Journal**

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