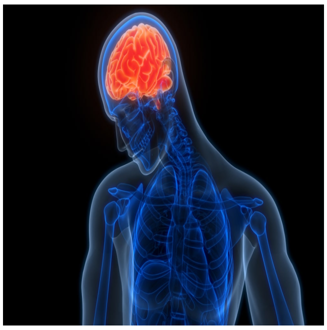
Predicting Haemorrhagic Transformation of AIS with AI Models



Haemorrhagic transformation (HT) represents a critical complication for patients with acute ischemic stroke (AIS) undergoing intravenous thrombolysis (IVT). The risk of HT poses a significant challenge for clinicians, as it is associated with poor clinical outcomes and limits the widespread application of IVT. Accurate prediction of HT, particularly severe subtypes like parenchymal haemorrhage (PH) and PH-2, is crucial for guiding treatment decisions. A recent multicentre study introduced predictive models utilising deep learning (DL) and non-contrast computed tomography (NCCT), combined with clinical data, to address the limitations of existing scoring systems.

Deep Learning in Stroke Prediction

Deep learning has shown transformative potential in the medical field, particularly in analysing imaging data. In this study, a DenseNet50-based neural network was developed to extract critical features from NCCT scans. This model was designed to address limitations such as small datasets and variability in patient conditions. Techniques such as pretraining, self-supervised learning and data augmentation were employed to enhance the robustness of the model. The inclusion of multidimensional imaging data allowed the model to analyse not only infarcted regions but also surrounding areas, including tissue heterogeneity and density, which are often linked to HT.

The DL model demonstrated superior performance in predicting HT compared to established clinical scores such as SEDAN and GRASPS. In the test cohort, it achieved an area under the receiver operating characteristic curve (AUROC) of 0.920, underscoring its potential as a reliable tool for identifying at-risk patients. Additionally, the study incorporated Grad-CAM visualisation to provide interpretability, showing that the model's regions of interest often overlapped with those identified by radiologists. This alignment highlighted the model's capability to focus on critical areas influencing HT outcomes.

Integrating Clinical and Imaging Data

To further improve accuracy, the researchers developed an ensemble model combining imaging and clinical data. Six clinical factors were identified as significant predictors of HT: the National Institute of Health Stroke Scale (NIHSS) score at admission, monocyte count, baseline blood glucose levels, neutrophil-to-lymphocyte ratio (NLR), history of atrial fibrillation and the time from symptom onset to CT scan. These factors were selected through univariable and multivariable analyses, ensuring that the model integrated key predictors of HT risk.

The ensemble model achieved an AUROC of 0.937 in the test cohort, outperforming both the standalone DL and clinical models. Notably, it provided accurate risk assessments for severe subtypes of HT, including PH and PH-2, which are associated with poor prognoses. The ability to combine whole-body clinical data with localised imaging findings enabled the model to capture a comprehensive picture of each patient's condition. This holistic approach marked a significant improvement over existing clinical scores, which often rely on narrower datasets.

Clinical Implications and Future Directions

The findings of this study have important implications for clinical practice. By offering rapid and accurate predictions of HT, the ensemble model has the potential to transform decision-making for AIS patients undergoing IVT. Its performance surpasses traditional scoring systems, providing clinicians with a more reliable tool to assess the risk of adverse outcomes and tailor treatment strategies accordingly. For example, patients identified as high-risk could be prioritised for closer monitoring or alternative therapies, thereby mitigating the likelihood of complications.

Despite its promising results, the study acknowledges several limitations. The dataset, while multicentre, requires further validation in larger and more diverse populations to ensure generalisability. Additionally, the model does not differentiate between symptomatic and asymptomatic HT, nor does it predict long-term clinical outcomes. Addressing these limitations in future research could refine the model's applicability and utility in routine clinical settings.

Another area for future exploration is enhancing the interpretability of DL models. While techniques like Grad-CAM provide insights into the decision-making process, achieving greater transparency remains a challenge for neural networks. Further advancements in visualisation techniques could help clinicians better understand the rationale behind model predictions, increasing trust and adoption in clinical practice.

The integration of deep learning and clinical data into predictive models represents a significant step forward in the management of acute ischemic stroke. By providing a rapid and accurate method for assessing the risk of HT and its subtypes, these models address critical gaps in existing approaches. The ensemble model's ability to combine imaging and clinical data has the potential to improve patient outcomes, reduce the risks associated with IVT and support personalised treatment strategies. While further research is needed to validate and expand its application, the study highlights the transformative potential of AI in advancing stroke care.

Source: **European Radiology Experimental**

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