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Automatic detection of intradialytic paroxysmal atrial fibrillation and flutter in single-lead ECG

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Objectives: Intradialytic paroxysmal atrial fibrillation and flutter (AF/AFL) can result in hemodynamic instability and suboptimal dialysis dose. To achieve appropriate prevention and management of intradialytic paroxysmal AF/AFL, the first step is precise detection during hemodialysis session. Herein, we developed a Transformer-based model to automatically segment AF/AFL in single-lead echocardiography (ECG) by self-supervised learning and masked signal modelling.

Methods: To develop a model, we used 11 open source databases containing 5,684-hour ECG signals from 2,017 patients. To validate a model, intradialytic ECG signals were retrieved from 4-hour 30 hemodialysis sessions at Seoul National University Hospital. AF/AFL was defined as ≥ 10 -second duration, and the Swin Transformer model with wide window-size was adopted as a main architecture. The model performance was evaluated with F1 score.

Results: The model achieved F1 scores of 0.9612 and 0.9731 in segmenting AF/AFL and other rhythms, respectively. Throughout cross-database, F1 scores ranged between 0.8889 and 0.9896 depending on the prevalence of AF/AFL. Ablation analysis identified that the performance was attributable to pretraining with masking random signals and unlabeled database. The present model was superior to previous models in detecting AF/AFL particularly when training and testing databases were matched. When applying to intradialytic ECGs, the model showed favorable performance in segmenting AF/AFL areas.

Conclusions: The model with self-supervised learning and masked signal modelling maintains robust performance in various databases, which will help automatic detection of intradialytic paroxysmal AF/AFL.

Figure 1. Masked Signal Modelling for Transformer pretraining