The Extended ECG Improves Classification of Atrial Fibrillation Type and Prediction of Recurrence after Catheter Ablation

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Background

The standard 10-second 12-lead electrocardiogram (ECG) is the default tool to diagnose ongoing atrial fibrillation (AF). Suboptimal lead placement to capture atrial conduction properties and short recording length may however limit its use as a tool to classify AF complexity and predict treatment outcome.

Objective

We investigated the added value of features derived from an extended ECG (eECG) with additional atrial-specific lead locations and longer recording length, when classifying AF type and predicting AF recurrence after catheter ablation, compared to features derived from the standard ECG.

Methods

ECGs with 3 additional atrial leads, 5-minute duration, and 500 Hz sampling frequency, were recorded in 242 patients before catheter ablation of AF, during sinus rhythm (SR, n=159) or AF (n=83). In SR features of the signal averaged P-wave (amplitude, area, entropy, and complexity) and beat-to-beat P-wave variability were computed. In AF F-wave features (dominant frequency, spectral organization index and entropy, amplitude, and variability) were determined. P- and F-wave features were used to classify AF type (paroxysmal or persistent AF) and to predict AF recurrence within 1 year after ablation. Classification and prediction models were constructed using feature selection (elastic net logistic regression) and performance (area under the receiver operation characteristics curve, AUC) was compared to models restricted to features that could be derived from a standard 10-second 12-lead ECG.

Results

Classification of paroxysmal/persistent AF using SR ECGs (n=119/40 respectively) was improved by using eECG P-wave features compared to standard features (median AUC 0.76 vs 0.58, $p < 0.001$, using P-wave amplitude, entropy, complexity, and variability), also after correcting for clinical characteristics. In AF ECGs a small improvement in classification of AF type (n=30/53) was observed when comparing standard and eECG models that corrected for clinical characteristics (AUC 0.74 vs 0.71, $p < 0.01$, using F-wave amplitude, variability, and weight). Follow-up of atrial rhythm after ablation was available in 161 patients (SR ECG: n=110, 32 AF recurrences; AF ECG: n=51, 31 recurrences). Prediction performance of recurrence after ablation was poor using standard P-wave features but improved by using eECG features (AUC 0.60 vs 0.70, $p < 0.001$, using P-wave entropy and complexity), and further increased when complemented by clinical characteristics (AUC 0.81, $p < 0.001$ compared to eECG model, using AF type). Both standard and eECG F-wave features prediction models performed well (AUC 0.75 vs 0.78, p=0.06, using dominant frequency and organization index). Performance increased by adding clinical characteristics (AUC 0.81 and 0.83, using history of vascular disease).

Discussion

P- and F-wave features of the extended ECG enable moderate to good classification of paroxysmal versus persistent AF and prediction of AF recurrence after catheter ablation. The extended ECG significantly improved classification or prediction performance with respect to a standard 10-second 12-lead ECG.