Refined Multiscale Entropy Predicts Early Failure in Electrical Cardioversion of Atrial Fibrillation

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Background and Aim. Electrical cardioversion (ECV) is a well-established part of the rhythm control strategy for atrial fibrillation (AF) management. Even though its high initial effectiveness, most patients relapse to AF during the first weeks. Hence, identification of patients at high risk of early AF recurrence is important for a rationale therapeutic strategy. For that purpose, a variety of indices characterizing fibrillatory (f) waves have been proposed, but they have revealed limited predictive ability, mostly below 60%. Moreover, these metrics cannot consider the presence of nonlinear dynamics at different time-scales within the cardiovascular system. This work thus explores whether a multiscale entropy (MSE) analysis applied to the f-waves can provide improved preoperative predictions about ECV outcome in AF patients.

Methods. Two MSE approaches were considered, including traditional MSE and a refined version (RMSE). Both algorithms were applied to the main component of f-waves extracted from standard surface lead V1 by adaptive QRST cancellation. Entropy values were then computed for the first 20 time-scales (i.e. τ = 1:20). As a reference, previously proposed predictors, such as dominant frequency (DF) and f-wave amplitude (FWA), were also computed. A database of 70 patients with persistent AF undergoing ECV was analyzed. After 4 weeks follow-up, 39 patients relapsed to AF and 31 maintained sinus rhythm (SR).

Results. All the parameters but FWA showed statistically significant differences between patients relapsing to AF or maintaining SR (see table below). RMSE reported the best results for τ = 19, improving its area under the ROC curve (AUC) more than 10% with respect to traditional metrics. Additionally, MSE achieved good results as well for τ = 19.

Conclusions. Investigation of nonlinear dynamics at large time-scales can provide useful insights about underlying complex processes of AF mechanisms, thus improving reliable preoperative predictions of early ECV failure.

Parameter	AF group	SR group	p	Se (%)	Sp (%)	AUC (%)
FWA	0.051 (0.039)	0.049 (0.080)	0.356	41.936	84.615	56.493
DF	5.615 (1.160)	4.883 (1.404)	0.003	69.231	61.290	70.678
MSE ($\tau = 1$)	0.114 (0.039)	0.094 (0.050)	0.004	71.795	58.064	70.389
MSE ($\tau = 19$)	0.616 (0.075)	0.565 (0.066)	< 0.001	92.308	61.290	75.517
RMSE ($\tau = 19$)	0.627 (0.077)	0.568 (0.065)	< 0.001	94.871	58.064	78.164