Renewal rate constants of phase singularity formation and destruction in atrial fibrillation are temporally stable measures of fibrillatory dynamics

Background: The optimal approach for atrial fibrillation (AF) ablation is unknown, with a subset of patients unresponsive to current strategies. In such patients, development of novel mechanism-based approaches could be needed, but this requires a stable, robust and easily measurable marker of underlying AF dynamics. We hypothesized that renewal rate constants λ_f and λ_d, previously shown to quantify rates of phase singularity (PS) formation and destruction during fibrillation, could be used as such a marker.

Objective: We hypothesised λ_f/λ_d are temporally stable and can be used as robust markers of underlying fibrillatory dynamics.

Methods: Basket recordings from n=20 patients (43 epochs) and n= 12 sheep (20 epochs) were studied. Temporal stability of λ_f/λ_d was analyzed by investigating if averages created using 20 second windows (i) have a stable mean, ii) time-independent autocorrelation functions, and iii) if coefficient of variation (CV) of λ_f/λ_d over time are lower than for established measures (dominant frequency (DF) and AF cycle length (AFCL)).

Results: Mean λ_f/λ_d estimated from 20 second windows was constant ($R^2\lambda_f$=0.97; $R^2\lambda_d$=0.99), with time-invariant autocorrelation functions. CV was also lowest for λ_f (3.7% (95%CI,1.6,5.9)) and λ_d (2.6% (1.5,3.8)) compared to DF (16.3% (95%CI,2.5,30)) and AFCL (12.2% (95%CI,6.7,17.7)), and also significantly different to DF ($P < 0.001$) and AFCL ($P < 0.001$).

Conclusions: λ_f/λ_d are temporally stable, providing a robust and clinically usable mechanistic tool to directly quantify AF dynamics, mechanistically connected to rotor regeneration that is the key to underlying AF perpetuation.