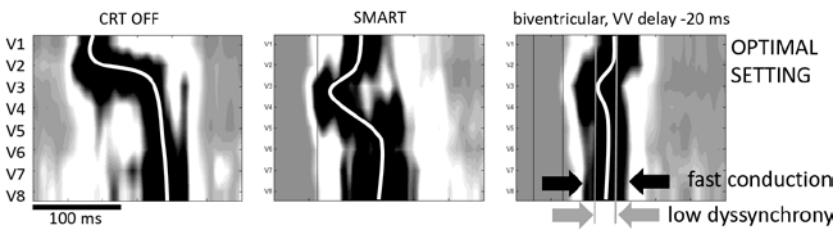
Cardiac Resynchronization Guided by Ultra-High Frequency ECG Maps

P. Jurak[1], M. Matejkova[2], J. Halamek[1], F. Plesinger[1], I. Viscor[1], V. Vondra[1], J. Lipoldova[2], M. Novak[2], R. Smisek[1], and P. Leinveber[2]

[1] The Czech Academy of Sciences, Institute of Scientific Instruments, Brno, CZ
[2] International Clinical Research Center, St. Anne's University Hospital, Brno, CZ

Background: Cardiac resynchronization therapy (CRT) aims to eliminate ventricular dyssynchrony. However, approximately 30 percent of patients are still not appropriately treated. Here we present a technique based on 14-lead ultra-high frequency electrocardiogram (UHFECG, 5kHz) able to measure the immediate effect of CRT settings on electrical ventricular resynchronization.

Method: Resting 1-3 minute UHFECGs were sequentially recorded during different CRT settings: CRT OFF, CRT ON VV delays 0, -20, -40 ms, and SMART sensing (Boston Scientific) in 33 patients. Electrical activation maps were computed from signal-averaged UHFECGs in frequency band 150-1000Hz. The horizontal axis of each map indicates time, and the vertical axis indicates the activation location (V1-V8 lead). The black areas show the location-time of the maximal volume of simultaneously depolarized myocardial cells. The optimal CRT setting is characterized by narrow and vertical activation pattern. Narrowing means faster conduction, narrow and vertical pattern means the elimination of ventricular dyssynchrony.



Electrical activation maps, from left: CRT OFF in LBBB patient, SMART sensing, selected optimal CRT setting.

Results: Optimal CRT setting selected by a physician from electrical activation maps corresponded to minimal mechanical intraventricular delay obtained from echocardiography in 61% of patients, in 27% of patients the difference was within 10 ms interval. Activation maps provide deterministic and straightforward insight into the ventricular depolarization activation pattern. Simultaneous comparison of multiple maps for different CRT settings can be used for selection of optimal pacemaker configuration.