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Resynchronization for shifting conduction patterns - When a coronary sinus lead is not enough

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A 60-year–old patient with heart failure (NYHA II) due to non-ischemic cardiomyopathy with a left ventricular end-diastolic diameter (LVEDD) of 73 mm and left ventricular ejection fraction (LVEF) 20% presented with intraventricular conduction delay (IVCD) and rate-dependent left bundle branch block (LBBB) at a rate above 90/min. During IVCD, ultra-high-frequency ECG (UHF-ECG) ventricular dyssynchrony was 40 ms (Fig. 1, Panel A, top). During LBBB, dyssynchrony increased to 107 ms (Fig. 1, Panel A, bottom). The patient was indicated for resynchronization therapy. One lead was placed in the only available (anterolateral) branch of the coronary sinus (CS), where a Q-LV (i.e., the distance from the onset of the surface QRS complex to the maximal negative deflection of the sensed LV electrogram) was 120 ms during IVCD and 140 ms during the LBBB. The other was placed in the left bundle branch area. Left ventricular (LV) only pacing from the lead placed in the CS, with the atrioventricular delay optimized to allow spontaneous right ventricular (RV) activation, reduced ventricular dyssynchrony during IVCD (Fig. 1, Panel B, top) but could not maintain synchronous activation when the LBBB appeared (Fig. 1, Panel B, bottom). Left bundle branch area pacing (LBBAP) resulted in a pseudo-right bundle branch block with the same morphology during IVCD and LBBB; UHF-ECG mapping showed excellent V3–V8 synchrony and slightly delayed RV activation (Fig. 1, Panel C). After six months of follow-up utilizing LBBAP patient improved in the LVEF to 42%, and LVEDD reduced to 62 mm.

Resynchronization therapy aims to restore normal LV activation resulting from conduction system abnormalities. LV pacing during traditional atrio-biventricular pacing results in a slowly conducting LV wave-front, which may be effective depending on the interaction between LV activation during the conduction abnormality and pacing. Furthermore, the same pacing site may be suboptimal under different conditions, as illustrated when the pattern of LV activation delay changes from IVCD to LBBB (Fig. 1, Panel B, top and bottom). In contrast, LBBAP, by utilizing more natural conduction pathways, was effective during both, which was demonstrated in this case by UHF-ECG mapping (note that UHF-ECG describes electrical synchrony more accurately than QRS duration).

Novel pacing strategies such as LBBAP may provide a single solution for heterogeneous conduction system deficits.

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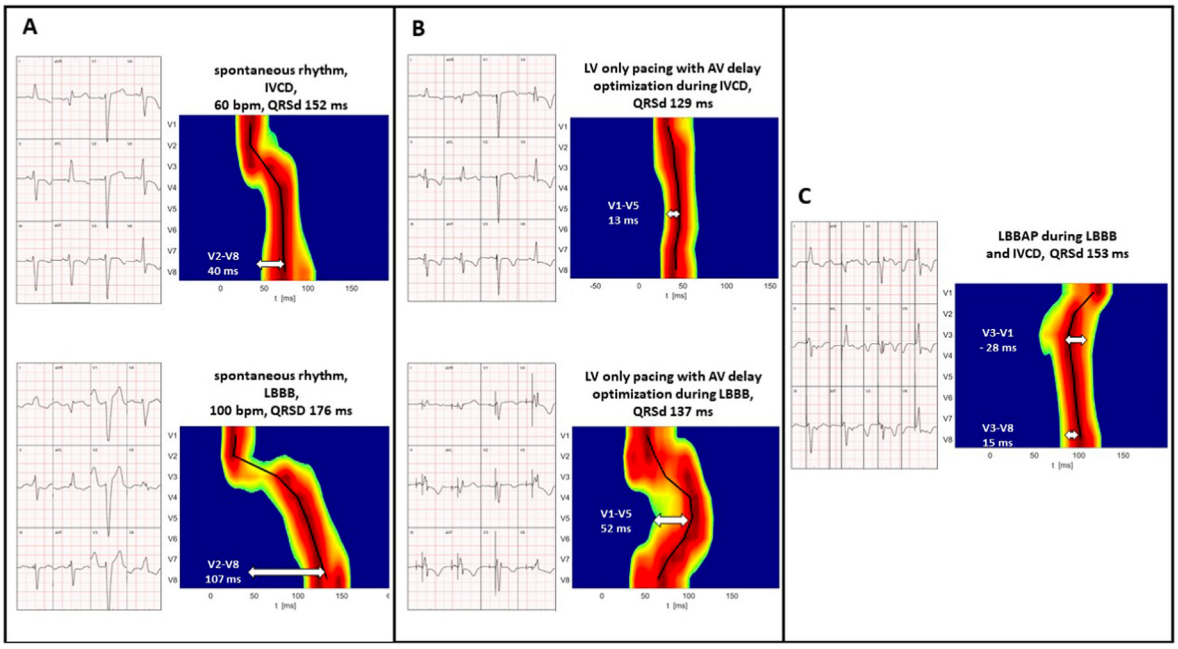

Fig. 1. Figure legend: In each UHF-ECG depolarization map, time is displayed on the x-axis, and V1–V8 chest leads are displayed on the y-axis. The maxima of local activation under specific leads are dark red, and the centers of masses of local activations are connected with a dark line (for details, see Jurak et al. [1]).

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Data availability statement

The data supporting this study's findings are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Karol Curila and Pavel Jurak have filed an US patent No: US 11,517,243B2: "Method of electrocardiographic signal processing and apparatus for performing the method.", and are shareholders of the company VDI technologies.

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