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Mechanisms of action of cardiac resynchronisation therapy by his bundle pacing in patients with heart failure and LBBB

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Background

His bundle pacing (HBP) is a new method for delivering cardiac resynchronization therapy (CRT) but how it achieves resynchronization and how it compares with biventricular pacing (BVP) is not yet understood.

Purpose

1) To perform an acute crossover comparison between HBP and biventricular pacing (BVP), measuring effects on ventricular activation and haemodynamic function.

2) To explore the mechanisms by which HBP shortens left ventricular activation time (LVAT) and improves haemodynamic function compared to BVP.

Methods

We recruited patients with heart failure and left bundle branch block (LBBB) referred for conventional biventricular CRT. We used non-invasive epicardial ECGI mapping to measure left ventricular (LV) activation time and pattern. We compared the haemodynamic effects of HBP with BVP using a high-precision beat-by-beat assessment of systolic blood pressure.

Results

17 patients had a complete electromechanical dataset. HBP was more effective at delivering ventricular resynchronization than BVP: greater reduction in QRS duration (-18.6ms, 95% CI -31.6 to -5.7, p=0.007) and LVAT (-26ms 95% CI -41 to -21, p=0.002). HBP also produced a greater acute haemodynamic response than BVP (4.6mmHg, 95% CI 0.2 to 9.1, p=0.04). The incremental activation time reduction with HBP over BVP correlated with the incremental haemodynamic improvement with HBP over BVP (R=0.7, p=0.04).

ECGI propagation maps were generated, which display activation wavefronts moving over the surface of the ventricles.

In 10 patients, ECGI propagation maps of intrinsic activation (atrial pacing) revealed LV wavefronts obstructed by lines of conduction block. The region beyond the block was activated later and from a different direction. During HBP, wavefronts propagated, uninterrupted, across the line of block.

Conclusions

In patients with heart failure and LBBB, His bundle pacing delivers improved haemodynamic function compared to biventricular pacing. The haemodynamic benefit appears to be driven by more effective ventricular resynchronization. His bundle pacing can overcome conduction block, accelerate wavefront propagation and alter the origins of left ventricular activation, whereas biventricular pacing results in colliding wavefronts from non-physiological origins.
In the remaining 7 patients, propagation maps of intrinsic activation showed LV wavefronts propagating slowly from breakout regions at the border between the left and right ventricles (LV-RV border). During HBP, LV wavefronts originated from different breakout regions and trans-myocardial propagation was more rapid.

During BVP, LV wavefronts originated both from regions on the LV-RV border and from regions within the LV. These wavefronts collided on the LV surface.

Figure 1: LVAT and haemodynamic comparisons of HBP versus BVP as well as static activation maps for atrial pacing (LBBB), His bundle pacing (LBBB resolved) and BVP (non-physiological activation).

Conclusions

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