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CASE REPORT

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Acute electrical and hemodynamic effects of endocardial biventricular pacing using the WiSE CRT system and conventional epicardial biventricular pacing

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Abstract

Wireless left ventricular endocardial pacing with the WiSE CRT system has recently become available as alternative to conventional epicardial CRT pacing. We report the first comparison of the acute electrical and hemodynamic response produced by the two CRT pacing modalities in a patient undergoing WiSE CRT implant after a failed conventional CRT procedure. WiSE CRT pacing showed an additive acute benefit compared with conventional CRT. These findings could potentially translate into long-term clinical benefit and introduce the potential for tri-ventricular pacing using both systems simultaneously.

KEYWORDS

acute hemodynamic response, cardiac resynchronization therapy, heart failure, left ventricular endocardial stimulation, left ventricular epicardial stimulation

1 | INTRODUCTION

Wireless left ventricular endocardial (LV) pacing via the WiSE CRT system (EBR Systems, Inc., Sunnyvale, CA, USA) is an alternative to conventional cardiac resynchronization therapy (CRT) pacing in case of failed CRT procedures, absence of venous access, or in nonresponders.[1] No comparison studies are currently available between the two pacing modalities.

2 | CASE REPORT

A 76-year-old man was admitted with worsening heart failure symptoms despite maximal medical therapy. He had a background of surgical mitral and tricuspid repair with residual moderate LV systolic dysfunction, permanent atrial fibrillation, and AV node ablation, and a St Jude Medical Allure Quadra RF CRT pacemaker was implanted 2 years earlier. A significant increase in the LV pacing threshold was detected, requiring maximum pacing output to achieve LV capture and biventricular pacing. The chest X-ray confirmed an unchanged position of the LV lead. At maximum output, the projected battery life was <12 months.

An LV lead revision was undesirable due to known suboptimal coronary vein anatomy, with no adequate target veins except for the small posterior branch already targeted during the previous CRT implant. A WiSE CRT system with wireless LV endocardial stimulation in combination with the preimplanted right ventricular (RV) pacing device was then offered.

The implant was performed in two stages. Initially, the battery and the ultrasound transmitter were implanted under general anesthesia, in a subcutaneous pocket in the left axilla and in the V intercostal space below the pectoralis muscle, respectively. One week later, after recommencing oral anticoagulant therapy with warfarin (for permanent atrial fibrillation), the endocardial receiver electrode was implanted, under conscious sedation, via right femoral arterial access using a retrograde aortic approach. The site of latest electrical activation during RV-only pacing (Q-LV 140 ms), corresponding to the midbasal lateral segment, was chosen for placement of the endocardial electrode (Figure 1, left panel).[2]

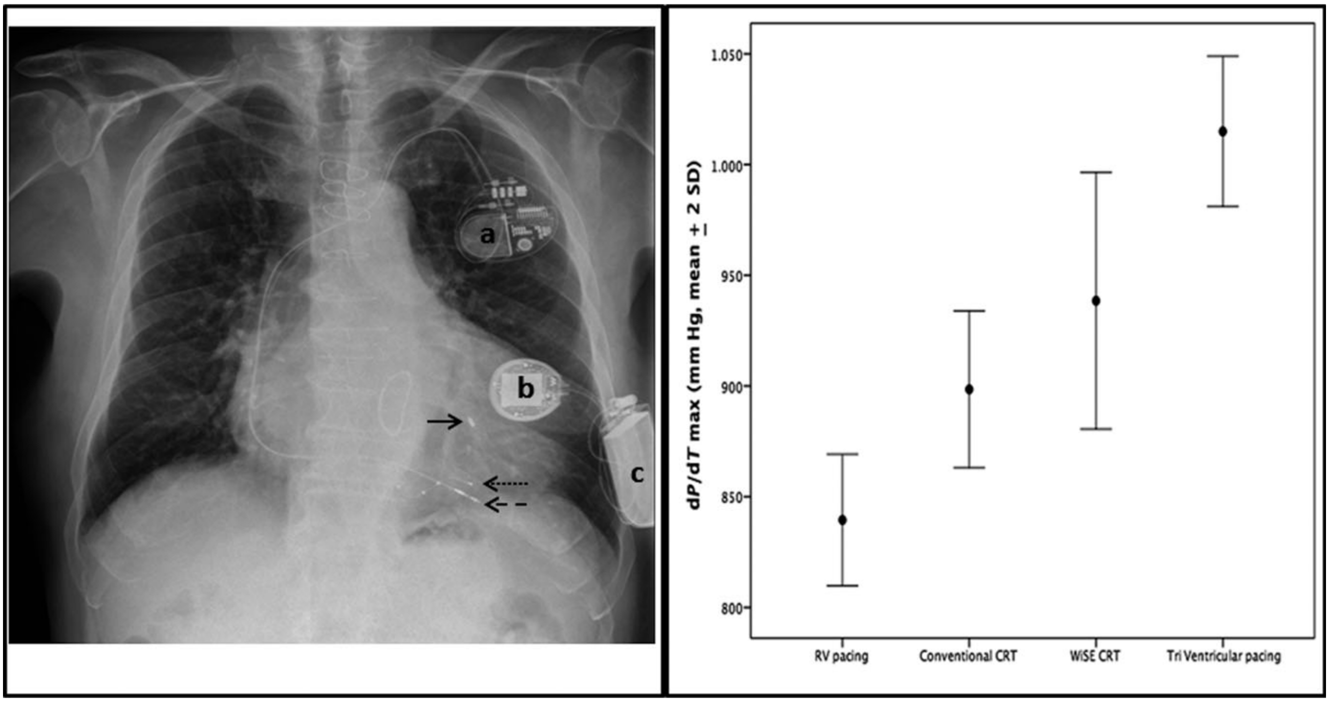

FIGURE 1 Left panel: chest X-ray after WiSE CRT implant. Conventional CRT components: battery in left infraclavicular pocket (a)and pacing leads in RV apex (dashed arrow) and CS vein (dotted arrow). WiSE CRT components: battery (b), powering the transmitter (c), and receiver electrode (continuous arrow), converting ultrasound energy into electrical energy to provide LV stimulation within 2 ms of RV stimulation. Right panel: acute LVdp/dT max measured during different pacing configurations

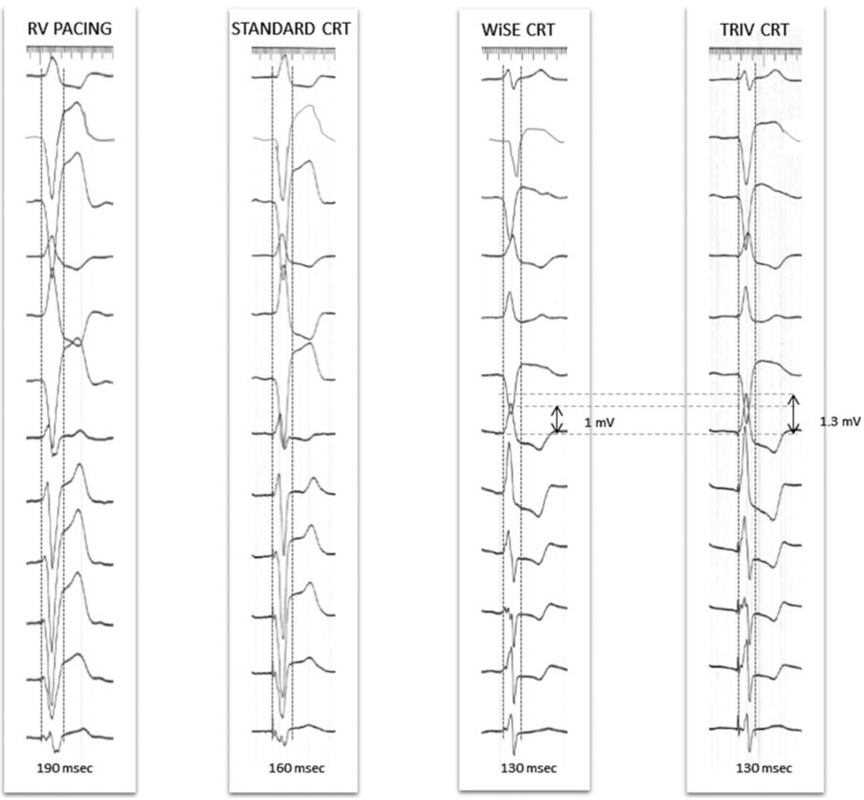

FIGURE 2 ECG morphologies during different pacing configurations

After the implant, a 0.014-inch-diameter high-fidelity Certus Pressure Wire (St Jude Medical—Abbott) was placed retrogradely into the LV via femoral arterial access and used with the accompanying PhysioMon software (RADI Medical Systems, Wilmington, MA, USA) to measure the acute hemodynamic response (LV dP/dT max, maximum rate of rise, or decay of LV pressure) produced by different pacing configurations.

Conventional CRT, WiSE CRT, and triventricular pacing (combination of best epicardial LV pacing, endocardial LV pacing, and RV pacing) were tested (30 seconds each for a minimum of 3 times in random order and return to 30 seconds of RV-only pacing in between measures). Based on the previous echo-guided optimization, three different LV-RV timing offsets were tested with the conventional CRT pacing configuration: LV 30 ms before RV, synchronous LV-RV pacing, and RV 10 ms before LV.

Compared with RV-only pacing, the best conventional CRT pacing (LV to RV 30 ms, CS pacing at maximum output) produced a 7% increase in the dP/dTmax, WiSE CRT pacing (RV synchronous) produced a 12% increase, and triventricular pacing produced a 20% increase (Figure 1, right panel).

On ECG, compared with RV-only pacing (QRS duration 190 ms), the best conventional CRT pacing produced a QRS duration of 160 ms, WiSE CRT pacing produced a dominant R wave in V1 and RS pattern in lead I on ECG with a QRS duration of 130 ms, triventricular pacing produced similar QRS morphology and duration of WiSE CRT pacing, but with a higher amplitude R wave in V1 (1.3 mV vs 1 mV) (Figure 2).

In consideration of the high-pacing threshold of the CS lead, WiSE CRT pacing was preferred to triventricular pacing as the final programmed configuration for the patient. Six months after the implant, the patient reported a significant symptomatic improvement, attaining NYHA class II status. The pacing check showed 99% biventricular pacing. The transthoracic echocardiogram showed 27.5% increase in left ventricular ejection fraction (LVEF) (from 40% to 51%), 27.5% reduction in left ventricular end-systolic volume index (LVESVI) (from 44 to 32 m1/m2), and 18% reduction in left ventricular end-diastolic volume index (LVEDVI) (from 73.5 to 60.5 m1/m2).

3 | DISCUSSION

To our knowledge, this is the first description of the acute electrical and hemodynamic response produced by WiSE CRT pacing in comparison with RV-only pacing, conventional CRT, and triventricular pacing using both systems simultaneously.

The principal findings were as follows:

1. Compared with conventional CRT pacing, WiSE CRT pacing produced an additional increase in the LV dP/dT max and a better acute electrical response (dominant R wave in V1, RS pattern in lead I, and shortest QRS duration) over RV-only pacing.
2. Triventricular pacing produced the best acute hemodynamic effect compared with the other pacing configurations.

Acute ECG changes and LV dP/dT max changes are two of the proposed intraprocedural predictors of CRT response, the rationale being that the hemodynamic, mechanical, and electrical effects of CRT can be immediately seen on a beat-to-beat basis and should be maintained for as long as CRT is delivered.

Our findings support the increasing evidence that endocardial stimulation has several advantages over conventional epicardial pacing: selection of the pacing site not restricted by coronary venous anatomy or phrenic nerve stimulation, faster more homogenous LV activation.[3,4]

Triventricular pacing produced the best hemodynamic effect, likely due to simultaneous recruitment of larger myocardial areas, with more synchronous electrical activation and more effective contraction.

4 | CONCLUSIONS

Our case report suggests an additive electrical and hemodynamic benefit of WiSE CRT compared with conventional CRT, possibly translating into long-term clinical benefit, and introduces the potential for triventricular pacing in appropriate individuals who have functioning LV leads, or multisite ultrasound-based LV endocardial stimulation.

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CONFLICT OF INTEREST

Authors declare no Conflict of Interests for this article.

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