Potential for leadless left bundle branch pacing for cardiac resynchronization: a case report

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Abstract

Introduction: Left bundle branch pacing is a recently described form of conduction system pacing which can correct left-bundle branch block and deliver cardiac resynchronization therapy (CRT). The WiSE-CRT system delivers leadless endocardial pacing and can improve symptoms and left ventricular remodelling in CRT non-responders. Case Report: We describe the case of a 57 year old male who underwent implantation of the WiSE-CRT system after failed conventional CRT. Pacing the left bundle during implant achieved superior electrical resynchronization and equivalent hemodynamic response compared to pacing the lateral wall. Conclusion: This case demonstrates the potential for leadless left bundle branch pacing.

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Case Report:

We describe the case of a 57 year old male who underwent implantation of the WiSE-CRT system after failed conventional CRT. Pacing the left bundle during implant achieved superior electrical resynchronization and equivalent hemodynamic response compared to pacing the lateral wall.

Conclusion:

This case demonstrates the potential for leadless left bundle branch pacing.

Key Words

Cardiac resynchronization therapy, Endocardial pacing, Leadless pacemaker, Conduction system pacing, Left bundle branch pacing.

Introduction:

Left bundle branch pacing (LBBP) has been proposed as an alternative to His bundle pacing, and has been shown to correct left bundle branch block (LBBB) and deliver cardiac resynchronization therapy (CRT) in small observational studies.[1,2] The WiSE-CRT system (EBR systems, Sunnyvale, CA) provides leadless endocardial left ventricular (LV) pacing and improves symptoms and LV remodelling in CRT non-responders.[3,4] The system was originally designed to deliver a leadless electrode to the endocardium of the LV lateral wall to achieve CRT. We describe a case of a patient undergoing leadless LV endocardial pacing following failed conventional CRT. Assessment of different LV endocardial pacing sites prior to electrode implantation revealed stimulation of the LV septum at the site of the left bundle resulted in optimal electrical and hemodynamic indices. This case demonstrates the potential for conduction system pacing by leadless stimulation of the left bundle branch.

Case Report:

A 57-year-old male with ischaemic cardiomyopathy (LV ejection fraction 32%), prior anterior myocardial infarction, and dual-chamber pacemaker for complete heart block underwent upgrade to a CRT-defibrillator. The upgrade procedure was difficult due to small calibre coronary sinus tributaries. The LV lead was placed in a lateral branch of the coronary sinus, however during routine follow-up the lead threshold increased with eventual loss of capture. Further transvenous attempts were unlikely to be successful given the difficulty of the original procedure and therefore we proceeded with leadless endocardial pacing using the WiSE-CRT system as part of an observational cohort study (clinicaltrials.gov NCT03495505). The patient provided written consent for the study, which was approved by local ethics committee.

The WiSE-CRT system was implanted using a previously described technique with a retrograde transaortic approach.[3] Prior to implantation of the LV electrode, different myocardial locations were tested using a roving decapolar catheter (6-F Livewire 115cm, St Jude Medical, Inc., St Paul, Minnesota) to assess for the optimal acute hemodynamic response (AHR) and paced QRS duration. Hemodynamic assessment (LV dP/dt_{max}) was performed with a PressureWire X (Abbott, CA, USA) in the LV cavity using a previously described protocol.[5] LV dP/dt_{max} measurements were recorded using CoroFlow (Coroventis, Uppsala, Sweden) and AHR was expressed as percentage improvement from baseline dual-chamber right ventricular (RV) pacing to pacing performed at different LV endocardial sites. ECGs were recorded simultaneously. LBBP was achieved by pacing the left ventricular aspect of the interventricular septum (figure 1a) at the site of a left bundle potential (figure 2). AHR for different endocardial electrode locations are shown in table 1. An AHR of [?]10% is considered to be a significant response and has been shown to be predictive of LV remodelling.[5] The greatest AHR was seen when pacing the left bundle (34% increase from baseline) and was equivalent to biventricular endocardial stimulation at the mid-lateral wall, although LBBP showed greater electrical resynchronization (QRS duration 106ms, compared to pacing at the mid-lateral LV wall (132ms) and baseline RV-pacing (172ms) as shown in figure 3). The endocardial electrode was deployed in the mid-lateral wall of the LV as the current WiSE-CRT system is not designed to target the left bundle (figure 1b).

Discussion:

Both conventional (epicardial) and endocardial CRT deliver two non-physiological wave-fronts which merge to resynchronize the myocardium. Conduction system pacing can recruit the intrinsic His-Purkinje system and correct LBBB. His bundle pacing is feasible in delivering CRT in heart failure patients, with electrical resynchronization and AHR superior to conventional CRT.[6] However, it may be limited by elevated pacing thresholds at follow-up. LBBP has been more recently proposed as a method to correct LBBB at lower thresholds [1,2] and is usually achieved with delivery tools and techniques for His bundle pacing, with the electrode fixed deep in the interventricular septum via a right ventricular approach. The ability to perform temporary LBBP via a retrograde trans-aortic approach has been demonstrated, with favourable hemodynamics[7] however permanent placement of a lead to the LV septum is not feasible due to the risk of embolic stroke. The WiSE-CRT system does not suffer from this drawback as the device becomes fully endothelialized and therefore does not pose a long-term risk of embolism.

In this case, LBBP was associated with excellent electrical resynchronisation (QRS duration 106ms) and hemodynamic indices. Entirely leadless CRT systems are an attractive option in patients with vascular access issues, such as hemodialysis patients, and in those with recurrent lead complications. While the majority of WiSE-CRT systems are implanted in patients with standard right-sided pacing systems, there have been reports of entirely leadless systems using the WiSE-CRT system in conjunction with a leadless pacemaker in the right ventricle.[8] The current delivery system is designed for implantation of the LV electrode in the lateral wall and rotation of the delivery catheter to reach the septum is technically challenging. Therefore, if leadless LBBP is to be pursued, new delivery systems will likely need to be developed. Furthermore, the endocardial electrode has not been specifically designed to ensure that the 3.6mm barb will sufficiently penetrate from the endocardial surface down to the Purkinje tissue within the septum. The left bundle branch sits closer to the LV aspect of the septum, and LBBP from a right ventricular approach requires deep penetration into the septum, with a reported range of 11-18mm in an observational study of 100 patients.[2] It is therefore likely that a left ventricular approach requires more superficial penetration, but further evaluation is needed.

Conclusions:

In this case, electrical resynchronization appeared superior during LBBP, compared to endocardial pacing in the lateral LV wall, with similar hemodynamic responses. Further studies are required to assess if leadless LBBP is a feasible and effective strategy to deliver CRT.

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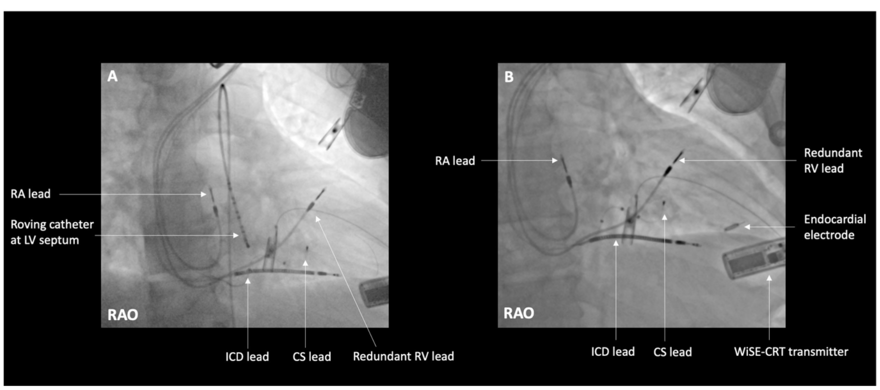
Figure 1. A: Catheter positions during temporary left bundle branch pacing. B: Final endocardial electrode placement in mid-lateral wall of the LV. The existing CS lead is noted to be very proximal in position, with the proximal pole likely located in the main body of the coronary sinus, which explains the high lead capture threshold and eventual failure.

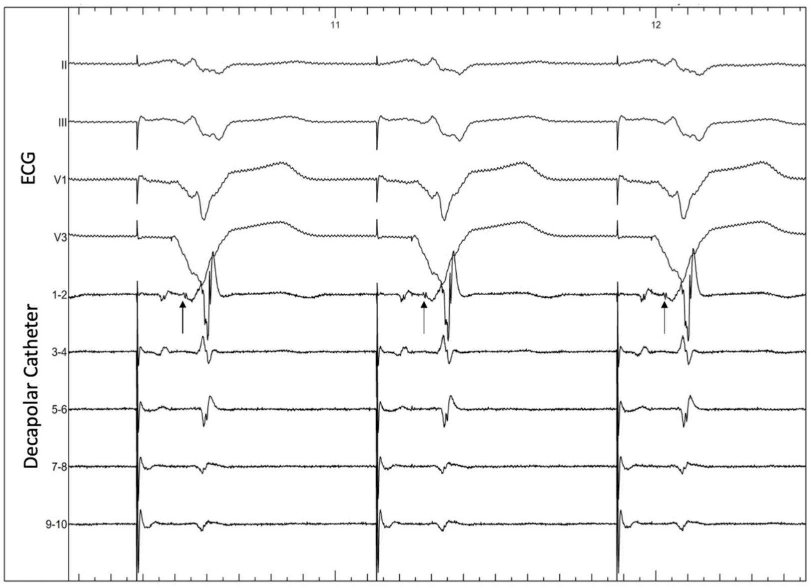
CRT: cardiac resynchronization therapy; CS: coronary sinus; ICD: implantable cardioverter defibrillator; LV: left ventricular; RAO: right anterior oblique; RA: right atrial; RV: right ventricular.

Figure 2. Surface ECG and intracardiac electrograms from the roving decapolar catheter during baseline dual-chamber right ventricular pacing. The decapolar catheter is positioned on the left ventricular aspect of the septum and dipoles are ordered from distal (1-2) to proximal (9-10). The retrograde left bundle potential is marked with arrows on poles 1-2. Sweep speed 100 mm/s.

Table 1. Acute hemodynamic response with biventricular pacing for different left ventricular pacing locations. Acute hemodynamic response is expressed as a percentage increase in dP/dt_{max} compared to baseline right ventricular pacing.

Figure 3. Surface ECGs. A: Right ventricular pacing. B: Biventricular pacing with electrode at mid-lateral wall of left ventricle. C: Left bundle branch pacing.





Pacing Location in Left Ventricle	Acute Hemodynamic Response (%)
Basal lateral	27
Mid lateral	34
Apical septum	22
Left bundle	34


A
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
QRS 172 ms
B
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
QRS 132 ms
C
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
QRS 106 ms