ESC European Society of Cardiology

European Heart Journal - Case Reports (2024) **8**, ytae591
https://doi.org/10.1093/ehjcr/ytae591

CASE REPORT
Electrophysiology

Reverse electrical remodelling after cardiac resynchronization therapy in a patient undergoing left bundle branch area pacing: a case report

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Received 30 January 2024; revised 24 April 2024; accepted 25 October 2024; online publish-ahead-of-print 4 November 2024

Background Left bundle branch area pacing (LBBAP) has been introduced as an alternative to biventricular pacing in cardiac resynchronization therapy (CRT). Several studies describe echocardiographic reverse remodelling after LBBAP. Reverse electrical remodelling after LBBAP has not yet been described.

Case summary A 77-year-old female with non-ischaemic heart failure with reduced ejection fraction [left ventricular ejection fraction (LVEF) 30–35%], left bundle branch block (QRS duration 164 ms), and symptomatic atrial fibrillation irresponsive to pharmacological therapy was evaluated for CRT with LBBAP and atrioventricular node ablation. Successful LBBAP implantation resulted in confirmed left bundle branch capture. Immediately after implantation, paced QRS duration was 194 ms with a long stimulus-V6RWPT (time to peak R wave in V6) of 93 ms, suggesting distal conduction system disease. Patient showed an echocardiographic improvement (LVEF 35–50%) and improvement in symptoms (NYHA class III to NYHA class II) at 1-year follow-up. Moreover, an improvement in conduction delays was found present. Paced QRS duration improved to 159 ms and stimulus-V6RWPT improved to 78 ms. This improvement might be due to reverse electrical remodelling.

Discussion This case demonstrates that LBBAP can induce reverse electrical remodelling, even in the presence of distal conduction system disease. With the current availability of different pacing strategies in CRT (i.e. biventricular CRT, LBBAP, and left bundle branch-optimized CRT), more research on patient selection and pacing strategy selection is needed.

Keywords Left bundle branch area pacing • Cardiac resynchronization therapy • Conduction system pacing • Case report

ESC curriculum 5.3 Atrial fibrillation • 5.9 Pacemakers • 5.11 Cardiac resynchronization therapy devices • 6.2 Heart failure with reduced ejection fraction

Learning points

- Left bundle branch area pacing might induce reverse electrical remodelling in a patient with heart failure with reduced ejection fraction and a left bundle branch block.
- Even despite evidence of distal conduction system disease, left bundle branch area pacing alone can lead to reverse electrical remodelling in terms of reduction in paced QRS duration and stimulus-V6RWPT.
- With the availability of different pacing strategies in cardiac resynchronization therapy (CRT) (i.e. biventricular CRT, left bundle branch area pacing, and left bundle branch pacing-optimized CRT, more research on patient selection and pacing strategy selection is needed.

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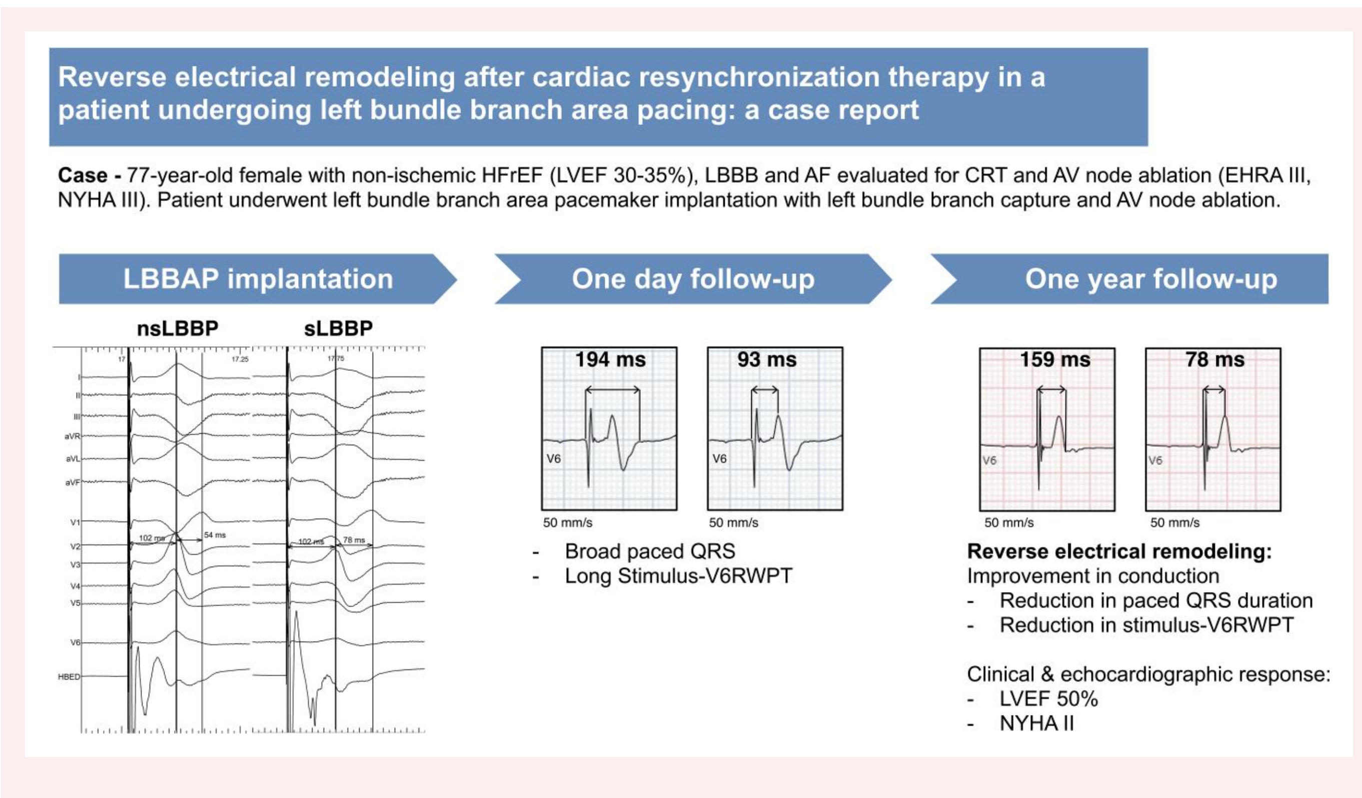
Handling Editor: Stefan Simovic
Peer-reviewers: Vera Maslova; Sebastian Ekkehard Beyer; Ugur Canpolat
Compliance Editor: Ralph Mark Louis Neijenhuis

Introduction

Left bundle branch area pacing (LBBAP) has been introduced as an alternative pacing strategy to conventional biventricular cardiac resynchronization therapy (BiV-CRT).[1] In a randomized trial, LBBAP has shown to be associated with a significant improvement in left ventricular ejection fraction (LVEF), superior to BiV-CRT.[2] Moreover, the observational I-CLAS study showed an improvement in clinical outcomes (time to death or heart failure hospitalization) in LBBAP when compared with BiV-CRT.[3] In addition to several studies showing echocardiographic reverse remodelling after LBBAP as an alternative to BiV-CRT,[4] we describe a patient with reverse electrical remodelling (RER) after LBBAP for CRT.

Summary figure



Case report

A 77-year-old female with heart failure with reduced ejection fraction (HFrEF), complete left bundle branch block (LBBB), and persistent atrial fibrillation (AF) diagnosed 5 years prior to referral was referred to our device department for pace-and-ablate therapy and CRT. The electrocardiogram at the outpatient clinic showed AF with a ventricular rate of 87 b.p.m. and a complete LBBB with QRS duration 164 ms (*Figure 1A*). Transthoracic echocardiography (TTE) showed a reduced LVEF ±30–35% with a dyssynchronous contraction pattern, a left ventricular end-diastolic dimension (LVEDD) of 47 mm and severe bi-atrial enlargement. Transthoracic echocardiography performed 6 months prior to referral showed an LVEF of 50%. Previous myocardial perfusion single-photon emission computed tomography showed no signs of myocardial ischaemia. The patient received pharmacological treatment for new-onset heart failure with beta-blocker (metoprolol 50 mg) and angiotensin-converting enzyme inhibitor (enalapril 20 mg). Because of the recent onset, pharmacological heart failure treatment was still suboptimal. Atrial fibrillation was pharmacologically treated with amiodarone. A dyssynchronopathy was suspected to be the main heart failure aetiology, possibly combined with an irregulopathy due to AF. Since the ventricular rate during AF was ~90 b.p.m., a tachycardiomyopathy was deemed to be of less importance in the HFrEF aetiology of this patient. Due to severe symptoms of AF (EHRA class III) and heart failure (NYHA class III), we opted for implantation of a dual-chamber (DDD) pacemaker with LBBAP combined with an atrioventricular (AV) node ablation (pace-and-ablate). A left-sided catheter ablation for AF was deemed not effective in this patient due to comorbidities, high age, and severe bi-atrial enlargement. The LBBAP lead was implanted as previously described.[5] During implantation, the LBBAP lead was deployed at the left side of the interventricular septum. Decremental voltage output pacing showed an output-dependent transition in QRS morphology from non-selective to selective left bundle branch pacing (*Figure 1B*), confirming left bundle branch capture.[6] Stimulus-V6RWPT (time from pacing stimulus to peak R-wave in lead V6) was 102 ms and remained stable during decremental voltage output pacing (*Figure 1B*). This long stimulus-V6RWPT might be due to distal conduction system disease. A stimulus-V6RWPT < 80 ms is usually indicative for left bundle branch capture in patients with an LBBB prior to implantation.[6] Because of confirmed left bundle branch capture, this position was accepted. The electrocardiogram 1-day post-implantation showed a paced qR morphology in lead V1 with stimulus-V6RWPT of 93 ms and a paced QRS duration of 194 ms (*Figure 2A*). Patient underwent successful AV node ablation 6 weeks later.

Besides discontinuation of amiodarone, the pharmacological therapy for the patient remained unchanged. At 1-year follow-up, symptoms improved to NYHA II. Follow-up TTE showed an improvement in LVEF to ±50% with no visual dyssynchrony and an LVEDD of

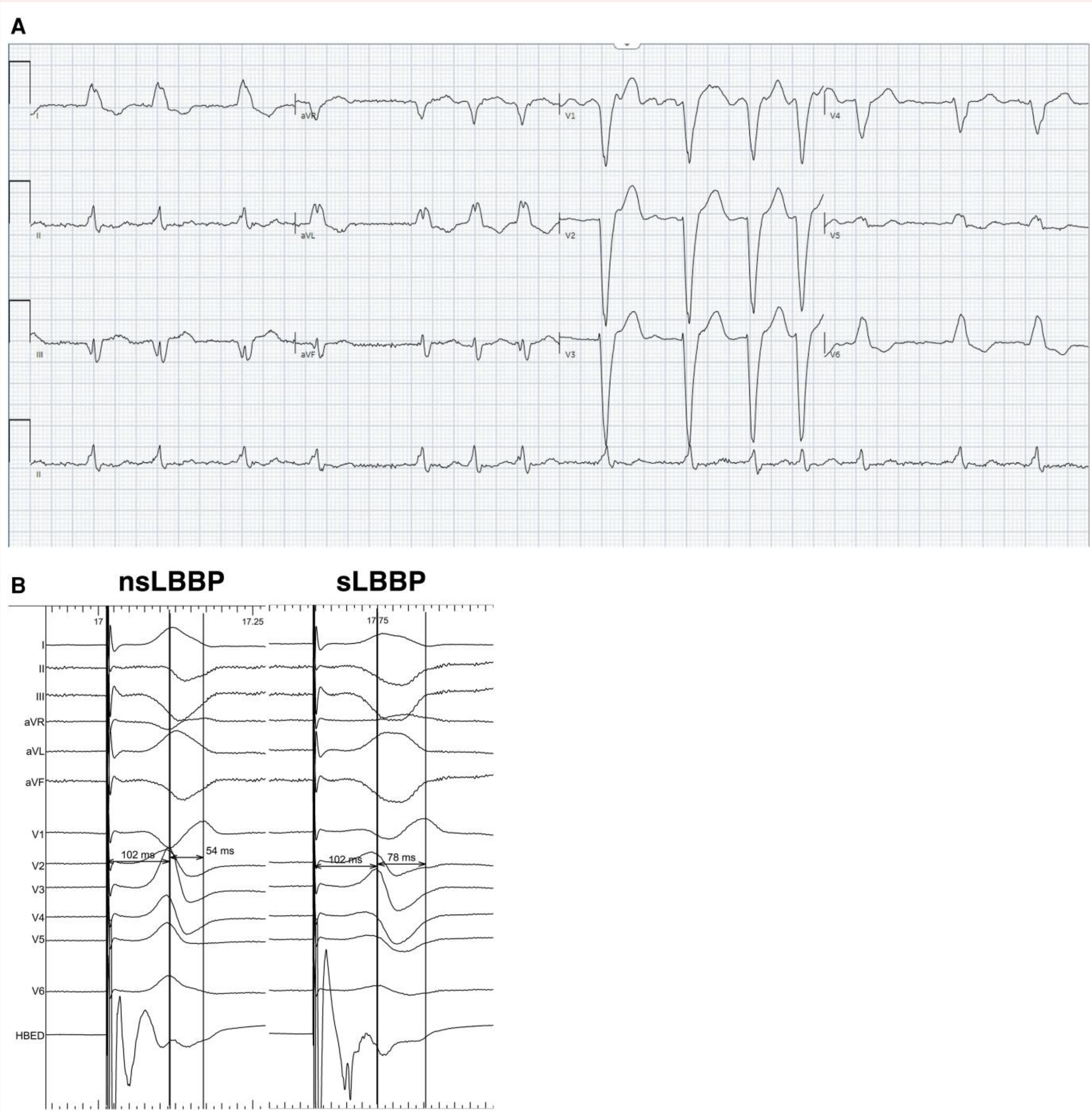


Figure 1 Baseline electrocardiogram (ECG) (*A*); per-procedural ECG and local electrogram (EGM) with transition from non-selective left bundle branch pacing to selective left bundle branch pacing with decremental voltage output pacing (*B*). A stable stimulus to V6RWPT (102 ms) at decremental output pacing is suggesting a comparable left ventricular wall delay at both high and low output pacing. A clear prolongation in V6-V1 interpeak time (54–78 ms) at decremental output pacing is suggesting a delay in right ventricular activation at low output pacing. This is because of an immediate myocardial transseptal left-to-right activation at high output pacing, resulting in earlier right ventricular activation (non-selective left bundle branch pacing). At low output pacing, myocardial capture is lost resulting in a delayed right ventricular activation (selective left bundle branch pacing). Moreover, a change in local EGM (HBED) was found present during decremental voltage output pacing, with the pacing stimulus discrete from the local depolarization at low output pacing, also indicating a transition from non-selective left bundle branch pacing at high output pacing to selective left bundle branch pacing at low output pacing. HBED = local EGM from the tip of the LBBAP pacing lead. nsLBBP, non-selective left bundle branch pacing; sLBBP, selective left bundle branch pacing.

41 mm. Strikingly, the electrocardiogram also showed an improvement in electrical conduction. Stimulus-V6RWPT improved to 78 ms and paced QRS duration improved to 159 ms (*Figure 2B*), with similar pacemaker settings as 1-day post-implantation. Due to the performed AV node ablation, it was not possible to test improvement in intrinsic conduction.

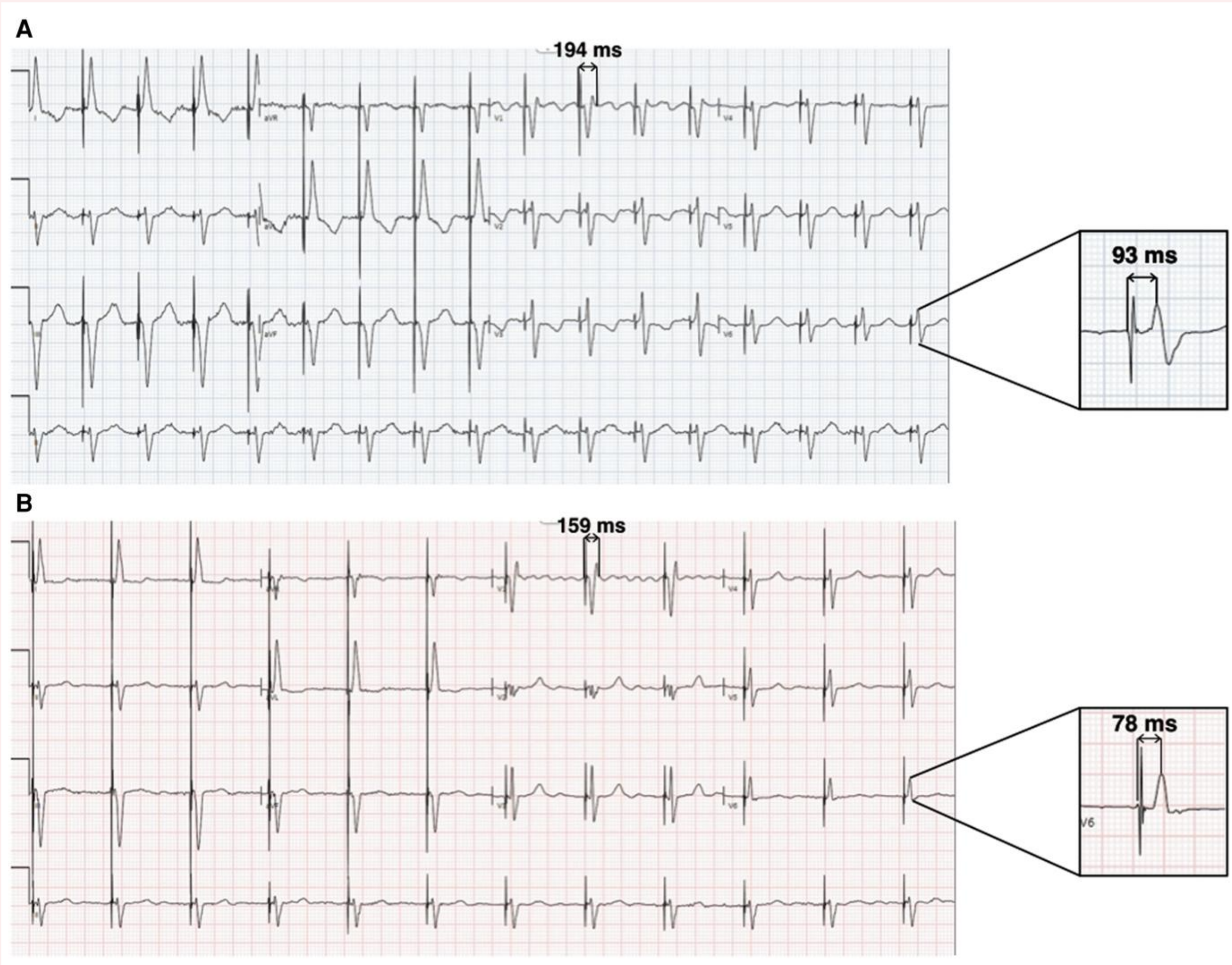


Figure 2 Acute electrocardiogram (ECG) 1-day post-implantation with QRS duration (in lead V1) and V6RWPT (in lead V6) (*A*). ECG 1-year post-implantation with QRS duration (in lead V1) and V6RWPT (in lead V6) (*B*).

Discussion

Reverse electrical remodelling in terms of narrowing of intrinsic QRS after BiV-CRT was described previously.[7,8] Reverse electrical remodelling after BiV-CRT has been associated with clinical and echocardiographic response.[7,9] Although previous studies on LBBAP in CRT have shown an improvement in clinical end echocardiographic outcomes,[2,3] RER has not yet been described in a patient undergoing LBBAP-CRT and AV node ablation with evidence of distal conduction system disease.

Previous studies imply that a long stimulus-V6RWPT and long QRS duration after LBBAP are signs of insufficient electrical resynchronization, which might lead to lower response rates in CRT using LBBAP.[10–12] Addition of a coronary sinus lead, resulting in left bundle branch pacing-optimized CRT (LOT-CRT), is suggested to improve response to CRT.[10–12] Left bundle branch pacing-optimized CRT is shown to provide greater electrical resynchronization than conventional BiV-CRT[12] and LBBAP in patients with insufficient correction of QRS duration after LBBAP.[13] Based on the acute measurements in the patient described in this case report (stimulus-V6RWPT and paced QRS duration), LOT-CRT could have been considered. Nevertheless, a clinical and echocardiographic improvement was present 1 year after LBBAP and AVNA. Moreover, an improvement in electrical resynchronization at 1-year follow-up was found present, with a reduction in stimulus-V6RWPT from 102 to 78 ms and a reduction in paced QRS duration from 194 to 159 ms. This implies that, despite the suggestion of severe distal conduction system disease at implantation, LBBAP with left bundle branch capture can improve electrical conduction and induce RER in a patient undergoing LBBAP-CRT combined with an AV node ablation for symptomatic AF.

Conclusion

In this case report, we show you that LBBAP might induce RER. Moreover, despite evidence of distal conduction system disease during implantation, LBBAP alone might still induce RER with improvement in paced QRS duration and stimulus-V6RWPT. Since different pacing strategies (i.e. BiV-CRT, LBBAP, and LOT-CRT) can be considered in these patients, more research on patient selection and pacing strategy selection is needed.

Lead author biography

Jesse H.J. Rijks is a cardiologist in training and PhD candidate in the Maastricht University Medical Center in Maastricht, the Netherlands. He started his training in 2017. His clinical focus is on cardiac device therapy. His research focuses on conduction system pacing, especially left bundle branch area pacing.

Consent: Patient provided written informed consent in line with the COPE guidance.

Conflict of interest: J.H.J.R.: no conflicts of interest to declare; J.L.: research grant and consultancy agreement with Medtronic (all grants are paid to the institute); K.V.: research and educational grants and consultancy agreements with Medtronic, Abbott, Boston Scientific, Philips, and Biosense Webster (all grants are paid to the institute).

Funding: None declared.

Data availability

All relevant available patient data are presented within the manuscript.

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