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Left-bundle branch pacing as bail-out strategy after failed coronary sinus lead placement for cardiac resynchronization: a case report

Thomas Fink[1], Thomas Eitz[2], Christian Sohns[1], Philipp Sommer [1]*, and Guram Imnadze [1]

[1]Clinic for Electrophysiology, Herz- und Diabeteszentrum NRW, Ruhr-Universität Bochum, Georgstraße 11, 32545 Bad Oeynhausen, Germany; and [2]Clinic for Thoracic and Cardiovascular Surgery, Herz- und Diabeteszentrum NRW, Bad Oeynhausen, Germany

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Background Cardiac resynchronization therapy (CRT) by implantation of an endocardial coronary sinus (CS) pacing lead is an established heart failure therapy. The recent European Society of Cardiology (ESC) guidelines on cardiac pacing and CRT recommend conduction system pacing (CSP) as a potential bail-out therapy in patients with previously unsuccessful CS-lead implantation. We present a case in which unsuccessful implantation of a CS pacing and ineffective QRS correction by His-bundle pacing (HBP) was overcome by left-bundle branch pacing (LBBP) to achieve cardiac resynchronization.

Case summary The patient had to undergo revision of a CS lead for CRT due to rising pacing thresholds and pacing impedance. CS-lead implantation was omitted by a stenotic posterolateral CS branch. HBP did not lead to adequate QRS correction. The patient underwent successful LBB lead implantation as bail-out therapy. After LBBP lead implantation electrocardiographic and echocardiographic parameters were evident of effective CRT.

Discussion Conduction system pacing may be an alternative to CS pacing for CRT in heart failure patients, which is endorsed by the current European guidelines. LBBP may overcome limitations of HBP and provide an alternative to other strategies such as surgical implantation of epicardial left-ventricular pacing leads. Further studies are needed to fully clarify the role of LBBP for heart failure treatment.

Keywords Conduction system pacing • Left-bundle branch pacing • Failed cardiac resynchronization therapy • Heart failure • Case report

ESC curriculum 5.11 Cardiac resynchronization therapy devices • 6.2 Heart failure with reduced ejection fraction

* Corresponding author. Tel: +49 573 1971327, Fax: +49 573 1972123, Email: psommer@hdz-nrw.de
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Learning points

- Cardiac resynchronization therapy remains the standard of care with proved benefits for treated patients in heart failure with concomitant conduction disturbance.
- Conduction system pacing (CSP) via His-bundle pacing (HBP) or left-bundle branch pacing (LBBP) may be an alternative to other treatment options like surgical placement of an epicardial left-ventricular pacing lead in case of failed CS-lead placement.
- CSP was implemented in recent European guidelines with a Class IIa (Level B) recommendation in patients with previously unsuccessful coronary sinus lead implantation.
- LBBP is another option beyond recent guideline recommendations, may overcome limitations of HBP, and is less invasive when compared with surgical approaches. Further studies have to confirm preliminary experience.

Introduction

Cardiac resynchronization therapy (CRT) is an established therapy in symptomatic heart failure with electrical dyssynchrony. CRT implantation may be challenging and coronary sinus (CS) lead implantation may fail due to anatomical and technical difficulties. The recently updated European Society of Cardiology (ESC) guidelines on cardiac pacing and cardiac resynchronization recommend conduction system pacing (CSP) by His-bundle pacing (HBP) to achieve resynchronisation in patients with failed CS-lead implantation.[1]

Left-bundle branch pacing (LBBP) has recently emerged an alternative to traditional right ventricular (RV) pacing and HBP. The role of LBBP in cardiac resynchronization is poorly understood. We present a case in which resynchronization was achieved by LBBP after unsuccessful implantation of a CS pacing lead and ineffective HBP.

Timeline

2005	
	Implantable cardioverter defibrillator (ICD) implantation for primary prevention
2013	
	ICD generator change
2019	
	Upgrade to CRT-D system due to clinical heart failure and new complete LBBB
	EF increased from 24 to 33%, clinical improvement (NYHA III to NYHA I–II)
2020	
	Left-ventricular (LV) lead: dysfunction (pacing impedance >3000 Ohm, stimulation threshold >7.5 V/1.0 ms)
	RV lead: Ineffective ICD shock
	Failed revision of LV lead due to CS branch occlusion, new RV lead implantation
2020	
	Current attempt to undergo LBBP

Case report

A 59-year-old male patient with a history of anterior myocardial infarction underwent ICD implantation for primary prevention 16 years ago. He underwent upgrade to a CRT device for newly developed atypical left-bundle branch block (LBBB; QRS duration 165 ms) and symptomatic heart failure (NYHA III). Clinical improvement (NYHA I–II) and echocardiographic improvement (from 24 to 33%) was achieved.

Six months ago, the patient was admitted after remote monitoring alert concerning rapid increase of pacing impedance and threshold of the LV lead. Echocardiography found severely reduced LV-EF and signs of interventricular dyssynchrony (Supplementary material online, *Video S1*).

The patient was scheduled for CS- and ICD-lead revision. CS-lead revision failed due to occlusion of the previously used posterolateral CS target branch after extraction of the defective LV lead with ineffective attempt of CS branch angioplasty and lead placement (*Figure 1*). The procedure was preliminary stopped. Implantation of an epicardial LV pacing lead and endocardial intracavitary CSP were discussed with the patient as alternatives. A common decision for an attempt of CSP in lieu of CS pacing was made.

The procedure was conducted using a 3D mapping system (EnSite Precision Cardiac Mapping System; Abbott, St Paul, MN, USA) with non-fluoroscopic catheter visualization (MediGuide; Abbott).

A fixed curve lead delivery sheath (C315; Medtronic, Minneapolis, MN, USA) and an active fixation lead with a fixed helix (3830–69 Select secure; Medtronic) were introduced into the RV. A His-bundle potential was identified and the lead was advanced into the septum. HBP did not effectively correct QRS below 160 ms. Decision was made to attempt LBBP in the patient. A decapolar mapping catheter (Lifewire; Abbott) was retrogradely inserted into the LV to visualize the LV conduction system. Intracardiac mapping revealed an LBB potential during antegrade conduction of the LBB. This area was tagged in the non-fluoroscopic image (bright tag on *Figure 2*). The RV target area was further marked about 1–1.5 cm distal to the His-bundle (at poles 5–6 of the decapolar catheter, *Figure 2*).

The pacing lead was manoeuvred to the tagged LV recording site of an LBB potential on the decapolar catheter (bright tags in *Figure 2*). Unipolar electrode tip pacing demonstrated a narrow QRS complex with a 'W pattern' in electrocardiogram Lead V1 and a positive R in Lead II. During lead advancement, the W shape in Lead V1 changed to an incomplete right-bundle branch block with a QRS duration of 110 ms. Additionally, a shortening of LV peak activation timing (measured from pacing stimulus to the QRS peak in Lead V6, <80 ms) was noticed. During threshold testing with decreasing pacing output a change in QRS morphology from a narrow QRS complex of 110 ms to a broad QRS complex with right-bundle branch block with a width of 160 ms with concomitant prolongation of the LV peak activation time was noticed (*Figure 3*). Recordings from the decapolar mapping catheter visualized a sharp LBB potential retrogradely after LV activation immediately when the change to the broad QRS complex occurred (Supplementary material online, *Video S2*).

In summary, findings indicated non-selective LBB capture followed by deep septal LV pacing at the final lead position during unipolar pacing and pacing threshold measurement.

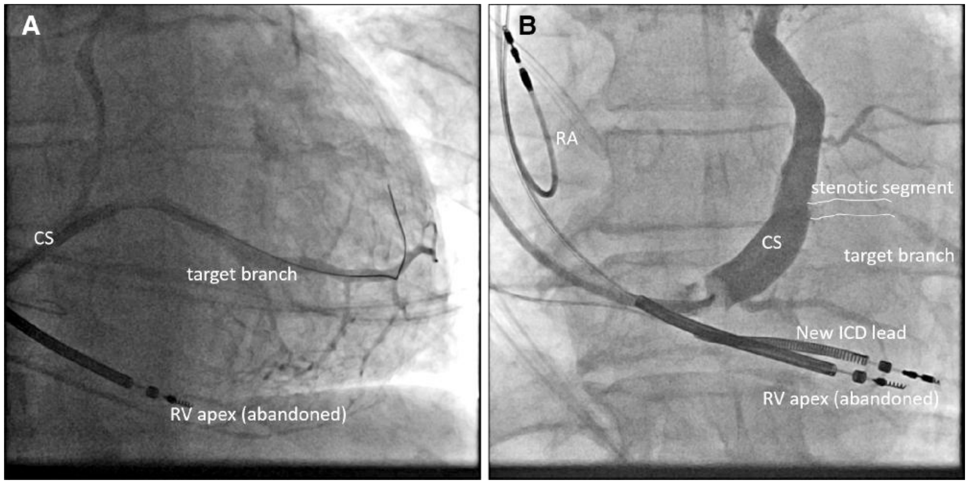

Figure 1 (*A*) after extraction of the defective lead, a wire was left inside the posterolateral target branch. (*B*) Coronary sinus angiography demonstrates stenosis of the branch preventing successful left-ventricular lead placement. CS, coronary sinus, ICD, implantable cardioverter defibrillator; RV, right ventricular; RA, right atrial pacing lead.

Measurements from the LBBP lead obtained satisfactory values (sensing 8.9 mV, unipolar pacing threshold 0.6 V/0.5 ms). After the procedure pacing parameters were programmed to unipolar pacing of the LBBP lead resulting in a narrow QRS complex without an isoelectric segment before QRS onset, suggestive of non-selective LBBP (*Figure 3*). Assessment after LBBP lead implantation demonstrated echocardiographic signs of efficient cardiac resynchronization under LBBP (Supplementary material online, *Video S3*).

Discussion

We present a case of successful CSP by LBBP after previously unsuccessful CS-lead implantation. Our case highlights the potential of LBBP as alternative in patients with otherwise failed endocardial CRT.

Status of cardiac resynchronization therapy and conduction system pacing in heart failure

Cardiac resynchronization therapy has emerged as standard of care in patients with heart failure and interventricular dyssynchrony.[1,2] Technical progress and increased operator experience have led to high procedural success recently. Nevertheless, CRT is not possible in all patients due to anatomical variability. Usually, unfavourable CS anatomy, myocardial scarring or proximity to the adjacent phrenic nerve may hinder effective CS-lead implantation. Additionally, revision of previously implanted CS pacing leads may lead to injury of CS target branches omitting successful implantation. CSP by HBP has recently emerged an alternative to conventional RV pacing and CRT in selected patients[3] as HBP global operator experience has grown extensively.[4,5] Multiple studies demonstrated beneficial effects of HBP in patients with and without heart failure, acceptable safety and procedural success.[6,7,8] CSP may achieve a more physiologic conduction when compared with CS-lead pacing. Previous reports found narrowing of QRS complexes during HBP even in patients with pre-existing LBBB. Exact mechanisms are not fully understood, but ventricular capture beyond the area of LBBB is suspected to play a major role. Nevertheless, altered electrical conduction across the conduction system may hinder adequate resynchronization via HBP which usually has its stimulation site proximal to sites of conduction blocks in advanced disease states.

The ESC guidelines on cardiac pacing and resynchronization therapy recommend HBP in patients with failed CS-lead implantation along with epicardial lead placement with a Class IIa recommendation (Level of evidence B). Recent guidelines mention LBBP as potential pacing modality, but no recommendation is given due to limited experience of long-term pacing thresholds and limited experience with extractions of LBBP leads.[1] Current guidelines are interpreted by many operators to be fairly conservative when compared with the recent American Heart Rhythm Society guidelines on cardiac pacing of 2018, in which HBP was already recommended along CRT as an alternative pacing site to conventional RV pacing for patients with LV-EF >36% (Class IIA, Level of evidence B).[9] Nevertheless, European guidelines refer to limited available data on HBP in terms of mid- and long-term experience with these new techniques. A further upgrade of recommendations can be expected in future guidelines when growing evidence and expected results of larger randomized studies become available.

Left-bundle branch pacing as alternative for cardiac resynchronization therapy

His-bundle pacing has several limitations when used as alternative to RV pacing and CRT. LBBB correction may be achieved by HBP with high pacing outputs. Additionally, concerns have been raised about long-term durability of HBP leads after demonstration of raising thresholds in multiple studies.[8] In contrast, surgical placement of LV leads by thoracotomy or thoracoscopy was feasible in numerous studies.[10,11] Surgical LV pacing for CRT may overcome above-mentioned anatomical and technical limitations of endocardial CS leads. Surgical lead placement offers further advantages in patients with lead infections and previous endocarditis. Nevertheless, the procedure requires a thoracoscopy or a lateral mini-thoracotomy potentially increasing perioperative morbidity. Different techniques for implantation of an intracavitary endocardial LV pacing device is still in an experimental stadium.[12]

Our case highlights the potential use of LBBP in patients with indication for CRT with failed CS-lead deployment as well as failed QRS correction during HBP. Pacing is to be expected to occur distal to the LBBB area when LBBP leads are deployed. Pacing thresholds and sensing

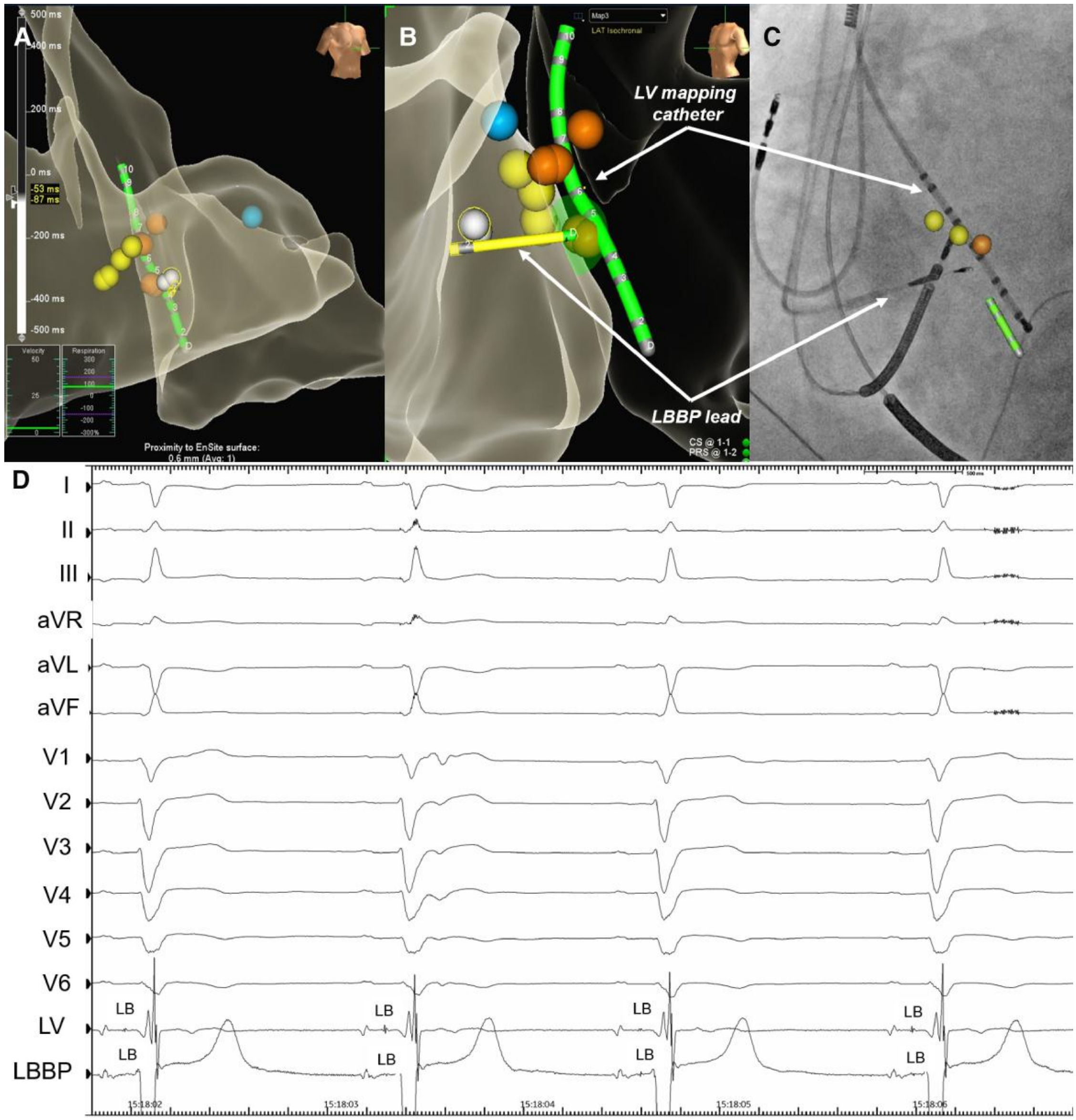

Figure 2 (*A, B*) Non-fluoroscopic catheter visualization was used to mark the left-bundle branch target area with a decapolar mapping catheter in the left ventricle (bright tags at His-bundle recording sites, dark tag at recording site of right-bundle branch potentials and bright tags at sites of the left-bundle branches): (A) RAO 30°, (B) LAO 40°. (*C*) Fluoroscopic image of placement of the pacing lead inside the interventricular septum close to the marked left-bundle branch area. (*D*) Twelve-lead electrocardiogram and intracardiac electrogram from the left-ventricular mapping catheter and the left-bundle branch pacing lead during intrinsic sinus rhythm. QRS morphology shows atypical left-bundle branch block with S waves in lateral leads. A left-bundle potential with a pathologically prolonged activation time of the left-ventricular myocardium is recorded by the intracardiac catheters, demonstrating preserved antegrade activation of the left-bundle branch during atypical left-bundle branch block. LBP, left-bundle potential; LBBP, left-bundle branch pacing lead; LV, left ventricular; RA, right atrial pacing lead; RV, right ventricular; RVOT, ICD lead placed in the right ventricular outflow tract.

parameters in available studies did not differ substantially from parameters obtained from RV or CS leads. There are no reports on excessive lead failures in LBBP so far but long-term experience on this pacing modality is limited to a small number of studies.

Some limitations have to be taken into account when LBBP is considered to be an alternate CRT system. The technique will have to demonstrate its safety and long-term effectiveness in large patient cohorts and trials with adequate quality and statistical power have to address its value in comparison with other CRT approaches. Additionally, experience of LBBP lead extraction is so far limited to single case reports.[13,14] The optimal programming parameters have yet to be defined. There are no data supporting advantages of selective vs. non-selective LBB capture. In our case, no selective LBB capture occurred. Nevertheless, adequate QRS correction occurred during non-selective LBBP.

In summary, LBBP may be an alternative to HBP and surgical LV lead implantation in heart failure patients with previously failed CS-lead placement. LBBP may overcome typical limitations of HBP and is less invasive when compared with surgical lead implantation techniques.

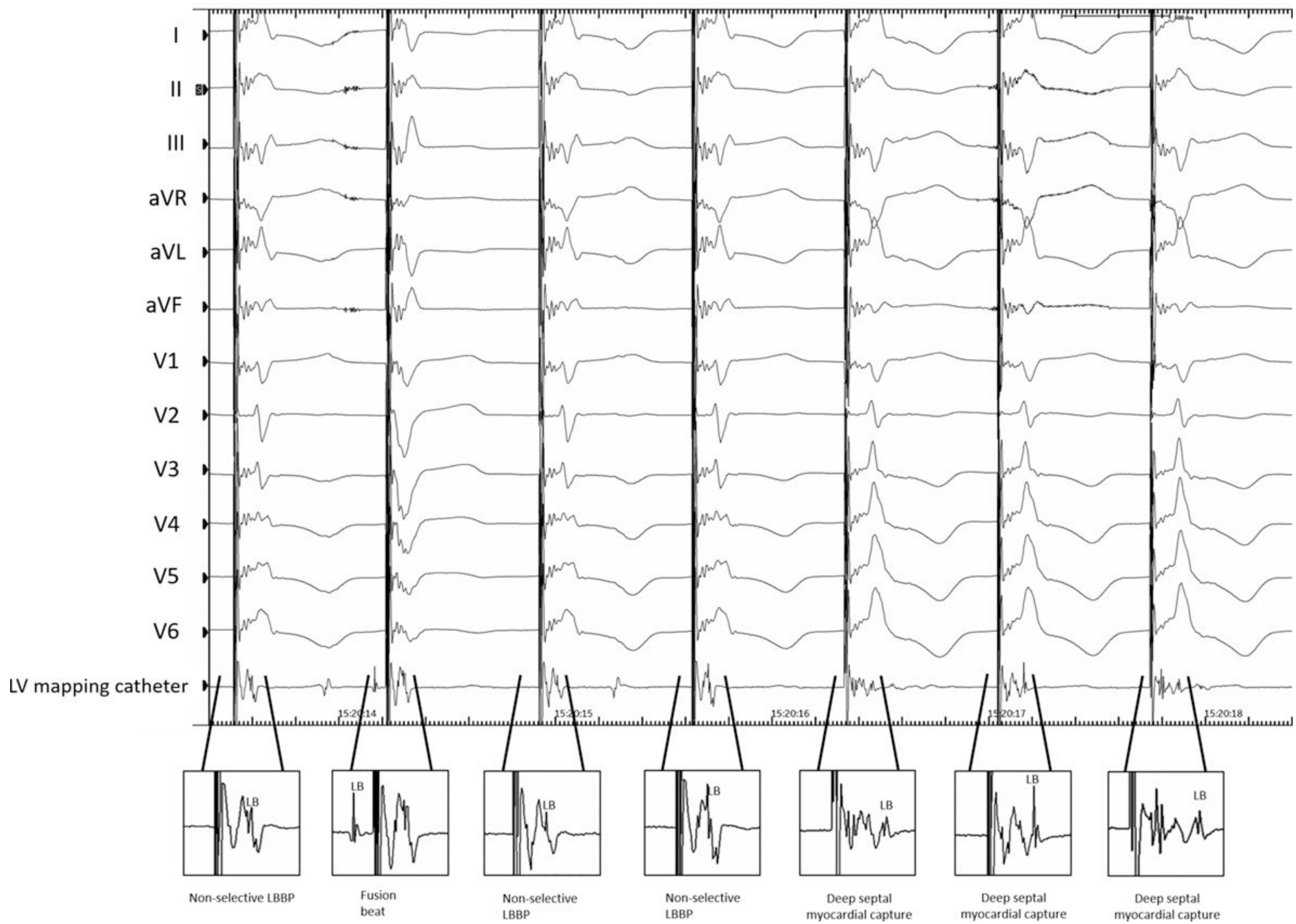

Figure 3 Twelve-lead electrocardiogram and intracardiac recording from the left-ventricular bundle branch area during unipolar left-bundle branch pacing close to the threshold of non-selective left-bundle branch capture and deep septal myocardial pacing. The first beats demonstrate non-selective left-bundle branch pacing with an isoelectric interval between pacing spike and a narrow QRS, a short peak left-ventricular activation time (80 ms) and recording of a left-bundle potential previous to ventricular activation on the left-ventricular mapping catheter. Note the delayed activation from left-bundle potential to ventricular activation indication severe conduction system disease in the patient. The last three beats represent deep septal myocardial capture without non-selective left-bundle branch pacing resulting in a broader QRS complex. LB, left-bundle potential.

We propose that today LBBP may be offered to selected patients in case of failed CS-lead placement as an alternative to HBP and surgical epicardial lead placement.

Conclusion

Left-bundle branch pacing may be an alternative to HBP and surgical LV pacing for cardiac resynchronization if CS-lead placement fails. LBBP may be favoured above HBP in patients with advanced conduction system abnormalities.

Lead author biography

Dr Thomas Fink, MD, is a board-certified cardiologist at Herz- und Diabeteszentrum, Bad Oeynhausen, University of Bochum, Germany. He is specialized in interventional electrophysiology and has a growing expertise in cardiac device therapy. His scientific interests fall within the field of catheter ablation of atrial and ventricular arrhythmias.

Supplementary material

Supplementary material is available at *European Heart Journal – Case Reports* online.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The patient signed written informed consent for all treatment procedures. The journal consent form [in line with the Committee on Publication Ethics (COPE)] has been signed by the patient. Patient information in this case report is provided anonymous.

Conflict of interest: P.S. is advisory board member of Abbott, Biosense Webster, Boston Scientific and Medtronic. C.S. received research support and lecture fees from Medtronic, Boston Scientific and Biosense Webster. In addition, C.S. is a consultant for Medtronic, Boston Scientific and Biosense Webster.

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