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Left Bundle Branch-Optimized Cardiac Resynchronization Therapy in a Patient with a Carillon Annuloplasty Device: Challenges and Solutions

Karillon Anüloplasti Cihazı Bulunan Bir Hastada Sol Dal Demeti Optimizasyonlu Kardiyak Resenkronizasyon Tedavisi: Zorluklar ve Çözümler

ABSTRACT

Cardiac resynchronization therapy (CRT) improves outcomes in heart failure, but prior interventions like percutaneous mitral annuloplasty may hinder lead placement. We present a 70-year-old male with ischemic cardiomyopathy and severe functional mitral regurgitation who previously received a Carillon device. Due to coronary sinus inaccessibility, left bundle branch area pacing optimized cardiac resynchronization therapy (LOT-CRT) was performed. The procedure was successful, with improved QRS duration, echocardiographic findings, and clinical status. This case highlights LOT-CRT as a viable alternative in patients with challenging anatomy, offering physiological pacing when conventional CRT is not feasible.

Keywords: Carillon mitral contour system, conduction system pacing, left bundle branch-optimized cardiac resynchronization therapy

ÖZET

Kardiyak resenkronizasyon tedavisi (CRT), kalp yetersizliği olan hastalarda klinik sonuçları iyileştirmektedir. Ancak daha önce uygulanan perkütan mitral anüloplasti gibi girişimler, sol ventrikül lead yerleşimini engelleyebilir. Bu yazıda, iskemik kardiyomiyopati ve ciddi fonksiyonel mitral yetersizliği olan, daha önce Karillon cihazı implante edilmiş 70 yaşında erkek bir hasta sunulmaktadır. Koroner sinüs yolunun erişilemez olması nedeniyle, sol dal demeti alanına pil yerleştirilerek optimizasyonlu CRT (LOT-CRT) uygulanmıştır. İşlem başarılı olmuş; QRS süresi, ekokardiyografik parametreler ve klinik durum iyileşmiştir. Bu olgu, anatomik zorlukların bulunduğu hastalarda, konvansiyonel CRT'nin uygulanamadığı durumlarda fizyolojik bir alternatif olarak LOT-CRT yönteminin uygulanabilirliğini göstermektedir.

Anahtar Kelimeler: Carillon mitral kontur sistemi, İletim sistemi pili, sol dal demeti optimizasyonlu kardiyak resenkronizasyon tedavisi

CASE REPORT
OLGU SUNUMU

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Ventricular dyssynchrony is common in patients with reduced left ventricular ejection fraction and contributes to worsening heart failure.[1] Cardiac resynchronization therapy (CRT) has been shown to improve left ventricular function, reduce mitral regurgitation (MR), and enhance clinical outcomes.[2] While conventional biventricular pacing is the standard approach, left bundle branch-optimized cardiac resynchronization therapy (LOT-CRT) has emerged as a promising alternative, utilizing the native conduction system to achieve more physiological ventricular activation.[3]

Mitral regurgitation frequently coexists with heart failure due to left ventricular dilation. The Carillon Mitral Contour System, a transvenous mitral annuloplasty device, has been developed to reduce MR through external annular restriction.[4] However, its presence may complicate the implantation of CRT leads. The literature on LOT-CRT in patients with Carillon devices is sparse, with only one previously reported case.[5] This report presents the second known case, demonstrating that LOT-CRT can be a viable approach in selected patients.

Case Report

A 70-year-old male with ischemic cardiomyopathy and severe functional MR presented with worsening dyspnea and reduced exercise tolerance (New York Heart Association [NYHA] class III) despite optimal guideline-directed medical therapy. Previously, he had Carillon device implantation due to severe MR (2014). However, his clinical condition deteriorated, and coronary artery bypass grafting (CABG) along with mitral valve replacement were performed eight years after (2022) Carillon device implantation.

A year after the cardiac surgery, he had an implantable cardioverter-defibrillator (ICD) implantation for primary prevention. At the time of ICD implantation, a 12-lead electrocardiogram (ECG) showed atrial fibrillation (AF) and right bundle branch block (RBBB) with a QRS duration of 130 ms. One year after ICD implantation, follow-up 12-lead ECG revealed a paced rhythm with a markedly prolonged QRS duration (> 200 ms) (Figure 1). Device interrogation showed a ventricular pacing rate of 78%. Underlying rhythm at 40 bpm revealed AF with complete atrioventricular (AV) block. Transthoracic echocardiography demonstrated a severely reduced left ventricular ejection fraction (LVEF) of 20% with a markedly dilated left ventricle (LV) end-diastolic diameter: 62 mm), consistent with advanced heart failure and significant ventricular dyssynchrony. Additionally, the patient had markedly elevated N-terminal pro-B-type natriuretic peptide (NT-proBNP) levels (11,705 pg/mL), further supporting the presence of severe heart failure.

Given his worsening symptoms, significant ventricular pacing burden, and echocardiographic findings, an upgrade to either conventional CRT or left bundle branch-optimized cardiac resynchronization therapy with defibrillator (LOT-CRT-D) was planned.

ABBREVIATIONS

AF	Atrial fibrillation
AV	Atrioventricular
CABG	Coronary artery bypass graftin
CRT	Cardiac resynchronization therapy
CS	Coronary sinus
CSP	Conduction system pacing
ECG	Electrocardiogram
HRS	Heart Rhythm Society
ICD	Implantable cardioverter-defibrillator
LBB	Left bundle branch
LBBAP	Left bundle branch area pacing
LBBB	Left bundle branch block
LOT-CRT-D	Left bundle branch-optimized cardiac resynchronization therapy with defibrillator
LV	Left ventricle
LVEF	Left ventricular ejection fraction
LVSP	Left ventricular septal pacing
MR	Mitral regurgitation
NT-proBNP	N-terminal pro-B-type natriuretic peptide
NYHA	New York Heart Association
RBBB	Right bundle branch block
RV	Right ventricular

After obtaining both verbal and written consent, the patient was taken to the laboratory. A coronary sinus (CS) venogram revealed distal narrowing due to the distal anchor of the Carillon device but a well-developed posterolateral branch, which was considered for lead placement (Figure 2A). However, due to high thresholds obtained from all polarities of the quadripolar lead, we considered adding an additional left bundle branch area lead. Left bundle branch area pacing (LBBAP) was attempted

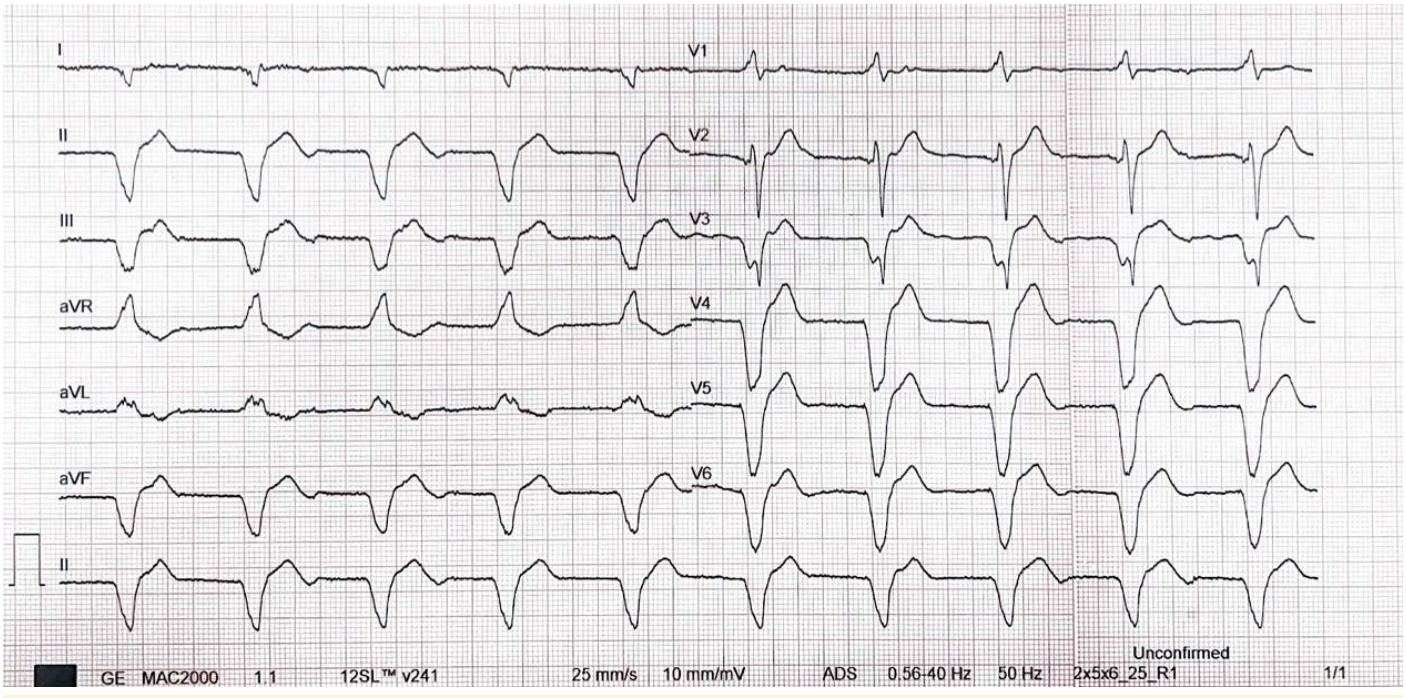

Figure 1. Baseline 12-lead electrocardiogram (ECG) recorded in a ventricular paced rhythm, demonstrating a widened paced QRS complex (240 ms).

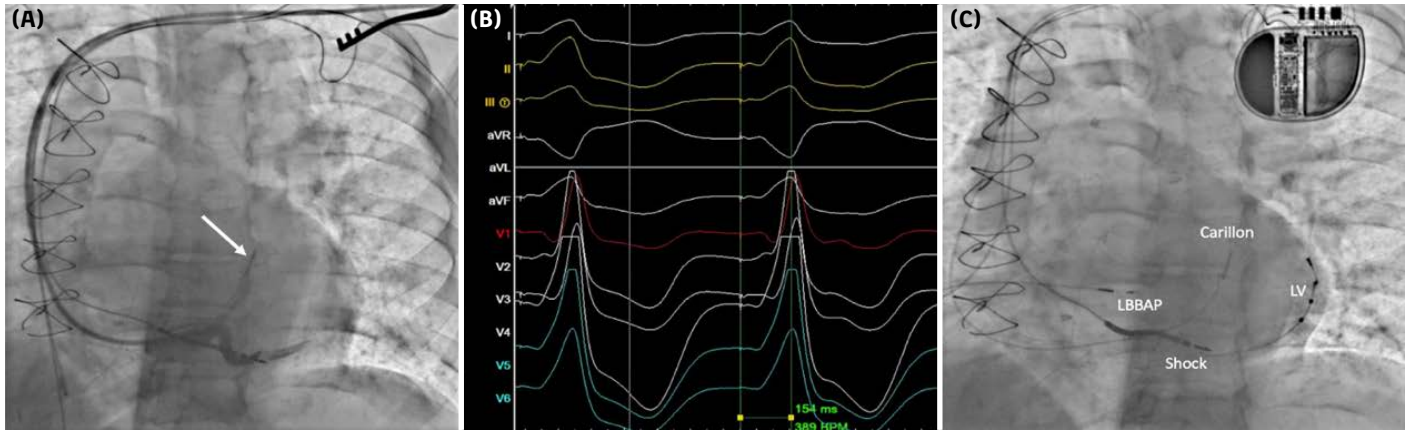

Figure 2. (A) Coronary sinus venography showing the Carillon Mitral Contour System; arrow indicates the distal anchor causing narrowing of the distal CS, with a well-developed posterolateral branch targeted for LV lead placement. (B) Intraprocedural findings during LBBAP, demonstrating an R-wave peak time (RWPT) of 154 ms in lead V5 with a latency of 40 ms. (C) Final fluoroscopic view demonstrating the positions of the LV lead, LBBAP lead, and ICD shock lead relative to the Carillon device, enabling LOT-CRT configuration.

with a Selectra 55/42 sheath and Solia S 60 leads (Biotronik, Germany). Despite multiple attempts, we were unable to penetrate the septum with the stylet-driven lead (Solisa S 60). Then we switched to the lumenless lead (Medtronic 3830 lead, Minnesota, MN, US). This time we were able to penetrate the septum and capture the conduction system. Although we had a nice qR morphology in lead V1, the R-wave peak time in leads V5 and V6 was very prolonged (154 ms) (Figure 2B). Therefore, we decided to use both LV and LBBAP leads to obtain better synchronization (Figure 2C). The previous right ventricular (RV) shock lead was DF-4, and due to permanent AF, the LBBAP lead was placed in the atrial port. The device was programmed as DDDR (dual chamber, dual sensed, dual response, rate-modulated) at 60 bpm, paced AV delay 15 ms, and LV > RV offset 100 ms. The LV lead was programmed in a bipolar configuration with a pacing threshold of 1.0 V at 0.5 ms. Final 12-lead ECG showed a paced rhythm with a QRS duration of 155 ms (Figure 3). Procedure and fluoroscopy times were 83 minutes and 21 minutes, respectively. The patient was discharged the day after the procedure without any complication.

Discussion

Heart failure is frequently associated with conduction system abnormalities, including left bundle branch block (LBBB), which can further impair ventricular synchrony and exacerbate symptoms.[6] Cardiac resynchronization therapy has been a cornerstone in addressing these electrical dyssynchronies, leading to improved functional status, reduced hospitalizations, and enhanced survival rates. Despite its benefits, CRT implantation can be technically challenging, especially in patients with prior structural interventions, such as percutaneous annuloplasty devices, which may limit coronary sinus lead placement.

Emerging evidence supports conduction system pacing (CSP), particularly LBBAP, as an alternative to traditional biventricular pacing. The 2023 Heart Rhythm Society (HRS) Conduction System Pacing guidelines acknowledge CSP as an effective alternative when standard CRT is not feasible, offering improved electrical synchrony by engaging the native conduction system.[7] In cases where coronary sinus lead placement is challenging due to anatomic constraints, CSP provides a promising solution for achieving cardiac resynchronization.[8]

The presence of an annuloplasty device in the coronary sinus alters lead placement strategies, necessitating pre-procedural imaging and careful planning. LV lead implantation through the Carillon device might be challenging due to altered geometry and risk of CS dissection. Our case demonstrates the feasibility of LOT-CRT in a patient with a Carillon annuloplasty device, an approach supported by recent reports. Jamil et al.[9] described CRT implantation in a patient with a Carillon device, highlighting the technical feasibility and potential for synergistic benefits. Similarly, Aschacher et al.[5] presented a case of LOT-CRT in a patient with both a Carillon device and a percutaneous tricuspid valve repair, demonstrating that conduction system pacing can be effectively employed in patients with complex structural heart disease. Previous reports of LOT-CRT in patients with Carillon devices are summarized (Table 1). In our case, the decision to pursue LOT-CRT instead of either conventional CRT or LBBAP was guided by two factors: high LV thresholds and very prolonged RWPT (R-wave peak time). Measurement of RWPT in patients with very dilated LV and septal fibrosis (latency) is not reliable. Therefore, without clear demonstration of left bundle branch (LBB) or fascicular potential as well as in the absence of transition, it is difficult to make a diagnosis of whether we achieved left ventricular septal pacing (LVSP) or LBBAP. Therefore, adding an extra LV lead might improve the clinical outcomes if LBBAP alone fails, which has been proposed by experts in the field.[3,10]

Another interesting point in our case was that switching from the stylet-driven lead to the lumenless lead allowed successful septal penetration and capturing of the conduction system. Although stylet-driven leads allow better antegrade force, in selected cases, particularly in cases with septal fibrosis, switching to the lumenless lead might provide better penetration due to the fixed, extended helix.

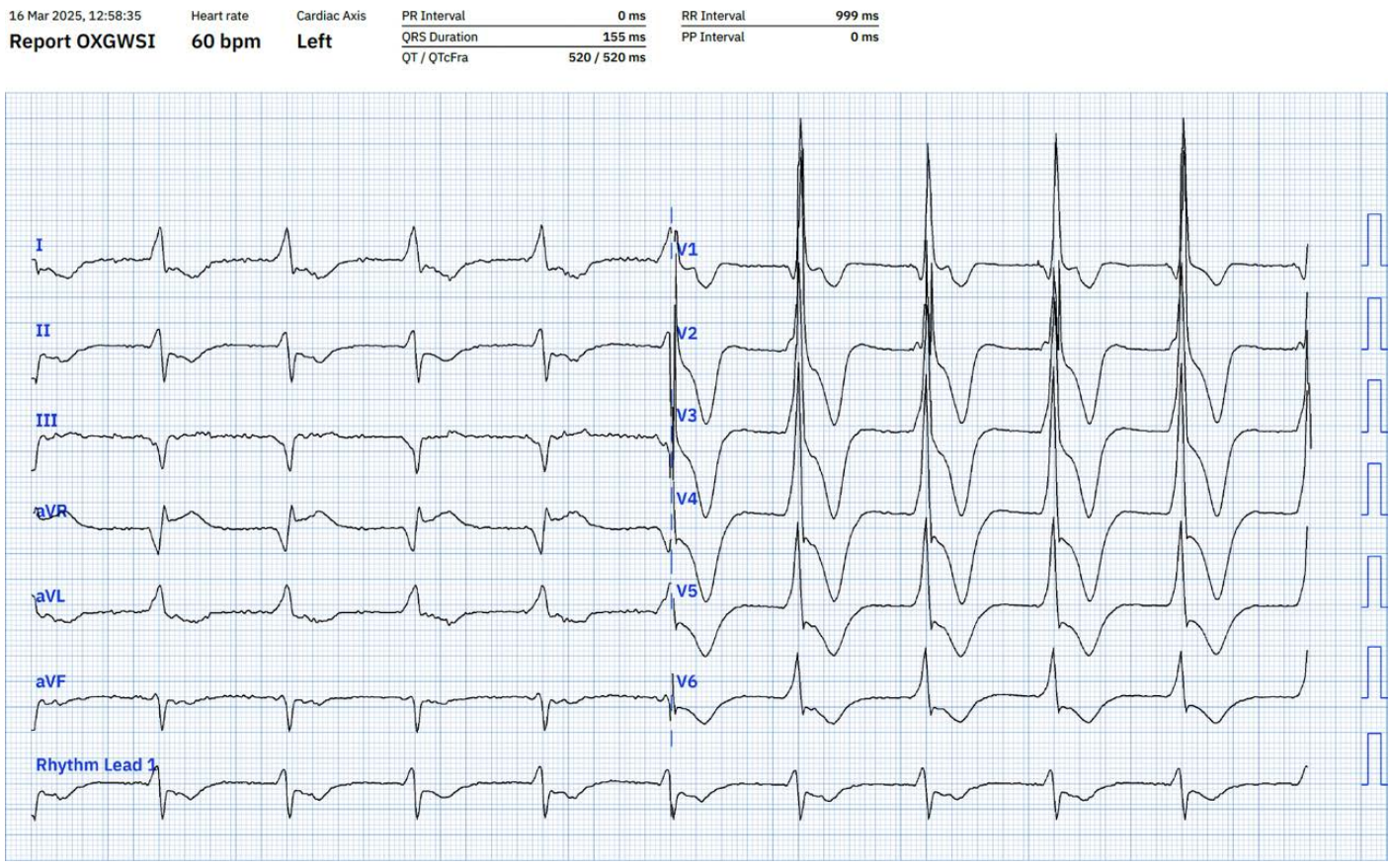

Figure 3. Final ECG following LOT-CRT, showing a narrower QRS complex (155 ms), indicative of improved ventricular synchrony (PMcardio (Powerful Medical, Slovakia), an AI-based ECG interpretation software, was used post-procedurally to confirm QRS narrowing and to standardize measurement of QRS duration. The software was not used to guide intra-procedural decision-making).

Table 1. Clinical, electrocardiographic, and procedure characteristics of patients with carillon annuloplasty device undergoing LOT-CRT

	Present case	Aschacher et al. (5)
Year	2025	2024
Origin	–	Austria
Age, years	70	80
Sex	M	M
Indication	ICM, LBBB	DCM, AVB
AF	Yes	Yes
QRS, ms	240	249
LVEF, %	20	30–35
Procedure	LOT-CRT	LOT-CRT
Lead type	LL	SDL
PD, min	83	NA
FT, min	21	NA
pQRS, ms	155	132
Complications	None	None
FU, weeks	0	2

AF, Atrial fibrillation; AVB, Atrioventricular block; DCM, Dilated cardiomyopathy; FT, Fluoroscopy time; FU, Follow-up; ICM, Ischemic cardiomyopathy; LBBB, Left bundle branch block; LL, Lumenless lead; LOT-CRT, Left bundle branch-optimized cardiac resynchronization therapy; PD, Procedure duration; SDL, Stylet-driven lead.

This case also highlights an important practical point: operators should consider LOT-CRT when conventional BiVP-CRT (biventricular pacing cardiac resynchronization therapy) is not feasible due to high LV lead thresholds or anatomic barriers (e.g., annuloplasty devices), or when LBBAP alone yields inadequate resynchronization such as excessively prolonged RWPT. In such scenarios, combining LV and LBBAP leads offers an effective alternative strategy. Further studies are needed to establish standardized approaches and assess the long-term outcomes of LOT-CRT in patients with transvenous annuloplasty devices. Beyond the present case, the hybrid LOT-CRT approach may also have broader implications for patients undergoing transcatheter valve therapies, such as transcatheter mitral, tricuspid, and combined interventions. As the utilization of percutaneous valve repair strategies increases, challenges related to lead placement and optimal ventricular resynchronization are expected to become more frequent. In such anatomically complex scenarios, hybrid strategies integrating conduction system pacing with conventional coronary venous pacing could provide a reproducible solution for maintaining electrical synchrony. Given these trends, the integration of CSP into heart failure management algorithms will be crucial, and as collective experience grows, LOT-CRT may become an increasingly viable option, aligning with the evolving recommendations of international pacing guidelines.

Conclusion

This case demonstrates that LOT-CRT can be successfully performed in patients with a Carillon annuloplasty device when other standard options are not feasible. Advanced imaging, meticulous procedural planning, and alternative pacing strategies should be kept in mind in patients with complex anatomies.

Ethics Committee Approval: This is a single case report, and therefore ethics committee approval was not required in accordance with institutional policies.

Informed Consent: The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE (Committee on Publication Ethics) guidance.

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