Phase analysis using cadmium-zinc-telluride single photon emission computed tomography for evaluating mechanical synchronization: A case report on left bundle branch–optimized cardiac resynchronization therapy

Qiting Sun, PhD,*[1] Haixiong Wang, PhD,†[1] Zhifang Wu, PhD,‡ Ruiliang Huang, MD,§ Jing Ma, MD,‖ Sijin Li, PhD‡¶

*From the *Department of Nuclear medicine, Shanxi Cardiovascular Hospital, Taiyuan, China, †Department of Cardiology, Shanxi Cardiovascular Hospital, Taiyuan, China, ‡Collaborative Innovation Center for Molecular Imaging of Precision Medicine, Taiyuan, China, §Department of Radiology, Shanxi Cardiovascular Hospital, Taiyuan, China, ‖Medical Records and Statistics Department, Shanxi Cardiovascular Hospital, Taiyuan, China, and ¶Department of Nuclear Medicine, First Hospital of Shanxi Medical University, Taiyuan, China.*

Introduction

Left bundle branch area pacing (LBBAP) is a promising physiological pacing strategy for patients with heart failure.[1,2] LBBAP improved clinical outcomes compared with biventricular pacing in patients with cardiac resynchronization therapy (CRT) indications and may be a reasonable alternative to biventricular pacing.[3] However, left bundle branch (LBB) pacing exhibits some limitations. LBB-optimized CRT (LOT-CRT) is an innovative technique based on conventional CRT implanting pacing in the lateral wall of the left ventricle. LBBAP lead implantation is also indicated to improve the response rate for CRT. Currently, limited large-sample follow-up studies suggest that LOT-CRT could improve the long-term prognosis for patients with heart failure.[4] Accordingly, it is necessary to identify a simple and feasible method to confirm which implantation technique, including conventional CRT, LBBAP, and LOT-CRT, can accurately improve left ventricular (LV) synchrony and the outcome for individual patients. To the best of our knowledge, few reports have adopted imaging methods to explore this scientific aspect. A patient undergoing LOT-CRT was evaluated by cadmium-zinc-telluride single photon emission computed tomography (CZT-SPECT) gated myocardial perfusion imaging (GMPI) phase analysis technique. We analyzed which locations during pacing lead implantation played an important role in improving mechanical synchronization for patient response.

KEYWORDS Phase analysis; Mechanical synchronization; CZT-SPECT; LOT-CRT; Cardiac resynchronization therapy
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[1]Qiting Sun and Haixiong Wang contributed equally to this work. **Address reprint requests and correspondence:** Dr Sijin Li, Department of Nuclear Medicine, The First Hospital of Shanxi Medical University, Collaborative Innovation Center for Molecular Imaging of Precision Medicine, 85 JiefangNan Rd, Taiyuan, 030001, Shanxi Province, China. E-mail address: lisjnm123@163.com.

KEY TEACHING POINTS

- Left bundle branch–optimized cardiac resynchronization therapy (LOT-CRT) is an innovative technique. Currently, limited large-sample follow-up studies suggest that LOT-CRT could improve the long-term prognosis for patients with heart failure.
- Gated myocardial perfusion imaging phase analysis technique is a simple and feasible method to evaluate mechanical synchronization.
- It is necessary to explore the application of cadmium-zinc-telluride single photon emission computed tomography mechanical synchrony evaluation in resynchronization therapy; it may save medical costs.

Methods

A 54-year-old male patient with dilated cardiomyopathy underwent LOT-CRT in the Cardiology Department of Shanxi

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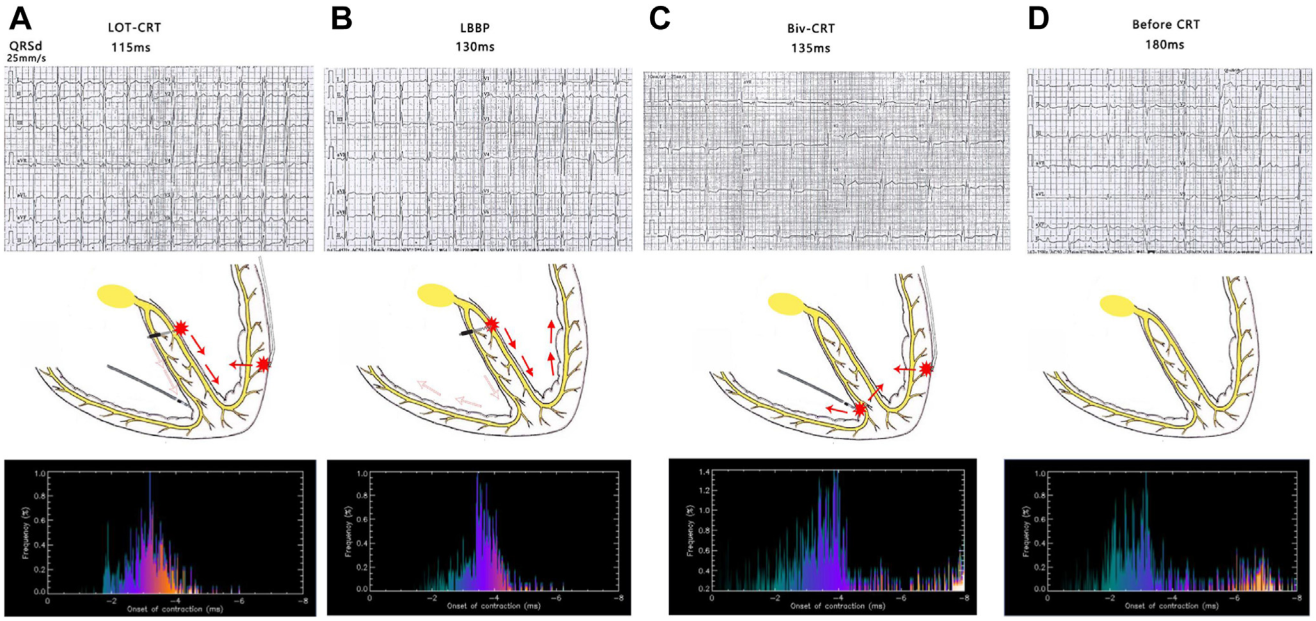

Figure 1 QRS duration acquisition methods and phase analysis images of cadmium-zinc-telluride single photon emission computed tomography gated myocardial perfusion imaging.

Cardiovascular Hospital on December 4, 2021, enrolled in this study, with NYHA class IV, intraventricular conduction delay, and QRS duration 180 ms. The patient underwent GMPI using CZT-SPECT (Discovery NM 530c; GE Healthcare, Haifa, Israel) before LOT-CRT. LV systolic function parameters included end-diastolic volume, end-systolic volume, LV ejection fraction, and mechanical systolic synchronization parameters included phase standard deviation, which is the standard deviation of phase distribution, and phase histogram bandwidth, which represents 95% width of phase histogram, were obtained using GMPI (Emory Cardiac Toolbox [version 3.2] software) before implantation. Moreover, the patient received a single intravenous injection of ^{99m}Tc-MIBI 370MBq, after which resting GMPI was performed 3 times at 1.0–1.5 hours postinjection on day 3 after implantation. The total acquisition time was approximately 20 minutes. The acquisition sequence and method are shown in Figure 1 and are summarized as follows: first time: unclosed electrode (normal optimization LOT-CRT); second time: LBBAP means closed coronary venous (CV) electrode; third time: CV pacing means closed LBB electrode. To ensure the reliability of the parameters, the interval between 2 acquisitions was 5 minutes. Patients undergoing GMPI were followed for 6 months after LOT-CRT.

Results

Mechanical synchronization parameters were analyzed; 4 imaging results are presented in Figure 1 and Figure 2. At 6-month follow-up, the LV cardiac function parameters and phase analysis parameters of CZT-SPECT GMPI images were observed. This is a responder to LOT-CRT implantation. There was significant improvement in the LV cardiac function parameters between baseline parameters and 6-month parameters after LOT-CRT: end-diastolic volume decreased from 170 mL to 161 mL, end-systolic volume decreased from 149 mL to 107 mL, and LV ejection fraction improved from 12% to 34%. In addition, CZT-SPECT phase analysis mechanical synchronicity parameters were significantly improved. Phase standard deviation decreased from 78.97° to 42.84° and phase histogram bandwidth decreased from 247° to 121°. In addition, his heart failure symptoms have significantly improved from NYHA class IV to class II.

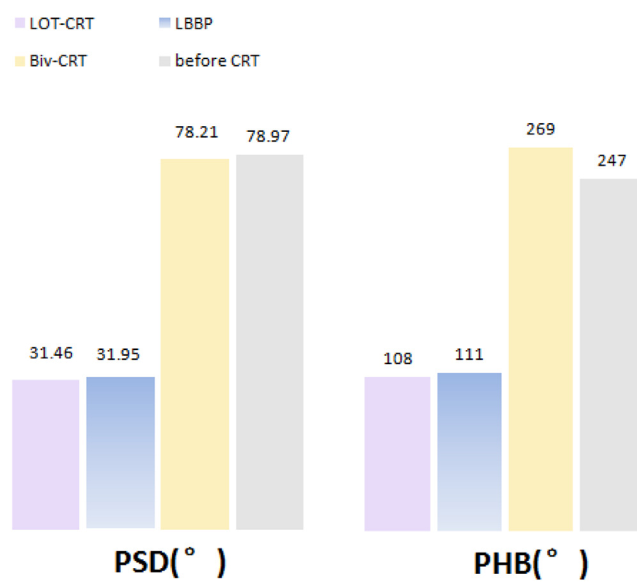

Figure 2 Phase analysis results of cadmium-zinc-telluride single photon emission computed tomography gated myocardial perfusion imaging. Biv-CRT = biventricular cardiac resynchronization therapy; CRT = cardiac resynchronization therapy; LBBP = left bundle branch pacing; LOT-CRT = left bundle branch–optimized cardiac resynchronization therapy; PHB = phase histogram bandwidth; PSD = phase standard deviation.

Discussion

It is widely acknowledged that CRT improves LV systolic function by improving LV systolic synchrony and can improve the quality of life and survival outcomes for patients with heart failure, but conventional CRT has some limitations. The response rate was affected by finding the accurate target vein and the mismatch between the electrode implantation site and the latest excitation point.

Currently, the QRS duration is used as an inclusion criterion for CRT implantation; however, the essence of CRT is to solve mechanical dyssynchrony. Accordingly, mechanical synchronization is also important for performing CRT. Direct evidence of mechanical contraction synchronicity improvement could be provided using the CZT-SPECT GMPI phase analysis technique. Although ultrasound imaging is widely used to evaluate mechanical synchronization, it is associated with some limitations, such as poor repeatability and complex software processing. GMPI phase analysis is a technique for quantitative evaluation of LV myocardial mechanical synchronization. Phase analysis involves a short-axis diagram with 8 phases in 1 cardiac cycle using the GMPI image as input information. The left ventricle is divided into more than 700 areas, and 3D count distributions are extracted from each of the left ventricle short-axis data sets. Phase distribution of the initial time of myocardial contraction in different parts and the whole phase of the LV distribution are then obtained by calculating the radioactivity count rate of each area.[5] The CZT-SPECT phase analysis technique used in this study is simpler, more objective, and more reproducible compared to ultrasound imaging.

Observations in our case suggested that the pacing effect of LBB pacing was similar to LOT-CRT. There were a few differences in mechanical synchronization between the 2 electrode implantation methods, suggesting that physiological pacing can substantially improve patient prognosis. However, CV pacing did not improve mechanical synchronization, and the parameters between CV pacing and the preoperative parameters were not significantly different, which may be because CV pacing is often implanted in the left ventricle lateral wall; however, there was no obvious scar on the lateral wall of the perfusion image for the patient. The essential reason may be that pacing in the LBB region is more consistent with physiological conduction. Moreover, the electrical conduction abnormality was resolved, and the mechanical synchronization was improved. CV pacing did not improve mechanical synchronization in this case. The QRS duration has certain limitations in screening patients and evaluating prognosis for patients. The essence of any synchronous therapy is to solve mechanical synchronization, and evidence from our case may provide new ideas for clinicians. Clinicians can use the CZT-SPECT phase analysis technique to explore new imaging evidence for physiological regional pacing and LOT-CRT. It is necessary to explore the application of CZT-SPECT mechanical synchrony evaluation in selecting resynchronization therapy for patients with chronic heart failure. It can save medical costs.

Limitations

The findings of this study need to be confirmed in large-sample-size studies in the future.

Conclusion

The pacing effect of the LBB region is similar to LOT-CRT, and there are few differences in mechanical synchronization between the 2 kinds of electrode implantation methods. Moreover, there are no significant differences in mechanical synchronization parameters between CV pacing and preoperative parameters.

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