

Original Article

Comparison of the Results of Left Ventricular Epicardial and Endocardial Pacing Through the Coronary Sinus in Patients With Triple-Chamber Pacing

Aboalfath Alizadeh¹, MD; Ehsan Ghourchian^{*2}, MD; Sajad Naderi², MD;
Mohammadesmaeil Zanganehfar², MD; Ali Ghasemi², MD;
Najand Salek², MD; Sara Baramaki², MD

ABSTRACT

Background: Considering the many reports of elevated threshold levels and left ventricular dysfunction in epicardial leads, the evaluation of the short- and long-term efficacy of this type of leads is necessary in comparison with the coronary sinus (CS) leads. The present study compared left ventricular epicardial pacing via surgery and CS pacing in patients with triple-chamber pacemakers.

Methods: This retrospective cohort study was performed on patients referred for cardiac resynchronization therapy. The patients were re-evaluated with ECG after pacemaker implantation and before discharge. The evaluations were performed in 2 patient groups under left ventricular epicardial pacing and CS pacing.

Results: At 12 months' follow-up, the mean left ventricular pacing lead threshold was significantly higher in the patients with epicardial lead pacing than in those with endocardial lead pacing. Additionally, regarding the ECG pattern after lead pacing, the morphology of QRS at V₁ lead and also the type of the QRS axis significantly differed between epicardial pacing and CS pacing 6–12 months after pacemaker implantation. The mean left ventricular pacing lead threshold was at its highest in the posterolateral area and at its lowest in the anterolateral area, but without any significant difference.

Conclusions: Comparisons between the results and the long-term effects of CS pacing and surgical epicardial lead pacing in the present study indicated that the increase and changes in the left ventricular leading threshold in the epicardial pacing lead were much more pronounced than those in CS pacing through the CS. Therefore, the use of CS leads might be preferred to pericardial leads due to the stability of left ventricular leads. (*Iranian Heart Journal 2019; 20(2): 69-74*)

KEYWORDS: Epicardial LV lead, Endocardial LV lead, Coronary sinus

¹ Cardiac Electrophysiology Research Center, Rajaie Cardiovascular, Medical, and Research Center, Iran University of Medical Sciences, Tehran, IR Iran.

² Rajaie Cardiovascular, Medical, and Research Center, Iran University of Medical Sciences, Tehran, IR Iran.

* **Corresponding Author:** Ehsan Ghourchian. MD.

Email: eghoorchian@yahoo.com

Tel: 09024239545

Received: September 22, 2018

Accepted: December 6, 2019

Treatment by cardiac resynchronization therapy (CRT) synchronicity preserves and stores ventricular, interventricular, and intraventricular contractility and results in improved clinical outcomes and cardiac function in patients with congestive heart failure along with a broad QRS complex.¹ However, a significant percentage of patients with CRT (about 40%) do not show improvement in clinical manifestations or cardiac function.² A lack of left ventricular dyssynchrony, the inappropriate placement of the left ventricle lead, a high myocardial pulsation rate, and undesirable programming of CRT devices all contribute to the absence of a proper response to CRT.³ In particular, the proper positioning of the left ventricular lead in a branch of the coronary sinus (CS) is one of the technical challenges in implanting the CRT device. A comprehensive evaluation of CRT candidates should include an evaluation of all these CRT responses (the last level of the activation of the left ventricle, the presence of various branches of the CS, and the assessment of the location of myocardial scar). In addition, recent experience has shown that the placing of leads in multiple zones has far more benefits than implanting leads in a single region.^{4,5} Therefore, in order to achieve a successful placing of biventricular pacing, the operator should perform lead placing by considering 3 characteristics of determining the last region activated in the left ventricle, the lack of implantation in the area without myocardial scar, and the determination of the exact anatomy of the CS. However, between 8% and 10% of patients under CRT experience unsuccessful CS cannulation.^{6,7} The surgical procedure for the insertion of epicardial pacing may be prioritized. In addition to the pacing of the left ventricular epicardial area using the transvenous method or the surgical technique, alternate sites for pacemakers are also considered.^{8,9} In particular, endocardial pacing has yielded favorable results for the clinical and hemodynamic improvement of patients

compared with epicardial pacing. Instead, the endocardial pace may be more activated by physiological electrical activation.¹⁰ Improving the quality of life and the survival of patients with left ventricular dysfunction has been successful with CRT implantation. This is achieved by 2 methods of the insertion of the leads through the CS and the other through an open epicardial surgery in the left ventricle. However, what has not been thus far evaluated is the impact of some other factors such as gender and age of the patients, ischemic patterns, ECG parameters, types of pacemakers, left ventricular ejection fraction, mortality and threshold, and features of the pace device. Furthermore, in many cases, due to the lack of an appropriate branch of the CS, the implantation of the epicardial lead in the left ventricle is necessary. Considering the many reports of elevated threshold levels and left ventricular dysfunction in epicardial leads, the evaluation of the short- and long-term efficacy of this type of leads is necessary in comparison with CS leads. The present study aimed to compare left ventricular epicardial pacing and CS pacing in patients with triple-chamber pacemakers.

METHODS

This retrospective cohort study was performed on patients referred to Rajaie Cardiovascular, Medical, and Research Center between 2011 and 2016 for CRT implantation. At the time of referral, baseline 12-lead ECG at rest was considered for all the patients. The patients' baseline characteristics, as well as their ECGs, were all collected from the records in the hospital. The patients were re-evaluated with ECG after device implantation and before discharge. The evaluations were performed in 2 groups of patients under left ventricular epicardial pacing and CS pacing. In addition, the characteristics of pacing, the type of lead, the time course, the increase in threshold, and the risk of lead dysfunction were evaluated within 1 year after lead implantation. Finally,

the characteristics of repolarization were evaluated before and after implantation. ECG parameters such as baseline QRS and post-CRT QRS were assessed. Additionally, pacing parameters and probable mortality events were assessed during the 1-year period after pace implantation and compared between the 2 groups.

Statistical Analysis

For the statistical analysis, the results were presented as mean \pm standard deviation (SD) for the quantitative variables and were summarized by absolute frequencies and percentages for the categorical variables. The normality of the data was analyzed using the Kolmogorov–Smirnov test. The categorical variables were compared using the χ^2 test or the Fisher exact test when more than 20% of the cells with expected counts <5 were observed. The quantitative variables were also compared using the *t*-test or Mann–Whitney *U*-test. For the statistical analyses, the SPSS software, version 16.0, for Windows (SPSS Inc, Chicago, IL) was used. A *P* value ≤ 0.05 was considered statistically significant.

RESULTS

The study population was divided into 2 groups: the group with left ventricular epicardial pacing ($n=25$) and the group with CS pacing ($n=25$). As is shown in Table 1, comparisons of the baseline characteristics showed a significantly higher mean age in those with endocardial lead pacing than in those with

epicardial pacing, but there were no differences in terms of gender distribution, baseline diagnosis (ie, dilated cardiomyopathy or inflammatory cardiomyopathy), and traditional cardiovascular risk factors including hypertension and diabetes mellitus. In 12-lead ECG and echocardiography assessments (Table 2), the mean left ventricular ejection fraction was significantly higher in the patients with epicardial lead pacing. The mean PR segment was significantly more prolonged in the patients with endocardial lead pacing. There was no difference in the QRS pattern between the 2 groups. Within the follow-up period (2 months after lead pacing), no difference was revealed between the 2 groups with epicardial and CS pacing with respect to the average left ventricular pacing lead threshold, right ventricular pacing lead threshold, and right ventricular lead sensing. A 6 and 12 months' follow-up, the mean left ventricular pacing lead threshold was significantly higher in the patients with epicardial lead pacing than in those with endocardial lead pacing (Table 3). Further, regarding the ECG pattern after lead pacing (Table 4), the morphology of QRS at V_1 lead and also the type of the QRS axis significantly differed between the 2 groups of epicardial and endocardial lead pacing. In total, as is shown in Table 5, at 6 and 12 months after pacemaker implantation, the mean left ventricular pacing lead threshold was at its highest in the posterolateral area and at its lowest in the anterolateral area, but without any significant difference.

Table 1. Baseline characteristics in epicardial and endocardial leading pace

| Item | Epicardial Lead | Endocardial Lead | <i>P</i> value |
|---------------------------|-------------------|-------------------|----------------|
| Gender | | | |
| Men | 14 (56) | 29 (56.9) | 0.943 |
| Women | 11 (44) | 22 (43.1) | |
| Mean age, (y) | 55.40 \pm 13.43 | 63.08 \pm 10.75 | 0.009 |
| Basic Diagnosis | | | |
| Dilated cardiomyopathy | 12 (48) | 21 (41.2) | 0.573 |
| Ischemic cardiomyopathy | 13 (52) | 30 (58.8) | |
| Risk Factor | | | |
| Hypertension | 2 (8) | 4 (7.8) | 0.939 |
| Diabetes | 5 (20) | 9 (17.6) | |
| Hypertension and diabetes | 4 (16) | 6 (11.8) | |

Table 2. ECG and echocardiography findings in epicardial and endocardial leading pace

| Item | Epicardial Lead | Endocardial Lead | P value |
|-------------------------|-----------------|------------------|---------|
| Echocardiography | | | |
| Mean LVEF | 20.40 ± 6.11 | 19.96 ± 5.75 | 0.019 |
| Mean pacing threshold | 0.59 ± 0.35 | 0.72 ± 0.86 | 0.479 |
| ECG | | | |
| Mean PR segment | 15.00 ± 2.74 | 17.10 ± 2.34 | 0.001 |
| QRS pattern | | | |
| IVCD | 3 (12) | 5 (9.8) | 0.532 |
| LBBB | 19 (76) | 42 (82.4) | |
| RBBB | 2 (8) | 4 (7.8) | |
| Normal | 1 (4) | 0 (0) | |
| Mean QRS interval, ms | 15.58 ± 16.81 | 159.61 ± 13.56 | 0.995 |
| QRS Axis | | | |
| LAD | 10 (40) | 18 (35.3) | 0.911 |
| Extreme | 2 (8) | 5 (9.8) | |
| Normal | 13 (52) | 28 (54.9) | |

LVEF, Left ventricular ejection fraction; IVCD, Intraventricular conduction delay; LBBB, Left bundle branch block; RBBB, Right bundle branch block; LAD, Left axis deviation

Table 3. Pacing characteristics within the follow-up period

| Item | Epicardial Lead | Endocardial Lead | P value |
|--|-----------------|------------------|---------|
| 2 months | | | |
| Mean left ventricular pacing lead threshold | 0.76 ± 0.88 | 0.76 ± 0.98 | 0.997 |
| Mean right ventricular pacing lead threshold | 0.50 ± 0.56 | 0.42 ± 0.40 | 0.456 |
| Right ventricular lead sensing | 14.02 ± 5.04 | 13.48 ± 3.25 | 0.584 |
| 6 months | | | |
| Mean left ventricular pacing lead threshold | 1.30 ± 1.37 | 0.77 ± 1.09 | 0.046 |
| Mean right ventricular pacing lead threshold | 0.91 ± 1.75 | 0.65 ± 0.40 | 0.091 |
| Right ventricular lead sensing | 13.21 ± 6.68 | 3.94 ± 3.57 | 0.548 |
| 12 months | | | |
| Mean left ventricular pacing lead threshold | 1.66 ± 1.48 | 0.88 ± 1.23 | 0.027 |
| Mean right ventricular pacing lead threshold | 0.88 ± 1.63 | 0.63 ± 0.44 | 0.456 |
| Right ventricular lead sensing | 14.47 ± 6.07 | 14.06 ± 4.00 | 0.758 |

Table 4. ECG characteristics after lead pacing

| Item | Epicardial Lead | Endocardial Lead | P value |
|--|-----------------|------------------|---------|
| Mean QRS duration | 146.25±17.15 | 140.39±15.23 | 0.140 |
| QRS Axis | | | |
| Normal axis | 2 (8) | 11 (21.6) | 0.021 |
| Axis extreme | 12 (48) | 17 (33.3) | |
| Axis LAD | 5 (20) | 20 (39.2) | |
| Axis RAD | 3 (12) | 3 (5.9) | |
| QRS Morphology at V₁ | | | |
| QS pattern | 7 (28) | 3 (5.9) | 0.019 |
| RS pattern | 3 (12) | 2 (3.9) | |
| qR pattern | 3 (12) | 12 (23.5) | |
| rS pattern | 12 (48) | 34 (66.7) | |

LAD, Left axis deviation; RAD, Right axis deviation

Table 5. Endocardial lead pace features based on the leading position

| Item | Epicardial Lead | Endocardial Lead |
|-----------------------|-----------------|------------------|
| Baseline | | |
| Lateral | 0.48 ± 0.36 | 0.43 ± 0.61 |
| Posterolateral | 1.15 ± 1.59 | 0.41 ± 0.19 |
| Anterolateral | 0.71 ± 0.53 | 0.42 ± 0.19 |
| Anterior | 0.75 | 0.25 |
| 6 months later | | |
| Lateral | 0.69 ± 0.87 | 0.30 ± 0.10 |
| Posterolateral | 1.17 ± 1.64 | 0.56 ± 0.72 |
| Anterolateral | 0.43 ± 0.21 | 0.52 ± 0.26 |
| Anterior | 0.88 | 0.25 |
| 1 year later | | |
| Lateral | 0.77 ± 0.99 | 0.48 ± 0.61 |
| Posterolateral | 1.23 ± 1.85 | 0.42 ± 0.39 |
| Anterolateral | 0.65 ± 0.47 | 0.36 ± 0.13 |
| Anterior | 1.00 | 0.25 |

DISCUSSION

In the present study and in line with previous studies, we sought to evaluate the implications of implanting 2 types of pacemakers: surgical epicardial lead pacing and endocardial lead pacing through the CS. The most notable finding in the current study was that the mean left and right ventricular lead thresholds were not significantly different between the 2 types of epithelial and endocardial lead pacing at baseline and 2 months later; nonetheless, at 6 and 12 months' follow-up, the mean left ventricular lead threshold was higher in epicardial pacing than in CS lead pacing. Moreover, there was no difference in sensing the right ventricle at different times after the pacemaker implantation. Also of note was that the increase in the threshold of left ventricular leading was observed within 1 year after the implantation of the lead only in the epicardial lead pacing group, while it was not visible in the endocardial lead pacing group. What is considered to be optimal by experts is that the stability of the threshold of the lead in patients with chronic and advanced heart failure is particularly high. In other words, the occurrence of changes in the pacing threshold is always associated with the cause of the

pathological background such as the failure of the implant and the displacement of the lead.

The results of various studies on the threshold values for pacing leads are completely different in each lead type. In a study by Mair et al,¹¹ the pacing threshold of the CS leads increased more than that of the epicardial leads, which is in complete contradiction with our study. In a study by Izutani et al,¹² there was no difference between the 2 groups in terms of thresholds; their finding is not consistent with our study. In an investigation by van Gelder et al,¹³ at 2 months' follow-up of endocardial lead implantation, the threshold of stimulation showed a significant increase. In our study, this increase was significantly higher in epicardial lead pacing. Nega et al¹⁴ reported that the pacing threshold in the epicardial lead significantly increased, which is consistent with our study. In point of fact, what we see as the final product in our study is that, firstly, the increase in the threshold of epicardial pacing leads is far more than that of endocardial pacing leads through the venous sinus and secondly, changes to the threshold of pacing are not affected by sensing. In comparison with CS pacing, epicardial pacing offered a more invasive approach and lead to the following changes:

1) more injury and bleeding in the epicardial area, 2) more inflammatory response, and 3) more fibrosis after repair.

For these reasons, the pacing threshold in the epicardial approach will increase over time.

CONCLUSIONS

Comparisons of the results and the long-term effects between endocardial and epicardial lead pacing in the present study indicate that the increase and changes in the left ventricular leading threshold in the epicardial pacing lead are much more pronounced than those in the endocardial pacing lead through the venous sinus. Therefore, the use of CS leads will be

preferred to pericardial leads due to the stability of the pacing threshold over time.

REFERENCES

1. Abraham WT, Hayes DL. Cardiac resynchronization therapy for heart failure. *Circulation* 2003;108:2596–603.
2. Bleeker GB, Bax JJ, Fung JW, van der Wall EE, Zhang Q, Schalij MJ et al. Clinical versus echocardiographic parameters to assess response to cardiac resynchronization therapy. *Am J Cardiol* 2006;97:260–3.
3. Ypenburg C, van de Veire N, Westenberg JJ, Bleeker GB, Marsan NA, Henneman MM et al. Noninvasive imaging in cardiac resynchronization therapy—Part 2: follow-up and optimization of settings. *Pacing Clin Electrophysiol* 2008;31:1628–39.
4. Garrigue S, Jais P, Espil G, Labeque JN, Hocini M, Shah DC et al. Comparison of chronic biventricular pacing between epicardial and endocardial left ventricular stimulation using Doppler tissue imaging in patients with heart failure. *Am J Cardiol* 2001;88:858–62.
5. Van Gelder BM, Scheffer MG, Meijer A, Bracke FA. Transseptal endocardial left ventricular pacing: an alternative technique for coronary sinus lead placement in cardiac resynchronization therapy. *Heart Rhythm* 2007;4:454–60.
6. DeRose JJ, Ashton RC, Belsley S, Swistel DG, Vloka M, Ehlert F et al. Robotically assisted left ventricular epicardial lead implantation for biventricular pacing. *J Am Coll Cardiol* 2003;41:1414–9.
7. Fernandez AL, Garcia-Bengochea JB, Ledo R, Vega M, Amaro A, Alvarez J et al. Minimally invasive surgical implantation of left ventricular epicardial leads for ventricular resynchronization using video-assisted thoracoscopy. *Rev Esp Cardiol* 2004;57:313–9.
8. Jais P, Takahashi A, Garrigue S, Yamane T, Hocini M, Shah DC et al. Mid-term follow-up of endocardial biventricular pacing. *Pacing Clin Electrophysiol* 2000;23: 1744–7.
9. Leclercq C, Gadler F, Kranig W, Ellery S, Gras D, Lazarus A et al. A randomized comparison of triple-site versus dual-site ventricular stimulation in patients with congestive heart failure. *J Am Coll Cardiol* 2008;51:1455–62.
10. van Deursen C, van Geldorp IE, Rademakers LM, van Hunnik A, Kuiper M, Klersy C et al. LV Endocardial pacing improves resynchronization therapy in canine LBBB hearts. *Circ Arrhythmia Electrophysiol* 2009; Epub ahead of print 10 August 2009.
11. Mair H1, Sachweh J, Meuris B, Nollert G, Schmoeckel M, Schuetz A, Reichart B, Daebritz S. Surgical epicardial left ventricular lead versus coronary sinus lead placement in biventricular pacing. *Eur J Cardiothorac Surg*. 2005 Feb;27(2):235-42.
12. Izutani H1, Quan KJ, Biblo LA, Gill IS. Biventricular pacing for congestive heart failure: early experience in surgical epicardial versus coronary sinus lead placement. *Heart Surg Forum*. 2002;6(1):E1-6; discussion E1-6.
13. van Gelder BM1, Scheffer MG, Meijer A, Bracke FA. Transseptal endocardial left ventricular pacing: an alternative technique for coronary sinus lead placement in cardiac resynchronization therapy. *Heart Rhythm*. 2007 Apr;4(4):454-60. Epub 2006 Nov 29.
14. Naga V, Garikipati, MD, MPH, Suneet ittal, MD, Farooq Chaudhry, MD, Dan L. Musat, MD, Tina Sichrovsky, MD: Comparison of Endovascular versus epicardial lead placement for resynchronization therapy: The mount Sinai hospital, new York, New York, Manuscript received August 6, 2013; revised manuscript received and accepted November 8, 2013.