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Quadripolar leads are associated with better results according to bipolar leads in cardiac resynchronization therapy in one-year follow-up: Multicenter, retrospective study

Kuadripolar sol ventrikül leadler, bir yıllık takipte kardiyak resenkronizasyon tedavisinde bipolar leadlere göre daha iyi sonuçlarla ilişkilidir: Çok merkezli, retrospektif çalışma

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ABSTRACT

Aim: In this study, we compared patients who were performed cardiac resynchronization therapy with quadripolar left ventricle lead or bipolar left ventricle lead in one-year follow-up. We investigated the relationship between the improvements of New York Heart Association classification, electrocardiography and echocardiography parameters according to lead type at one-year follow-up after CRT treatment.

Materials and Methods: In this study, 91 patients were enrolled respectively as bipolar left ventricle lead and quadripolar left ventricle lead. 40 patients are quadripolar left ventricle lead and 51 patients are bipolar left ventricle lead.

Results: After cardiac resynchronization therapy treatment in one year follow-up, patients with ≥1 NYHA improvement was 80% vs 56.8%, p=0.006 and left ventricular ejection fraction ≥5% was 77.5% vs 54.9%, p=0.031 and QRS duration 140.4±11.7 vs 151.7±19.4 ms, p=0.018 in quadripolar and bipolar left ventricle lead respectively. The univariable regression analysis revealed that left ventricular ejection fraction (OR:1.082 95%CI [1.005–1.165], p=0.037), QRS duration (OR:0.980 95%CI [0.961–0.999], p=0.038), NYHA class (OR:1.107 95%CI [0.075–0.682], p=0.008) and left ventricular ejection fraction improvement (OR:2.959 95%CI [1.083–8.086], p=0.034) were better response cardiac resynchronization therapy with quadripolar left ventricle rather than bipolar left ventricle lead.

Conclusion: Qdp LVL can be considered instead of BiP LVL to shorten QRS duration and better improve LVEF and NYHA in patients undergoing CRT in long-term follow-up

Keywords: Cardiac resynchronization therapy, quadripolar left ventricular leads, bipolar left ventricular leads, left ventricular ejection fraction, NYHA classification.

ÖZ

Amaç: *Bu çalışmada, bir yıllık takipte kuadripolar sol ventrikül leadi veya bipolar sol ventrikül leadi ile kardiyak resenkronizasyon tedavisi uygulanan hastaları karşılaştırdık. Kardiyak resenkronizasyon tedavisi sonrası NYHA (*New York Heart Association) sınıflaması*, elektrokardiyografi ve ekokardiyografi parametrelerinin lead tipine göre bir yıllık takipteki düzelmelerini araştırdık.*

Gereç ve Yöntem: *Bu çalışmada 91 hasta sırasıyla bipolar sol ventrikül lead'i ve kuadripolar sol ventrikül lead'i olarak kaydedildi. 40 hasta kuadripolar sol ventrikül lead'i ve 51 hasta bipolar sol ventrikül leadi takıldı.*

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Bulgular: *Bir yıllık takipte kardiyak resenkronizasyon tedavisi tedavisinden sonra, ≥1 NYHA iyileşmesi olan hastalar %80'e karşı %56,8, p=0.006 ve sol ventrikül ejeksiyon fraksiyonu ≥%5 %77,5'ya karşılık %54,9, p=0.031 ve QRS süresi 140,4 idi. ±11,7 vs 151,7±19,4 p=0.018 ms, sırasıyla kuadripolar ve bipolar sol ventrikül leadinde. Tek değişkenli regresyon analizi, sol ventrikül ejeksiyon fraksiyonu (OR:1.082 %95 CI [1.005–1.165], p=0.037), QRS süresi (OR:0.980 %95 CI [0.961–0.999], p=0.038), NYHA sınıfı (OR:1.107 %95 GA [0.075-0.682], p=0.008) ve sol ventrikül ejeksiyon fraksiyonu iyileşmesi (OR:2.959 %95 CI [1.083-8.086], p=0.034) kardiyak kardiyak resenkronizasyon tedavisi uygulanan ve kuadripolar sol ventrikül leadi uygulananlarda bipolar sol ventrikül leadi takılanlara göre daha iyi yanıtla ilişkili bulundu.*

Sonuç: *Kardiyak resenkronizasyon tedavisi uygulanan hastalarda uzun dönem takipte QRS süresini kısaltmak, sol ventrikül ejeksiyon fraksiyonunu ve NYHA'yı daha iyi iyileştirmek için bipolar sol ventrikül leadi yerine kuadripolar sol ventrikül leadi seçilmelidir.*

Anahtar Sözcükler: *Kardiyak resenkronizasyon tedavisi, kuadripolar sol ventrikül lead, bipolar sol ventrikül lead, sol ventrikül ejeksiyon fraksiyonu, NYHA sınıflaması.*

INTRODUCTION

Cardiac resynchronization therapy (CRT) is an appropriate treatment modality for patients with wide QRS (QRS≥130 ms) and low ejection fraction. Also, CRT is a chosen treatment method for patients who have atrioventricular block and reduced ejection fraction. Unfortunately, not all patients receiving CRT may benefit equally. Patients' clinical characterises, basal electrocardiographic, echocardiographic parameters and procedural success change clinical results (1, 2).

Successful CRT procedure depends on finding a reliable vein that went to through to the posterolateral left ventricle region. The left ventricular lead must be placed in this vein to pace the left ventricular posterolateral region. Even though left ventricle lead inserted posterolateral vein, CRT might not be effective. Scar, phrenic nerve stimulation, high ventricular capture threshold, lead dislodgement might hinder to pace left ventricle. With the development of Quadripolar left ventricular leads (QdP LVL) in 2011, it was aimed to increase the procedural success rate and to overcome these problems (3). QdP LVL have four electrodes and offer ten left ventricular pacing configurations compered to bipolar left ventricular leads (BiP LVL) and unipolar leads. QdP LVL has better clinical results that successful procedural rate and long-term clinical follow-up than BiP LVL.(3, 4)

In this study, we compared patients who were performed CRT with QdP LVL or BiP LVL in one-year follow-up. We investigated the results of one-year clinical follow-up of New York Heart Association (NYHA) classification, electrocardiography (ECG) and echocardiography parameters according to lead type after CRT treatment.

MATERIALS and METHODS

Study population

Patients underwent CRT were enrolled retrospectively according to the type of lead. CRT implantation took place based on current ACC-AHA and ESC heart failure guidelines. Patients who were performed the upgrade from the pacemaker or intracardiac defibrillator (ICD) were excluded because of the complexity of implantation. All patients had NYHAII-III ambulatory IV, QRS>130 ms, normal sinus rhythm and left bundle brachial block (LBBB) (1, 5). All of the patients were received demographic characteristics, biochemical parameters, used medication, ECG, echocardiography from the medical records on admission. After that, all patients were performed CRT and these parameters were recorded 1 year later again. Patients were treated optimal medication including angiotensin-converting enzyme inhibitor (ACE-I), angiotensin receptor blocker (ARB), mineralocorticoid antagonist, acetylsalicylic acid, ivabradine, b blockers, loop diuretics for heart failure (1). CRT implantation was performed with five experience operators in two centres.

Patients had a life expectancy of less than one-year, serious valve disease, performed revascularization in last six months, severe right heart failure and pacemaker or ICD were excluded.

CRT implantation procedure and lead type

CRT implantations were performed via sol subclavian vein, firstly ICD lead placement right ventricular apical after that coronary sinus was cannulated via a commercially available long peel away guiding sheet. QdP LVL (Boston Scientific, Marlborough, MA) or BiP LVL (Boston Scientific, Marlborough, MA) were inserted lateral (basal, posterior, anterior) coronary sinus branch in right anterior oblique 30-degree or sol anterior oblique

30–40-degree position in fluoroscopy. Lastly, atrial lead was inserted right atrial appendix. CRT optimization was done with ECG to find the narrowest QRS width (6, 7).

Electrocardiography

ECG (GE MAC 1200, USA) was taken before implantation, just after implantation and 1 year later from the electronic record or hospital data. QRS (was measured from the beginning of the Q wave to the end of the S wave), QT (was measured from beginning QRS complex to the end of T wave) and corrected QT (QT was calculated by using Bazett formula (QTc= QT/√R-R) were measured two experienced cardiologists who were blinded to patients data (8, 9).

Echocardiography

Echocardiography (Vivid 9 Pro, GE Vingmed, Milwaukee, Wisconsin, USA) was performed before implantation, just after implantation and 1 year later in the left lateral decubitus position. Left ventricular ejection fraction (LVEF) was calculated to use Modify Simpson method (10).

Follow-up

Patients who were performed CRT were followed up for 1 year. Biventricular pacing percentage were above %95 in all patients. Echocardiography (defined as ≥5% absolute increase in LVEF), ECG (decrease QRS duration) and clinical (decrease NYHA class) recovery were evaluated according to lead type (3).

Ethics committee approval (Decision No: 116.2017.178, Date: 02.07.2020) was obtained from the Non-Interventional Clinical Research Ethics Committee before the initiation of the study. Written and verbal consent was obtained from all participants. The Declaration of Helsinki was followed in the application of the ethical rules of the study.

Statistical analysis

The sample size was calculated in this study by taking into account the healthy population, and specific time period using the "simple random sampling method". Power analysis was calculated by using the post hoc analysis method and G power 3.1 package program. The study sample size was 91 patients, the margin of error was 0.05, the power of the study was 0.71 %, and the standard effect power was 0.52 % Statistical analyses were performed using SPSS 20.0 (IBM Corporation, Armonk, NY, USA). Continuous variables are presented as the mean ± standard deviation (SD) and categorical variables are expressed as n (number) and percentages (%). Normality assumptions were checked by the Shapiro-Wilk and Kolmogorov-Smirnov tests due to the number of cases in the groups. The baseline characteristics of the CRT patients were compared using Student's t-test for continuous variables that were normally distributed and the Pearson's X^2 test was used for categorical variables. Univariable and multivariable logistic regression analyses were performed for the association between quadripolar left ventricular lead implantation and age functional NYHA class improvement, LVEF, QRS duration, cQT interval. Univariable and multivariable logistic regression analyses were performed to identify independent possible risk factors using the parameter for functional NYHA class development in individuals who responded favourably to the quadripolar left ventricular lead implantation for all statistics, a two-tailed p-value below 0.05 was considered significant.

RESULTS

In this study, 91 patients were enrolled respectively as BiP LVL and QdP LVL. 40 patients are QdP LVLand 51 patients are BiP LVL. The mean age of QdP LVL was 62.2 years and BiP LVL was 61.3 years. Basal LVEF were 27.5% in QdP LVL and 28.3% in BiP LVL (p = 0.443), QRS duration were 152.5 ± 11.9 ms in QdP LVL and 154.4 ± 14.3 ms in BiP LVL (p = 0.256). NYHA II patients 24 (60%), NYHA III patients 16 (40%) and NYHA II patients 27(52.9%), NYHA III patients 24 (47.1%) were QdP LVL, BiP LVL respectively (Table-1).

After CRT treatment in one year follow-up LVEF were ([39.9 ± 5.5] vs [36.5 ± 7.5], p=0.028), QRS duration ([140.4 ± 11.7] vs [151.7 ± 19.4], p=0.018) in QdP LVL, BiP LVL respectively. NYHA I patients 16(44.4%), II 15(41.7%), III 5(13.9%). Patients with ≥1 NYHA improvement was (86.1% vs 58.3%, p=0.006) and LVEF ≥5% was (80.6% vs 58.3%, p=0.031). QRS duration (140.4 ± 11.7 vs 151.7 ± 19.4 ms, p = 0.018) and cQT interval (461.1 ± 57.2 vs 482.7 ± 54.6 ms, p=0.037) were narrower in those with QdPLVL. The univariable regression analysis revealed that LVEF (OR:1.082 95% CI [1.005–1.165], p = 0.037), QRS duration (OR:0.980 95% CI [0.961–0.999], p = 0.038), NYHA class (OR:1.107 95% CI [0.075–0.682], p = 0.008) and LVEF improvement (OR:2.959 95% CI [1.083–8.086], p = 0.034) were better response CRT therapy with QdP LVL that BiP LVL (Table-2). Qdp LVL was inserted in only one patient in posterior vein and apical locations. BiP LVL was inserted in two patients in posterior vein and apical locations. In the remaining patients, the lead position was in the lateral veins and mid-basal region.

Table-1. Demographic, clinical, and electrocardiographic characteristics of patients receiving CRT with bipolar and quadripolar left ventricular leads.

Variables	Quadripolar (n=40)	Bipolar (n=51)	p-value
Age, years	62.2 ± 8.7	61.3 ± 10.1	0.896
Sex, female	13 (32.5)	19 (37.2)	0.393
Follow-up duration, months	13.4 ± 4.1	13.4 ± 1	0.578
Hypertension, %	13 (32.5)	19 (37.2)	0.467
Diabetes mellitus, %	11 (27.5)	13 (25.4)	0.278
İschaemic CMP[1], %	14 (35)	17 (33.3)	0.432
NYHA[2] improvement, %	32 (80.0)	29 (56.8)	**0.006**
LVEF[3]improvement, %	31(77.5)	28(54.9)	**0.031**
Basal value			
NYHA class II, %	24(60.0)	27(529)	0.703
NYHA class III, %	16(40.0)	24 (47.1)	
LVEF, %	27.5 ± 3.2	28.3 ± 4.5	0.433
Heart rate, beat/min	71.6 ±13.2	74.7 ± 15.2	0.247
PR duration, ms	169.9 ± 51.1	172.0 ± 44.0	0.478
QRS duration, ms	152.4 ± 11.9	154.1 ± 14.3	0.256
QT interval, ms	461.2 ± 42.4	462.9 ± 44.5	0.387
cQT interval, ms	452.9 ± 57.8	451.8 ± 58.6	
Control values			
NYHA class I, %	20 (50.0)	20 (39.2)	**0.036**
NYHA class II, %	15 (37.5)	12 (23.5)	
NYHA class III, %	5 (12.5)	19 (37.2)	
LVEF, %	39.9 ± 5.5	36.5 ± 7.5	**0.028**
Heart rate, beat/min	76.6 ± 15.1	77.9 ± 14.7	0.498
PR duration, ms	130.5 ± 33.8	136.8 ± 40.6	0.363
QRS duration, ms	140.4 ± 11.7	151.7 ± 19.4	**0.018**
QT interval, ms	433.5 ± 46.7	441.2 ± 48.8	0.098
cQT interval, ms	461.1 ± 57.2	482.7 ± 54.6	**0.037**

[1] Cardiomyopath (CMP), [2] New York Heart Association (NYHA), [3] Left ventricular ejection fractions (LVEF)

Table-2. The association between quadripolar left ventricular lead and possible independent risk factors.

	Univariable analyses			Multivariable analyses		
Variables	OR	95% CI	p-value	OR	95% CI	p-value
Control LVEF	1.082	1.005 - 1.165	**0.037**	1.031	0.937 - 1.132	0.528
Control QRS duration	0.980	0.961 - 0.999	**0.038**	0.984	0.959 - 1.010	0.217
Control cQT interval	0.991	0.982 - 1.000	0.062	0.992	0.981 - 1.003	0.155
NYHA improvement	1.107	0.075 - 0.682	**0.008**	0.989	0.751 - 1.084	0.765
LVEF improvement	2.959	1.083 - 8.086	**0.034**	0.994	0.984 - 1.067	0.846

DISCUSSION

As a result of this study, it was seen that CRT patients with quadripolar lead had more favourable outcomes in one-years after clinical follow-up when evaluated in terms of NYHA, ECG and echocardiography. When compared with previous studies, it was observed that our study was compatible with the literature data.

Erath et al (11) performed CRT with 556 patients using BiP LVL (n=423) or QdP LVL (n=123). Patients who used QdP LVL was better NYHA improvement (77% vs. 63%; p < 0.001) and greater reduction in QRS duration (- 21 ± 30 vs. - 8 ± 35 ms, p = 0.004) in six months follow-up. Yang et al (12) described CRT response as an increase >5% improvement in the LVEF from baseline. Quadripolar lead placement was found an independent predictor of CRT response at 12 months (hazard ratio, 0.76; 95% confidence interval, 0.58–0.98; p = 0.04).

Currently, CRT non-responder patients are an important part of who was performed CRT. There is a lot of factors about patients' non-responders with CRT treatment. The causes of non-response might be slightly enlarged QRS (QRS<150), LV lead positioning in an anterior branch of the coronary sinus, pacing from areas of the scar. Also, response to CRT change according to the site of pacing. Especially left mid-ventricular, and basal region pacing is better than left ventricular apical portions in long-term clinic results. Left ventricular lead must be inserted into lateral veins of the coronary sinus to pace left ventricle mid and basal portions. Even lead is inserted lateral vein of the coronary sinus, it might not pace left ventricle basal and mid-portions. BiP LVL allows limited pacing configuration (tip to ring, ring to tip, tip to the coil, etc) but QdP LVL have ten pacing configurations to pace optimal left ventricular site. Ten configurations give more chance to make a narrower QRS and narrower QRS is a predictor of better CRT response. In our study, for patients who used QdP LVL, we tested ten configurations to receive the narrowest QRS duration. We accepted as the right configuration where we take the narrowest QRS duration. QRS duration was narrower patients who were used QdP LVL than BiP LVL (13, 14).

Korantzopouloset al (15). have shown that narrower QRS is a predictor of better clinic results. We took a narrower QRS duration with QdP LVL. As a result of narrower QRS duration, patients with QdP LVL had better improvement in LVEF and NYHA class.

In our study, unlike previous studies; the clinical (NYHA), electrocardiographic, and echocardiographic difference together between QdP LVL and BiP LVL was evaluated.

Limitations

Firstly, the number of patients and centres was limited in this study. Secondly, we evaluate clinic response, but we didn't evaluate mortality, recurrent heart failure hospitalizations, procedural success rate and complications according to lead type. Lastly we didn't take patients had atrial fibrillation.

CONCLUSION

In conclusion, patients who performed CRT can be considered Qdp LVL rather than BiP LVL to make a narrower QRS duration, better improve LVEF and NYHA in long-term follow-up.

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Conflict of Interest: We declare that we have no conflict of interest.

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