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Research Article

Resynchronizing Implantable Cardioverter-Defibrillator (CRT-D) for Left Ventricular Dysfunction in Patients with Chronic Heart Failure

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Abstract

A cardiacresynchronization therapy defibrillator (CRT-D) corrects intracardiac mechanical dyssynchrony by pacing the right and left ventricles synchronized with the atrial rhythm. The CRT-D implantable cardioverter defibrillator is used in chronic heart failure (CHF) because patients with heart failure have a poor prognosis, with mortality rates averaging 15–60% per year. Implantable cardioverter defibrillator CRT-D improves the functional state of the heart and increases left ventricular systolic dysfunction.The purpose of the study wasto evaluate the effect of the implantable cardioverter-defibrillator CRT-D device on left ventricular function in patients with CHF.We selected patients with NYHA class III or IV heart failure, left ventricular ejection fraction (LVEF) less than 35%, and internal QRS complex duration of more than 150 ms for CRT-D implantation among patients hospitalized in the cardiology department of Aktobe Medical Center (AMC) in Aktobe, Kazakhstan, from 2022 to 2023. Total 60 patients were monitored for 48 weeks with an assessment of left ventricular function after CRT-D implantation. At 48 weeks after implantation of the ventricular assist device, significant treatment outcomes were observed (p=0.001): physical tolerance increased from 268 m to 326 m within 6 minutes of the test and LV ejection fraction (EF,%) from 33 to 37% and decrease in QRSms duration from 154 to 128ms .Also, EDV/EDS (ml/cm) decreased from 249 to 160 mL/174 to 110cm. There was a correlation between EDS (cm) and 6MWD (m) levels (r=0.376; p=0.001). Thus, patients with CHF who were implanted with the CRT-D device showed improvement in left ventricular function.

Keywords: implantable cardioverter/defibrillator (CRT-D), chronic heart failure (CHF), LV dyssynchrony, left ventricular ejection fraction (LVEF), QRS duration

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1. Introduction

The urgency of the problem of chronic heart failure (CHF) is associated with high mortality and disability in patients suffering from this pathology [1,2].The prevalence of HF in the developed world is 1–2% of the adult population, increasing by more than 10% among patients 70 years of age [3]. One of the independent risk factors that can have a negative impact on the course of the disease in patients with HF is considered to be cardiac dyssynchrony, which occurs in 25–30% of cases due to the widening of the QRS complex on the ECG.Despite the widespread use of pharmacological agents in the treatment of heart failure, including circulating neurohormones, its prognosis is unfavorable: mortality averages 15–60% per year [4,5].Cardiac resynchronization therapy (CRT), as a nonpharmacologic therapy for CHF, can activate both ventricles by increasing left ventricular stimulation based on traditional dual-chamber pacing of the right atrium and right ventricle, resulting in full contraction and early relaxation of the left ventricle, increasing the frequency of stimulation of the left ventricle, reducing septal dyskinesia and mitral regurgitation [6].Depending on the condition of heart failure, resynchronizing therapy using a pacemaker (CRT-P) or resynchronizing therapy using a defibrillator (CRT-D) or with an implantable cardioverter defibrillator may be indicated.

In recent years, implantable cardiac resynchronization therapy has emerged as a promising treatment option for patients with heart failure. Elimination of cardiac dyssynchrony using an implantable defibrillator allows the correction of the intracardiac conduction in case of mechanical dyssynchrony of the heart by stimulating the right and left ventricles with a synchronized atrial rhythm, which helps reduce symptoms of disease progression and improves the functional state of the heart, normalizing the sequence of excitation of various parts of the heart, in turn, increases the work of the heart, in some cases the ejection of the left ventricular fraction and increases tolerance to physical activity [4,6].

2. Materials and Methods

2.1. Study design

Clinical observational study—interventional therapy:

Inclusion criteria: patients with NYHA class III or IV heart failure left ventricular ejection fraction (LVEF) less than 35%, and intrinsic QRS complex duration greater than 150 ms.

Exclusion criteria: patients with severe lung, liver, and kidney disease, poor general condition or incapacity for self-care; with failed CRT-D implantation caused by various factors.

Patients were treated at the interventional Cardiology Department of Aktobe Medical Center in Aktobe, Kazakhstan. Informed consent for the implantation of the device was obtained from all patients. The recorded data was compiled and entered aspreadsheet (Microsoft Excel) and then exported to the data editor of SPSS Version 20.0(SPSS Inc., Chicago, Illinois, USA).

2.2. Characteristics of patients

Sixty patients with CHF treated at our hospital between October 2022 and December 2023 were included in the study. We selected patients according to ESC Clinical Practice Guidelines, 2021 [3] with NYHA class III or IV heart failure, left ventricular ejection fraction (LVEF) less than 35%, and intrinsic QRS complex duration more than 150 ms for CRT-D implantation among patients hospitalized in the cardiology department of Aktobe Medical Center (AMC) in Aktobe, Kazakhstan, from December 2022 to December 2023.We compared the data before and after CRT-D implantation. Patients received basic therapy for the treatment of CHF. The study involved 47 men and 13 women, whose average age was 63.2±8.6 years.The characteristics of the individuals included in the study are presented in Table **1**. The causes of CHF in patients were of ischemic and nonischemic origin. This study was approved by our hospital's medical ethics association, and all patients signed an informed consent form.

The use of CRT-D in patients with heart failure in Kazakhstan, including in the AMS, is carried out within the framework of the rules for the provision of specialized, including high-tech medical care by Order No. 95 of the Ministry of Health of the Republic of Kazakhstan dated September 7, 2022, in the Ministry of Justice of the Republic of Kazakhstan dated September 8, 2022 No. 29474 [7].

Table 1: Characteristics of patients with chronic heart failure at enrollment.

Characteristics	Parameters
Patients	60
Age, years	63.2±8.6 [77-34]
Gender: M/F	47 (78.3%)/13(1.6%)
CHF[a] non - ischemic	35 (58.33%)
CHF of ischemic	25 (41.67%)
NYHA-FC[b]:	
Class I Class II Class III	≥420 340-419 260 – 339[d] 268.63[e] [332-253]
Class IV	≤260
LVEF[c], %	≤35
Intrinsic QRS duration, ms	≥150

Abbreviations:
[a]chronic heart failure
[b]Functional class according to the New York Heart Association, determined by 6-minute walking distance test (6MWT)
[c]left ventricular ejection fraction
[d]normal value
[e]according to the selection criteria, this corresponded to patients III FC 6MWT

2.2.1. Treatment methods

All patientswere implanted with Compia MRI^{TM} Quad CRT-D implantable cardioverter-defibrillator: Manufacturer: Medtronic Inc., USA, production site: Medtronic Europe Sarl, Switzerland.This Compia MRI CRT-D cardiac resynchronization therapy defibrillator is designed to provide cardiac resynchronization therapy to heart failure patients receiving stable, optimal drug therapy for heart failure, as well as stepwise treatment of lifelong ventricular arrhythmias.

The CRT-D system includes three electrodes. Two of them are traditionally located in the right atrium and right ventricle. The third electrode is designed to stimulate the left ventricle, the electrodes of which monitor the functioning of the heart and help its chambers contract synchronously, thereby reducing the symptoms of CHF.The device (biventricular pacemaker) consists of microchips and a battery. The device body is usually implanted into the subclavian region on the right or left (Figure **1**). CRT-D implantation in adults is usually performed under local anesthesia. A small incision is made under the collarbone and the electrode is inserted into the heart through the connective vein under X-ray control. The outer end of the electrode is connected to the device itself, which is immersed in subcutaneous fat in the junction area, then the incision is sewn up. (installation method not mentioned).After installing the device, the patient needs to undergo a check of its operation every year. It is important to understand that the battery charge has a certain period of operation, on average 5–7 years. If the battery needs to be replaced, only the device is replaced, but not the electrodes.All patients were advised to return to the outpatient clinic for regular follow-up and program monitoring at 4, 12, 24, and 48 weeks after discharge. If the symptoms of heart failure and electrical shock worsened, they were monitored in the hospital's cardiology department. Left ventricular function parameters were measured at baseline and 48 weeks according to CRT-D guidelines.

2.3. Statistical analysis

The results were analyzed using the methods of M±SD, maximum and minimum values. The nonparametric Wilcoxon criterion with a sign rank was used to assess the differences between the two dependent samples. The difference was considered statistically significant at $P>0.05$. The Spearman coefficient was used to identify and describe the statistical relationship between the characteristics.

3. Results

We compared the general data before and after CPT-D implantation and its effect on the functional state of the left ventricle.The functional class of CHF, measured using a 6-minute walk, showed a significant increase in exercise tolerance in patients from 268.63 to 326.94 m; there was a partial transition to FC II, but a complete transition of all patients to a high NYHA FCs (I and II) were not observed.All significant results of processing the data of the left ventricle of the heart are presented in Table **2**.

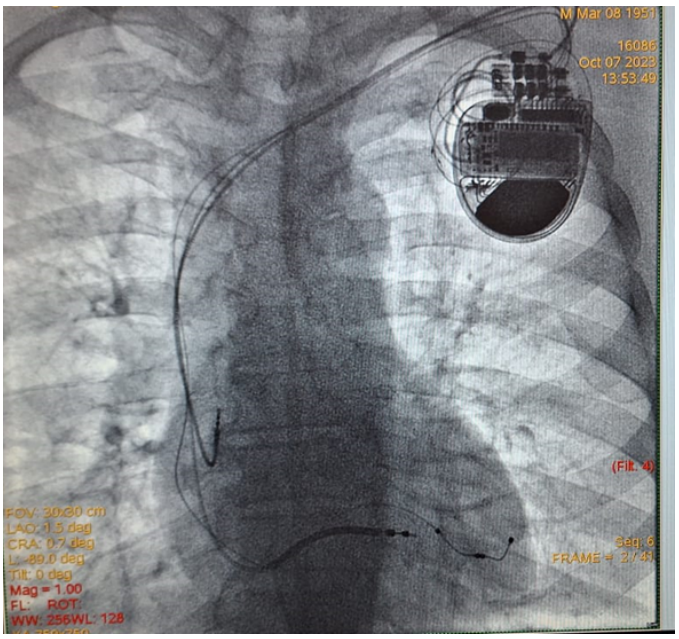

Figure 1: Patient M, 54 years old, with an implanted CRT-D cardioverter defibrillator, the electrode body is located in the left subclavian region.

Table 2: Comparative indicators of 6-minute walk, ECG, and echocardiogram before and after the implantation of the implantable cardioverter defibrillator (CPT-D).

Parameters	Indicators		P* value
	Baseline data before CPT-D implantation	After CRT-D implantation 48 weeks	0.001
6 minuteWalktest, m	268.63±23.2[332-253]	326.94±16.5 [370-290]	0.001
Intrinsic QRS duration, ms	154.26±3.52[160-150]	128.03±3.06[137-125]	0.001
LVEF, %	33.34±1.74 [35-30]	37.31±1.18 [40-36]	0.001
EDV, ml	246.29±31.9 [262-158]	160.20±3.8 [166-153]	0.001
EDS, cm	174.71±2.72 [178-170]	110.06±3.9[115-100]	0.001

Mean (M) ± standard deviation (SD); Max and min; *- Wilcoxon criterion, $p < 0.0500$.

A positive correlation was established between the levels of EDS (cm) and 6MWD (m) ($r=0.376$; $p=0.001$), i.e., a decrease in the final diastolic size of the left ventricle of the heart contributed to an increase in exercise tolerance (Figure **2**).

4. Discussion

Chronic heart failure (CHF) is a common disease worldwide with high morbidity and mortality rates. The worldwide prevalence of CHF is estimated to be 26 million, contributing to increased healthcare costs, decreased functional capacity, and a significant impact on the quality of life. It is critical to diagnose and effectively treat the disease to prevent readmissions, reduce morbidity and mortality, and improve patient outcomes [8]. The etiology of heart failure (HF) is varied and broad. General treatment is aimed at eliminating systemic and pulmonary congestion and stabilizing the hemodynamic status, regardless

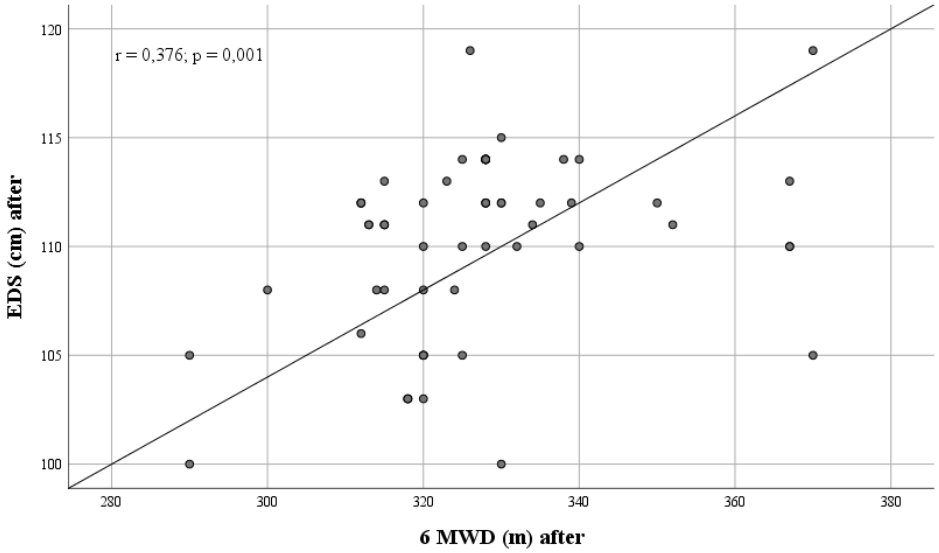

Figure 2: Correlation indicators between EDS (cm) and 6MWD (m) after implantation.

of the cause. Treatment of HF requires a multifaceted approach that includes patient education, optimal medication management, and reduction of acute exacerbations [9]. An estimated 17.9 million people died from cardiovascular diseases (CVDs) in 2019, representing 32% of all global deaths. Of these deaths, 85% were due to heart attack and stroke.Due to the trend of population aging and improved treatment of coronary heart disease, hypertension, and cardiomyopathy, the incidence of heart failure is currently being detected in Kazakhstan.To solve problems, specialized high-tech medical care is provided [10].

The authors of the subsequent case series systematically followed up 11 patients (six women, mean age 48 years) date wise parameters checked not given with an implantable cardioverter/defibrillator and a CRT-D system. After a mean follow-up of 35 months, three of five (60%) patients experienced volume remodeling with CRT resulted in a significant improvement in LVEF. The authors' opinion is that this method is an option even for the most complex patients with cardiovascular diseases who have no other options for cardiac resynchronization [11].

In 60 patients, including 47 men and 13 women, with an average age of 63.2±8.6 years, over 48 weeks we observed a significant increase in LVEF from 33% to 37% (p=0.001).A small number of women were involved in the development of ICD and cardiac resynchronization defibrillation (CRT-D) guidelines [12].

Another study examined 21 patients (mean age 65.0 ± 8.0 years, 76.2% male) who underwent extraction cardioverter/defibrillator or CRT-D in all patients with local infection. With a mean follow-up of 392 ± 206 days, no re-infection was observed in all patients. In our 48-week follow-up, there were no local infectious complications.

In a study [13] of 2618 patients with primary prevention (PP) followed for an average of 20.8 ± 10.8 months, 1,073 required CRT-D and 1,545 patients were eligible for an ICD. Patients receiving CRT-D therapy for PP indications had a 58% reduced risk of mortality compared with those without an implant

(adjusted hazard ratio [HR]: 0.42, 95% confidence interval [CI]: 0. 28 – 0.61, p <0.0001). PP patients with an ICD indication had a 43% reduced risk of mortality with an ICD implant compared with patients without an implant (adjusted HR: 0.57, 95% CI: 0.41 (0.81, p = .002). The result of the study confirms a decrease in mortality due to compliance with implantation recommendations. In our observations, in patients with CHF, after implantation of the CRN-D cardioverter/defibrillator, LV function improved: QRS (ms) from 154 to 128 (ms), reduction in EDS (cm) from 174 to 110 correlated with 6MWD (m) (r = 0.376; p = 0.001), which accordingly increased the exercise tolerance.

The largest prospective study improve SCA [14,15], assessed the benefits of ICD therapy in 3,889 patients to evaluate the treatment of ventricular tachycardia or atrial fibrillation and mortality rates with predominant nonischemic cardiomyopathy. In patients implanted with a 1.5PP ICD, the relative risk of all-cause mortality decreased by 49%. In addition, the number of patients needed to be treated to save one life at 3 years was 10.0 in the 1.5 PP cohort compared with 40.0 in the PP cohort without any 1.5PP criteria. In our observation, we observed 25 (41.67%) ischemic and 25 (58.33%) nonischemic causes of CHF.

Many cardioverter-defibrillator/CRT-D studies favor rather than oppose this device. The preponderance of data suggests that CRT-D provides significant protection superior to optimal pharmacological therapy, and other authors have followed patients with implantable cardioverter defibrillators for primary and secondary prevention over time [16–18].

According to the researchers, the use of implantable cardioverter defibrillator/CRT-D in patients with CHF, by improving left ventricular function, improves quality of life and supports pharmacological treatment of patients with CHF.

5. Conclusion

Thus, clinical observation of patients with left ventricular dysfunction after implantation of implantable cardioverter-defibrillator (CPT-D) revealed improvement of functional indices of the left ventricle and increased tolerance to exercise.

Declarations

Author contribution

Conceptualization: Aringazina A. Raisa, NurgulAbenova, Amaliia R. Muradymova, Petra Stachova,Eda Mehmedali; **methodology**: Aringazina A. Raisa, Amaliia R. Muradymova, Petra Stachova, Eda Mehmedali; **software**: Aringazina A. Raisa, ZhanylsynGaisiyeva; **Validation, resources and writing/original draft:** Aringazina A. Raisa, NurgulAbenova, Amaliia R. Muradymova, Petra Stachova, Eda Mehmedali; **Investigation**: Aringazina A. Raisa, BulatKh. Khamidulla.

Ethics and consent to participate

Informed consent was obtained from all patients

Consent to publish

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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