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State of Care of Egyptian Patients Post CRT Implantation in Heart Failure Patients

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Abstract

Background: Heart failure (HF) is a prevalent clinical syndrome classified by ejection fraction (EF) into reduced (HFrEF), mildly reduced (HFmrEF), preserved (HFpEF), and improved EF. Cardiac resynchronization therapy (CRT) improves left ventricular (LV) synchrony, reducing symptoms and enhancing survival. However, optimizing post-implantation management remains essential to ensure favorable outcomes.

Aim of Study: To assess the state of care of patients post implantation regarding optimization of therapy and improvement of clinical status.

Patients and Methods: A cross-sectional study was conducted on 50 HF patients post-CRT implantation. Patients underwent clinical and echocardiographic evaluation before and after implantation, assessing New York Heart Association (NYHA) class, EF, QRS width, and LV dimensions at baseline, 3, and 6 months. Device-related parameters, including LV and RV lead positioning, were analyzed.

Results: The cohort (50) (80% male, mean age 66.26 ± 8.33 years) showed significant post-CRT improvements. NYHA Grade I increased from 4% to 90%, while Grades III and IV declined from 38% and 52% to 0% (p<0.001). QRS duration reduced from 148.12±17.13 ms to 125.04±15.61 ms (p<0.001), with 92% showing a decrease. EF improved from a median of 29.0% (IQR: 25.0-33.0) to 38.5% (IQR: 34.0-41.0) (p<0.001). LV lead placement was predominantly mid-lateral (84%), and RV leads were primarily apical (94%).

Conclusions: CRT significantly enhances functional capacity and cardiac function in HF patients. Optimization of therapy through patient selection, lead positioning, and systematic follow-up is crucial for maximizing benefits.

Key Words: Cardiac Resynchronization Therapy – Heart Failure – Ejection Fraction – QRS Duration – NYHA Class.

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Introduction

HEART Failure (HF) is a clinical syndrome defined by symptoms stemming from structural or functional cardiac abnormalities and is classified by ejection fraction (EF) into reduced (HFrEF), mildly reduced (HFmrEF), preserved (HFpEF), and improved EF. HFrEF involves significant cardiomyocyte loss leading to systolic dysfunction, whereas HFpEF is marked by structural changes that impair left ventricular relaxation **[1].** Affecting over 64 million people worldwide, HF is associated with high morbidity, mortality, diminished functional capacity, poor quality of life, and substantial healthcare costs **[2].** In Egypt, optimizing HF diagnosis and management remains a critical need **[3].**

Cardiac resynchronization therapy (CRT) has revolutionized HF management by restoring left ventricular synchrony, thereby reducing symptoms, improving ventricular function, and enhancing survival **[4].** Current evidence-based guidelines recommend CRT for symptomatic patients with HF, particularly those in sinus rhythm with an LVEF ≤35% and prolonged QRS duration especially with left bundle branch block while also considering its use in selected patients with non-LBBB morphology or atrial fibrillation when biventricular pacing can be ensured **[5].** Despite its transformative impact, optimal outcomes depend on careful patient selection, precise lead placement, and comprehensive post-implantation management to address the significant variability in clinical response **[6].**

Routine device and clinical follow-up, along with CRT optimization, should be performed at baseline and every 3 months thereafter. Patient response should be assessed at 6 months using the following criteria: At least a one-class improvement in New York Heart Association (NYHA) functional status, more than a 10% increase in the 6-minute walk distance, a reduction of over 15% in the left ventricular end-systolic diameter, and/or an improvement in LVEF by more than 10% **[7]**. The two primary challenges in implementing the CRT program were the shortage of experienced electrophysiologists to perform the implantations and the high cost of the devices **[8]**.

The aim of study is to assess the state of care of patients post implantation regarding optimization of therapy and improvement of clinical status.

Patients and Methods

Study design:

This cross-sectional prospective observational study was conducted over a one-year period from June 2021 to March 2022 on 50 patients in the Cardiology Department at Ain Shams University Hospitals. The study was conducted following approval from the Ethical Committee of Ain Shams University (Approval code: FMASU MS 163/ 2021), and all patients provided informed consent before enrolment.

Eligibility criteria:

Patients with HF who underwent CRT implantation [Pacemaker (P) or defibrillator (D)] within the last three months were included, while those with multiple co-morbidities were excluded.

All patients were subjected to the following:

Comprehensive data collection included detailed history of the cause and duration of HF; the timing, and type of CRT implantation; and the operator's specialty. Pre-implantation data encompassed NYHA class **[9]**, electrocardiogram (ECG) and echocardiographic findings, as well as a detailed drug history. Additionally, the position of the left ventricular (LV) lead was confirmed using cine imaging and ECG.

Follow-up:

Follow-up evaluations were conducted at 3 and 6 months. At these visits, patients completed a questionnaire assessing NYHA class and clinical improvement. Each patient subsequently underwent echocardiography to evaluate EF and LV dimensions specifically LVEDD (left ventricular end-diastolic diameter) and LVESD (left ventricular end-systolic diameter) as well as IVC (inferior vena cava) diameter and collapsibility, MR (mitral regurgitation), SWMA (segmental wall motion abnormalities), and RVSP (right ventricular systolic pressure).

Additionally, an ECG was performed to monitor QRS duration, axis, rhythm, and rate to determine the pacing mode (biventricular, LV, or RV pacing) (Fig. 1). Device programming details (frequency, timing, and operator) were reviewed, a CXR (chest X-ray) was obtained to assess for lead displacement, and parameters for mechanical dyssynchrony were evaluated.

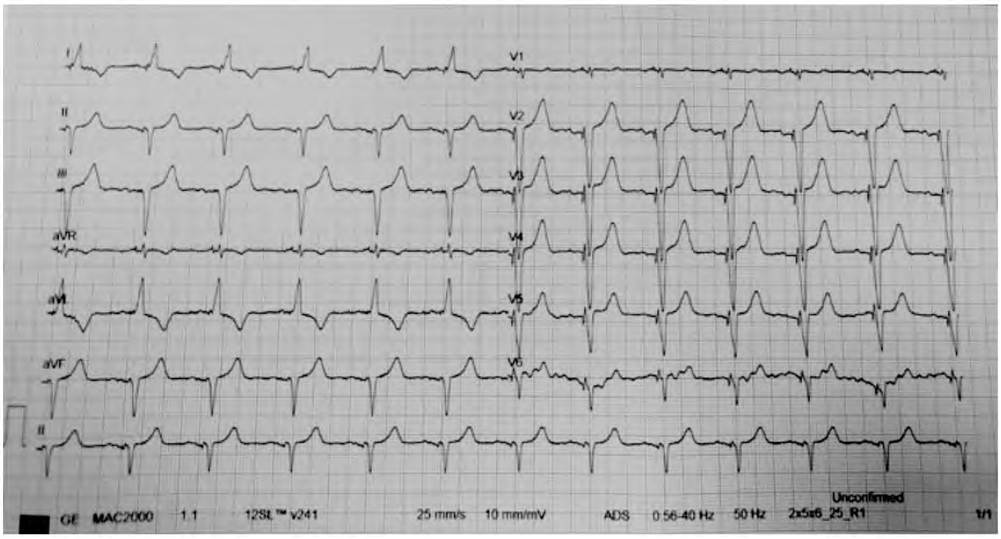

Fig. (1): ECG post CRT implantation with QRS duration reduction from 155 msec to 122 msec, superior axis signifying a posterior lateral tributary (patient number 22).

Statistical methods:

Data management and statistical analysis were done using SPSS version 27 (IBM, Armonk, New York, United States). Quantitative data were assessed for normality using the Shapiro-Wilk test and direct data visualization methods. According to normality, quantitative data were summarized as means and standard deviations or medians and interquartile ranges (IQR). Categorical data were summarized as numbers and percentages. Quantitative data were compared between the groups using Independent "*t*" test and Mann–Whitney U-Test for parametric and non-parametric variables, respectively. Categorical data were compared using the Chi-square or Fisher's exact test. All statistical tests were two-sided. *p*-values less than 0.05 were considered significant.

Results

The cohort (n=50) was predominantly male (80%), with a mean age of 66.26±8.33 years, and was equally divided between CRT-P and CRT-D devices. In both groups, 15 devices (60%) were from Sanjude Medical Devices; among CRT-P patients, the remaining 10 devices (40%) were from Boston, while among CRT-D patients, seven devices (28%) were from Medtronic, 1 device (4%) from Biotronic, and 2 devices (8%) from Boston. Additionally, 86% of patients underwent CRT implantation for ischemic cardiomyopathy (ICM) and 14% for dilated cardiomyopathy (DCM). Furthermore, 11% had associated arrhythmias, including slow atrial fibrillation, complete heart block, or ventricular tachycardia.

Before and after CRT implantation (n=50), there were significant improvements across clinical and diagnostic parameters. NYHA class improved markedly, with Grade I increasing from 4% to 90%, Grade III and IV dropping from 38% and 52% to 0%, respectively (*p*<0.001). ECG analysis revealed a significant reduction in QRS width, with the mean decreasing from 148.12±17.13 ms to 125.04±15.61 ms (*p*<0.001), and 92% of cases showing a decrease (ΔQRS: 23.08 ± 21.35 ms). Echocardiography demonstrated a significant improvement in ejection fraction, rising from 29.0 (25.0-33.0) to 38.50 (34.0 – 41.0) (*p*<0.001) Table (1).

Table (1): Comparison between before and after implantation according to NYHA class, ECG (QRS width), and Echo % (n=50).

	Before Implantation	After Implantation	*p*-value
NYHA Class:			
Grade I	2 (4.0%)	45 (90.0%)	
Grade II	3 (6.0%)	5 (10.0%)	<0.001*
Grade III	19 (38.0%)	0 (0.0%)	
Grade IV	26 (52.0%)	0 (0.0%)	
ECG (QRS Width):			
RBBB	2 (4.0%)	8 (16.0%)	0.031*
LBBB	48 (96.0%)	42 (84.0%)	
Mean ± SD (ms)	148.12±17.13	125.04±15.61	<0.001*
No. of cases with decreased QRS width	46 (92.0%)	–	–
ΔQRS (Mean ± SD) (ms)	23.08±21.35	–	–
Echocardiography (EF %):			
Median (IQR)	29.0 (25.0 – 33.0)	38.50 (34.0 – 41.0)	<0.001*

NYHA: New York Heart Association.
ECG : Electrocardiogram.
QRS : Q wave, R wave, S wave.
RBBB: Right Bundle Branch Block.
LBBB: Left Bundle Branch Block.
SD : Standard Deviation.
ms : Milliseconds.
ΔQRS: Change in QRS Width.
EF : Ejection Fraction.
IQR : Interquartile Range.
* : Statistically significant as *p*-value <0.05.

Among patients with improved NYHA class (n=48, excluding 2 Grade I cases), there was no significant difference between those with DCM and ICM: 85.7% of DCM patients and 90.2% of ICM patients improved to Grade I (*p*=0.562). Additionally, while the median ΔQRS was higher in the DCM group 40.0 (IQR: 24.0–40.0) compared to the ICM group 20.0 (10.0–30.0), this difference did not reach statistical significance (*p*=0.203) Table (2).

Among the 50 cases, LV lead placement by fluoroscopy was predominantly mid lateral (84%), with 8% lateral, 6% postero-lateral, and 2% posterior. In contrast, RV lead placement was mainly apical (94%), with only 4% mid septal and 2% high septal positions. Table (3).

Among patients with DCM (n=7) and ICM (n=37), the majority had a mid lateral LV lead position, accounting for 71.4% and 86.0% of cases, respectively (p=0.204). In the DCM group, 28.6% had a lateral position, compared to only 4.7% in ICM, while postero-lateral and posterior positions were observed only in ICM patients (7.0% and 2.3%, respectively). No statistically significant differences were found between the groups regarding ΔQRS distribution by LV lead position (lead positioning had no direct impact on clinical response). Table (4).

Among 50 patients, programming frequency ranged from 1 to 6 sessions per year, with 24% receiving only one session (non-adequate) and 76% receiving multiple sessions (adequate), yielding a median of 2.0 sessions per year (IQR: 2.0–4.0). Additionally, the LV pacing threshold voltage ranged from 0.50 to 4.0 V, with a mean of 2.13±0.69 V and a median of 2.0 V (IQR: 1.80–2.75 V), while the pulse width varied from 0.40 to 1.0ms, with a mean of 0.69±0.29ms and a median of 0.60ms (IQR: 0.40–10.0ms). Table (5).

Table (2): Relation between DCM and ICM with Improved NYHA class, and ΔQRS.

Parameter			p-value
Improved NYHA class	DCM (n=7)	ICM (n=41)	
Improved – GI	6 (85.7%)	37 (90.2%)	0.562
Improved – GII	1 (14.3%)	4 (9.8%)	
ΔQRS	DCM (n=7)	ICM (n=43)	0.203
Median (IQR)	40.0 (24.0–40.0)	20.0 (10.0–30.0)	

NYHA: New York Heart Association. GI: Grade I.
DCM: Dilated Cardiomyopathy. GII: Grade II.
ICM: Ischemic Cardiomyopathy. ΔQRS: Change in QRS Width.
IQR: Interquartile Range.

Table (3): Distribution of the studied cases according to LV position by fluoroscopy and RV lead position by fluoroscopy.

Position	n (%)
LV Lead Position:	
Mid-Lateral	42 (84)
Lateral	4 (8)
Postero-Lateral	3 (6)
Posterior	1 (2)
RV Lead Position:	
Mid-Septal	2 (4.)
Apical	47 (94)
High-Septal	1 (2)

LV: Left Ventricle. RV: Right Ventricle.

Table (4): Relation between ΔQRS in DCM and ICM patients with LV position by fluoroscopy x.

LV Position	ΔQRS in DCM (n=7)	ΔQRS in ICM (n=37)	p-value
Mid-Lateral	5 (71.4%)	32 (86.0%)	0.201
Lateral	2 (28.6%)	2 (4.7%)	
Postero-Lateral	0 (0.0%)	2 (7.0%)	
Posterior	0 (0.0%)	1 (2.3%)	

LV : Left Ventricle. DCM : Dilated Cardiomyopathy.
ΔQRS: Change in QRS Width. ICM : Ischemic Cardiomyopathy.

Table (5): Descriptive analysis of the studied cases according to frequency of programming time/years, pulse width, and LV pacing threshold.

Parameter		
Programming Frequency (times/year):		
Non-Adequate	n (%)	12 (24)
Adequate	n (%)	38 (76)
• 2 times/year	n (%)	18 (36)
• 3 times/year	n (%)	1 (2)
• 4 times/year	n (%)	18 (36)
• 6 times/year	n (%)	1 (2)
Overall adequate	Median (IQR)	2.0 (2.0–4.0)
LV Threshold:		
• Voltage (V)	Median (IQR)	2.0 (1.80–2.75)
• Pulse Width (ms)	Median (IQR)	0.60 (0.40–10.0)

IQR: Interquartile Range. V : Voltage.
LV : Left Ventricle. ms: Milliseconds.

Discussion

HF remains a major global health challenge, necessitating advanced interventions like CRT to enhance patient outcomes. By restoring ventricular synchrony, CRT has significantly improved HF management, alleviating symptoms and increasing survival, particularly in individuals with reduced LVEF and prolonged QRS duration **[10]**.

However, maximizing its therapeutic benefits requires meticulous patient selection, optimal lead positioning, and structured post-implantation management. Routine clinical and device assessments, typically conducted at six months, are crucial for evaluating response based on functional and echocardiographic parameters **[11]**.

Despite its well-established efficacy, the widespread adoption of CRT is hindered by barriers such as limited availability of experienced electrophysiologists and the high cost of devices **[12]**. Hence, this study aims to evaluate post-implantation care, focusing on therapy optimization and clinical improvement in CRT recipients.

In our study, NYHA class improved markedly after implantation. Consistent with these findings, Tawfik Ghanem et al. *[13]* reported a significant improvement in NYHA functional class after CRT-P (p<0.001). Similarly, Al-Mashat et al. *[14]*, in a study of 19 patients who underwent NYHA classification before and after CRT, observed improvements in NYHA classification (p=0.0456). Also, Ramdat Misier et al. *[15]* stated that after implantation patients had a significantly improved NYHA functional class after CRT implantation at each time point compared with baseline (p<0.002).

In contrast, Bleeker et al., *[16]* found no significant differences in NYHA classification before and after implantation (p<0.05). This discrepancy may be attributed to differences in patient selection, baseline characteristics, follow-up duration or variations in CRT response.

The observed improvement in NYHA functional class following CRT implantation suggests a significant enhancement in patients' functional capacity and symptom relief *[13]*. This finding highlights the effectiveness of CRT in reducing heart failure severity, potentially leading to better exercise tolerance, improved quality of life, and reduced hospitalizations *[17,18]*.

In our investigation, ECG analysis revealed a significant reduction in QRS width after implantation (p<0.001). In accordance with our results, Molhoek et al., *[19]* measured QRS width before and after implantation and revealed that after CRT implantation QRS duration was reduced from 179±30ms to 150±26ms (p<0.01). In contrast, Mollema et al., *[20]* conducted that no significant differences were observed in QRS duration after implantation.

The significant reduction in QRS width following CRT implantation suggests improved ventricular synchrony, which is a key mechanism underlying the clinical benefits of CRT *[21]*. Narrowing of the QRS complex reflects enhanced electrical conduction and coordination of ventricular contractions, leading to more efficient myocardial performance *[22]*.

Our results revealed that echocardiography demonstrated a significant improvement in EF after device implantation (p<0.001). Similarly, Ramdat-Misier et al., *[15]* reported that patients who underwent CRT upgrade showed a consistent improvement in LVEF and QRS duration at each time point (p<0.004). Additionally, Brambatti et al, *[23]* observed a time-related improvement in LVEF across the entire population (+10.6% over 12 months) and within each subgroup following cardiac resynchronization therapy.

CRT effectively optimizes ventricular contraction by reducing mechanical dyssynchrony, leading to better cardiac output and hemodynamic stability *[10]*. Enhanced EF is associated with symptom relief, improved functional capacity, and potential long-term benefits such as reduced heart failure-related morbidity and mortality.

This study was conducted in a single center, which may limit the generalizability of the findings. Additionally, potential confounding factors, such as variations in patient comorbidities and operator experience, were not fully controlled. Further multi-center studies with larger sample sizes are recommended to validate the results.

Conclusions:

CRT markedly improves functional capacity and cardiac performance in HF patients. Maximizing its benefits requires careful patient selection, optimal lead placement, and structured follow-up.

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Conflict of interest: None to be declared.

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حالة رعاية المرضى المصريين بعد تركيب منظم ضربات القلب ثلاثى الحجرات لإعادة تزامن كهرباء القلب فى مرضى ضعف عضلة القلب

الخلفية: فشل القلب هو متلازمة سريرية شائعة تصنف حسب الكسر القذفى إلى فشل قلب مع انخفاض الكسر القذفى، فشل قلب مع انخفاض طفيف، فشل قلب مع الحفاظ على الكسر القذفى، وفشل قلب مع تحسن فى الكسر القذفى. يعمل العلاج بالتزامن القلبي على تحسين تناغم البطين الأيسر، مما يقلل من الأعراض ويعزز البقاء على قيد الحياة. ومع ذلك، يظل تحسين إدارة المرضى بعد الزرع أمرًا بالغ الأهمية لضمان الحصول على نتائج جيدة.

الأهداف: تقييم حالة رعاية المرضى بعد تركيب المنظم فيما يتعلق بتحسين العلاج وتحسن الحالة السريرية.

الطرق: تم إجراء دراسة مقطعية على خمسين مريضًا من مرضى فشل القلب بعد زرع العلاج بالتزامن القلبى. خضع المرضى لتقييم سريرى وصوتى للقلب قبل وبعد الزرع، مع تقييم فئة الجمعية الأمريكية للقلب، والكسر القذفى، وعرض QRS، وأبعاد البطين الأيسر في البداية، وبعد ثلاثة وستة أشهر. تم تحليل المعايير المتعلقة بالجهاز، بما فى ذلك وضعية الأقطاب فى البطين الأيسر والبطين الأيمن.

النتائج: أظهرت العينة تحسنًا كبيرًا بعد زرع العلاج بالتزامن القلبى. زادت الفئة من الدرجة الأولى من أربع فى المائة إلى تسعين فى المائة، بينما انخفضت الدرجات الثالثة والرابعة من ثمانى وثلاثين فى المائة وخمسين فى المائة إلى صفر فى المائة. تم تقليل مدة QRS من مائة وثمانية وأربعين مللى ثانية إلى مائة وخمسة وعشرين مللى ثانية، مع ظهور تحسن فى اثنين وتسعين فى المائة من المرضى. تحسن الكسر القذفى من متوسط تسعة وعشرين فى المائة إلى ثمانية وثلاثين ونصف فى المائة. تم وضع الأقطاب فى البطين الأيسر بشكل رئيسى فى المنطقة الجانبية المتوسطة، وكانت الأقطاب فى البطين الأيمن موضوعة بشكل أساسى فى القمة.

الاستنتاجات: يعزز العلاج بالتزامن القلبي بشكل كبير القدرة الوظيفية والوظائف القلبية فى مرضى فشل القلب. إن تحسين العلاج من خلال اختيار المرضى، ووضع الأقطاب، والمتابعة المنتظمة أمر بالغ الأهمية لتحقيق أقصى الفوائد.