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Research Article

Focus on the First Ten Years of Cardiac Resynchronization Therapy Practice in Senegal: Modalities and Results in Two Reference Centers in Dakar

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Abstract

Introduction: Cardiac resynchronization therapy (CRT) is an electrical treatment for heart failure with reduced ejection fraction, which has been practiced in Senegal since 2011. This study was conducted to evaluate the first ten years of CRT practice in Senegal. *Methods:* We conducted a descriptive and analytical cross-sectional study in the cardiology departments of Aristide Le Dantec University Hospital and Principal Hospital of Dakar, covering the period from June 11, 2011, to May 1, 2021. All patients who underwent cardiac resynchronization were included. The studied parameters included clinical, paraclinical, therapeutic, and progression data. Subsequently, patients were contacted for a follow-up evaluation 18 months after device implantation. *Results:* During the study period, 21 cases were recorded. The mean age was 61 ±11 years, with a male predominance (sex ratio M/F = 2). At implantation, all patients had dyspnea with 76% classified as NYHA class IV. Sixty-two percent of patients were in sinus rhythm, 14% had complete AV block, and 24% were in atrial fibrillation/atrial flutter. The mean QRS duration was 153.83 ms. The mean left ventricular ejection fraction (LVEF) was 27 ±6% at baseline (range: 13% to 38%). In our cohort, CRT-P devices accounted for 76% of implants, compared to 24% for CRT-D devices. The primary indication was refractory heart failure despite optimal medical therapy in patients with sinus rhythm, left bundle branch block, QRS duration ≥150 ms, and LVEF ≤35%. Left ventricular leads were quadripolar in 11 cases (52%). One case of coronary sinus dissection without pericardial tamponade was noted. After a mean follow-up of 18 months post-implantation, 10 patients were fully reassessed. Rehospitalization was observed in 33% of patients. Seventeen patients (82%) responded to the therapy. Bivariate analysis showed that rehospitalizations and deaths were statistically linked to non-response. A total of six deaths were recorded, three of which (14%) were cardiac-related. *Conclusion:* Cardiac resynchronization therapy is an available and effective treatment in Senegal for the optimal management of heart failure patients.

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Keywords

Cardiac Resynchronization, Heart Failure, Senegal

1. Introduction

Cardiac Resynchronization Therapy (CRT) is an interventional treatment for heart failure with reduced left ventricular systolic ejection fraction (LVEF). It works by restoring synchronized myocardial contraction through multisite pacing, including stimulation of the left ventricle via the coronary sinus [1]. Its effectiveness has been proven in multiple clinical trials [2-5].

In Senegal, it was first performed in 2010 at the Idrissa Pouye General Hospital of Grand Yoff as part of a medical mission [6]. The local Senegalese team performed their first independent cardiac resynchronization procedure at the Aristide Le Dantec Hospital (ALDH) in 2011, followed by the Principal Hospital of Dakar (PHD) in June 2019.

However, in Francophone sub-Saharan Africa, this technique is still not widely disseminated, and consequently, little data on the subject are available.

It is within this context that we conducted this study, aiming to determine the methods and outcomes of cardiac resynchronization therapy in Senegal.

2. Methods

2.1. Patients

This was a retrospective, multicentric, cross-sectional, descriptive, and analytical study conducted from June 11, 2011, to June 1, 2021.

The study included all patients who underwent cardiac resynchronization therapy (CRT) during the specified period in the cardiology departments of the Aristide Le Dantec Hospital (ALDH) and the Principal Hospital of Dakar (PHD).

We excluded patients who received CRT but had incomplete or unusable medical records.

2.2. Studied Parameters

We studied the following:

1) Epidemiological data: gender, age, date, and hospital of CRT implantation.
2) Clinical data: presence of ischemic heart disease, cardiovascular risk factors, dyspnea (NYHA functional class), physical signs of heart failure, and medication prior to cardiac resynchronization.
3) Electrocardiography (ECG) data before and after CRT: baseline rhythm, QRS duration, type of bundle branch block.
4) Transthoracic Echocardiography (TTE) data before and after CRT: left ventricular ejection fraction.
5) Cardiac resynchronization therapy: type, devices used, indications, technique, immediate results, intraoperative incidents and complications.
6) Evolutionary outcomes: responders and non-responders, rehospitalizations, and death.

2.3. Data Collection

Data were collected using a survey form completed for each patient eligible for the study.

Sources also included patient hospitalization records, operative reports and the pacemaker room registry. Furthermore, patients were re-evaluated with direct data collection through interview, physical examination, echocardiography, and device interrogation using a pacemaker programmer.

2.4. Data Analysis and Processing

Data entry and analysis were performed using SPSS 24.0 and Excel 2017, respectively. Quantitative data were expressed as mean with standard deviation. Qualitative data were expressed as percentages. We also performed a multivariate analysis using binary logistic regression with a forward stepwise procedure to identify factors associated with responders. The factors examined included age, sex, NYHA class, QRS duration before stimulation, the presence of left bundle branch block (LBBB), the delta QRS and delta LVEF before and after CRT, rehospitalization after CRT, and the mortality rate.

For correlations, we used the Chi-square test and Fisher's Exact Test, with a significance threshold set at $p\text{-value} < 0.05$.

2.5. Operational Definition of Variables

Good responders were defined by an improvement in:

1) Dyspnea by at least one NYHA class and in LVEF by at least 7%,
2) The "Minnesota Living with Heart Failure" quality of life score by at least 8 points, or the patient's subjective feeling of improvement in dyspnea and/or quality of life at 6 months,
3) A reduction in the rate of cardiovascular rehospitaliza-

tions and death.

Informed consent was obtained from all patients.

3. Results

A total of 26 cases of resynchronization procedures were performed during our study period, and 21 were included, (81.7%). Sixteen procedures were performed at ALDH (76%) and five at PHD (24%), with 52% of procedures performed in 2020. There were 14 men (67%) and 7 women (33%). The mean age was 61 ±11 years.

3.1. Clinical Data Before Cardiac Resynchronization

Cardiovascular risk factors were dominated by physical inactivity (90%), age (81%), and hypertension (52%). Two cases of ischemic heart disease were noted.

Dyspnea was present in all patients: 76% were in NYHA class IV and the remaining 24% were in class III. All patients were receiving heart failure treatment with various medications and dosages.

3.2. Paraclinical Data Before Cardiac Resynchronization

On ECG, 62% of patients were in sinus rhythm, 14% had atrioventricular (AV) block, and 24% had atrial flutter/fibrillation. The mean QRS duration was 153.83ms (range 80ms to 200ms), with 90% of patients having a QRS ≥130ms, including 71% cases of LBBB.

The mean LVEF was 27 ± 6% by biplane Simpson's method (BS). The range was 13% BS to 38% BS, with 95% of patients having an LVEF ≤ 35% by BS.

3.3. Modalities of Cardiac Resynchronization

The main indication was symptomatic heart failure despite optimal medical therapy in patients presenting with LBBB, a QRS greater than 150ms, and an LVEF less than 35% by BS.

According to the ESC 2021 guidelines on pacing and CRT, the levels of evidence were:

Class IA in 43% of cases, Class IIa B in 33% of cases, and IIa C in 24% of cases, as shown in Table 1.

Table 1. *Indications for Cardiac Resynchronization Therapy.*

Indications	Number	Percentage	Level of evidence
HF + Sinus Rhythm + LBBB + QRS ≥ 150ms + LVEF ≤ 35%	7	33,3	I A
HF + Atrial Flutter/Af + QRS ≥ 130ms + LVEF ≤ 35%	5	23,9	IIa C
HF + Sinus Rhythm + LBBB + QRS [130-149] ms + LVEF ≤ 35%	4	19	IIa B
HF + Sinus Rhythm + RBBB + QRS ≥ 150ms + LVEF ≤ 35%	2	9,5	IIa B
AV Block + LVEF < 40%	2	9,5	I A
Upgrade from DDD pacemaker	1	4,8	IIa B

The most used brand was MEDTRONIC in 57% of patients, followed by St Jude (24%) and Biotronik (19%). Cardiac resynchronization therapy with pacemaker function (CRT-P) accounted for 76% of cases, compared to 24% with defibrillator function (CRT-D).

Quadripolar leads were used in 52% of cases versus 48% bipolar leads. The use of quadripolar leads began in 2019, relegating bipolar leads to a secondary role. In all patients, the left subclavian approach was used to place the left lead in a lateral vein of the coronary sinus. Atrial lead was placed on the lateral wall of the atrium in 67% of cases. In 90% of patients, the right ventricular lead was at the apex.

Immediately post-procedure, the various measurements of stimulation threshold, sensing, and impedances are summarized in Table 2.

Table 2. *Stimulation thresholds, sensing, and impedances immediately post-stimulation.*

Measurements during the pacemaker check	Chambers	Means	Range	Standard Deviation
Stimulation threshold (V)	RA	0,5	0,3-1,99	0,41
	RV	0,717	0,2-2	0,34

Measurements during the pacemaker check	Chambers	Means	Range	Standard Deviation
Sensing (mV)	LV	0,92	0,4-4	0,82
	RA	5,95	0,8-20	5,65
	RV	12,76	5-20	5,07
Impedance (Ohms)	LV	13,4	6-20	5,5
	RA	594,88	292-861	122,8
	RV	695	351-1222	208
	LV	691	250-1010	222

Two periprocedural incidents were noted: displacement of the atrial lead during the attempt to cannulate the coronary sinus and dissection of the initial portion of the coronary sinus without tamponade.

Below is Figure 1 showing an image of CRT-P and Figure 2 showing a CRT-D.

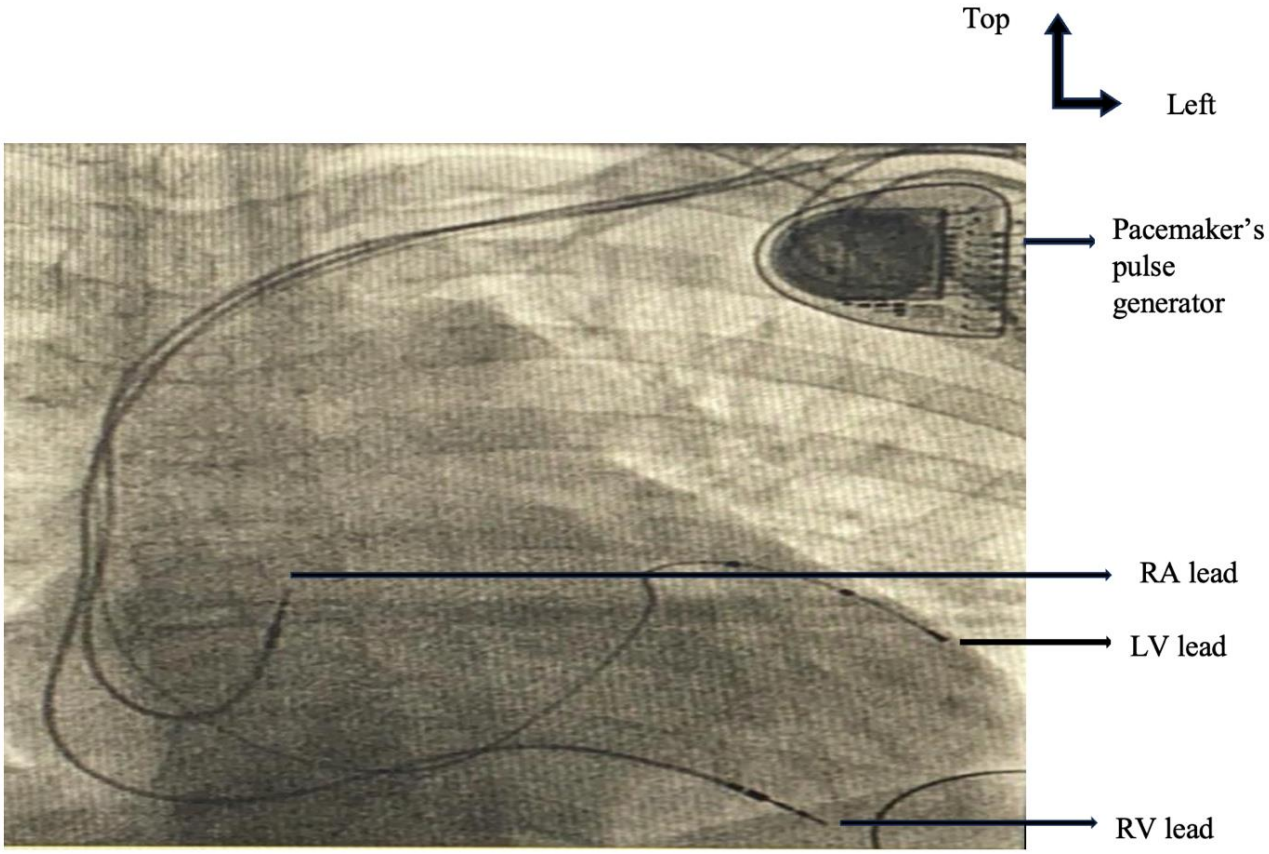

Figure 1. *Fluoroscopy Image of a CRT-P with the first lead in the right atrium (RA), the second in the septum of the right ventricle (RV), and the third, which is a quadripolar lead, positioned in a lateral vein of the coronary sinus.*

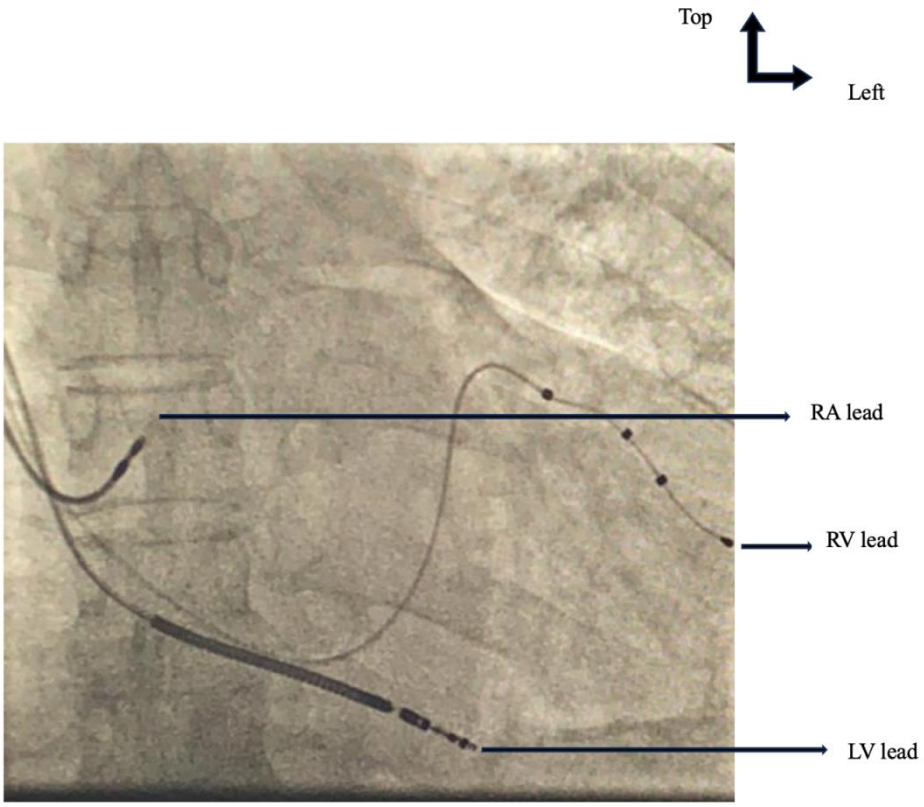

Figure 2. *Fluoroscopy of a CRT-D with a coil in the right ventricle, a quadripolar lead in a lateral vein of the coronary sinus, and a third lead in the right atrium.*

3.4. Evolution Between Stimulation and Re-evaluation at 18 Months

Rehospitalization was reported in 7 patients (33% of cases): 5 for global heart failure and two others for loss of cardiac resynchronization due to atrial fibrillation/atrial flutter with rapid conduction.

After failure of rhythm and rate control, the two subjects with atrial fibrillation/atrial flutter and loss of CRT underwent atrioventricular node ablation.

3.5. Re-evaluation of Patients After at Least 18 Months Post-stimulation

Ten patients were able to be fully re-evaluated. The other 11 could not travel for a pacemaker check and echocardiography; however, they were interviewed to assess their dyspnea class, their quality-of-life score, and whether there had been any rehospitalization after their stimulation.

The NYHA class had improved in all patients. Seven patients (33%) had improved by two classes, moving from class IV to stage II. No signs of right heart failure were found.

The QRS narrowed, with the mean decreasing from 153.83ms to 134.4ms.

The mean LVEF also improved, increasing from 27.47% to 35.5% by BS. An increase of more than 7% in their LVEF was noted in 33% of patients, with 19% of them achieving an increase ≥15% by BS. One patient normalized their LVEF, going from 35% BS to 50% BS. The values of stimulation threshold, sensing, and impedances at the check-up are summarized in Table 3.

Table 3. *Pacemaker Check Measurements After a Follow-up of at Least 18 Months Post-Stimulation.*

Measurements during the pacemaker check	Chambers	Means	Range	Standard Deviation
Stimulation threshold (V)	RA	0,5	0,25-0,75	0,22
	RV	0,78	3,6-20	5,82

Measurements during the pace-maker check	Chambers	Means	Range	Standard Deviation
Sensing (mV)	LV	1,25	0,5-3,75	1
	RA	5	1,4-15	4,67
	RV	10,7	3,6-20	5,8
Impedance (Ohms)	LV	11,5	3,6-20	6,03
	RA	337	200-461	50
	RV	695	370-608	79
	LV	560	390-763	132

3.6. Response to Resynchronization

During our study, we noted 17 responders, representing a rate of 81%. They consisted of 12 men and 5 women. They had all improved their NYHA class by at least one class. Four non-responders were noted. They had all been rehospitalized at least once.

Bivariate analysis showed that rehospitalizations and death were statistically linked to non-response The increase in LVEF was also predictive of a good response, as shown in Table 4.

Table 4. *Correlation Between Studied Parameters and the Responder Rate.*

Studied Parameters			Responders		Total	P
			YES	NO		
Sex	M	Number	12	2	14	0,43
		%	70,6	50	66,7	
	F	Effectif	5	2	7	
		%	29,4	50	33, 3	
Age	< 60	Number	7	3	10	0,22
		%	41,2	75	47,6	
	≥60	Number	10	1	11	
		%	58,8	25	52,4	
NYHA class	Class III	Number	5	0	5	0,21
		%	29,4	0	23,8	
	Class IV	Number	12	4	16	
		%	70,6	100	76,2	
Baseline Rhythm	Sinus rhythm	Number	9	4	13	0,439
		%	52,9	100	61,9	
	Non-sinus rhythm	Number	8	0	8	
		%	47,1	0	38,1	
LBBB	Yes	Number	14	3	17	0,73
		%	82,4	75	81	
	No	Number	3	1	4	

Studied Parameters			Responders		Total	P
			YES	NO		
QRS Duration	≥150ms	%	17,6	25	19	0,65
		Number	3	1	4	
	<150ms	%	21,4	33,3	23,5	
		Number	11	2	13	
		%	78,6	66,7	76,5	
Type of LV lead	Bipolar	Number	6	2	8	0,71
		%	40	50	42,1	
	Quadripolar	Number	9	2	11	
		%	60	50	57,9	
Type of stimulation	CRT-P	Number	13	3	16	1
		%	76,5	75	75	
	CRT-D	Number	4	1	5	
		%	23,5	25	25	
Delta QRS	<20ms	Number	10	2	12	0,33
		%	66,7	100	70,6	
	≥20ms	Number	5	0	5	
		%	33,3	0	29,4	
Delta LVEF	<7%	Number	4	3	7	**0,023**
		%	28,6	100	41,2	
	≥7%	Number	10	0	10	
		%	71,4	0	58,8	
Rehospitalizations	Yes	Number	3	4	7	**0,012**
		%	17,6	100	38,1	
	No	Number	13	0	13	
		%	82,4	0	61,9	
Deaths	Yes	Number	3	3	6	**0,029**
		%	17,6	75	28,6	
	No	Number	14	1	15	
		%	82,4	25	71	

3.7. Deaths

In total, 6 patients died, including three from refractory heart failure in patients who were all non-responders. The other three deaths were not of cardiovascular origin.

4. Discussion

4.1. Study Limitations

Our study had several limitations due to:

1) The under-reporting of data in the records used for collection.

2) The fact that only 48% of patients could benefit from a complete re-evaluation at 18 months post-stimulation.
3) The relatively small number of our study population, which can be a source of non-negligible bias.

4.2. Epidemiological Data

Our study population was predominantly male (75%). This was also found by Abraham et al. in the MIRACLE study (63.9% men) [7] and by Kambire in Burkina (66.7% men) [8]. This male majority could be explained by the fact that women have a lower myocardial mass compared to men. This means they may have true LBBB but with a narrower QRS complex. Consequently, some women who could benefit from CRT remain ineligible according to the 2021 ESC guidelines [9]. However, many studies have demonstrated that patients with a narrower QRS complex between 120-130 ms can respond favorably to CRT [10, 11].

Our patients were relatively elderly with a mean age of 61 years, which was similar to that found in the MIRACLE [7], MUSTIC [12] studies and in the series reported in Burkina [8].

The prevalence of hypertension and diabetes was 52% and 19% of case, respectively. This was higher than the data found in the THESUS-HF study where HTA had a prevalence of 45.4% and diabetes 11% [13].

4.3. Before Implantation

All patients were either in NYHA class III (24%) or class IV (76%), similar to the patient profile of the Kambire study conducted in Burkina. However, these results are higher than those of the MIRACLE study, in which only 10% of patients were at stage IV.

Atrial fibrillation/atrial flutter was present in 23% of patients. This was similar to the rate found in the European cardiac resynchronization registry, presented at the ESC congress in 2009 [14].

The mean QRS duration (153.83ms) was lower than that found in the MUSTIC study (172ms) [12] and in the MIRACLE study (167ms) [7].

In our population, 71% of patients had LBBB, which is equal to what was found in the COMPANION study [15]. These results were lower than those of the Galand study, which found 76.6% in France and 75.1% in Europe [16].

The mean LVEF before stimulation was 27.47%. It was higher than that found in the MIRACLE study (21.8%) and lower than that found in Burkina Faso, which was 34.8%. Galand et al. found 30.5% in France and 28.7% in Europe. The severe LVEF reduction noted in our population is partly explained by delays in management.

Eighty-six percent of the indications were for heart failure with severely reduced LVEF associated with a wide QRS. These data are higher than those of Galand who, for this indication, found 51% in France and 47% in Europe, respectively. In only the remaining 14% of cases, the indication was for permanent cardiac pacing in the context of reduced LVEF. This discrepancy is likely due to the fact that in Senegal, the high cost of CRT leads many patients with AV block and reduced LVEF to choose conventional pacing instead.

We performed 76.2% CRT-P against 23.8% CRT-D. Galand found the opposite with 65.5% CRT-D in France and 70.1% in Europe. This difference is due to the lower economic level in our regions, which leads patients to choose a CRT-P even if the indication for a defibrillator is established.

Quadripolar leads were used in 52% of cases, whereas in Galand's work they were used at a rate of 70.5% in France and 56.1% in Europe. This can be explained by the fact that they started to be used 8 years after the start of multisite pacing. However, they are now used preferentially because they offer more configuration possibilities to optimize the chances of obtaining a better response to CRT.

Furthermore, coronary sinus venography was not performed in any case, whereas in France it was performed in 74% of cases versus 92% in Europe [16].

All left ventricular leads were positioned in a lateral vein of the coronary sinus. In the Galand study, the left ventricular leads were in a lateral vein of the coronary sinus in 83.6% of cases in France and 84.5% in Europe. Furthermore, the left ventricular lead was always the first to be placed. This approach is based on the fact that if the left lead cannot be placed, a conventional pacemaker would not be indicated.

4.4. Re-evaluation of Patients After a Follow-up of at Least 18 Months

The NYHA class had improved in 81% of cases. These results are higher than those of the MIRACLE study, where an improvement in dyspnea was noted in 78% of cases at 06 months post-implantation. However, the study conducted in Burkina Faso found a regression of dyspnea in 100% of cases after 3 months.

The QRS had narrowed, with the mean decreasing from 153.83ms to 134.4 ms. This decrease in QRS duration was lower than in the study done in Burkina Faso [8], where it decreased from 138 ms to 110 ms.

We observed a mean delta LVEF of 8.5%, which was much higher than that obtained by Kambir é (0.7%).

The pacing percentage at the check-up was 97.8%, slightly below that of Kambir é (98%). Indeed, one patient had a low stimulation percentage at 94% due to episodes of rapid AF. He subsequently underwent AV node ablation.

We noted 81% responders. This was higher than what was found in Burkina Faso (66.7%). This finding is partly related to the appropriate selection of our indications, which were strong class IA in nearly 43% of cases.

All four non-responder patients had been rehospitalized at least once because when CRT fails, the underlying heart disease progresses due to its natural course.

Overall, we found 33% re-hospitalizations, which is lower than the percentage found in Burkina Faso (87.5%).

In total, we recorded 6 deaths, i.e., a rate of 28.5%, which is lower than that recorded by Kambiré (33.3%).

5. Conclusion

Our study shows that, even though cardiac resynchronization is in its early stages in Senegal, local expertise is well established with very satisfactory results.

However, the problem of non-response remains, hence the need for rigorous selection of patients for stimulation.

6. Recommendations

6.1. To Physicians

1) Refer the patient for CRT as soon as the indication is established.
2) Perform careful patient selection to avoid non-response.
3) Create an African CRT registry.

6.2. To the Government

Provide subsidies for Cardiac Resynchronization Therapy (CRT) to improve patient access.

Abbreviations

ALDH	Aristide Le Dantec Hospital
CRT	Cardiac Resynchronization Therapy
CRT-P	Cardiac Resynchronization Therapy with Pacemaker Function
CRT-D	Cardiac Resynchronization Therapy with Defibrillator Function
ECG	Electrocardiography
HF	Heart Failure
LBBB	Left Bundle Branch Block
LV	Left Ventricular
LVEF	Ventricular Ejection Fraction
PHD	Principal Hospital of Dakar
TTE	Transthoracic Echocardiography
RA	Right Atrium
RBBB	Right Bundle Branch Block

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Author Contributions

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Djibril Marie Ba: Data Acquisition and Analysis.

Alassane Mbaye: Methodology, Data Acquisition.

Mame Awa Sene: Writing, Revision and Editing.

Conflicts of Interest

The authors declare no conflicts of interest.

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