Utilization of cardiac resynchronization therapy in patients with heart failure in the Northern Region of New Zealand

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Abstract

Background: Cardiac resynchronization therapy (CRT) has been shown to improve morbidity and mortality for heart failure (HF) patients. Little is known about the trends in CRT use and outcomes of these patients in New Zealand.

Method: Mortality, hospitalization events and complications in HF patients in the Northern Region of New Zealand implanted with CRT devices from Jan-2007 to June-2015 were reviewed.

Results: Two-hundred patients underwent CRT implantation during the study period. There was a gradual increase in CRT-D implantation (n = 157) but the number remained static for CRT-P (n = 43). Patients who received CRT-P were older (mean age 65.9 ± 14.0 years vs 61.5 ± 10.2 years, \( P < 0.0007 \)) but had a higher left ventricular ejection fraction (LVEF) (33.7 ± 10.5% vs 24.7 ± 6.1%, \( P < 0.0001 \)) than those undergoing CRT-D implant procedures. During a median follow-up of 4 (2.8) years, 29 (14.5%) patients (14.7% in CRT-D vs 13.9% in CRT-P, \( P = 0.91 \)) had died. HF was the cause of death in 73.9% of the patients. There was no difference in all-cause mortality between patients with CRT-D and CRT-P.

Conclusions: Despite the proven benefits of CRT in selected HF patients, there continued to be under-utilization of these devices in HF patients in the Northern Region. Reasons for under-utilization of these devices need further exploration. These data should be useful for benchmarking individual patient management and national practice against wider experience in the country.

Keywords
cardiac resynchronization therapy, heart failure, left ventricular ejection fraction, mortality, New York Heart Association class

1 | INTRODUCTION

Heart failure (HF) is a major health burden in many developed countries. The prevalence of HF is estimated at 1%-2% in the western world, and the incidence approaches 5-10 per 1000 persons per year.\(^1\) In New Zealand, approximately 5500 patients are hospitalized due to decompensated HF annually.\(^2\)

Cardiac resynchronization therapy (CRT) has been shown in multiple studies to improve symptoms, quality of life, and survival in HF patients who remain symptomatic despite optimal medical
Table 1. New Zealand primary implantable cardioverter-defibrillator implantation and cardiac resynchronization therapy guidelines

| Recommendations for primary ICD implantation in New Zealand: |
|-------------------------------------------------------------|
| • Patients with ICM at least 1 mo after acute MI or a NICM present for at least 3 mo |
| • EF ≤30% measured ≥3 mo after optimal heart failure treatment |
| • NYHA class II or III |
| • On maximal heart failure medications, including ACE-inhibitors or angiotensin receptor blockers, beta-blockers and spironolactone as tolerated for at least 3 and preferably 6 mo |
| • No clinical symptoms or findings that would make them a candidate for a revascularization procedure |
| • At least 3 mo remote from any revascularization procedure |
| • No associated disease with a likelihood of survival <18 mo |
| • Age ≤75 y |

| Recommendations for Cardiac Resynchronization Therapy in New Zealand: |
|---------------------------------------------------------------------|
| • EF ≤35% after ≥6 wk of optimal heart failure treatment, with QRS duration is >149 ms or is 120-149 ms with 2 additional criteria for dyssynchrony (aortic pre-ejection delay >140 ms, interventricular mechanical delay >40 ms or delayed activation of the posterolateral left ventricular wall) |
| • NYHA class III |
| • No major cardiovascular event in the prior 6 wk and be in sinus rhythm |
| • No major comorbidity reducing survival <18 mo or seriously impairing quality of life |

ACE, angiotensin converting enzyme; EF, ejection fraction; ICD, implantable cardioverter-defibrillator; ICM, ischemic cardiomyopathy; MI, myocardial infarction; NICM, Non-ischemic cardiomyopathy; NYHA, New York Heart Association.

therapy, who have left ventricular ejection fraction (LVEF) ≤35% and left bundle branch block (LBBB) with QRS width ≥120 ms.5 Despite recommendations, there remain many barriers and challenges to implanting CRT in patients with HF patients who meet guideline criteria. The 2006-2007 US National ICD Registry data showed that 32.2% of patients eligible for implantable cardioverter-defibrillator (ICD) also met criteria for CRT.6 Of those eligible, only 4 of 5 received a CRT-capable device. The largest published series of CRT procedures in New Zealand had only 139 patients during the period between 2000 and April 2011.9

Little is known about the CRT use and outcomes of these patients in New Zealand. Our study aimed to examine the trends of CRT use in eligible HF patients living in the Northern Region of New Zealand and their outcomes.

2 METHODS

This was an observational study documenting the use of CRT in HF patients in the Northern Region of New Zealand. New Zealand has a population of 4.43 million. The Northern Region of New Zealand is defined as the four northernmost District Health Board (DHB) areas that consist of the Auckland DHB (ADHB), Counties Manukau DHB (CMDHB), Northland DHB (NDHB), and Waitemata DHB (WDHB). The four DHBs in the Northern Region serve 38% of the total New Zealand population.10 Patients residing in the catchment areas of the four DHB were included over the study period from 1 January 2007 to 1 June 2015. All de novo transvenous CRT-pacemaker (CRT-P) and CRT-defibrillator (CRT-D) implants, all upgrades of pacemakers to CRT-P or CRT-D, upgrades of ICD to CRT-D and epicardial lead placement for CRT-P or CRT-D capable devices were included. Procedures involving solely pulse generator replacement were excluded. The indications for CRT-D and CRT-P were based on the published 2010 New Zealand guidelines (Table 1).11 All referrals for CRT were discussed by the Northern Region implanting electrophysiologists regarding suitability and appropriateness of CRT-support. To illustrate the number of potential candidates needed to be reviewed for CRT-support, the number of unique patients hospitalized with HF in each year from year 2007 to 2015 in the Northern Region were reviewed using the data of Ministry of Health (MoH) and National Minimum Datasets (NMDS) inpatient hospitalization data.

Data pertaining to the procedure and the post-procedure period were obtained via review of clinical records held on electronic Clinical Record Information System (CRIS). Data collected via notes review included patient demographic data, procedure-related data, acute (within 24 hours of implant), early (>24 hours to 2 weeks after implant) and late (≥2 weeks after device implantation) complications.

Hospitalization events were identified using the administrative data of MoH and NMDS inpatient hospitalization data via National Health Index (NHI) number linkage up to December 2015. The NHI number is a unique identifier that is assigned to every person who uses health and disability support services in New Zealand. HF hospitalization was defined using the International Classification of Diseases diagnosis 10 (ICD-10) codes (I110, I130, I132, I500, I501, I505, I501, and I509).

Mortality data were collected using New Zealand mortality collection and NMDS. These include all registered deaths not just in-hospital deaths. The cause of death data was available up until the end of 2013. For those with no cause of death data from NMDS, adjudicated review of clinical records was performed to further determine the cause of death.

Ethics approval of the study was obtained from the Central Health and Disability Ethics Committee (Ethics ref: 15/CEN/58/AM02).
2.1 Statistical analysis

Baseline characteristics were summarized as either mean with standard deviation (SD), median with interquartile range (IQR) or frequency with percentage depending on the nature of the data. Comparisons between CRT-P and CRT-D were conducted using either the Wilcoxon rank-sum test, the chi-squared test or the two-sample Z test. Survival rates over time were depicted in Kaplan-Meier curves and the differences between survival distributions were evaluated with the log-rank test. Statistical analyses were performed using the statistical package SAS version 9.3 (SAS Institute, Cary, NC). All P-values resulted from two-sided tests and a P-value of <0.05 was considered statistically significant.

3 RESULTS

A total of 200 patients had a CRT device (157 CRT-D and 43 CRT-P) implanted during the study period. The majority of patients were male (76%) and of European descent (79.5%). Mean age of patients was 62.4 ± 11.2 and median age was 64.4 (12.8) years, respectively. The median duration of follow-up was 4 [2.8-9] years. Patients were more likely to have non-ischemic cardiomyopathy (NICM) (49.5%). Ischemic cardiomyopathy (ICM) (22.5%) and pacemaker-induced cardiomyopathy (19.5%) were the other common etiologies for underlying cardiomyopathy.

Among the 157 CRT-D patients, 116 (73.9%) patients received these devices as primary prevention for sudden cardiac death (SCD). Five patients had epicardial lead placement at initial procedure because of known difficult anatomy (ie, upgrades with occluded venous access and extraction was not considered appropriate or declined). A left ventricular lead was successfully placed transvenously via the coronary sinus (CS) in 136 patients (89.5%) at the initial procedure. Eight required a second procedure with three unsuccessful CS-lead implantations needing epicardial lead placement. Two patients underwent a redo-procedure using an epicardial lead because of adverse coronary sinus anatomy, and/or unintended stimulation of the left phrenic nerve during transvenous CS-lead placement; in total 10 patients had epicardial lead placement for CRT-D devices. Only six patients did not receive CRT-D because of failed left ventricular lead placement. Twenty-three (14.7%) patients were upgraded from pacemakers to CRT-D and 18 (11.5%) were upgraded from ICDs to CRT-D.

In the CRT-P group, left ventricular lead placement was successful at initial implant in 41 patients (95.3%) and one patient required a second procedure which failed and required epicardial lead placement. Thirty-two (74.4%) were upgrades from pacemakers to CRT-P. One patient did not receive the intended CRT-P device because of failed left ventricular lead placement.

3.1 Context of Northern Region in CRT implantation

In the Northern Region, the number of individuals admitted with a diagnosis of HF was increasing year-by-year (Figure 1). In a Swedish Heart Failure Registry, QRS prolongation with LBBB morphology ≥120 ms was present in 31% of patients with HF. If ~30% of patients each year with HF have underlying LBBB and systolic dysfunction, then the number of patients to be considered for CRT-support in the Northern Region should also increase proportionally. However, throughout the study period, the number of CRT implanted remained low (Figure 2). There were differences in CRT-D and CRT-P utilization (Figure 2). The percentage of CRT-D utilization gradually increased from 2007 to mid-2015. However, the utilization of CRT-P remained static during these times.

Shown in Table 2 are the baseline characteristics of patients who received CRT-P and CRT-D. In general, patients receiving CRT-P...
were older, more likely to have pacemaker-induced cardiomyopathy, have more severe HF symptoms (NYHA class III) but better LVEF, higher prevalence of permanent atrial fibrillation (AF) and previous history of atrio-ventricular (AV) nodal ablation, and have smaller body habitus than those who received CRT-D.

3.1.1 | Complications
There was a total of 26 complications between the groups (12.7% in CRT-D group vs 13.9% in CRT-P group, \(P = 0.83\)) (Table 3). During the first 24-hour after device implantation, there were 11 perioperative complications (5.7% in CRT-D vs 4.7% CRT-P, \(P = 0.78\)). There was no difference in the occurrence of early and late complications (Table 3).

3.1.2 | Mortality
During the follow-up of up to 10.2 years (median of 4 [2.8] years), 29 (14.5%) patients (14.7% in CRT-D vs 13.9% in CRT-P, \(P = 0.91\)) had died. Of these deaths, 23 were classified as cardiovascular death, three deaths were due to malignancy and two from other non-cardiac causes (\(P = 0.91\)). One was classified as unspecified cause.

Of the 23 cardiovascular deaths, 17 (73.9%) were due to HF and six (26.1%) deaths were attributable to myocardial infarction (MI), or cerebrovascular accidents. No sudden arrhythmic death was reported. There was no difference in all-cause mortality observed over time (Figure 3).

3.1.3 | All-cause and heart failure hospitalizations
During follow-up, there were 566 all-cause hospitalizations in 139 patients. These include 114 (20.1%) HF admissions. The median duration from implant to first HF hospitalization were 2.86 (9.23) months. The median length of stay was 4 (2) days. For CRT-D and CRT-P patients, the median duration to first HF hospitalization after implant was similar (2.9 [0.53] months vs 2.7 [1.3] months, respectively).

3.1.4 | Device therapy
Among the 157 CRT-D patients, 34 (21.7%) had device therapy (anti-tachycardia pacing [ATP] with or without shocks). Twenty-three (19.8%) of these occurred in those with a primary prophylactic device and 11 (26.8%) in patients with secondary prevention devices (\(P = 0.35\)). Overall 6.4% (10) of the patients had inappropriate shocks, most commonly because of AF (60%) or supraventricular tachycardia (SVT) (30%).

4 | DISCUSSION
This study describes the trends in CRT therapy use for eligible HF patients in New Zealand. We have observed a gradual increase in CRT-D implantation across the study period, with an increase in the proportion of patients receiving these devices for primary prevention of SCD and management of HF. However, CRT-P devices still accounted for <25% of the total CRT devices implanted over the study period. Despite the increasing evidence supporting CRT use in appropriate HF patients and a rapidly growing HF population, there are still a large number of eligible patients not receiving this therapy. In the Registry to Improve the Use of Evidence-Based Heart Failure Therapies in the Outpatient Setting (IMPROVE HF) Study, a total of 1373 patients were eligible for CRT devices based on guideline criteria but only 533 (38.8%) received CRT devices, with 84.1% of these treated with CRT-D.\(^{13}\) In the Swedish Heart Failure Registry (SwedeHF), 3094 patients (24%) of 12807 patients met the indication for CRT but did not receive the device and only 841 (7%) had CRT.\(^{14}\) The trends in CRT implantation in the United States from the Nationwide Inpatient Sample (NIS)
database showed that the total number of CRT implants increased significantly between year 2002 and 2006 but has not shown a significant increase since 2006. The majority of the devices implanted were CRT-D (86%) with CRT-P constituting the minority, with a progressive decrease in use from 28.8% in 2002 to 15.2% in 2010. By contrast, other European countries are still implanting a significant number of CRT-P: 39% in France, 44% in Sweden, 46% in Belgium in 2013. The regional differences in implant rates most likely reflect the differences in health care system and the reimbursement situations.

### TABLE 2 Baseline characteristics of patients who received CRT-P and CRT-D

|                  | CRT-D (n = 157) | CRT-P (n = 43) | P-value |
|------------------|-----------------|----------------|---------|
| Mean age (y ± SD)| 61.5 ± 10.2     | 65.9 ± 14.0    | 0.0007  |
| Median age (IQR) | 63.4 (57.3)     | 69.7 (60.4)    |         |
| Gender           |                 |                |         |
| Male (%)         | 123 (78.3)      | 29 (67.4)      | 0.14    |
| Female (%)       | 34 (21.7)       | 14 (32.6)      |         |
| Ethnicity (%)    |                 |                |         |
| New Zealand European/other | 121 (77.1) | 38 (88.3) | 0.35 |
| Maori            | 9 (5.7)         | 2 (4.7)        |         |
| Pacific Island   | 19 (12.1)       | 1 (2.3)        |         |
| Asian            | 7 (4.5)         | 2 (4.7)        |         |
| Underlying aetiology (%) |          |                |         |
| Non-ischemic cardiomyopathy | 93 (59.2) | 6 (14)      | <0.0001 |
| Ischemic cardiomyopathy | 40 (25.5) | 4 (9.3)     | 0.02    |
| Pacemaker-induced cardiomyopathy | 10 (6.4) | 29 (67.4) | <0.0001 |
| Valvular heart disease | 4 (2.6) | 3 (7)        | 0.16    |
| Mean LVEF (% ± SD) | 24.7 ± 6.1 | 33.7 ± 10.5 | <0.0001 |
| NYHA class (%)   |                 |                |         |
| I                | 18 (11.5)       | 6 (14)         | 0.03    |
| II               | 75 (47.8)       | (27.9)         |         |
| III              | 64 (40.8)       | (55.8)         |         |
| IV               | 0               | 1 (2.3)        |         |
| Median height (m) (IQR) | 1.74 (1.67) | 1.72 (1.67) | 0.91    |
| Median weight (kg) (IQR) | 86.3 (74.1) | 81.5 (75) | 0.02    |
| Median BMI (m/kg^2) (IQR) | 28.3 (25.9) | 26.5 (24.8) | 0.01    |
| Atrial arrhythmias (%) |          |                |         |
| Permanent AF     | 16 (10.2)       | 15 (34.9)      | <0.0001 |
| Paroxysmal AF    | 20 (12.7)       | 3 (7)          | 0.29    |
| AV node ablation | 3 (1.9)         | 11 (25.6)      | <0.0001 |
| Diabetes mellitus (%) | 41 (26.3) | 3 (7.1)       | 0.008   |
| Hypertension (%) | 44 (28.2)       | 12 (28.6)      | 0.96    |
| QRS morphology (%) |          |                |         |
| IVCD             | 1 (0.6)         | 1 (2.3)        | <0.0001 |
| LBBB             | 131 (83.4)      | (27.9)         |         |
| Paced            | 23 (14.7)       | 29 (67.4)      |         |
| QRS duration (ms) |          |                |         |
| Mean (± SD)      | 175.1 ± 24.6    | 177.3 ± 33.0   | 0.36    |
| Estimated glomerular filtration rate (eGFR) |          |                |         |
| Median (IQR)     | 60 (51)         | 60 (50)        | 0.33    |

AF, atrial fibrillation; AV, atrio-ventricular; BMI, body mass index; CRT-P, cardiac resynchronization therapy-pacemaker; CRT-D, cardiac resynchronization therapy-defibrillator; IQR, interquartile range; IVCD, intraventricular conduction delay; LVEF, left ventricular ejection fraction; LBBB, left bundle branch block; NYHA, New York Heart Association.
Martin et al published the largest series of CRT procedures in New Zealand with only 139 patients between year 2000 and April 2011 in the Auckland region. Since then, there has been a steady increase in the number of implant of these devices as shown in our study with the majority of the devices implanted being CRT-D. The number of CRT-P implanted remained static throughout the study. Affordability and capacity are of concern in this region. Despite the increasing number of HF patients year-by-year, only a small proportion of patients received these devices (Figures 1 and 2). For example, in the 2014 year, 8311 patients with HF were admitted within the region. Assuming that approximately 30% would potentially meet criteria for consideration of CRT-support, there is a clear evidence of under referral for and implantation of such devices (Figure 1).

There are numerous potential reasons for this including: (a) concerns regarding affordability and capacity, (b) lack of familiarity with the indications for CRT, under-appreciation of the potential benefits of an upgrade to CRT from an existing ICD or pacemaker, and (c) physicians misconceptions about the procedural risks and device complications, which may discourage referrals for implantation. Identification of eligible patients for possible CRT implantation is important. It may seem to be a relatively straightforward to identify the inclusion and exclusion criteria as outlined in peer-reviewed guidelines, but in clinical practice recognition of appropriate patients and utilization rate of CRT are far from satisfactory.

### TABLE 3 Complications among CRT-D and CRT-P patients

| Complication                                      | CRT-D (n = 157) | CRT-P (n = 43) | P-Value |
|---------------------------------------------------|-----------------|----------------|---------|
| Acute perioperative complications                | 9 (5.7%)        | 2 (4.7%)       | 0.78    |
| Lead displacement/remanipulation                  | 7 (4.5%)        | 1 (2.3%)       | 0.53    |
| Coronary sinus dissection                         | 1 (0.6%)        | 1 (2.3%)       | 0.97    |
| Cardiac Tamponade needing intervention            | 1 (0.6%)        | 0              | –       |
| Early complications                               | 2 (1.3%)        | –              | –       |
| Lead displacement/remanipulation                  | 2 (1.3%)        | 0              | –       |
| Late complications                                | 9 (5.7%)        | 4 (9.3%)       | 0.4     |
| Lead issues needing intervention                  | 7 (4.5%)        | 3 (6.9%)       | 0.5     |
| Device/pocket issues requiring intervention       | 1 (0.6%)        | 0              | –       |
| Device pocket infection needing extraction        | 1 (0.6%)        | 1 (2.3%)       | 0.97    |

CRT-D, cardiac resynchronization therapy-defibrillator; CRT-P, cardiac resynchronization therapy-pacemaker.

FIGURE 3 Kaplan-Meier survival curve of all-cause mortality in CRT-D and CRT-P patients. CRT-D, cardiac resynchronization therapy-defibrillator; CRT-P, cardiac resynchronization therapy-pacemaker.
 ranging from 38.8% of eligible patients receiving CRT-P to 84.1% of eligible patients receiving CRT-D. Considering current workforce, funding constraints and the conservative approach taken, the published 2010 New Zealand guidelines (Table 1) have more restrictive recommendations for CRT. Given the funding issues, all referrals required discussion by the Northern Region implanting electrophysiologists regarding suitability and appropriateness before undergoing implantation.

Cardiac resynchronization therapy is limited to HF patients who meet specific clinical criteria (low LVEF and wide QRS duration on ECG). The assessment of LVEF is a criteria common to ICD and CRT referrals but McHale et al showed that restricted access to investigations such as echocardiography are considered a significant barrier to referral. Regional differences in echocardiography services were described in New Zealand in 2005 using the Survey of Clinical Echocardiography Around New Zealand (SCANZ). In the Recent 2013 SCANZ Workforce Survey, Buckley et al demonstrated that regional disparity in public echocardiography in New Zealand still exists with unequal geographic distribution of echo services. The reasons are likely multifactorial and contributed to by DHB demographic differences in age, ethnicity, and socioeconomic deprivation status as well as the size and demographics of the cardiology workforce. In our study, echocardiographic assessments and cardiac MRI were the most commonly used measures, with all patients requiring LVEF to be quantified prior to discussion regarding clinical care with device support. LVEF is one of the most commonly reported measures of left ventricular systolic function. LVEF can be determined using several invasive and noninvasive imaging modalities, either subjectively by visual estimation or objectively by quantitative methods. Currently, there is no universally accepted “gold standard” for measuring LVEF. Each method has limitations and potential for error. Many factors should be taken into account when deciding which method is the most appropriate for an individual patient. The different ways to assess LVEF is beyond the scope of the current study because our study aimed to review the utilization and outcomes of CRT patients in the Northern Region of New Zealand.

In our study, 29 (14.5%) patients (14.7% in CRT-D vs 13.9% in CRT-P, $P = 0.91$) had died at the end of follow-up. The total mortality was relatively low compared to the published Comparison of Medical Therapy, Pacing, and Defibrillation in Heart Failure (COMPANION) trial (15%) and the Cardiac RESynchronization-Heart Failure (CARE-HF) trial (20%). One explanation is the younger population in our study. The mean age of our patients was 62.4 years vs 67 years in both COMPANION and CARE-HF. Even though our CRT-P patients was older compared to the CRT-D patients, they were still relatively younger (mean age of 64.9 years) when compared to CARE-HF where only the impact of CRT-P was assessed. This is likely due to the more conservative New Zealand guidelines for ICD and CRT-D in patients with HF compared to the International guidelines. Another potential factor contributing to the lower mortality relates to the majority of the cohort have NICM or pacemaker-induced cardiomyopathy. Patients with NICM are known to respond better to CRT than those with ICM. Data from recent clinical trials showed that patients with ICM and NICM gained similar clinical benefit from CRT when compared with medical treatment, but NICM patients had greater reverse remodeling compared with ICM patients. In the Multicenter Automatic Defibrillator Implantation Trial with Cardiac Resynchronization Therapy (MADIT-CRT), the magnitude of the echocardiographic effects of CRT-D with reverse remodeling effects were shown to be significantly higher among NICM patients.

Thirty-nine (19.5%) of our patients had underlying pacemaker-induced cardiomyopathy. Pacemaker-induced cardiomyopathy may be more common than previously reported. Yu et al found a 9% incidence of pacemaker-induced cardiomyopathy and Zhang et al reported new-onset HF symptoms in 26% of patients with frequent right ventricular (RV) pacing over 7.8 years follow-up. In a retrospective study by Khurshid et al, 19.5% developed pacemaker-induced cardiomyopathy with a decrease in mean LVEF from 62.1% to 36.2% over a mean follow-up period of 3.3 years. In the Mode Selection (MOST) Trial, RV pacing >40% increased risk for HF hospitalization and incidence of AF compared to values below 40%. We defined pacemaker-induced cardiomyopathy based on the preserved/normal LVEF and absence of HF symptoms at the time of initial pacemaker implantation and the progressive deterioration of HF symptoms and deterioration of LVEF years after chronic RV pacing without any other plausible alternate explanation. Eleven of the 29 patients with pacemaker-induced cardiomyopathy underwent AV nodal ablation therefore rendering them pacemaker-dependent. The remainder has had at least 98% RV pacing with deteriorating LVEF and HF symptoms over time. According to recent guidelines, upgrade from conventional pacemaker or ICD to CRT is a class 1 indication in HF patients with LVEF <35% and a high percentage of RV pacing who remain between NYHA class III and ambulatory class IV despite adequate medical treatment. An upgrade to CRT can potentially prevent the adverse remodeling associated with chronic RV pacing. Response to CRT further decreases the risk for ventricular arrhythmias, SCD, and all-cause mortality which could account for the lower mortality in our study patients.

Changes in the way in which HF patients are managed (including advances in medical therapy, treatment of comorbid disease and risk factors for the development of HF, and the recognition of the value of HF disease management programs) throughout the study period could also explain the lower mortality in our study. All of our CRT-P patients met indications for primary prevention ICD implantation based on international guidelines but not the New Zealand guidelines. An ICD was not implanted in this group of patients with a poorer baseline status and higher LVEF compared with those who received CRT-D. However, the number of deaths observed was similar and there was no survival difference between the two groups. No sudden arrhythmic death was reported in either group. This could be explained by the small sample size of both CRT-D and CRT-P and potential selection bias of candidates due to the more conservative recommendations of the New Zealand guidelines.

During the longer follow-up period in our study, 27.6% deaths were a result of progressive HF. This suggests that despite a more
conservative approach, there was no survival penalty for those undergoing CRT-P rather than CRT-D support in our study. The mode of death in the COMPANION trial was most commonly pump failure (44.4%) even though both CRT-D and CRT-P modestly reduced mortality. The CARE-HF trial confirmed that progressive HF deaths remained the leading cause of death in HF populations. Current international guidelines give the same level of recommendation for CRT-P and CRT-D use. No clear preference is given to any treatment modality compared with the other. Prescription of these costly and complex devices should be preferentially for patients in need of secondary prevention or for the purpose of primary prevention in younger patients without major comorbidities.

Despite the low implant numbers, our perioperative and late complication rates are comparable to published data. There is cumulative evidence that implanting CRT-D devices is associated with a higher perioperative and postoperative risk of major complications compared with CRT-P. Romeyer-Bouchard et al reported an increased risk of infection with CRT-D devices compared with CRT-P. Another Danish study showed that the incremental risk of perioperative or 6-month postoperative complications was 1.5 (0.9-2.3) (P = 0.11) for CRT-P and 2.6 (1.9-3.4) (P < 0.001) for CRT-D compared with conventional pacemakers. However, in our study there were no differences in perioperative and late complication rates between the two groups. This may be explained by the small number of CRT-P included in the study, and therefore no conclusive differences in complications could be drawn.

4.1 Limitations

Our study is a retrospective study with prospective follow-up. The sample size of CRT-P was very small compared with CRT-D. Device prescription was not randomized, therefore patients with poorer functional status and limited expected survival were implanted preferentially with CRT-P compared to CRT-D.

There were more NICM and pacemaker-induced cardiomyopathy patients compared to ICM patients in our study. The published 2010 New Zealand guidelines have stricter recommendations for ICD and CRT-D in patients with HF compared to the International guidelines. Considering only a small proportion of HF patients in the Northern Region have been selected for CRT-support, it is likely that a sizable group of HF patients are not being referred therefore, missing out on appropriate device support. Confounder and selection bias should be kept in mind when interpreting the results of our study.

Our study does not represent the entire New Zealand. The four DHBs in Northern Region serve 38% of the total New Zealand population. The implant numbers and the practice will be different from other implanting centers in the country.

The main strength of our study was long duration of follow-up (total duration of 10.2 years), accepting the limitation of a small cohort size. Uniquely we were able to classify the mode of death in 99.5% patients and able to capture all deaths rather than just in-hospital death. Only one patient had an unspecified cause of death in the community. We were also able to capture all the hospitalization events in detail for patients. Furthermore, our study measured the outcomes including mortality and hospitalizations after implant, which is important when making decisions about the appropriate device choice for individual HF management.

5 Conclusion

There has been a steady increase in CRT implantation over time in the Northern Region of New Zealand. While the optimal per population implantation rate is speculative, these data suggest that there is a significant unmet clinical need for CRT implantation in the Northern Region. The reasons for low implantation of CRT devices require further examination.

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Conflicts of Interest

The authors have no conflicts of interest to declare.

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