CASE REPORTS

Cardiac resynchronization as rescue therapy for ventilator-dependent heart failure

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Abstract

The role of cardiac resynchronization therapy (CRT) in treating non-ambulatory patients with severe heart failure (HF) remains controversial. We present 2 cases in which CRT was successfully utilized in patients with very poor prognosis that had failed multiple attempts at weaning from the ventilator. Both patients improved rapidly, and were successfully weaned shortly after implant. One patient is still alive, living independently without HF symptoms, 23 months after implant. The other patient died 19.5 months after implant due to an unrelated condition. These cases demonstrate that CRT can be successfully employed as rescue therapy in selected ventilator-dependent HF patients.

Keywords

Cardiac resynchronization therapy, Mechanical ventilator, New York Heart Association Class IV, Non-ambulatory

1 Background

Cardiac resynchronization therapy (CRT) is a well-accepted treatment for many patients with wide QRS, an ejection fraction (EF) $\leqslant$ 35% and NYHA Class II-III (and some Class I) heart failure (HF). However, the role of CRT in patients with NYHA Class IV HF is controversial. Large, randomized clinical trials of CRT have included very few Class IV patients, and those that were included were ambulatory [1]. This is reflected in current guidelines, which indicate that CRT is an appropriate treatment option in select patients with ambulatory Class IV HF [2, 3]. Decompensated patients who are hospitalized and may require acute HF therapies, including intravenous inotrope administration or mechanical ventilation, are often deemed both too unstable to risk a CRT implant procedure and too sick to realize a benefit from such therapy [4]. As a result, to our knowledge, no previous studies or case reports have specifically explored the use of CRT to improve cardiac hemodynamics in patients who are ventilator-dependent. We present 2 cases in which CRT was used as rescue therapy in ventilator-dependent HF patients, resulting in marked hemodynamic and clinical improvements, extubation, and discharge from the hospital.

2 Case reports

2.1 Patient A

A 71-year-old female was admitted to the hospital for treatment of acute onset of worsening dyspnea and orthopnea. The patient had a long history of HF with mild left ventricular (LV) dysfunction and a left bundle branch block (LBBB). Past medical history was significant for diabetes mellitus type II, coronary artery disease with previous 2 vessel coronary artery bypass surgery, hypertension, dyslipidemia, renal artery stenosis with renal artery stent, and peripheral vascular disease. Medications on admission included amlodipine, clonidine, furosemide, metoprolol, potassium chloride, pravastatin, fenofibrate, sitagliptin, and glypizide.

The patient was found by paramedics to be in respiratory distress with oxygen saturation of 78% and was treated with oxygen, continuous positive airway pressure, sublingual nitroglycerin, and intravenous lorazepam. She could not speak in full sentences due to dyspnea, and had bilateral rales, a tachycardic regular rhythm without murmurs and mild pitting pretibial edema.

Table 1. Vital signs and test values of patient A at admission and discharge

Vital Signs	**Admission**	**Discharge**
Heart Rate (beats/min)	96	62
Respiratory Rate (breaths/min)	36	18
Blood Pressure (mmHg)	236/109	154/58
Lab values		
White Blood Count (1,000/mm^3)	23.7	
Hemoglobin (g/dl)	14.6	8.5
BNP (mg/ml)	562	
BUN (mg/dl)	22	62
Creatinine (mg/dl)	1.5	1.2
Troponin (ng/ml)	0.01	
Arterial Blood Gas		
pH	7.29	
pCO_2 (mmHg)	52	
HCO_2 (mmHg)	28	
pO_2 (mmHg)	242 100%FIO_2	
ECG		
Rhythm	Sinus	BiV Paced
Heart Rate (beats/min)	99	106
QRS duration (ms)	158	134
PR interval (ms)	176	104
Echocardiography		
Ejection Fraction (%)	25 (27)	30-35 (35)
LVEDD (cm)	5.1	4.9
LVESD (cm)	4.5	4.0
Mitral Regurgitation	Mild	Mild
Radial Opposing Wall Delay (ms)	323	77

Other data on admission are summarized in Table 1 (Blood Pressure is systolic/diastolic, BNP = brain natriuteric peptide, BUN = blood urea nitrogen, pCO_2 = partial pressure of carbon dioxide, pO_2 = partial pressure of oxygen, FiO_2 = fraction inspired oxygen, AF = atrial fibrillation, RVR = rapid ventricular response). A LBBB pattern, with QRS duration of 158 ms was seen on ECG (see Figure 1, top panel). Echocardiogram demonstrated upper normal LV size, severe LV systolic dysfunction with an EF of 25%, global hypokinesis with dyskinetic and severely hypokinetic septal and anteroseptal wall motion, and mild LV hypertrophy. There was no evidence of myocardial scarring in this echocardiographic study, or in previous studies on this patient. The patient was treated in the ER and admitted to the intensive care unit (ICU).

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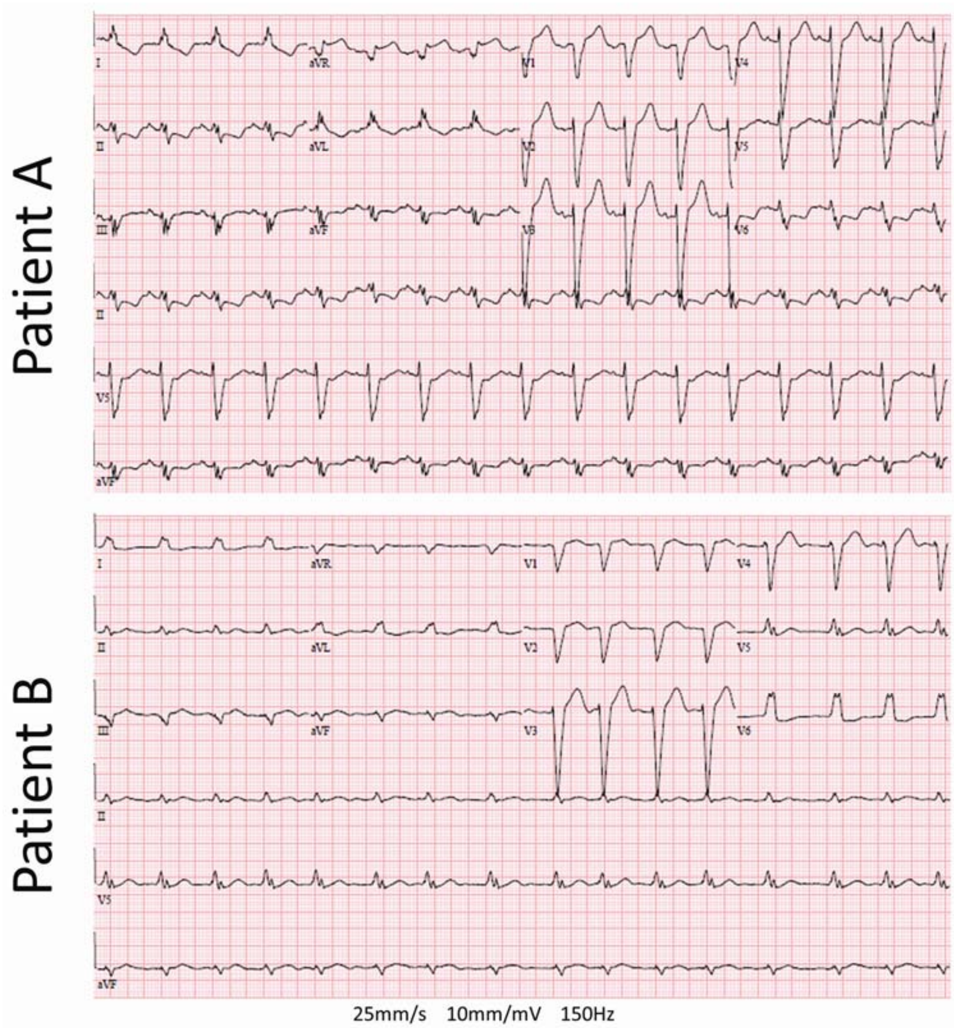

Figure 1. ECG tracings of both patients before CRT implant. Both patients had an LBBB pattern wide QRS durations of 158 ms and 162 ms for patients 1 (top panel) and 2 (bottom panel), respectively

The day after admission blood pressure and dyspnea were markedly improved, but the patient remained hypertensive. She underwent coronary angiography 2 days after admission showing an occluded left main coronary artery, 50%-60% diffuse right coronary artery disease and widely patent grafts at the sites of previous revascularization. The patient developed acute respiratory distress in the heart catheterization laboratory, and was treated with intravenous furosemide and hydralazine and was intubated.

Over the next 12 days the patient remained intubated and was managed by cardiology, pulmonology, critical care, nephrology, and infectious disease consultants. The patient developed acute renal failure and was treated with intravenous bumetanide, chlorothiazide, and blood pressure medications. She had intermittent hypotension and was treated with intravenous dopamine and dobutamine. Repeat echocardiogram showed no significant change. Multiple unsuccessful attempts were made to wean the patient from the ventilator. Because pulmonary and critical care consultants felt that the patient would need long-term ventilatory support, plans were made to perform a tracheostomy.

In an attempt to improve respiratory function by improving hemodynamics, a CRT-pacemaker without defibrillator was implanted without complication on day 13 of ventilatory support. The LV lead was placed in a lateral position. Dobutamine was discontinued, renal function improved and chest X-ray was consistent with improving HF. The patient was extubated 3 days after CRT placement. An echocardiogram showed an improvement in EF to 30%-35%, and her QRS duration was reduced. Nine days after extubation the patient was ambulatory and was discharged to a transitional care unit before being discharged home. The patient was seen in HF clinic 2.5 months after placement of the CRT device. She was asymptomatic, able to function normally and independently at home, and without signs of HF on examination.

The patient was re-hospitalized 7 months after her CRT implant with symptoms of worsening HF and multidrug resistant hypertension. The atrioventricular delay programming of her CRT device was optimized to improve synchrony and diastolic filling, and her hypertension was controlled medically. She was discharged home after 8 days. She has since remained free from HF symptoms, living independently at home without any further hospitalizations in the 16 months since her CRT optimization procedure.

2.2 Patient B

An 86-year-old female patient was transported to the ER by paramedics with chest pain and dyspnea. She had been diagnosed with HF 2.5 years earlier, with an EF of 50%. One year before this admission, she was diagnosed with asymptomatic atrial fibrillation. The patient had ischemic cardiomyopathy, and had undergone several percutaneous interventions, most recently 3.5 years prior. Her past medical history was significant for hypertension, mitral regurgitation, diabetes mellitus type II with peripheral neuropathy, and chronic renal failure. The patient was living independently but in an assisted living facility. Her medications on admission included amlodipine, aspirin, atorvastatin, clonidine, furosemide, glipizide, insulin glargine, and warfarin.

Table 2. Vital signs and test results for patient B, at hospital admission and discharge (abbreviations the same as Table 1)

Vital Signs	**Admission**	**Discharge**
Heart Rate (beats/min)	131	79
Respiratory Rate (breaths/min)	20	18
Blood Pressure (mmHg)	129/72	149/65
Lab values		
White Blood Count (1,000/mm^3)	19.2	
Hemoglobin (g/dl)	11.0	9.5
BNP (mg/ml)	1,269	
BUN (mg/dl)	49	26
Creatinine (mg/dl)	1.2	0.8
Troponin (ng/ml)	0.02	
Arterial Blood Gas		
pH	7.36	
pCO_2 (mmHg)	41	
HCO_2 (mmHg)	23	
pO_2 (mmHg)	59 on 100%FIO_2	
ECG		
Rhythm	AF with RVR	BiV Paced
Heart Rate (beats/min)	92	70
QRS duration (ms)	162	154
PR interval (ms)	NA	NA
Echocardiography		
Ejection Fraction (%)	35	40
LVEDD (cm)	5.2	4.9
LVESD (cm)	4.4	4.1
Mitral Regurgitation	Severe	Moderate
Radial Opposing Wall Delay (ms)	169	113

Paramedics found the patient in respiratory distress with oxygen saturation of 72%. She had bilateral rales, and complained of chronic foot pain and non-healing ulcers. The results of her initial work-up are summarized in Table 2.

Atrial fibrillation and a LBBB pattern with QRS duration of 162 ms was seen on ECG (see Figure 1, bottom panel). Echocardiogram demonstrated normal LV size, moderate LV systolic dysfunction with an EF of 35%, global hypokinesis with severely hypokinetic septal wall motion, and normal right ventricular size and function. There was no evidence of scarring in the LV myocardium on this echocardiogram, or during a nuclear stress test performed two years prior. The patient was treated in the ER and admitted to the ICU.

The day after admission her severe dyspnea persisted, despite continuous positive airway pressure treatment. Two days after admission, the patient was intubated prior to undergoing coronary angiography, which revealed 95% stenosis in the first diagonal that was treated with a bare metal stent. Echocardiography following this procedure showed no improvement in cardiac function, with a persistent dyskinetic septum. The patient's heart rate was maintained between 95-105 beats/min with IV medications but she failed weaning attempts due to increasing tachycardia and dropping arterial oxygen saturation.

The patient underwent atrioventricular node ablation with CRT-pacemaker (without defibrillator) implantation 5 days after admission, with no complications. The LV lead was placed in a lateral position. Arterial oxygen saturation improved almost immediately upon activating the device. The patient tolerated a 2-hour ventilator wean shortly after the implantation and was extubated the following day.

The patient was transferred out of the intensive care unit another 2 days later. An echocardiogram revealed improved LV function, with an EF of 40% and less mitral regurgitation. Sixteen days after admission, she was discharged to transitional care before being discharged to home. She passed away due to complications of diabetes and osteomyelitis, without further HF exacerbation, 19.5 months after her CRT implant.

3 Discussion

In this report, we describe 2 cases in which CRT was used to improve hemodynamic function in ventilator-dependent HF patients. Both patients were unable to be weaned from the ventilator despite multiple attempts and aggressive medical therapy. However, shortly after CRT implantation, both patients had major hemodynamic improvements, were extubated, and later successfully discharged from the hospital. One patient had a subsequent hospitalization for HF in the 23 months since her CRT placement, but has otherwise lived independently with minimal HF symptoms. The second patient survived 19.5 months after CRT implantation, without further HF or respiratory symptoms, and died due to an unrelated condition. These cases demonstrate that CRT can safely be accomplished despite very poor cardiorespiratory condition, and that the use of CRT appears to have quickly improved respiratory and cardiac function and enabled successful extubation.

The acute hemodynamic benefits of CRT have been previously documented, including improvements in LV stroke work [5], maximal rate of pressure rise [5-7], aortic pulse pressure [6], cardiac index [8], pulmonary capillary wedge pressure [8], mitral regurgitation [7], end-systolic volume [7, 9] and EF [7, 9]. These improvements in hemodynamics can occur almost immediately upon activating the CRT device and might be expected to occur in appropriately selected patients regardless of NYHA functional classification. However, current guidelines do not recommend CRT in non-ambulatory NYHA class IV HF patients [2, 3]. Several small, retrospective studies of CRT implantation in inotrope-dependent HF patients have described high rates of successful implant, weaning from inotrope, clinical improvement, hospital discharge, and in some cases echocardiographic improvements following CRT [10-17]. To our knowledge, no previous studies or cases have specifically described CRT implant in ventilator-dependent HF patients. One study, however, included 10 inotrope-dependent patients, one of whom also required ventilator support at the time of CRT implant [12]. Although all 10 patients in that study were alive at a follow-up of 1088 ± 284 days, no other details about this particular patient were included. Since these patients are medically complex, and factors other than CRT may have played a role in their recovery, larger, prospective randomized trials of CRT in non-ambulatory NYHA class IV patients, including those on IV inotropes or mechanical ventilators, should be considered.

Both of the patients presented here had very poor prognosis, but also had a high likelihood of benefit from CRT due to having low EF and LBBB with wide QRS (> 150 ms). In addition, both patients had significant radial mechanical dyssynchrony, measured by speckle-tracking echocardiography [18, 19], which improved after CRT. The potential hemodynamic benefits were weighed carefully against the risks and costs associated with the implant procedure. With the cost of a day on a ventilator in the ICU estimated to be approximately $11,000 [20], the implant procedure and CRT pacing device (approximately $15,000, without defibrillator) would be cost effective if ICU and ventilator time were reduced by just 1 or 2 days. Furthermore, extended intubation periods pose significant risks including infection and pneumothorax. Ventilator-associated pneumonia is acquired in 10%-20% of patients requiring long-term ventilatory support, for example, which doubles the risk of death and increases health care cost by over $10,000 [21]. Both of these patients had failed several weaning attempts before CRT implant, and were approaching the time suggested for tracheostomy. The hemodynamic benefits of CRT appeared to be immediate in these 2 cases, and likely reduced the number of days spent on the ventilator by more than enough to offset the costs and risks of implant.

Both of these patients had a very poor prognosis prior to CRT implantation, with long-term ventilator support likely, and a high mortality risk. However, both patients also had a high likelihood of beneficial response to CRT. The hemodynamic improvement in these two patients following CRT placement was sufficient to enable successful weaning from both the ventilator and inotropic agents, and both patients were discharged home. CRT likely improved the quality and quantity of life in these patients, and reduced overall healthcare costs. These cases demonstrate that CRT can be successfully utilized, in select cases, as a rescue therapy, even in very sick, ventilator-dependent, patients.

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