Case Report: Exercise in a Patient with Acute Decompensated Heart Failure Receiving Positive Inotropic Therapy

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ABSTRACT

Background and Purpose: The projected increase in persons with advanced heart failure and associated costs warrant the examination of exercise in patients receiving inotropic therapy. Literature supports the use of exercise and inotropic therapy in the treatment of patients with advanced heart failure. The purposes of this paper are to illustrate the use of exercise prescription and outcomes assessment with a 6-minute walk test in a patient with acute decompensated heart failure receiving tailored therapy with dobutamine and to discuss potential relationships resulting in observed improvements. **Case Description:** A 67-year-old man was admitted to an acute care hospital with acute decompensated heart failure for tailored medical therapy including dobutamine. The patient received 14 days of tailored medical therapy, of which 12 days included exercise training by a physical therapist. **Outcomes**: Functional outcomes showed a clinically significant improvement in distance walked and improvement in the cardiorespiratory response. The improvement in estimated peak oxygen consumption was 7% greater than that predicted to be from tailored medical therapy. **Discussion**: Exercise was safely provided to a patient hospitalized with advanced heart failure on continuous inotropic therapy. The 6-minute walk test was effectively used to prescribe exercise and examine patient outcomes.

Key Words: heart failure, 6-minute walk test, exercise

INTRODUCTION AND PURPOSE

Heart failure (HF) has been defined as the inability of the heart to provide the adequate blood supply for the metabolizing tissues of the body.[1] According to the Centers for Disease Control and Prevention, approximately 5 million people in the United States have HF, with an estimated direct cost of $29.6 billion in 2006.[2] Heart failure is the most common reason for hospitalization for those with Medicare.[2]

Patients with a diagnosis of HF are classified into groups based on their functional capacity. Functional capacity limitations associated with HF have been described using subjective ordinal scales such as the New York Heart Association (NYHA) Classification of HF.[3] The NYHA Classification of HF describes patient tolerance to physical activity and was revised in 1994 to include objective measurement of cardiac function and disease.[3] Despite the documentation of functional capacity on admission, very little investigation of functional capacity during or after inotrope administration has been performed.

Current literature supports an exercise-based rehabilitation program for patients with NYHA Class I to III HF to produce short-term benefits in quality of life and exercise capacity.[4] Patients admitted to the hospital for acute decompensated heart failure (ADHF) or NYHA Class IV are not included in these recommendations. Therefore, there is a need to examine the effects of exercise in patients with severe HF who are receiving inotropic therapy.

Baseline medical therapy for HF consists of using medications adjusted by practical experience to optimize cardiac function. Tailored medical therapy uses diuretics, supplemental oxygen, and vasodilator therapy to reduce intracardiac filling pressures and optimize cardiac loading conditions to reduce the medical costs associated with HF.[5,6] Tailored medical therapy for HF focuses on the improvement of patient outcomes, such as symptomatic relief of dyspnea and improved cardiovascular hemodynamics, and evidence suggests that tailored medical therapy, compared to baseline therapy, produces a greater improvement in these patient outcomes.[5] For those persons with advanced HF or ADHF, tailored therapy often includes the addition of positive inotropic agents such as dobutamine.[6] Inotropic medications exert their effects on the force and/or rate of myocardial contraction, thus improving inadequate end-organ perfusion.

Two case studies have been written to describe the functional improvements of patients with HF receiving tailored

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medical therapy with positive inotropic agents with the addition of exercise.[7,8] These two case studies showed that exercise training could be safely provided to a patient with HF while receiving a continuous infusion of positive inotropic support with improvements in exercise tolerance, however, neither study used readily accessible means to evaluate and prescribe exercise or elaborate on potential mechanisms of observed outcomes. The patients in these case studies were evaluated using a graded exercise test[7,8] and spirometry[7] for baseline and follow-up testing. While very accurate, these types of testing are not available to most clinicians treating patients in a hospital setting. In addition, while both case studies showed a significant increase in aerobic capacity, neither compared these observed values to those outcomes currently described in the literature resulting from medical therapy.[5] The six-minute walk test (6MWT) however, is easy to perform, requires little equipment, and has guidelines for the administration of the test that have been standardized.[9]

The 6MWT is considered a valid and reliable outcome measure and functional assessment tool for patients with HF when more than one trial has occurred.[10,11] The 6MWT has also been considered a valid assessment tool for exercise examination and produces readily usable results.[11-16] Separate research by Enright et al[17] in 1998 and Gibbons et al[18] in 2000 validated two different reference equations for predicted distance walked during a standardized 6MWT for healthy individuals with r^2 values of 0.40 and 0.41 respectively. At least two studies have suggested that results less than 300 meters during a 6MWT are associated with increased morbidity and mortality in patients with HF.[15,19] In addition, research by Cahalin et al[19] in 1996 used the results of a 6MWT compared with actual values achieved with a metabolic cart in developing an equation to estimate peak oxygen consumption (peak VO_2) for patients with HF (0.03 x distance in meters+3.98) with an r^2 value of 0.42. While the 6MWT can be used to estimate and prognosticate patient performance, a clinician can directly use the results of the 6MWT to develop an exercise program.

In those with advanced HF, the 6MWT may approach a maximal effort.[11,13,19] According to the American College of Sports Medicine, "the optimal exercise prescription for an individual is determined from an objective evaluation of that individual's response to exercise."[20] Therefore, examining and recording the cardiorespiratory response during the 6MWT can provide data used in the development of an optimal exercise prescription. Furthermore, the data acquired from a 6MWT can help the clinician describe the contributions of cardiac, pulmonary, and peripheral muscle impairments to the observed functional limitation of walking distance. Using these data, clinicians can interpret the 6MWT to identify specific interventions and adjuncts to therapy to facilitate functional training.

The 6MWT can be used to develop an interval exercise prescription based on the periodicity of exercise and rest durations during a single exercise session. Interval training techniques have been employed in patients with HF and have resulted in significant improvements in exercise tolerance and cardiorespiratory function.[7,21,22] Interval training has also been shown to be effective in training individuals with HF for aerobic improvements when long-duration activity is not tolerated.[23]

The primary purpose of this paper is to illustrate the use of the 6MWT in the evaluation of functional capacity and prescription of interval exercise in a patient with ADHF receiving tailored therapy with dobutamine. A secondary purpose is to discuss potential relationships resulting in observed improvements. This case study qualified for an exempt status by the Brigham & Women's Hospital's Institutional Review Board and the rights of the subject were protected. Exemption was granted as the physical therapy examination and exercise prescription was considered standard of care; patient consent was not required.

CASE DESCRIPTION

The patient was a 67-year-old Caucasian male from the northeastern United States, with known ischemic cardiomyopathy and a past medical history significant for diabetes, chronic kidney disease, pulmonary health conditions, and 6 admissions for ADHF within the past 12 months. He was retired from work in the public sector and lived with his wife in a single-level house with 2 entry stairs. He had a history of substantial alcohol use consisting of 6 glasses of scotch every day, but had not had an alcoholic drink in the past 6 months. He also had a significant history of tobacco use, 90-120 pack-years, but had quit 13 years ago. The patient was independent with functional activity and was actively participating in an outpatient pulmonary rehabilitation program. He required 2 liters per minute (L/min) supplemental oxygen at all times and 4 L/min during exercise and at night. His short-term goals were to decrease his dyspnea on exertion (DOE) and to be discharged from the hospital. His long-term goals were to resume his pulmonary rehabilitation program and travel to a warmer climate for the winter months.

On admission, the patient reported 10 days of progressive DOE and weight gain; admission weight was 110.9 kilograms (kg). Physical examination by the attending cardiologist revealed 3+ peripheral pitting edema, S3 gallop, and external jugular venous distension of 9 centimeters. With this patient's known cardiomyopathy and serum troponin less than 0.04 ng/ml, the medical diagnosis was determined to be ADHF and the patient was administered an intravenous diuretic in addition to his regular home medications that had been continued on admission. On hospital day 2, an additional oral diuretic was added to increase the rate of diuresis. The positive inotropic medication dobutamine was added when combined diuretic therapy failed to produce sufficient diuresis. On hospital day 4, physical therapy was consulted for evaluation and prescription of an exercise program.

Examination

Examination by the physical therapist revealed the patient to be 175 cm tall, have an estimated dry weight of approximately 104.5 kg, and an estimated body mass index (BMI) of 34 kg/m^2 indicating that he was obese. Increased extracellular water weight makes the estimated dry weight a useful method to determine BMI in patients with HF. The integumentary system was significant for 3+ pitting edema in bilateral lower extremities to the level of the patient's knees. A central venous catheter was inserted via the right brachial vein. Cardiac auscultation demonstrated an irregular rhythm and a positive S3 gallop. Electrocardiography (EKG) revealed atrial fibrillation. Pulmonary auscultation revealed diminished breath sounds with diffuse crackles throughout the posterior lung fields. His cough was moderate to strong in effort, wet sounding, and nonproductive. The patient's only learning barrier was difficulty hearing, which did not significantly impair his ability to follow verbal instructions. The review of the patient's other systems was not significant. During functional examination, the patient demonstrated need for standby assistance for his lines and portable oxygen tank; he was otherwise able to perform independent bed mobility, transfers, and demonstrated a normal gait pattern while ambulating in his room while using his IV pole. After a rest period of approximately 10 minutes, the patient's exercise capacity was examined using the 6MWT.

With the patient's cardiac history and medications, both rate of perceived exertion (RPE), using a modified Borg scale of 0-10, and his EKG were monitored during the test for safety. During the initial 6MWT, the patient ambulated 144 meters with 2 standing rests of less than 30 seconds each, while using a rolling walker. Based on the 6MWT prediction equation for males by Enright et al[17] (7.57 x height in cm - 5.02 x age in years - 1.76 x weight in kilograms -309) the patient's distance was 29.6% of his predicted distance. Based on the regression equation by Cahalin et al[19] (0.03 x distance in meters+3.98), the patient's estimated peak oxygen consumption (peak VO_2) was 8.3 ml/kg/min. A hospital summary and further patient details can be found in Table 1.

Clinical Impression

The patient did not meet any of the 6 criteria, described in the guidelines[9] to immediately stop the 6MWT. The patient's cardiorespiratory response and subjective rate of perceived exertion (RPE) during the 6MWT, found in Tables 2 and 3, confirmed a mixed cardiac and pulmonary system involvement. The blunted heart rate (HR) response and decrease in systolic blood pressure (SBP) indicated an inadequate cardiac response to activity, while the decrease in oxygen saturation (SpO_2) and respiratory rate (RR) identified the contribution of pulmonary impairments. While the changes in cardiac function demonstrated poor cardiac function, there was not a concomitant decrease in HR or change in EKG to indicate an acute decompensation of cardiac function and the 6MWT was completed. The patient's oxygen was not increased during the test due to the flow limitations of his nasal cannula and the fact that the patient did not report intolerable dyspnea. In addition, the patient had previously reported that he frequently desaturated into the low 80 percents with exercise during his pulmonary rehabilitation due to his underlying pulmonary disease. The patient's subjective report of 8/10 RPE was corroborated with the objective data that indicated a poor tolerance to activity. These results were consistent with the patient's reported inability to sustain

Table 1. Patient Admission Information and Daily Hospital Course

Past Medical History: Ischemic cardiomyopathy, diabetes mellitus type two, chronic kidney disease, amiodarone pulmonary toxicity, asbestos exposure with pleural plaques, stable left upper lobe pulmonary lesion, and gout.

Baseline pulmonary function tests prior to hospitalization (*Pre-bronchodilator*)
FEV1=1.13L(34%), FVC=1.50L(35%), FEV1/FVC=75%(96%), TLC =2.21L(34%), Lung Carbon Monoxide Diffusion Capacity (DLCO) Test [hemoglobin] = 8.72(33%) mL/min/mm Hg

Home/Admission Medications
Torsemide 100 mg twice daily, Acetylsalicyclic acid 81 mg daily, Warfarin 2.5 mg daily, Metoprolol 25 mg daily, Isosorbide mononitrate 120 mg daily, Atorvastatin 40 mg nightly, Lanoxin 0.125 mg every other day, Insulin 70/30 twice daily, Fluticasone propionate and Salmeterol inhaler 250/50 one puff twice daily, Tiopropium Bromide inhaled 18 mcg daily, Ipratropium inhaler prn
Medications added on admission: Furosemide 20mg/hr intravenously

Hospital Day 2: Metolazone, 5mg po BID, was added to the above medications in an attempt to increase diuresis, but was unsuccessful. Dobutamine (2 mcg/kg/min) was administered intravenously.

Hospital Day 4: A peripherally inserted central catheter (PICC) was inserted for multiple drug administration. Physical therapy was consulted for functional and exercise training consisting of: Systems review, Six-minute walk test, development and implementation of an exercise and functional training prescription.

Hospital Day 5-11: Functional/Exercise Prescription: Walking program of two, 2-minute walks interspersed with 2-minute seated rests, twice daily. Dobutamine dosage: 2 mcg/kg/min intravenous. Furosemide dosage: 20mg/hour intravenous

Hospital Day 8: Right Heart Catheterization: Cardiac Output=6.52 L/min, Cardiac Index=3.02 L/min/m^2, Pulmonary Artery Pressure=60/19 mm Hg (mean=36 mm Hg), Mean Pulmonary Capillary Wedge Pressure = 19 mm Hg

Hospital Day 11: The walking program was progressed to three, 2-minute walking intervals interspersed with 2-minute seated rests, twice daily.

Hospital Day 15: Final 6MWT off of dobutamine.

Hospital Day 16: The patient was discharged home.

efforts of physical activity in a community setting and impacted the patient's participation in his family role in travel as well as his community role of participation in a structured pulmonary rehabilitation program.

Intervention

A progressive, semi-independent interval-walking program was prescribed based on the 6MWT results. Interval duration was based on vital sign and subjective measures, which indicated pulmonary decompensation between minutes 2-4. The 2-minute recovery interval was based on post-test SpO_2, which returned to baseline after 2 minutes of seated rest. Therefore, the patient's exercise program consisted of two, 2-minute walking intervals interspersed with a 2-minute seated rest, twice daily (BID), for a total of 8 minutes of exercise training daily. The patient performed his exercise program in the hallway of the cardiac unit. Physical therapy continued to follow the patient from hospital day 5 to hospital day 10 to evaluate his performance during his exercise prescription. During these 6 days, the patient was seen for an additional 2 separate treatment sessions during which the patient was monitored during his exercise session and evaluated for progress. Adherence to the walking performed outside PT sessions was measured via patient report and direct observation.

The infusion of dobutamine continued, unchanged, until hospital day 15 at which time it was discontinued. Diuretic dosing was tailored to maintain negative fluid balance. The prescribed walking program continued until hospital day 11 when a physical therapy re-evaluation revealed a substantial decrease in patient effort after his second interval of walking with the patient's RPE reported to be 2-3/10. In addition, initial peak exercise vital signs both indicated an improved hemodynamic response (HR 90 to 110, BP 110/64 to 114/50). Thus, an additional 2-minute walking interval and 2-minute rest interval was added to his prescription for a total of 12 minutes of exercise duration daily. Exercise continued twice daily until hospital day 15, when the patient underwent a final 6MWT off of dobutamine (vital signs shown in Tables 2 & 3). During the second 6MWT the patient walked approximately 208 meters without a rest.

The results of the second 6MWT, including vital signs (Table 2), revealed that the patient had increased the percent of his predicted distance from 29.6% to 44%, increased his estimated peak VO_2 from 8.3 ml/kg/min to 10.2 ml/kg/min, and increased his total distance ambulated by 64 meters. The increase in distance of 64 meters represented a clinically significant change.[24,25] The patient was discharged home on hospital day 16 at a weight of 97.7 kg.

Clinical Impression

Medically, the patient's weight decreased by 6.8 kg from the date of the initial evaluation by physical therapy and by 13.2 kg from the hospital admission date. Subjectively, the patient reported a significant improvement in symptoms compared to the time of admission. Functionally, the patient remained independent with all activity, including stair climbing, but continued to use the rolling walker for breathing support. His discharge recommendations included the use of a 4-wheeled rolling walker for energy conservation and facilitation of accessory muscle use. Despite physical therapy recommendations, the patient declined use of the walker on the grounds that it made him feel "disabled" and "old." He was instructed to continue his current walking program as tolerated. He was to return to his outpatient pulmonary rehabilitation program once cleared by his primary care physician. Compared to his initial 6MWT, the patient's cardiovascular responses showed improvement despite being off inotropic support. He required 40% less supplemental oxygen and he reported a 50% reduction in RPE.

Table 2. Initial 6MWT (Top) and Final 6MWT (Bottom) vital sign data with Minute 8 representing a 2-minute seated recovery time. Heart Rate (HR), Systolic blood pressure (SBP) in mmHg, Diastolic blood pressure (DBP) in mmHg, Saturation of peripheral oxygen (SpO_2) in percent, O_2 flow in liters/minute, Respiratory Rate (RR) in breaths per minute, Rate of Perceived Exertion (RPE) on a 0-10 Modified Borg Scale.

Initial 6MWT	HR	SBP	DBP	SpO_2	O_2 Flow	RR	RPE
Initial	84	124	56	98	5	14	0
Minute 2	112			83	5	20	3
Minute 4	119			81	5	26	6
Minute 6	119	86	40	81	5	30	8
Minute 8	87	136	56	97	5	22	0
Final 6MWT	HR	SBP	DBP	SpO_2	O_2 Flow	RR	RPE
Initial	97	120	48	99	3	14	0
Minute 2	100			91	3	20	3
Minute 4	108			86	3	24	4
Minute 6	110	96	56	81	3	26	4
Minute 8	93	98	54	96	3	22	1

Table 3. Vital Sign Values and Percent Change from Initial and Final 6MWT: Taken at Minute 6

	Initial	Final	Percent Change
Heart Rate	119	110	8% Decrease
Systolic Blood Pressure	86	96	12% Increase
Diastolic Blood Pressure	40	56	40% Increase
Saturation of Peripheral Oxygen	81	81	0%
Supplemental Oxygen Flow (liters per minute)	5	3	40% Decrease
Respiratory Rate	30	26	13% Decrease
Rate of Percieved Exertion (Modified Borg: 0-10)	8	4	50% Decrease

DISCUSSION AND CONCLUSIONS

Physiologic and Functional Changes and Rationale

The key physiologic and functional changes observed in this case report include improvements in HR, and SBP response, a decreased supplemental oxygen requirement during exercise and the greater 6MWT distance ambulated. Although exercise training adaptations are typically associated with a longer training period (eg, 6-8 weeks), debilitated patients, such as those with advanced HF, appear to demonstrate training adaptations within a shorter time span. In fact, training periods of 3 to 4 weeks in persons with HF have been observed to produce typical exercise training adaptations such as increased skeletal muscle strength and endurance, peak VO_2, and quality of life.[22,26-29] The muscle hypothesis of chronic HF supports that the marked reductions in skeletal muscle strength and endurance of patients with HF contribute to the earlier and more profound training adaptations in patients with ADHF.[30-32] The resultant improvement in blood flow to exercising muscles from dobutamine is likely to improve skeletal muscle metabolic activity as well as facilitate the removal and supply of nutrients and waste products of metabolism. This improved blood flow may aid in the repair of skeletal muscle after exercise.

The most important adaptation after combined tailored medical therapy and exercise training, however, was the difference between the estimated and observed change in peak VO_2. The 64-meter (44%) increase in the 6MWT distance ambulated represents a 23% increase in estimated peak VO_2.[19] Previous reports of tailored medical therapy compared to baseline medical therapy predicted an increase in peak VO_2 of approximately 16% in patients with HF at 6 months.[5] Thus, the patient had an additional increase in estimated peak VO_2 of approximately 7% in 16 days. Such changes are important in the management of patients with severe HF.

Generalization of Findings

Findings of a case report cannot be generalized to all patients with ADHF. However, for clinicians treating this patient population, it is important to consider the clinical approach to examination and application of the 6MWT in establishing an exercise training prescription for patient management while hospitalized for tailored therapy for ADHF. Clinicians in other practice settings should consider our clinical approach with patients who may similarly benefit from the methods described to either implement or progress an exercise program during or following an acute hospital admission for ADHF.

Limitations

A single case presentation of a patient receiving both tailored medical therapy and exercise therapy makes it difficult to separate the effects of tailored medical therapy from exercise. Future investigation should attempt to determine the benefits associated with tailored medical therapy alone compared to tailored medical therapy combined with exercise therapy. It is possible that the additional improvement in estimated peak VO_2 observed might improve patient function, aid in discharge planning, and reduce readmissions for HF.[5,19]

SUMMARY

The 6MWT was used to effectively evaluate baseline and follow-up exercise testing, and to prescribe an exercise program for a patient with ADHF receiving tailored therapy with dobutamine. Consistent with the limited published literature, our case study shows that exercise can be safely provided to a patient with advanced HF on continuous dobutamine therapy and that functional improvements can be made in this patient population. This case study is the first to demonstrate the clinical utility of the 6MWT to prescribe exercise and examine patient outcomes in patients with ADHF on continuous dobutamine. Furthermore, it is the first case study to compare the results of functional testing after a combined exercise and tailored medical therapy program to those predicted to be from tailored medical therapy alone and postulate possible relationships. Further research is needed to determine the separate effects of tailored medical therapy and exercise on outcomes in patients with ADHF and NYHA Class IV HF and to identify the optimal exercise prescription for such patients in acute care and outpatient settings.

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