

## Multiple Benefits of Rehabilitation in a Patient with Heart and Renal Failure

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### Introduction

Heart failure is associated with high mortality and significantly reduced exercise capacity in many cases, despite medical treatment. Patients may present also renal failure, one of the most important comorbidities, which contributes even more to a poor prognosis, especially in patients who are already attending dialysis sessions<sup>1</sup>. Reduction of renal function occurs in approximately 25% of patients with chronic heart failure, regardless the severity of left ventricular dysfunction<sup>1</sup>.

Exercise training is formally recommended as a safe non-pharmacological intervention in stable heart failure<sup>2,3</sup>. Nevertheless, many patients in severe stage are extremely symptomatic and consider themselves as incapable to attend an exercise training program. The association of heart failure and renal failure in use of continuous ambulatory peritoneal dialysis makes this attendance even more complicated. The physicians also are insecure and resistant to recommend cardiopulmonary rehabilitation for a patient with such important impairment.

This case report aims at describing the clinical and physiological effects of an exercising program in a severe heart failure patient with renal failure in peritoneal dialysis.

### Case Report

Patient is a 54-year-old male, with heart failure secondary to idiopathic etiology, NYHA functional class III-IV for 8 years with implantable defibrillator and cardiac resynchronization in the last 2 years. The electrocardiogram before the defibrillator showed left bundle branch block. He also had suffered from chronic renal failure for the last 6 years, in continuous ambulatory peritoneal dialysis (CAPD) for the last 3 years undergoing 21 sessions/week. He was referred to our hospital for exercise training because his pharmacological therapy has already been optimized 2 years before: (Furosemide 40 mg/d, Spironolactone 25 mg/d, Angiotensin Receptor Blocker 80 mg/d and  $\beta$ -blockers Carvedilol 50 mg/d) and he persisted being extremely limited in his daily activities.

### Keywords

Heart Failure / rehabilitation; Exercise; Renal Insufficiency / rehabilitation; Exercise Therapy.

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Before and after rehabilitation, were assessed: left ventricular ejection fraction (LVEF, Simpson's method), maximal and submaximal cardiopulmonary exercise tests (CPET), quality of life (SF-36 questionnaire) and urea/creatinine levels in the blood. The maximal CPET, with incremental protocol on treadmill, was used not only to obtain the exercise capacity but also to define the threshold of exercise training during the rehabilitation. Still in the maximal CPET, it was evaluated the  $VE/VCO_2$  slope during incremental phase and the drop of the heart rate in the first minute of recovery phase, which was used to investigate the autonomic system<sup>4</sup>.

The submaximal CPET at 80% of maximal exercise capacity was applied to measure the endurance tolerance and the changes in different systems (cardiovascular, ventilatory and peripheral muscles) pre and post intervention. In order to evaluate the efficiency of oxidative metabolism in the peripheral muscles after exercise program, we used the time constant of oxygen consumption to achieve the steady state of 63% peak  $VO_2$  (kinetics analysis) in both endurance tests<sup>5</sup>.

Exercise rehabilitation sessions (45 min, 4 times/week for 8 weeks) were always supervised. Aerobic exercises (20-30 min) were performed in treadmill and cycle ergometer at anaerobic threshold achieved in maximal CPT ( $VO_2 = 4.7 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ , 42% of  $VO_{2\text{max}}$ ), and resistance exercises for upper and lower limbs at 40% of maximal voluntary contraction, 3 series of 10 repetitions with 1 min of rest for each series<sup>6,7</sup>. As this patient has a severe heart failure, the maximal voluntary contraction was estimated using 12 to 15 voluntary repetitions reaching moderate degree of fatigue (11 to 13 on the original Borg perceived exertion scale), which represents approximately 30 to 40% of one repetition maximum (1-RM) for the upper limbs and 40 to 50% to the lower limbs being performed<sup>6</sup>.

The patient was monitored by a multichannel telemetry system during all exercises to verify possible arrhythmias.

### Discussion

After 2 months of rehabilitation (Table 1), the patient showed an important improvement in maximal exercise performance (distance and peak  $VO_2$ ), ventilatory efficiency ( $V_E/VCO_2$  slope), increase of the systolic blood pressure delta, and higher LVEF. The renal function also improved substantially, decreasing the dialysis sessions from 21 to 4 per week. The patient became less symptomatic (NYHA II), the quality of life was substantially benefited in all domains of SF-36 and he returned to his job (office work).

The enhancement on exercise tolerance and symptoms is likely a consequence of the benefits over the body systems, taking into account mainly the cardiovascular, skeletal

**Table 1 – Exercise, metabolic and hemodynamic variables obtained during maximal incremental test before and after cardiopulmonary rehabilitation**

	Before	After
<b>Incremental test</b>		
Time (min)	5.9	9.9
Distance (m)	330	660
Peak VO <sub>2</sub> (ml/kg/min)	10.2	13.0
V <sub>E</sub> /VCO <sub>2</sub> Slope	51	46
RER at peak	1.37	1.28
VO <sub>2</sub> AT (ml.kg <sup>-1</sup> .min <sup>-1</sup> )	4.7	6.7
Peak O <sub>2</sub> Pulse (ml.kg <sup>-1</sup> .min <sup>-1</sup> /bpm)	6.6	7.0
Peak Heart Rate (bpm)	94	123
Heart Rate Recovery 1 <sup>st</sup> min (bpm)	6	13
Delta Systolic BP (mmHg)	9	35
<b>Clinical and functional responses</b>		
NYHA functional class	III	II
LVEF (%)	27	33
Urea (mg/dl)	188	75
Creatinine (mg/dl)	3.88	1.7
Dialysis per week	21	4
Physical Component (SF-36)	40	78
Mental Component (SF-36)	50	85

VO<sub>2</sub>: oxygen consumption; AT: anaerobic threshold; NYHA: New York Heart Association; LVEF: left ventricle ejection fraction. RER: respiratory exchange ratio; O<sub>2</sub>: pulse oxygen pulse

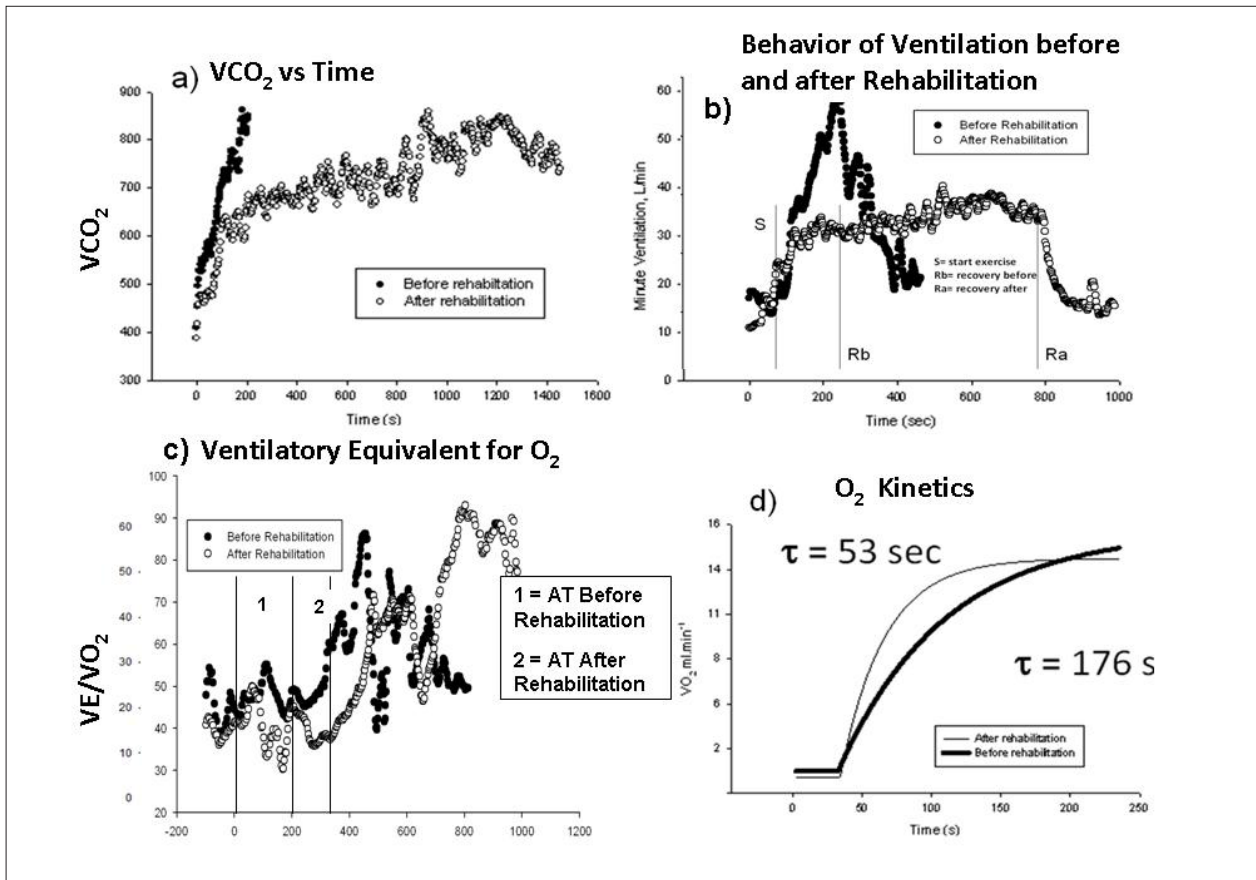
muscle, ventilatory and renal. In this case, exercise training resulted in an augment on cardiac performance reflected even at rest by the higher LVEF. The reduction of minute ventilation (Figure 1b, lower VE/VCO<sub>2</sub> slope), an index of greater ventilatory efficiency, is also a benefit of greater cardiac output since the anaerobic threshold was achieved later post rehabilitation, attenuating the ventilatory response.

Other afferent stimulus to the respiratory center is the CO<sub>2</sub> produced in the skeletal muscles. Considering the endurance tests, after intervention, the patient was able to tolerate much more exercise with a significant lower CO<sub>2</sub> production from the peripheral muscles (Figure 1a). This phenomenon reflects a better metabolic efficiency after training. It is already known the aerobic rehabilitation has relevant implications on muscle metabolism, mainly due to higher capillarization (higher oxygen output), increase of mitochondrial density and higher proportion of oxidative fibers<sup>3,7</sup>. The analysis of oxygen kinetics shows the behavior of muscle oxidative metabolism to exercise, with severe patients presenting a delay in this variable. The current case demonstrates an improvement on O<sub>2</sub> kinetics, with a shorter time to achieve the steady state after rehabilitation (Figure 1d). Thus, in this case there was a clear gain in the peripheral muscles, considering that their energetic metabolism became more efficient after rehabilitation.

Not only was the lower ventilation relevant for this patient, but also the pattern of breathing (Figure 1b and 1c). Before the rehabilitation, in the incremental cardiopulmonary test there was a marked pattern of periodic ventilation during the phase of increment and also in the recovery. After the program, the periodic ventilation was not abolished but decreased significantly in the increment and recovery phases of cardiopulmonary test. Although the mechanisms of periodic breathing have not been fully elucidated yet, it is present exactly in patients with severe heart failure and, of note, has prognostic implications<sup>2,3</sup>. The improvement found in this patient was certainly related to the improved cardiac function post rehabilitation.

Finally, there was a benefit also in the renal failuresince the frequency of dialysis sessions decreased from 21 to 4/week. This represents an interesting effect of cardiopulmonary rehabilitation and is probably related to better balance in the autonomic system, likely more related to renin-angiotensin system. Previous studies have described a lower activity of sympathetic drive after exercise program, which is in agreement with the faster recovery of heart rate after incremental test, suggesting lower sympathetic activation post rehabilitation in this patient<sup>8</sup>. In addition, the reduction in the renin-angiotensin-aldosterone system is also a result of exercise program, leading to a higher blood flow into renal arteries and, in this way, a better filtration<sup>9,10</sup>.

## Case Report



**Figure 1** – Constant load tests (80% of the maximum incremental test) before and after cardiopulmonary rehabilitation.  $VCO_2$ :  $CO_2$  production, VE: minute ventilation,  $VO_2$ : oxygen consumption,  $VE/VO_2$ : ventilatory equivalent for  $O_2$ ,  $\tau$  = oxygen kinetics, AT = anaerobic threshold.

In short, this case demonstrates that even in patients with significant limitation of functional capacity, the possibility of multi-disciplinary intervention programmes such as the RCPM described should be considered.

### Author contributions

Conception and design of the research: Hossri CAC, Queiroga Júnior FP, Carvalho VO, Carvalho CRR, Albuquerque ALP; Acquisition of data: Hossri CAC; Analysis and interpretation of the data: Hossri CAC, Queiroga Júnior FP, Carvalho CRR, Albuquerque ALP; Statistical analysis: Hossri CAC, Queiroga Júnior FP, Carvalho VO, Albuquerque ALP; Writing of the manuscript: Hossri CAC, Carvalho VO, Albuquerque ALP; Critical revision of the manuscript for

intellectual content: Hossri CAC, Queiroga Júnior FP, Carvalho VO, Carvalho CRR, Albuquerque ALP.

### Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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### Study Association

This study is not associated with any thesis or dissertation work.

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