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Perioperative variables of ventilatory function and physical capacity in heart transplant patients

Variáveis perioperatórias de função ventilatória e capacidade física em indivíduos submetidos a transplante cardíaco

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Abstract

Introduction: **Heart transplantation is currently the only widely accepted surgical alternative to treat patients with severe heart failure (HF) drug therapy cannot maintain optimal quality of life appropriate.**

Objective: **To describe and to compare the values between pre-and postoperative physical capacity and pulmonary patients who underwent heart transplantation.**

Methods: **A retrospective cohort composed of patients undergoing heart transplantation between January 2001 to March 2005 in IC-FUC/RS.**

Results: **Were included in the 21 individuals. We observed decreased levels of volume and lung capacity (FEV1 and FVC) in the first days after surgery compared to preoperatively (*P* <0.001) and recovery of these values in the 14th postoperative day (*P* <0.001). The values of muscle strength showed similar trends in reducing post-operative period compared to preoperative (*P* <0.001) and recovered on the 14th postoperative day (*P* <0.001). A useful functional capacity, measured by testing 6-minute walk test (T6') showed improvement in the 14th postoperative day in relation to pre-operatively (*P* <0.001).**

Conclusion: **Changes in ventilatory function of subjects undergoing cardiac transplantation are predictable, but these recover respiratory muscle strength and lung capacity within two weeks, and improve functional capacity useful in relation to pre-operative, the transplantation, when indicated, associated with good functional rehabilitation is very god treatment strategy.**

Descriptors: **Heart transplantation. Respiratory function tests. Forced expiratory flow rates. Exercise therapy.**

Resumo

Introdução: **O transplante cardíaco é atualmente a única alternativa cirúrgica amplamente aceita para tratar pacientes com insuficiência cardíaca (IC) grave que a terapia medicamentosa otimizada não consiga manter qualidade de vida adequada.**

Objetivo: **Descrever e comparar os valores entre pré e pós-operatório, das capacidades física e pulmonar de pacientes que realizaram transplante cardíaco.**

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Métodos: **Estudo de coorte retrospectivo composto por indivíduos submetidos ao transplante cardíaco, entre janeiro de 2001 a março de 2005, no IC-FUC/RS.**

Resultados: **Foram incluídos na análise 21 indivíduos. Observou-se redução dos valores de volumes e capacidades pulmonares (VEF1 e CVF) no 1º dia de pós-operatório em relação ao pré-operatório (*P*<0,001) e recuperação destes valores no 14º dia de pós-operatório (*P*<0,001). Os valores de força muscular inspiratória demonstraram tendências semelhantes, reduzindo no 1º dia de pós-operatório em relação ao pré-operatório (*P*< 0,001) e recuperando no 14º pós-operatório (*P*< 0,001). A capacidade funcional útil, mensurada por meio do teste de caminhada de 6 minutos (T6') mostrou melhora no 14º pós-operatório em relação ao pré-operatório (*P*< 0,001).**

Conclusão: **Alterações na função ventilatória de indivíduos submetidos a transplante cardíaco são previsíveis, porém estes recuperam a força de músculos ventilatórios e capacidades pulmonares dentro de duas semanas, além de melhorar a capacidade funcional útil em relação ao pré-operatório, sendo o transplante, quando indicado, associado à reabilitação funcional boa estratégia terapêutica.**

Descritores: **Transplante de coração. Testes de função respiratória. Fluxo expiratório forçado. Terapia por exercício.**

INTRODUCTION

Despite therapeutic advances in the previous two decades, heart failure (HF) is a disease with severe prognosis. Heart transplantation is now a widely accepted surgical alternative to treat patients with severe HF [1-3] when the medicinal therapy is unable to maintain adequate quality of life [4].

The indications of transplantation in our country are expressed in the Guidelines of the Brazilian Society of Cardiology for Heart Transplantation [5] and take into account both the patient's clinical condition, socioeconomic and psychological characteristics, availability of organs donor and operational aspects, which restrict the availability of these treatment methods, because the postoperative care of cardiac transplantation are complex and require the patient's understanding and collaboration [6]. The selection for transplantation is a dynamic process that must be reperformed every 3-6 months, and patients can be removed or included in the waiting line depending on the clinical condition [5].

Pulmonary complications in the postoperative period of cardiac surgery are a significant source of morbidity and mortality [4.7 to 16]. The lungs are particularly vulnerable and represent a potential site of infection in patients undergoing cardiac transplantation [4,15]. This vulnerability is mainly due to immunosuppressive therapy, surgical procedure and the quality of life of patients and can be avoided through preventive measures for infection control [4,15].

Postoperative strategies must also be used to reduce pulmonary complications after cardiac surgery, among them we can mention deep ventilation exercises, incentive spirometry [9], continuous positive airway pressure in the bed, coughing and control techniques of pain [7,12], in addition to the practice of aerobic exercises. [17].

Despite all the risks that patients with transplanted organ has to infection and rejection, this technique has shown great efficacy in survival, presenting results of survival rate of 90% in the first year and 87% in the fifth year post-transplant with good quality of life [18].

This study aims to describe the values of physical and pulmonary abilities of patients who underwent heart transplant and who underwent conventional physiotherapy. Moreover, it aims to evaluate and compare the physical capacity of patients preoperatively and on day 14th postoperative heart transplant and to evaluate and compare the forced vital capacity, forced expiratory volume in one second, maximum inspiratory muscle strength and the maximal expiratory muscle strength in pre-, 1st, 7th and 14th postoperative day of heart transplant.

METHODS

The research is a retrospective cohort study, performed by review of the medical records and files, composed of patients undergoing orthotopic cardiac transplantation in the period from 1st January 2001 to March 31th, 2005, at the Institute of Cardiology - Cardiology University Foundation of Rio Grande do Sul. The project was approved by the Research Ethics Committee of IC/FUC. It was signed a term of review of files to assess data, and all participants signed a written informed consent prior to study entry.

The assessment was performed with data from patient identification, history, underlying disease, values of maximum ventilatory pressures (maximal inspiratory pressure and maximal expiratory pressure), lung volume and

capacity (forced expiratory volume in 1 second and forced vital capacity), collected preoperatively, 1st, 7th and 14th postoperative day, and six-minutes walk test, collected preoperatively and on 14th postoperative day.

Sample

In the period aforementioned a total of 36 heart transplants were performed in the institution, of these, 21 subjects were included in the study, men and women of different ages and skin color, underwent heart transplantation, and remained on mechanical ventilation for a maximum of 24 hours, being weaned by conventional methods and aged above 18 years (Figure 1).

Were used as a criterion for exclusion from the study all patients who presented with neurological sequelae postoperatively (ischemic or hemorrhagic stroke) patients who did not have ability to perform spirometry, manovacuometer and six-minute test [19], those who needed noninvasive ventilation in the postoperative or those who were reintubated until the fourteenth postoperative day and patients who underwent surgical reintervention for bleeding problems postoperatively.

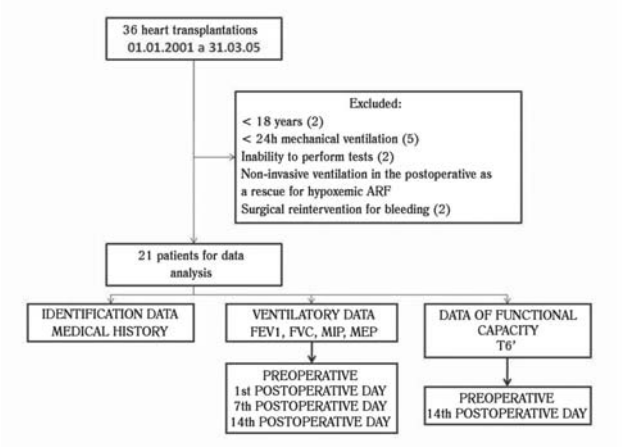

Fig 1 - Flowchart of inclusion and evaluation of the sample's patients NIV - Non-invasive ventilation; ARI - acute respiratory failure; FEV_1 - forced expiratory volume in 1 second, FVC - Forced vital capacity, MIP - maximum inspiratory pressure, MEP - maximum expiratory pressure; T6' - six-minute walk test

Data Collection

First, this study was approved by the Research Ethics Committee of IC/FUC (3158/02). Data were collected from medical records of patients who underwent cardiac transplantation at the Institute of Cardiology - University Cardiology Foundation, from 1/1/2001 to 3/31/2005. Each patient was assessed during his visit at the outpatient heart transplant clinic (and quarterly) or during the hospital stay, on the 1st postoperative day (until 24 hours after extubation), 7th and 14th postoperative day, as the evaluation form used by Physiotherapy Service of IC-FUC. These assessments, outpatient and inpatient, on the physical and lung capacity of these patients are routinely performed by the department of physiotherapy. All patients in this study underwent conventional techniques of chest physiotherapy (slow and abrupt manual chest compression, vibration, ventilatory patterns, active exercises of upper and lower limbs and deambulation) on the day of admission until discharge from hospital, with three to four sessions daily in the postoperative unit and two to three sessions per day in the inpatient unit.

Statistical analysis

Continuous variables were described by mean and standard deviation. Categorical variables were described using frequency tables with proportions.

It was also used analysis of variance for repeated measures in order to compare the changes in pulmonary function test between pre-, 1st, 7th and 14th postoperative days. The Tukey-Kramer test was used for multiple comparisons. In all comparisons it was considered an alpha level of 0.05.

RESULTS

The sample consisted of 21 patients. Of these, 20 (95.3%) were men. The average age was 46.84 ± 15.06 years, mean BMI was 25.81 ± 4.77 kg/m^2. The characteristics of the sample can be seen in Table 1. Of the 21 patients, one (4.7%) had diagnosis of diabetes mellitus, three (14.2%), arterial hypertension, one (4.7%), chronic pulmonary disease and nine (42.8%) had a history of smoking. No patients were current smokers (<60 days) in the sample. The mean CPB time was 191.85 minutes and mechanical ventilation, 13.47 hours. As for the underlying disease, eight (39%) patients had idiopathic dilated cardiomyopathy, seven (31%), ischemic heart disease, three (15%), valvular disease, two (10%), congenital heart disease and one (5%) cardiac tumor.

Changes in forced expiratory volume in one second (FEV1) on pre-, 1st, 7th and 14th postoperative days are shown in Figure 2. The preoperative FEV1 was 2.39 ± 0.84 l/sec, in the 1st postoperative day was 1.32 ± 0.42 l/sec (decrease of 44.8% compared to preoperative period). The values on the 7th postoperative day were 2.03 ± 0.77 l/sec (increase of 53.8% over the 1st postoperative day). On the 14th day after surgery, was of 2.35 ± 0.8 l/sec (increase of 78% over the 1st postoperative day).

Changes in forced vital capacity (FVC) on pre-, 1st, 7th and 14th postoperative days are shown in Figure 3. The mean preoperative FVC was 2.79 ± 0.83 l/min. On the 1st postoperative day, one can observe that the FVC in the group was 1.64 ± 0.51 l/min (decrease of 41.2% compared to preoperatively). On the 7th postoperative day, the FVC was 2.43 ± 0.79 l/min (increase of 48.1% compared to the 1st postoperative day). On the 14th postoperative day, the average FVC was 2.79 ± 0.8 l/min (increase of 70.1% compared to the 1st postoperative day).

Table 1. Sample characteristics

Characteristic	N=21
Age (years)*	46.84 ± 5.06
Male (%)	95.3
BMI (kg/m^2)	25.81 ± 4.77
Associated diseases (%)†	
Diabetes mellitus	4.7
Systemic Arterial Hypertension	14.2
COPD	4.7
Smoking history	42.8
Underlying diseases (%)†	
Idiopathic dilated cardiomyopathy	39
Ischemic heart disease	31
Valve disease	15
Congenital heart disease	10
Cardiad tumor	5
Mean time of CPB (minutes)	191.85
Mean time of MV (hours)	13.47

*Values described in * mean ± standard deviation and proportions †. BMI - body mass index, COPD - chronic obstructive pulmonary disease, CPB - cardiopulmonary bypass; MV - mechanical ventilation*

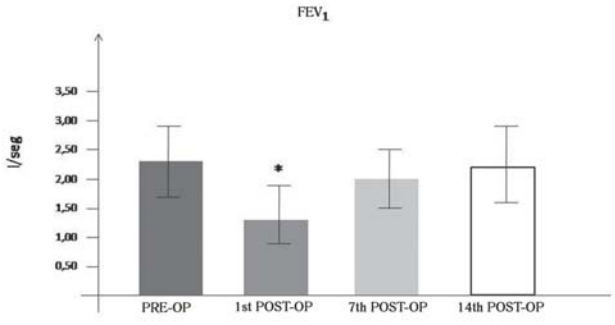

Fig. 2 - Comparison of forced expiratory volume in 1 second (FEV1) over 14 postoperative days.
*Data are expressed as mean and standard deviation. * P ≤ 0.001 when compared to other situations.*
l/sec - liters per second; PRE-OP - preoperative; 1st POST-OP - first day postoperative; 7th POST-OP - seventh postoperative day – 14th POST-OP - fourteenth postoperative day

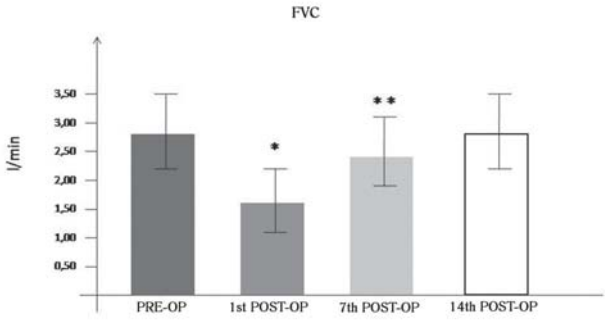

Fig. 3 - Comparison of Forced Vital Capacity (FVC) over 14 postoperative days
** P ≤ 0.001 when compared to other situations, ** P ≤0.001 when compared to preoperative and 14th postoperative day. Data are expressed as mean and standard deviation.*
l/min - liters per minute; PRE-OP - preoperative; 1st POST-OP - first postoperative day; 7th POST-OP - seventh postoperative day, 14th POST-OP - fourteenth postoperative day

The mean value for maximum inspiratory pressure (MIP) preoperatively was -88.85 ± 29.28 cmH_2O, whereas on the 1st postoperative day the mean value of MIP was -45.95 ± 15.38 cmH_2O (decrease of 48.3% compared to preoperatively). The mean value of MIP on the 7th postoperative day was -66.15 ± 30.79 cmH_2O (increase of 43.9% compared to the 1st postoperative day). The average value of MIP on the 14th postoperative day was -80.5 ± 26.42 cmH_2O (increase of 75.1% compared to the 1st postoperative day) - Figure 4.

The mean maximum expiratory pressure (MEP) preoperatively was 122.7 ± 42.02 cmH_2O. The mean value of MEP in the first postoperative day was 65.95 ± 22.95 cmH_2O (decrease of 46.3% compared to preoperative period). The mean MEP on the 7th postoperative day was 89.85 ± 28.12 cmH_2O (increase of 36.2% on the 1st postoperative day). The mean MEP on the 14th postoperative day was 107.4 ± 31.03 cmH_2O, (increase of 62.8% on the 1st postoperative day) - Figure 5.

A useful functional capacity measured using the 6-minute walk test (T6') can be found in Figure 6. The mean distance covered on the T6' on the preoperative period of the group was 341.72 ± 53.99 m, and on the 14th post-operative period was 380.15 ± 45.35 meters (increase of 11.2% compared to the preoperative period).

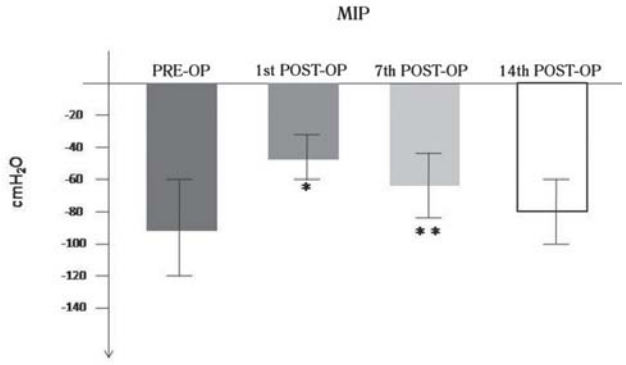

Fig. 4 - Comparison of Maximum Inspiratory Pressure (MIP) over 14 postoperative days
** P ≤ 0.001 when compared to other situations, ** P ≤ 0.001 when compared to preoperative and 14th postoperative day. Data are expressed as mean and standard deviation.*
cmH_2O - cm of water; PRE-OP - preoperative; 1st POST-OP - first postoperative day; 7th POST-OP - seventh postoperative day, 14th POST-OP - fourteenth postoperative day

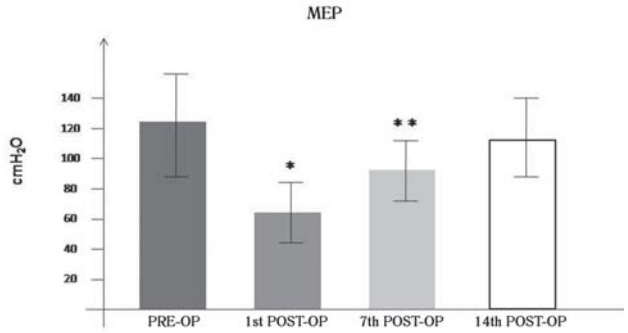

Fig. 5 - Comparison of maximal expiratory pressure (MEP) over 14 postoperative days
** P ≤ 0.001 when compared to other situations, ** P ≤ 0.001 when compared to preoperative and 14th postoperative day. Data are expressed as mean and standard deviation.*
cmH_2O - cm of water; PRE-OP - preoperative; 1st POST-OP - first postoperative day; 7th POST-OP - seventh postoperative day, 14th POST-OP - fourteenth postoperative day

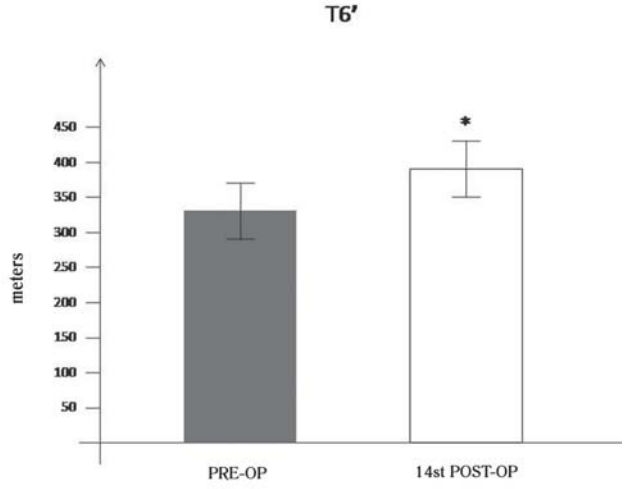

Fig. 6 - Comparison Test Walk 6 minutes (T6') in the pre- and 14th postoperative day
** P ≤ 0.001 when compared to preoperative.*
PRE-OP - preoperative; 14th POST-OP - fourteenth postoperative day

DISCUSSION

Changes in pulmonary function occur in all patients after hours of surgical procedure [20,21]. Decreases of 44.8% in FEV1 and 41.2% in FVC were observed from the preoperative period to the 1st postoperative day. According Meyers et al. [20], pulmonary volumes (FEV1, FVC) decreased postoperatively [22], with the maximum decrease in the 1st postoperative day, returning close to preoperative levels at 5 days postoperatively [20]. Morsch et al. [21] demonstrated in patients undergoing coronary artery bypass surgery, a statistically significant reduction in FEV1 and FVC when comparing the periods of pre- and sixth postoperative day, occurring the same with values of ventilatory muscle strength (MIP and MEP).

We had similar results when comparing these variables in the preoperative period with the 1st postoperative day, with decrease of 48.3% of MIP and 43.6% of MEP. Unlike the latter author, we observed an increase in pulmonary volumes in FEV1 (53.8% on 7th and 78% at 14th postoperative days), FVC (48.1% on 7th day and 70.1% on 14th postoperative day), MIP (43.9% on 7th and 75.1% on 14th postoperative days) and MEP (36.2% on 7th and 62.8% on 14th postoperative days) compared to 1st postoperative day. These increases in the values probably occur because of perceptual improvement in dyspnea due to improvement of cardiac pump function. Another factor of great importance is that these individuals were monitored routinely and the tests also are influenced by specific maneuvers to be performed and the will of the patient to collaborate in performing the movements and efforts really with the maximum [23].

Thus, it is believed that factors such as pain, abnormal ventilatory mechanics due to the sternotomy [22] and the deleterious effects of general anesthesia on pulmonary function, have contributed to these findings.

Another important factor to be emphasized is that patients with heart failure have limited physical activity due to fatigue and dyspnoea [24] and that this is due to deconditioning of respiratory muscles and increased ventilatory work during hyperpneia. In this group it was observed that, after replacing the failing heart, the individuals recovered values of inspiratory muscle strength and increased in 11.2% the useful functional capacity on 14th postoperative day, viewed through the 6MWT. This is probably due to the better cardiovascular function and better blood supply to skeletal muscles and better cardiac dynamics [25].

Postoperative patients of cardiac transplantation have improved quality of life. However, often present physical deconditioning, atrophy and muscle weakness and reduced aerobic capacity, resulting in part from inactivity and preoperative factors such as differences in body surface donor/recipient and denervation of the heart [26]. Regular physical activity has an important role post-transplant and should be started early for the restoration of physical capacity, enabling to patients to back to perform most of their daily activities and also recreation.

Possible mechanisms for this improvement are increased peripheral metabolism, primarily due to better extraction of oxygen and hemodynamic changes, including increased heart rate, cardiac output, endothelial function and reduction of neurohormonal activity. Moreover, the breathing efficiency is also improved during exercise [26]. These individuals showed that when implementing a basic program of mobilization and respiratory physiotherapy, they were able to recover the values of lung volumes and capacities and to improve useful functional capacity.

The improvement in physical function observed in patients undergoing cardiac transplantation is also attributed to the psychological status [27,28], because as a function of reduced functional capacity in general and "fear of dyspnea" these individuals enter into a cyclic process of inactivity and reclusion. Although in our study we have not performed any form of assessment of this psychological status, we observed significant improvement in ventilatory muscle function and functional capacity by means of the spirometric, manovacuometer measurements and walk test, which can also be attributed, besides the physical work performed, by improvement of motivation of these patients.

Another factor of great importance is that the six-minute walk test, when performed in patients with preoperative heart transplant, has proven to be a safe method and its performance may be associated with mortality in these patients evaluated [29]. In performing the walking test preoperatively we did not quantify normality in relation to age, gender and body mass index of the patient, but we observed significant increase in distance traveled in the postoperative of 11.2% compared to preoperative, which predicts the functional improvement that can be attributed to improvement in cardiac pump.

CONCLUSION

Alterações na função ventilatória de indivíduos submetidos a transplante cardíaco são previsíveis, porém estes recuperam a força de músculos ventilatórios e capacidades pulmonares dentro de duas semanas, além de melhorar a capacidade funcional útil em relação ao pré-operatório, sendo o transplante, quando indicado, associado à reabilitação funcional boa estratégia terapêutica.

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