EFFECTS OF THE USE OF EPAP (EXPIRATORY POSITIVE AIRWAY PRESSURE) ON EXERCISE TOLERANCE IN PATIENTS WITH HEART FAILURE

EXERCISE AND SPORTS MEDICINE CLINIC

ORIGINAL ARTICLE

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ABSTRACT

Introduction: New therapeutic approaches that aim to improve the sensation of dyspnea and fatigue in patients with heart failure, as the application of expiratory positive airway pressure (EPAP) should be tested in an attempt to improve functional capacity and quality of life. Objective: To evaluate the effects of the use of EPAP during exercise in patients with heart failure functional class II and III (NYHA). Methods: Of 390 patients, 28 were selected with LVEF <40%. The six-minute walk test (6'WT) was performed three times with and without the EPAP, reflecting the greater distance in the analysis. The comparison between the data obtained was performed by paired t test or Wilcoxon test as the normality of the data. Results: The use of EPAP increased volume without significant minutes, but the perceived exertion was higher after the walk with the use of the mask when compared in the absence of a mask. There was significant increase in oxygen saturation compared with the group that did not use the mask. There was no improvement in distance walked in 6'WT with the use of EPAP. Conclusion: Use of EPAP mask increases the perception of ventilatory effort and work, but its applicability in routine cardiac rehabilitation programs based on our preliminary data is questionable.

Keywords: heart failure, expiratory positive pressure airway, exercise.

INTRODUCTION

The diseases of the circulatory system composed the third highest cause for hospital submissions by the Unified Health System (SUS) in Brazil between the years of 2000 and 2007. Heart failure (HF) is the most frequent among these, being responsible for over 2.7 million of submissions and is equivalent to 29.35% of the total by cardiovascular diseases and 3.0% of the general total[1]. In the year of 2003, the heart and coronary insufficiencies appear as the most expensive diseases in men and women aged between 60 and 80 years[2].

Heart failure (HF) is a complex clinical syndrome result of any functional or structural heart disorder which harms ventricular performance. The clinical manifestations are dyspnea and fatigue, which may limit tolerance to exercise, cause fluid retention and lead to pulmonary congestion as well as strength and resistance of ventilator muscles decrease. Weakness of the ventilator musculature is directly associated with HF progression[3-5].

Studies have shown that the use of Expiratory Positive Airway Pressure (EPAP) promotes significant improvement of the gas exchange, reduction of dyspnea and of ventilatory work, providing increase of the training threshold through maintenance of the positive pressure in the airway in the expiratory phase[6-8]. To verify the EPAP use, the 6-minute walk test (6'WT) is well-tolerated by the patients for measurement of the functional capacity[8-11]. When EPAP is applied to patients with HF, it presents high reproducibility and good correlation with the variables measured in the test of cardiopulmonary exercise[12-14].

Thus, the aim of this study was to verify the effects of the expiratory positive airway pressure through the use of a mask promoter of EPAP during physical effort in individuals with HF functional class II and III (NYHA).

METHODS

EPAP mask

The EPAP kit used was by NewMed®, with adjustable PEEP valve from five to 20 cmH2O.

Six-minute walk test

The walk test was performed according to the guidelines from the American Thoracic Society[15]. The equipment needed for the test performance was: a timer (Sport Timer®), tape measure, pulse oximeter (OxyWatch®), heart rate monitor (Polar®), aneroid esphygmomanometer (Diasyst®) and stethoscope (Littmann®), scale with stadiometer (scale Welmy®).

The test was performed using a 30-meter flat and covered corridor, marked with two cones, without external interferences, at least two hour prior to the meals. The individual had no previous warm-up and was told to walk the longest distance possible, having received standard verbal encouragement repeated at every minute: (first minute) "You are doing fine"; (second minute) "Keep it up"; (third minute)

"You are doing fine, we are half way the test", (fourth minute) "Keep walking, only two minutes to go"; (fifth minute) "Is everything ok? The test is almost done". Three tests were performed where the first one had the aim of teaching and adapting. A 30-minute interval was observed between them. After the walk test for teaching, the two remaining ones (with and without the EPAP mask) had their performance sequence established by draw in order to minimize occasional bias[15].

Vital data as systemic blood pressure, heart rate, respiratory rate, dyspnea level (Borg's scale) and oxygen saturation were verified before, during and after the test. The test was ended when the patient completed the six minutes or if there was angina, intense dyspnea, dizziness, sudoresis, pale or cyanotic appearance[15].

Study population

From a total of 390 patients followed in the Immediate Care Unit of Myocardiopathies of the Institute of Cardiology of Santa Catarina (AM – ICSC), patients with systolic dysfunction and left ventricular ejection fraction (LVEF) below 40%, myocardiopathy of any etiology; sinusal cardiac rhythm, functional class II and III (NYHA), stable, with no history of hospital submission in the last three months through data analysis of the medical reports, complementary examinations and medication treatment currently established, and who signed the free and clarified consent form, were selected.

Patients with disturb of the cardiac rhythm, active smoking, non-controlled systemic blood hypertension, aassociated pulmonary diseases, neurological and/or orthopedic limitations which made the six-minute walk test performance impossible were excluded.

The research was approved by the Ethics and Research in Humans Committee, Institute of Cardiology of Santa Catarina, São José, SC, according to the resolution of the National Health Board 196/96.

Study type

This investigation was a clinical, prospective and controlled assay with random order of application of the tests.

Study protocol

The effects of the EPAP application during effort in individuals with HF functional class II and III (NYHA) were assessed.

The three tests with each patient were performed on the same day. Concerning the tests order, a draw defined the tests performance sequence with or without the mask. When the first participant started with the mask on, the following one started the test without the mask. All patients were followed and monitored during the performance of each test; after the performance, the patient would sit, the mask was removed (in case it was being used) and the data were collected. The interval between tests was of 30' for stabilization of the vital signs and possible ventilatory alterations.

The pressure used on the EPAP mask was of 8 cmH2O, and each patient performed five minutes of adaptation to the mask and to the pressoric level before the TC6'. The three tests with each patient were performed on the same day.

The Borg's scale used had score between zero and ten; the higher the value, the more intense was the patient's effort. Ventilometry was used through the Wright Respirometer Mark 8 Ferraris®, ventilometer for determination of the volume-minute[14,15].

The expected walked distance was obtained through the reference equations for distance prediction, according to Enright and Sherrill[16], and is as follows:

Men:

ED = (7.57 x height cm) - (5.02 x age) - (1.76 x weight kg) - 309 m.

Women:

ED = (2.11 x height cm) - (2.29x weight kg) - (5.78 x age) + 667 m.

ED = Expected distance in the 6'WT.

Statistical analysis

The data concerning the category variables were described by absolute and percentage frequency, while the continuous variables by measurements of central position (mean and median) and dispersion (standard deviation and interquartile range).The Wilcoxon test and two-way Analysis of Variance for repeated measures, with Bonferroni post hoc test were used for statistical analysis of the remaining data. The significance level adopted was of 5%.

RESULTS

A total of 28 patients were selected in the period between April and November, 2011. Mean age was of 50.57 ± 11.08 years, being 23 men (82.14%) and five women (17.86%). It was also verified that 19 patients (68.0%) presented FC II and nine (32.0%) FC III. The LVEF mean was of 27.14% (SD = ± 6.86%).

Based on the participants' weight and height (means of 81.04 ± 13.28 kg and 167.21 ± 7.45 cm, respectively), the expected walked distance whose mean was 576.07 (± 79.63) meters was measured. The low normality thershold was of 425.57 ± 80.06 meters.

Figure 1 presents the confidence intervals of the measurements of the distance walked with and without the use of the EPAP, whose means were respectively 431.07 ± 71.79 and 420.57 ± 79.28 meters.

Figure 1 verified there was no significant difference in the distance walked between patients who used or not the EPAP.

Table 1 demonstrates the comparison of the variables with and without the use of EPAP, at the pre-test, post-test and recovery conditions (after five minutes).

The factor group with and without EPAP mask played influence on the variables dyspnea and oxygen saturation, where the tiredness

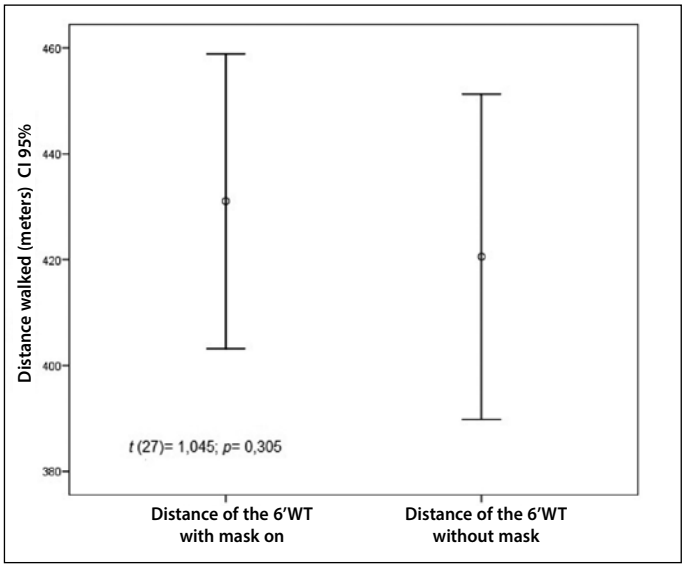

Figure 1. Comparison between the run distance and confidence intervals (CI) measurements.
*p < 0,001.

Table 1. Variance analysis of the group main effects (with and without the use of the mask) and the period (pre-test, post-test and recovery) and the interaction factor between groups and period of the vital signs variables dyspnea, peripheral saturation and ventilometry (n = 28).

Variables	With no mask			With mask on			Group	Period	Group* Period
	Pre	Post	Recovery	Pre	Post	Recovery			
Vital signs									
Systolic BP	123.57 (11.61)	126.07 (13.42)	124.29 (11.36)	121.79 (12.78)	127.14 (17.60)	123.93 (12.27)	0.764	0.010*	0.355
Diastolic BP	78.93 (7.37)	79.64 (7.44)	79.11 (7.20)	79.46 (6.98)	76.79 (15.17)	79.29 (7.66)	0.415	0.470	0.235
HR	70.71 (11.95)[a]	76.32 (17.67)[b]	71.07 (10.93)	70.46 (10.94)[a]	77.21 (15.64)[b]	72.54 (11.71)[c]	0.411	0.002*	0.543
Dyspnea									
Borg	0.57 (1.06)	2.61 (2.67)	0.68 (1.02)	0.71 (1.05)[a]	3.82 (3.11)[b]	0.79 (1.13)[a]	<0.001**	<0.001**	< 0.001**
Peripheral saturation									
SpO_2	96.75 (0.93)	96.61 (1.10)	96.50 (1.04)	96.54 (1.26)	97.25 (0.97)	96.86 (0.89)	0.028*	0.172	0.026*
Ventilometry									
Vol/Min	8.412.5 (3.146.38)	9.853.57 (2.883.39)[a]	7.794.64 (2.792.26)[b]	7.283.93 (2.688.14)[a]	11.194.64 (4.322.84)[b]	8.292.86 (2.949.72)[c]	0.514	<0.001**	0.006*

EPAP – expiratory positive airway pressure; BP – blood pressure; HR – heart rate; Borg – Borg's scale; SpO2 – oxygen peripheral saturation; Vol/Min – volume minute; Md – median; IQ – interquartile range; M – mean; SD – standard deviation; t – paired Student's t test; p – significance level.
(* $p \leq 0.05$; ** $p < 0.001$). $a \neq b$; $a \neq c$ e $b \neq c$.

sensation was higher at the situation without use of EPAP, while the highest oxygen saturation occurred during the use of the EPAP mask.

In the main factor period of evaluation (pre-test, post-test and recovery), the variables systolic blood pressure, heart rate, dyspnea and ventilometry presented statistically significant difference. In the experiment without mask, the post hoc test pointed out that the heart rate was higher in the post-test than in the pre-test. Concerning ventilometry, higher values were found in the post-test when compared with the recovery period.

In the experiment with the mask on, the variables heart rate and ventilometry were significantly higher in the post-test than in the pre-test. Moreover, lower values were found in the recovery period when compared with the post-test. Regarding dyspnea, the values of the Borg's scale were significantly higher in the post-test, with reduction in the recovery period.

The interaction between groups (with and without use of the mask) and the evaluation period (pre-test, post, test and recovery) were significant for the variables dyspnea, oxygen saturation and ventilometry. The association between these factors demonstrated that 35.4% of the alteration in the Borg's scale may be explained by the interaction between group and period. These associations were of 14.2% and 21.1% for the variables oxygen saturation and ventilometry, respectively.

DISCUSSION

Mean age and standard deviation of the study were of 50.57 ± 11.08 years, similar to the ones found in many studies which involved patients with HF in many functional classes: 36-68 years, FC II and III[17]; 53 ± 2 years, FC II and III[18]; 55 ± 11 years, FC IV[19]; 34-90 years, FC II and III[20]. The distribution per gender in our study was 23 men (82.14%) and five women (17.86%), similar to the important male predominance verified in many studies[16,20]. The left ventricular ejection fraction (LVEF), which is a measurement of the left cardiac function, main determinant of the heart performance and cardiovascular morbimortality[21] obtained mean of 27.14% ± 6.86; similar to the one found in many studies [22,23].

Concerning the 6'WT, the distances walked with and without the use of EPAP presented values below the expectation, demonstrating the low functional capacity of the evaluated patients. Although the EPAP application is a therapeutic alternative which provides effects such as variation in intra-alveolar pressure, increase of functional residual capacity (FRC), redistribution of the extravascular liquid and decrease of intrapulmonary shunt[24,25], its use in the 6'WT did not faithfully reflect the real physiological situation in hemodynamic and ventilator terms in this scenario.

The 6'WT has the aim to evaluate both the functional status of the cardiovascular and/or respiratory system and the effects of a therapeutic and rehabilitation program [25,26]. Such fact stresses the idea that the adopted strategy (6'WT) was not eficiente in improving the pulmonar congestion and ventilatory dynamics for being an evaluation method, compromising hence the EPAP use in patients with HF. However, the EPAP mask use associated with continuous training and supervised in programs of cardiovascular rehabilitation will be able to lead us to another long-term closing concerning pulmonary function [25].

A hypothesis to explain the lack of increment in the functional capacity with the use of the EPAP mask would be the good compensation status reached through the optimized clinical treatment, making it difficult to reach benefits with the tested strategy.

In the immediate post-test, it was verified that the oxygen arterial saturation ($SatO_2$) was significantly higher in the group which used the mask compared with the one which did not. Although the findings in the evaluated variables had reached statistical significance, the clinical implication of this technique is questionable, since all participants already presented stable basal variables. In a study with patients with COPD, the mean of basal saturation was lower in the pre-test (93.6 ± 5.1%) with significant improvement in the post-test with EPAP (95.4 ± 3.2%)[27]. Patients with COPD who were evaluated under the use of similar device, with imposition of expiratory resistive load (ERL), presented non-significant improvement in the oxygen saturation[27]. Van der Schans et al., when using EPAP in exertion, found out significantly lower oxygen consumption (VO_2) and carbonic gas production (VCO_2) with the use of the mask, with decrease in the Borg's scale after use of EPAP, though. In our study, the perceived exertion through the Borg's scale evidenced significantly higher values in the patients who performed walk with the use of the mask (Md = 4) when compared

with the patients who did not use the mask (Md = 2), justified by the expiration performed against pressoric resistance, making difficult the work and ventilator mechanics at the moment of the walk test.

These findings corroborate other studies with patients with COPD in 6'WT performance under use of PEP (positive expiratory pressure) during exercise[28]. Conversely, in a study which compared CRM post-surgery patients, COPD patients under use of EPAP, there was reduction of dyspnea perception and tiredness with the use of the mask[29]. The same fact was verified in a population with sleep obstructive apnea, with reduction of respiratory frequency after use of EPAP[9] and in patients with COPD, in which electromyographic activity of the accessory muscles was assessed with the use of EPAP[26].

Concerning the ventilometry data, the EPAP application may determine increase in ventilatory work which is proportional to the level of PEEP applied.

Regarding the increase of the hemodynamic variables (heart rate and systolic blood pressure) in the post-test verified in the patients with and without EPAP use, they demonstrate expected physiological increase due to the effort performed during the 6'WT.

CONCLUSION

Thus, our outcomes demonstrate that the use of the EPAP mask increases the respiratory exertion, verified through the Borg's scale and ventilometry, and promotes increase in the oxygen saturation; however, it did not increase the distance walked in the 6'WT, suggesting hence that the usual applicability of the EPAP mask in cardiovascular rehabilitation programs based on our data, generates the need for further investigation both concerning the modality of activity applied and the application of different EPAP pressoric levels.

All authors have declared there is not any potential conflict of interests concerning this article.

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