CLINICAL SCIENCE

EFFECTS OF CHEST PHYSIOTHERAPY ON THE RESPIRATORY FUNCTION OF POSTOPERATIVE GASTROPLASTY PATIENTS

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INTRODUCTION: Bariatric surgery has become increasingly more recommended for the treatment of morbidly obese individuals for whom it is possible to identify co-morbidities other than alterations in pulmonary function. The objective of this study was to evaluate the effects of conventional chest physiotherapy (CCP) and of conventional physiotherapy associated with transcutaneous electrical diaphragmatic stimulation (CCP+TEDS) on pulmonary function and respiratory muscle strength in patients who have undergone Roux-en-Y gastric bypass.
METHODS: In total, 44 female patients with an average age of 37 ± 7.3 years and an average body mass index (BMI) of 47.4 ± 6.5 K/m² were selected as candidates for Roux-en-Y gastric bypass laparoscopy. They were evaluated for pulmonary volume and flow using spirometry and maximum respiratory pressure through manovacuometry during the preoperative period and on the fifteenth and thirtieth postoperative days.
RESULTS: No differences were detected between CCP and CCP+TEDS, and both factors contributed to the maintenance of pulmonary flow and volume as well as inhalation muscle strength. Exhalation muscle strength was not maintained in the CCP group at fifteen or thirty days postoperative, but it was maintained in patients treated with conventional chest physiotherapy + transcutaneous electric diaphragmatic stimulation.
DISCUSSION: These results suggest that both conventional chest physiotherapy and conventional chest physiotherapy + transcutaneous electric diaphragmatic stimulation prevent the reduction of pulmonary function during the Roux-en-Y gastric bypass postoperative period, and that transcutaneous electric diaphragmatic stimulation also contributes to expiratory muscle strength.

KEYWORDS: Electric stimulation; Bariatric surgery; Spirometry; Respiratory muscle strength; Physiotherapy.

INTRODUCTION

Obesity is an alteration in physical composition with genetic and environmental determinants that is defined by a relative or absolute excess of physical amounts of fat. In chronic obesity, more calories are consumed than are expended in physical energy, resulting in several significant health problems[1] including high blood pressure, *diabetes mellitus*, osteoarthritis, dyslipidemia and sleep apnea**,** as well as other morbid manifestations.[2]

According to Ladosky, Botelho and Albuquerque,[3] Paisani *et al.*[4] and Hamouni, Anthone and Crookes,[5] reductions in the pulmonary volumes and capacities as well as in the total pulmonary capacity increase as the body mass index (BMI) and age increase. This reflects an increase in abdominal pressure and a decrease in chest wall compliance, which affects thorax expansion and leads to a restrictive deterioration in pulmonary function. In addition, altered diaphragmatic movement in obesity caused by the accumulation of visceral fat results in increased oxygen consumption in the aspiratory overcharge and decreased strength and respiratory muscle endurance, as evidenced by the decrease in maximum voluntary ventilation (MVV).

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This was also shown by Koenig,[6] who analyzed the MVV of obese and non-obese individuals.

Since obesity is a chronic condition of multifactorial etiology, its treatment involves many types of approach. Dietetic orientation, physical activity programs and the use of anti-obesity medicines are the main pillars of treatment. However, since conventional treatment for grade III obesity continues to produce unsatisfactory results in the clinical treatment of severely obese individuals, there is a need for more effective interventions such as bariatric surgery.[7] However, bariatric surgery can cause additional alterations in pulmonary function due to the use of anesthesia and the actual surgical procedure, which results in a reduction in the residual functional capacity (RFC), the precocious closure of small airways, a greater degree of hypoxemia and a greater tendency for the development of atelectasy.[8,9] Thus, obese patients, who normally present alterations in respiratory muscle strength and function, become even worse as a result of abdominal surgery; the two factors combined have consequences in respiratory muscle mechanics. This occurs due to intra-operative handling, anesthesia, the incision and pain,[10] and it is especially due to the reflected inhibition of the diaphragm, which leads to diaphragmatic paresy and restrictive pulmonary behavior.[11,12]

In this context, respiratory physiotherapy has an important role in both the pre- and postoperative periods of bariatric surgery; it is therefore recommended for prophylaxis and in the treatment of complications arising during the postoperative period. Similarly, it is also recommended for the maintenance and fast restructuring of pulmonary function and respiratory muscle strength.[13-22] However, not much is known about the effects of different respiratory physiotherapy techniques, which justifies comparative studies among them.

Some authors have studied the use of electrical stimulation to induce respiration. Sarnoff[14] applied electrical stimuli to a patient with respiratory failure caused by carbon asphyxiation. As this was successful, Sarnoff et al.[15] and Goldenthal[16] subsequently used electrical stimulation for victims of poliomyelitis. However, not enough information is available to support the application of this technique.

The application of electrical stimuli was also carried out in pulmonary function studies using healthy humans and animals, with the objective of determining responses with respect to the location of electrodes, types of equipment, types of current and stimulation parameters, as well as studying the influence of electrical stimulation on pulmonary function. Due to a lack of consensus between researchers and to technical difficulties in its application, many researchers have abandoned their studies on electrical stimulation.[17]

Nevertheless, diaphragmatic electrical stimulation can be safely and easily applied to normal individuals, where it has resulted in increased diaphragmatic muscle strength in all individuals analyzed.[18]

OBJECTIVE

The objective of this study was to evaluate the effects of conventional chest physiotherapy (CCP) and of conventional physiotherapy associated with transcutaneous electric diaphragmatic stimulation (CCP+TEDS) on pulmonary function and respiratory muscle strength in patients undergoing Roux-en-Y gastric bypass.

METHODS

In total, 44 patients operated on between February 2006 and April 2007 fulfilled the inclusion criteria; they were morbidly obese females who did not smoke, did not practice physical activities more than once a week, were free of acute or chronic pulmonary disease and had the capacity to perform the protocol evaluation tests properly.

All patients were informed about the objectives of the study and signed a formal, free and explanatory consent form. The experimental protocol was approved by the Ethics Committee for Research on Human Beings of the Institution under the protocol number 08/05. From then on, the patients were considered to be volunteers.

The 44 volunteers were randomly divided into 2 groups of 22. The randomization was carried out before making contact with the patients by drawing lots to determine which therapy (CCP or CCP+TEDS) would be carried out immediately after the operation. Those in the group that received conventional chest physiotherapy (CCP) were 37.6 ± 7.3 years old, 1.61 ± 0.06 meters tall and had an initial weight of 122.5 ± 18.26 Kg and a BMI of 47.43 ± 6.56 Kg/m^2. The volunteers in the group that received conventional chest physiotherapy associated with TEDS (CCP+TEDS) were 37.2 ± 9.0 years old, 1.60 ± 0.07 meters tall, had an initial weight of 121.3 ± 15.9 Kg and a BMI of 47.4 ± 5.8 Kg/m^2.

The volunteers who took part in the study were evaluated three times. To avoid any bias in the results, all measurements were taken by a researcher who was blinded as to which group a given volunteer belonged.

The first evaluation occurred during the preoperative period, the second was fifteen days after surgery and the third was thirty days after surgery. The first evaluation included the patient's clinical history with an emphasis on co-morbidities, life habits and family background, followed by an evaluation of pulmonary function by spyrometry and of respiratory muscle strength by measuring the maximum respiratory pressures. With the exception of the clinical history, the procedure was repeated for the other two evaluations.

An ultrasonic, computerized EasyOne™ spyrometer (Model 2001, ndd Medizintechnik AG, Zurich, Switzerland) with a flow sensor and upgraded internal Win Spiro Software (version 1.04) that was connected to a PC was used to evaluate the pulmonary volumes and flows.

Three types of maneuvers were executed: Slow Vital Capacity (SVC), Forced Vital Capacity (FVC) and Maximum Voluntary Ventilation (MVV). Each maneuver was executed three times, according to the directions of the American Thoracic Society – ATS[23] and the directives for the pulmonary function test.[24] The highest values obtained for the Forced Vital Capacity (FVC), Forced Exhaling Volume in the first second (FEV1), FEV1/FVC ratio, Peak of Exhaling Flow (PEF), Vital Capacity (VC) and Maximum Voluntary Ventilation (MVV) were computed. For these procedures, all volunteers remained sitting down while using a nasal clip and were properly orientated to perform the maneuvers.

Maximum inspiratory pressure (MIP) and maximal expiratory pressure (MEP) were measured using an analogical manovacuometer (FAMABRAS, São Paulo, Brazil), with operating intervals from 0-300 cmH_20. The manovacuometer was properly equipped with a hard plastic mouthpiece adaptation with a small 2 mm internal diameter hole that was used as a safety valve to prevent pressure from increasing in the mouth cavity and to ensure that the pressure was produced exclusively by the contraction of the facial musculature with the glottis closed. During the MEP measurements, volunteers were directed to inhale deeply at the TCL level and then carry out maximum expiration and maintain it. MIP was measured after the volunteer made a maximum expiration that was close to the residual volume (RV) and then inhaled their maximum volume through the mouthpiece. Both were maintained for at least two seconds.[25]

A nasal clip was used to avoid air leakage during measurement of MIP and MEP; the volunteers remained sitting down and placed the mouthpiece firmly between the lips, avoiding perioral leakage while the examiner held the manuvacuometer.

After a training period that was long enough to learn the technique, each volunteer executed three measurements of maximum inhalation and expiration that were considered technically satisfactory [i.e., without perioral leakage and sustained for at least two seconds with values close to each other (≤10%)], and the greatest absolute value obtained was computed.[25]

In the execution of TEDS, Phrenix Dualpex (Quark, Piracicaba, São Paulo, Brazil) equipment was used with the following parameters: pulse frequency of 30Hz, respiratory frequency of 14 rpm, ascent time (ramp) of 0.7 s, pulse width of 1.2 ms and an intensity sufficient to cause a tangible contraction of the diaphragm muscle.[26]

Two pairs of carbon electrodes were used: one pair located in the paraesternal region beside the xiphoid process and the other in the region corresponding to the motor points of the diaphragm muscle, between the sixth and seventh intercostal spaces in line with the right and left front armpits.[26] The electrodes were fixed with a micropore bandage onto skin previously cleaned with alcohol.

The placement of the electrodes was by hand-touch, with the volunteer in the dorsal recumbent position. After marking the position, the point of electrode placement was confirmed by visual observation of muscle contraction when the electric current was applied.

To execute the technique, the volunteers remained in the dorsal recumbent position with the bed head raised by 30º, the knees semi-inflected, the feet supported, the arms stretched alongside the body and the head on the pillow. The application time was 30 minutes in each session.

The CCP consisted of diaphragmatic respiratory exercises, deep inhalation exercises, inhalations fragmented two to three times and respiratory exercises associated with shoulder flexion movements and extension of the upper limbs. One series of 10 repetitions was carried out for each exercise. Walking sessions and preventive exercises for deep vein thrombosis were carried out.

The CCP and CCP+TEDS sessions were applied from the first to the third postoperative days in the morning and in the afternoon, for a total of five sessions. All volunteers stayed in the hospital for four days and received physiotherapy treatment until discharged.

Graph Pad StatMate, version 1.01i, was used for the sample calculation, taking the variable PImax into consideration since it is a reliable parameter for determining respiratory muscle strength. The level of confidence was 95%, and the power was also 95% for a total of 44 individuals.

GraphPad InStat for Windows, version 3.05, was used for the statistical analysis. Values were tested for normality using the Kolmogorov Smirnov test, but the normality hypothesis was rejected. Samples were therefore tested using non-parametric tests. The Friedman test was used to compare the intra-group repeated samples, and the Mann-Whitney test was used for inter-group comparisons. The significance level was 5%.

RESULTS

According to the spirometric results for the pulmonary flow measurements (FVC, FEV_1, FEV_1/FVC and the PEF), volunteers treated with CCP and those treated with CCP+TEDS showed normal results in the three evaluations as shown in Table 1.

There were no significant differences in spirometric variables for the measurements of SVC and MVV between those that received CCP and those that received CCP+TEDS (Table 2).

As shown in Table 3, there were no significant differences in MIP amongst the three evaluations for either group. However, there was a significant decrease in MEP from the preoperative period to the 30th postoperative day in the group that received only CCP. There was no change in MEP in the CCP+TEDS group.

DISCUSSION

There were no obstructions in the airways or thorax-pulmonary restrictions that could interfere with the results. Thus, the lack of evidence of spirometric differences between the groups gives more reliability to the inclusion criteria as well as to the homogeneity of the sample used.

Because there were no significant differences between groups and because of the various evaluations of both groups studied, both treatments probably contributed to the prevention of decreases in pulmonary function parameters that are normally quoted in the literature.[4,26] However, it is necessary to emphasize that these authors did not use either CCP or CCP+TEDS in their studies.

Rubinstein et al.[27] found limitations in respiratory flow to between 50% and 75% of the vital capacity in obese patients. Although these authors either did not exclude or declined to mention that they did exclude patients with co-morbidities and/or with respiratory dysfunctions, volunteers with pulmonary dysfunction were excluded from the present study to avoid interference in the results.

Some authors such as Luce[28] have shown decreases in expiratory reserve volume, functional residual capacity (FRC) and tidal volume (TV) that have resulted in altered ventilation and perfusion or even shunts, causing subsequent

Table 1 - Means, standard deviations and statistical results for the pulmonary flow measurements: forced vital capacity (FVC), forced exhaling volume in the first second (FEV_1), FEV_1/FVC and the peak of exhaling flow (PEF) for both the experimental and predicted values, for the group treated with conventional chest physiotherapy (CCP) and the group treated with CCP + transcutaneous electric diaphragmatic stimulation (TEDS), in three evaluations.

Variables	Intervention		Preoperative	15 days	30 days
FVC (L)	CCP	Experimental	3.1 ± 0,4	3.2 ± 0.4	3.2 ± 0.4
		% of predict	95.1 ± 9.2	97.1± 11.4	97.0 ± 11
	CCP+TEDS	Experimental	3.2 ± 0.5	3.1 ± 0.6	3.3 ± 0.5
		% of predict	98 ± 13	95.4 ± 14	100.5 ± 11
FEV_1 (L)	CCP	**Experimental**	2.6 ± 0.4	2.6 ± 0.3	2.6 ± 0.3
		% of predict	92.1 ± 10	94.1 ± 11	94.1 ±11
	CCP+TEDS	**Experimental**	2.7 ± 0.5	2.6 ± 0.5	2.7 ± 0.4
		% of predict	96.6 ± 14.0	93.5 ± 14	98 ± 12
FEV_1/FVC	CCP	**Experimental**	0.8 ± 0.1	0.8 ± 0.01	0.8 ± 0.00
		% of predict	97 ± 6.3	97.1 ± 6.0	96.3 ± 5.2
	CCP+TEDS	**Experimental**	0.8 ± 0.00	0.8 ± 0,00	0.8 ± 0.00
		% of predict	98.6 ± 4.7	97.9 ± 4.6	97.23 ± 4.6
PEF (L/s)	**CCP**	**Experimental**	6.4 ± 1.2	6.5 ± 0.8	6.6 ± 0.8
		% of predict	102.8 ± 18	105.7 ± 12	107.2±12.2
	CCP+TEDS	**Experimental**	6.55 ±1,3	6.4 ±1.4	6.7 ± 1.3
		% of predict	106 ± 20	104 ± 21.3	107.5 ± 19.2

There was no statistical difference between any of the variables

Table 2 - Means, standard deviations and statistical results for the measurements of slow vital capacity (SVC) and maximum voluntary ventilation (MVV) for both the experimental and predicted values, for the group treated with conventional chest physiotherapy (CCP) and the group treated with CCP + transcutaneous electric diaphragmatic stimulation (TEDS), in three evaluations.

Variables	Intervention		Preoperative	15 days	30 days
SVC (L)	CCP	Experimental	3.0 ± 0.4	3.1 ± 0.4	3.2 ± 0.4
		% of predict	92.5 ± 11.3	105.7 ± 12	97.2 ± 12
	CCP+TEDS	**Experimental**	3.2 ± 0.5	3.1 ± 0.5	3.3 ± 0.5
		% of predict	97.5 ± 12.7	95.4 ± 14.2	99.6 ± 12.1
MVV (L/min)	CCP	**Experimental**	101 ± 18	105 ± 14	104 ± 16
		% of predict	97.4 ± 19	95.5 ± 10,4	100 ±16.3
	CCP + TEDS	**Experimental**	107 ± 22	104 ± 27	111 ± 25
		% of predict	102.6 ± 16.5	100.1 ± 22.8	106.1 ± 20.5

There was no statistical difference between any of the variables

Table 3- Means and standard deviations in values obtained and statistical results for the measurements of MIP and MEP for the group treated with conventional chest physiotherapy (CCP) and the group treated with CCP + transcutaneous electric diaphragmatic stimulation (TEDS), in three evaluations

Pressures		Preoperative	15 days	30 days
MIP (cmH_2O)	**CCP**	-84.3 ± 20.3	-77.9 ± 17.2	-77.9 ± 16
	CCP+TEDS	-84 ± 21.7	-81.8 ± 21.5	-87.7 ± 22.8
MEP (cmH_2O)	**CCP**	100.2 ± 18.1	87.9 ± 16. 9 *	85.9 ± 16.5 #
	CCP+TEDS	95.4 ± 21.9	83.6 ± 17.6	87.2 ± 19.8

*difference significant between the 1st and 2nd evaluations (p≤0,5)
difference significant between the 1st and 3rd evaluations (p≤0,5)

hypoxemia in obese individuals; these alterations probably only affected obese patients with pulmonary dysfunction.

The present results are in agreement with the findings of Silva et al.[22], who studied 26 patients given CCP and found no spirometric alterations either in the preoperative period or on the 14th and 30th days after gastric bypass. Rigatto[29] and Barros[30] concluded that during weight loss subsequent to surgery, there was a decrease in respiratory muscular strength that was related to reduced lean mass and led to a reduced thickness of the diaphragm muscle after two weeks on a hypocaloric diet. It was also concluded that the obese individuals only completed the organization and adaptation process of the ventilatory parameters six months after surgery. However, the present results demonstrated that treatment with CCP did not differ from treatment with CCP+TEDS in the maintenance of inhalation muscle strength. In addition, it was also shown that the expiratory muscle strength was not maintained after 15 and 30 postoperative days in the group treated with CCP, but was maintained in the group treated with CCP+TEDS (Table 3). This confirms that CCP+TEDS is an important preventative measure during the postoperative period after bariatric surgery.

Despite the loss or maintenance of respiratory muscle strength, Rovina, Bouros and Tzanakis[11] postulated that reflexive inhibition of the phrenic nerve could cause diaphragmatic dysfunction. This suggests that the decrease in MEP during the postoperative period after open abdominal surgery occurred because the abdominal muscles were cut during surgery, which consequently made it difficult to generate expiratory pressures. Joris et al.[31] considered the reflexive inhibition of the phrenic nerve to be a more probable cause of the dysfunction of the diaphragm muscle than a contractile collapse due to muscular trauma occurring during surgery. Nevertheless, we would like to suggest that CCP, especially in conjunction with TEDS, should be used as a preventive technique in the postoperative period after bariatric surgery.

Toledo and Garcia[32] detected MIP values on the 14th postoperative day that were very close to those obtained in the preoperative period, but did not mention the maintenance of MEP in volunteers who received physiotherapy. The present results reinforce the importance of respiratory physiotherapy in postoperative patients of bariatric surgery. This is especially true when compared with results obtained by Rovina, Bouros and Tzanakis,[11] who did not use respiratory physiotherapy and detected decreased MIP values during the postoperative period after abdominal surgery, and similarly when compared with the results of Paisani et al,[4] who found decreases in MIP and MEP values from the preoperative period to the 5th postoperative day after bariatric surgery.

While Silva et al.[33] concluded that respiratory muscle function was invariably damaged after open abdominal surgeries, the present study showed that pulmonary function and respiratory muscle strength were maintained in patients treated with CCP and those treated with CCP+TEDS 15 and 30 days after bariatric surgery, with special emphasis on the effect of TEDS on MEP.

Despite weight loss in patients who have undergone gastroplasty and the consequent deterioration in respiratory muscle strength,[29,30] the two postoperative evaluations made in this study were carried out fifteen and thirty days after patients were released from the hospital. The delay was used to prevent any deleterious effects occurring immediately after surgery, such as pain or diaphragmatic paresis,[11,31,33] from interfering with the variables under evaluation.

Geddes, Voorhes & Lagler[34] noted that positioning of the electrodes in the parasternal region at the height of the xiphoid process resulted in the liberation of the electric current to the phrenic nerve, which, for its part, penetrated the diaphragm and produced a contraction. However, the application of high intensity currents also caused contraction of the abdominal muscles. In an attempt to produce good contraction during the application of TEDS, the abdominal muscles were probably also stimulated, and this may have led to the maintenance of their strength in the postoperative period. Gray & Field also reported stimulation of the abdominal muscles by placement of the electrodes in the parasternal region (xiphoid).[35]

Finally, the results of this study suggest that both CCP and CCP+TEDS promote the maintenance of pulmonary function and therefore show an indispensable preventive character following bariatric surgeries. It was also concluded that inspiratory muscle strength was maintained within normal parameters by both of the proposed therapies, but the addition of TEDS also preserved expiratory muscle strength, which is fundamental to the recovery of obese patients submitted to RYGB.

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