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Benefits of postoperative respiratory kinesiotherapy following laparoscopic cholecystectomy

Benefícios da cinesioterapia respiratória no pós-operatório de colecistectomia laparoscópica

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Abstract

Introduction: Pulmonary function changes following abdominal surgery lead to reduced pulmonary volume, thus compromising gas exchanges. **Objective:** To evaluate the effects of respiratory kinesiotherapy on pulmonary function and respiratory muscle strength in patients who underwent laparoscopic cholecystectomy. **Methods:** Twenty women and 16 men (age 48.4 ± 9.55 years) who underwent laparoscopic cholecystectomy were prospectively studied. They were randomly divided as follows: 17 subjects performed breathing exercises (diaphragmatic respiration, maximum sustained inspiration and fractional inspiration) and 19 participated as a Control Group. All of them underwent evaluations of maximal inspiratory and expiratory pressures (MIP and MEP), peak expiratory flow (PEF) and spirometry, with measurements of vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1) and the FEV_1/FVC ratio before the operation and daily until the sixth postoperative day (POD). **Results:** The preoperative parameters were not statistically different between the two groups. Both groups presented decreases in all variables on the first POD ($p< 0.05$). The Exercise Group continued to present decreased values until the second POD for VC, FVC, and FEV1 ($p< 0.05$), until the third POD for MIP and PEF ($p< 0.05$) and the fourth POD for MEP ($p< 0.05$). For the Control Group, the values of all the variables began to normalize on the fifth POD. The MIP and MEP values in the Exercise Group were higher than those in the controls, from the third and second POD onwards, respectively. **Conclusions:** Respiratory kinesiotherapy contributed towards early recovery of pulmonary function and muscle strength among patients who had undergone laparoscopic cholecystectomy.

Key words: breathing exercises; cholecystectomy; respiratory mechanics; respiratory muscles.

Resumo

Introdução: Alterações da função pulmonar após cirurgia abdominal levam à redução do volume pulmonar, prejudicando as trocas gasosas. **Objetivo:** Avaliar os efeitos da cinesioterapia respiratória sobre a função pulmonar e a força muscular respiratória em pacientes submetidos à colecistectomia laparoscópica. **Materiais e métodos:** Em estudo prospectivo, 20 mulheres e 16 homens (idade: 48,4 ± 9,55 anos), submetidos à colecistectomia laparoscópica, foram divididos aleatoriamente: 17 realizaram exercícios respiratórios (respiração diafragmática, sustentação máxima da inspiração e inspiração fracionada) e 19 participaram como Grupo Controle. Todos realizaram avaliação das pressões respiratórias máximas (PImax e PEmax), pico de fluxo expiratório (PFE) e espirometria, medindo capacidade vital (CV), capacidade vital forçada (CVF), volume expiratório no primeiro segundo (VEF_1), relação VEF_1/CVF no pré-operatório e diariamente até o sexto pós-operatório (PO). **Resultados:** Os valores de pré-operatório não foram estatisticamente diferentes entre os dois grupos. Ambos os grupos apresentaram diminuição de todas as variáveis no 1º PO ($p< 0,05$). O Grupo Exercício permaneceu com diminuição até o 2º PO para CV, CVF e VEF1 ($p< 0,05$), 3º PO para PImax e PFE ($p< 0,05$) e 4º PO para PEmax ($p< 0,05$), enquanto que, no Grupo Controle, os valores de todas as variáveis retornaram a partir do 5º PO. Os valores de PImax e PEmax foram maiores no Grupo Exercício que no Grupo Controle desde o 3º e 2º PO ($p< 0,05$), respectivamente. **Conclusões:** A cinesioterapia respiratória contribuiu para a recuperação precoce da função pulmonar e da força muscular dos pacientes submetidos à colecistectomia laparoscópica.

Palavras-chave: exercícios respiratórios; colecistectomia; mecânica respiratória; músculos respiratórios.

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Introduction

Abdominal surgical procedures alter the pulmonary functions by reducing the pulmonary volumes and capacities, thus harming the gas exchanges. The causes of these alterations are manifold, and may relate to abdominal manipulation, effects of general anesthetics, pain where the incision occurred, and length of time in bed[1].

When the abdominal wall is intact, the content of the abdomen resists the lowering of the diaphragm, as if it were a fulcrum, hence increasing the abdominal pressure. This resistance to the diaphragm improves the zone of apposition with the abdomen, which allows the thorax to have a better expansibility. Though, if the abdomen is too resistant or too flaccid, it will hinder this support to the diaphragm. Since the diaphragm acts through transdiaphragmatic pressure, which corresponds to the difference between the abdominal and the pleural pressures, one can notice that the abdominal pressure also determines the thoracic expansibility[2]. Changes in the integrity of the abdominal muscles may, therefore, cause variations in the thoracic-abdominal interaction, thus harming the respiratory mechanics[3].

There have been reports of pulmonary function alterations following abdominal surgery, both in conventional surgeries and in laparoscopic ones[4-6]. These functional alterations are characterized by a reduction of the Vital Capacity (VC) as well as of the Forced Vital Capacity (FVC) related to the presence of hypoxemia and atelectasia; they are also marked by the reduction of the forced expiratory volume in the first second (FEV1) [7]. This reduction in the pulmonary volumes has also been related to decreases of the diaphragmatic strength[8].

The return of these values to their pre-operative values occurs from five to 10 days after the laparoscopic colectomy, and from 12 to 15 days after conventional surgery[8]. In major surgeries, involving several muscle groups, as in hepatectomies and liver transplants, there have also occured important functional alterations, with a loss of 27% of the current volume and 44% of the CV at the first PO and a descrease of 32% in Maximal Inspiratory Pressure (MIP) and 42% in Maximal Exspiratory Pressure MEP[9]. In laparoscopic surgeries, during which the abdominal cavity is not opened, there is a reduction in the strength of the respiratory muscles, though of minor proportions when compared to the conventional surgery, due to the reflex inhibitions of the frenic nerve[10].

Respiratory physical therapy is one of the therapeutic alternatives emplyoyed with the aim of reducing the occurence of complications resulting from pulmonary functional loss. Several pulmonary expansion techniques are used, particularly respiratory functional reeducation and respiratory kinesiotherapy. Both are carried out by means of active, free physical exercises, in which the trunk and the limbs may or may not be engaged. Since the diaphragm is the main respiratory muscle, these exercises give a specific intervention on diaphragmatic breathing pattern[11-13].

Respiratory kinesiotherapy is based on respiratory exercises and strategies to increase the pulmonary volume, decrease the respiratory workload and the sensation of dyspnea, redistribute and augment the efficiency of the pulmonary ventilation, improve the gas exchanges, enhance the ventilatory control and the contraction efficiency of the respiratory muscles[2,14,15]. The benefits of physical therapy in the post-operative period of high abdominal surgeries (HAS), either using manual or mechanical techniques, are still a matter for debate. Stiller and Munday[15] observed some beneficial effects, whereas Simmoneau et al.[8] did not report changes in pulmonary functions.

Many of the controversies found in the literature involving the benefits of respiratory physical therapy usually refer to open abdominal surgeries, in which the functional losses are more pronounced. For instance, specialists have questioned whether there should be indications of, or benefits from physical therapy interventions in laparoscopic procedures, which are usually accompanied by minor functional losses and a lower incidence of complications. Thus, the aim of this study was to evaluate the effects of respiratory kinesiotherapy on the pulmonary functions and the respiratory muscle strength in patients who underwent laparoscopic colecistectomy .

Methods

This was a prospective, randomized evaluation, approved by the Ethics Committee of the Centro Universitário do Triângulo (UNITRI) in a meeting held on July 3rd, 2001. All patients were informed concerning the protocol and they permitted the use of their data by signing a term of free agreement for participation form. At the outset, all patients were staying at the Hospital Vaz Monteiro and at the Santa Casa de Misericórdia de Lavras. After having been discharged, they were accompanied home. Forty-four patients, both male and female, who had applied for laparoscopic colecistectomy were evaluated, and the following criteria were considered for inclusion: individuals were aged from 35-65 years old., non-smokers, had normal results in the pre-operative pulmonary pre-operative pulmonary functional test, function, had an absence of respiratory symptoms, absence of chronic pulmonary diseases, aability to perform the muscular strength measurements and the respiratory exercises. Exclusion criteria included: patients who needed post-operative mechanical ventilation, or who demonstrated persistent pain and did not respond favourably to the treatment with painkillers.

Out of the 44 patients evaluated in the pre-operative phase, 36 were selected for the study and submitted to the pre-operative tests. Maximal Inspiratory Pressure (MIP) was measured stemming from the Residual Volume (RV), and the Maximal Expiratory Pressure (MEP) from the Total

Pulmonary Capacity (TPC)[16], by means of a manovacuometer (model MPG, Marshalltown, USA), in cmH2O. A mouthpiece containing a small orifice was used, in order to eliminate mouth pressure, as well as a nose clip, so that the patient would breath only through the mouth. Ten measures were taken, the highest of which was used. The pulmonary volumes and capacities were evaluated through spirometry (Spirotrac IV, model 2170, Vitalograph Inc., USA) which registered values for VC, FVC, FEV_1, and the FEV_1/FVC relationship according to the standards of the American Thoracic Society (ATS)[17]. The expiratory flow peak was determined by means of the Peak Flow Mini-writer (Respironics, USA), with five consecutive measures, the best of which was used. All of these tests were carried out in the pre-operative phase, having the patient seated, and were repeated from the first through the sixth day after surgery.

After the first evaluation, the patients were randomly divided by draw, into two groups: the exercise group (these underwent kinesiotherapic treatment) and the control group (these were not submitted to the treatment). The evaluator did not know to which group the patient belonged (blind). The exercise group was accompanied by an assistant physical therapist who guided the patients on how to execute the exercises before the surgery, and for the first six days afterwards.

The exercise group performed three types of exercises: diaphragmatic breathing, sustained maximal inspiration or fractionated inspiration. Each exercise was carried out having the patient seated, in three series of 20 repetitions, and with a two-minute pause between each series.

For the statistical analyses, the chi-square test was done in order to verify whether the groups were comparable. An analysis of variance (ANOVA) was used to compare the results of each group obtained in the pre-operative phase, as well as for all of the post-operative (PO) days, followed by the F-test for multiple comparisons. The non-paired Student *t*-test was used for comparing the measures of the exercise and of the control group on each day of the study at a significance level of 5% was set.

Results

Of the 36 patients selected for the study, 17 took part in the exercise group, from which 10 were female and 10 male, aged, on average 49.2 ± 10.93 years old, and 19 engaged in the control group, 10 female and 9 male, aged on average 47.7 ± 9.7 years old.

The mean values for muscular strength and pulmonary function in the pre-operative period and on the first day after the surgery are shown in Table 1. One can observe a meaningful reduction in the first PO in relation to the pre-operative phase for all variables analyzed ($p< 0.05$) for both groups, except in the relation FEV_1/FVC, which did not show any significant differences. The compasisons of the measurements taken in the pre-operative period between the two groups by means of the chi-square test did not show any significant differences, thus proving that the groups were comparable.

By comparing each variable in relation to the values obtained in the pre-operative period, for each of the groups studied, it was observed that the mean MIP values of the exercise group were lower in the 1st and 2nd PO ($p< 0.05$), with no significant differences, in turn, from the 3rd to the 6th PO. For the control group, however, these differences occurred, which showed a reduction in the post-operative parameters, which remained steady until the 6th PO ($p< 0.05$) (Figure 1). By comparing both groups, the values found in the exercise group were higher than those for the control group since the 3rd PO ($p< 0.05$).

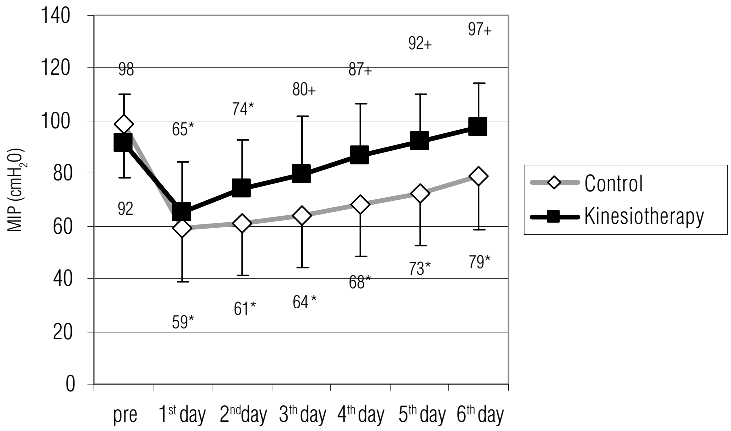
Similar results were found in the MEP evaluation. In the exercise group, the mean values were significantly reduced from the 1st to the 3rd PO ($p< 0.05$), and there were no differences from the 4th PO onwards. In the control group, the values remained lower until the 5th PO ($p< 0.05$), and there were no differences in the 6th PO (Figure 2). By comparing the two groups, the values found in the exercise-group were greater than those in the control group since the 2nd PO ($p< 0.05$).

The measures of the peak expiratory flow were reduced in the 1st and 2nd PO in the exercise group ($p< 0.05$), whereas in the control group this reduction was meaningful and remained until the 4th PO ($p< 0.05$) (Table 2). By comparing both groups,

Table 1. Means and standard deviations (mean ± SD) of the values of respiratory pressures, peak flow rate and spirometry obtained in the pre-operative period and first post-operative day for the exercise group and control groups.

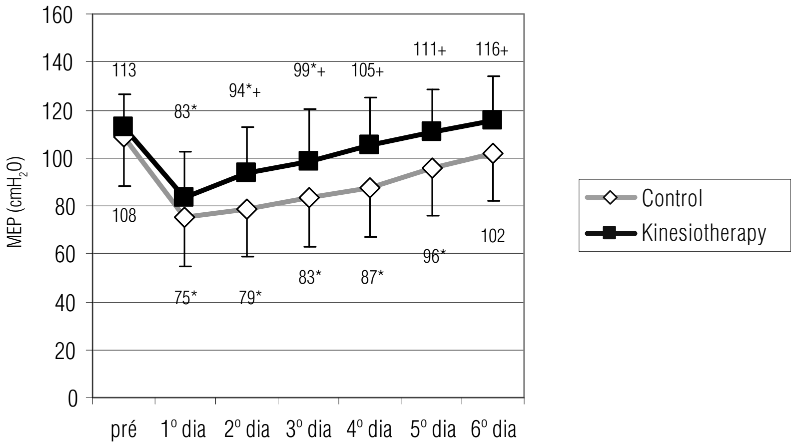
Variables	Exercise Group		Control Group	
	Preoperative	1st Postoperative	Preoperative	1st Postoperative
MIP (cmH_2O)	91.8 ± 23.9	65.4 ± 21.4*	98.5 ± 18.5	58.9 ± 18.7*
MEP (cmH_2O)	112.7 ± 14.0	83.3 ± 17.2*	108.4 ± 13.8	74.9 ± 19.5*
PEF (mL/s)	418.8 ± 99.2	309.4 ± 79.0*	427.9 ± 75.6	305.3 ± 49.9*
VC (L)	2.8 ± 1.0	2.1 ± 0.8*	3.1 ± 0.6	2.2 ± 0.5*
FVC (L)	3.5 ± 0.9	2.7 ± 0.9*	3.7 ± 0.6	2.8 ± 0.6*
FEV1 (L)	2.7 ± 0.9	2.0 ± 0.9*	2.9 ± 0.5	2.2 ± 0.5*
FEV1/FVC (%)	75.2 ± 8.7	73.6 ± 12.6*	78.2 ± 6.3	77.9 ± 7.21*

* Post-operative < Preoperative ($p< 0.05$)



* Post-operative < Pre-operative ($p < 0.05$); + Kinesiotherapy > Control ($p < 0.05$).

Figure 1. MIP median values from the group which submitted to respiratory kinesiotherapy and the control group from pre-operatively to the 6th day of post-operatively.



* Post-operative < Pré-operative ($p < 0.05$); + Kinesiotherapy > Control ($p < 0.05$).

Figure 2. MEP median values from the group which submitted to respiratory kinesiotherapy and the control group from pre-operatively to the 6th day of post-operatively.

Table 2. Means and standard deviations (mean ± SD) of the values of peak flow rate and spirometry obtained in the preoperative and post-operative periods of the exercise group and control group.

	Exercise Group						
	Preoperative	1st PO	2nd PO	3rd PO	4th PO	5th PO	6th PO
PEF (mL/s)	418.8 ± 99.2	309.4 ± 79.0*	352.9 ± 88.6*	382.9 ± 90.4	402.9 ± 85.1	426.5 ± 90.8	449.4 ± 92.7
VC(L)	2.8 ± 1.0	2.1 ± 0.8*	2.4 ± 0.8	2.6 ± 0.9	2.8 ± 0.9	3.0 ± 0.9	3.1 ± 0.9
FVC(L)	3.5 ± 0.9	2.7 ± 0.9*	3.0 ± 0.9	3.2 ± 1.0	3.3 ± 0.9	3.4 ± 1.0	3.5 ± 0.9
FEV1 (L)	2.7 ± 0.9	2.0 ± 0.9*	2.3 ± 0.8	2.4 ± 0.9	2.5 ± 0.9	2.7 ± 0.9	2.8 ± 0.9
FEV1/FVC%	75.2 ± 8.7	73.6 ± 12.6	75.8 ± 11.5	75.2 ± 12.9	76.9 ± 11.2	76.8 ± 10.1	77.4 ± 9.6
	Control Group						
	Preoperative	1st PO	2nd PO	3rd PO	4th PO	5th PO	6th PO
PEF (mL/s)	427.9 ± 75.6	305.3 ± 49.9*	327.9 ± 57.2*	352.1 ± 57.4*	374.2 ± 60.3*	396.8 ± 19.4*	412.1 ± 18.3
VC(L)	3.1 ± 0.6	2.2 ± 0.5*	2.3 ± 0.5*	2.4 ± 0.5*	2.5 ± 0.5*	2.7 ± 0.6*	2.8 ± 0.5
FVC(L)	3.7 ± 0.6	2.8 ± 0.6*	2.9 ± 0.6*	3.0 ± 0.6*	3.1 ± 0.6*	3.2 ± 0.6*	3.3 ± 0.7
FEV1 (L)	2.9 ± 0.5	2.2 ± 0.5*	2.3 ± 0.6*	2.3 ± 0.6*	2.4 ± 0.6*	2.5 ± 0.6*	2.6 ± 0.6
FEV1/FVC%	78.2 ± 6.3	77.9 ± 7.21	78.1 ± 7.08	78.4 ± 6.96	76.8 ± 6.5	76.5 ± 6.1	78.2 ± 5.5

* Post-operative < Preoperative ($p < 0.05$)

the values found in the exercise group were not higher than those of the control group.

The mean values for VC, FVC, and FEV in the first second (FEV_1) of the exercise group showed a significant fall in the 1st PO ($p< 0.05$), whereas in the control group these reductions remained until the 5th PO ($p< 0.05$). The relation FEV_1/FVC did not show any statistically significant differences in either group. The FVC results, as well as the other parameters are shown in Table 2. By comparing the two groups, the values found in the exercise group were not greater than those in the control group.

Discussion

This study evaluated the effects of respiratory kinesiotherapy on the pulmonary function of patients who underwent laparoscopic colecistectomy. The results showed that the respiratory exercises were responsible for a faster recovery of the pulmonary volumes, the same holding true for the strength of the respiratory muscles. It is necessary to point out that in the literature no such references were found for any works that linked the respiratory kinesiotherapy to other procedures such as respiratory physical therapy or laparoscopic surgery, which attests to the importance and pioneering nature of this study.

This shows that the use of respiratory exercises carried out by a specialized physical therapist sped up the patients' pulmonary condition recovery back to the pre-operative patterns. Although the incidence of pulmonary complications has not been covered in this study, the early normalization of the pulmonary functions suggest a lower risk of further development of the most common pulmonary complications, namely atelectasia and hypoxemia[1,2].

Physical therapy, despite its controversial components, is often used in the post-operative treatment of patients who undergo open abdominal surgeries. Thomas and McIntosh[12], in a systematic revision of the various techniques of respiratory physical therapy studied from 1966 to 1992, found heterogeneous results, which were mainly attributed to the methodologies used and to the different treatment methods. They concluded that deep respiratory exercises and the use of incentive spirometry are more effective than the absence of any physical therapy procedures, whatsoever. Nevertheless, upon comparing the different sorts of treatment (deep breathing, intermittent positive pressure breathing, and incentive spirometry), they did not find statistically meaningful differences between them.

About 10 years later, two recent systematic revisions which relate physical therapy and the incidence of post abdominal surgery complications, in which studies were selected involving respiratory exercises, incentive inspirometry and continuous positive pressure, but they still did not reach a consensus. Lawrence et al. showed that physical therapy works as a strategy to decrease the number of pulmonary complications, with A-level evidence[18], whereas Pasquina et al. state that few studies confirm the prophylactic effects of physical therapy and do not reccomend its routine[19].

It is known that the impairement of the pulmonary functions after laparoscopic surgeries is lower than after conventional surgeries, which suggests that these patients are less likely to develop complications. Nonetheless, it has been shown that laparoscopy produces minor alterations, but which have an impact on pulmonary functions, particularly in those patients who have had previous pulmonary impairments[7,8,10,20-24]. Other studies suggest that muscle weaknesses after both conventional and laparoscopic surgeries are similar, but they point out that the reduction of the muscular function lasts longer after the former, thus contributing to a higher incidence of respiratory complications[13,25]. The association between a longer impairement time and a higher incidence of complications clearly demonstrates that the precocious restoration of pulmonary functions by means of respiratory exercises may be beneficial to patients, especially for those with a smaller ventilatory reserve.

In order to define which respiratory exercises should be adopted in this study, the aims of this work were correlated with the alterations provoked by the abdominal surgery. It was decided the respiratory patterns described by Cuello et al.[26], which are therapeutic procedures to be performed in a quiet manner, which require minimum ventilatory effort, without the use of the accessory muscles in the pursuit of greater and more uniform ventilation resulting in an improvement of gas exchanges. In addition, the advantage of performing active exercises and without the accessories of respiratory therapy results in great practical applicability, low costs, and easy accessibility for any physical therapy service.

Like other studies in the literature, a reduction in the 1st PO values of the pulmonary function and of the respiratory muscle strength were also observed[6,7,27]. However, none of the retrieved intervention studies showed a recovery of the variables to the pre-operative state as early as on the 2nd day after the surgery (CV, CVF e VEF_1), as was demonstrated in the present study. The precocious return of the MIP and PFE values from the 3rd and 4th PO, respectively, is also noteworthy.

The impairement of the inspiratory muscular strength leads to a diminishment of the inspired pulmonary volume and the diminshment of the volume, combined with the expiratory muscle impairement, caused a reduction of the expiratory flow and damage to the coughing mechanism, favouring the retention of pulmonary secretions[28]. A decreased MIP in the 1st PO was found when compared to the pre-operative phase, for both groups. This reduction may have reflected the ocurrence of diaphragmatic paresia, since the MIP measure is an estimate of global inspiratory muscle strength[1,3]. Although the presence of the diaphragm reflex inhibition is defined in conventional surgeries, there is an emphasis on the occurence of this disfunction also in the laparoscopic colecistectomy, which promotes minor alterations in pulmonary functions resulting from the lesser manipulation of the abdominal structures. The patients of this study may have presented diaphragmatic reflex paresia, by the reduction of the MIP and of the functional capacity found in PO, also reported in the studies carried out by Puttensen-Himmer et al.[6] and by Rovina et al.[10].

The MIP values were higher, i.e., more negative, in patients who performed respiratory exercises when compared to the control group, probably because the respiratory exercises acted upon the maintainance of muscle tonus, and avoided a greater loss of strength due to the inactivity already reduced by the stress from the surgery[1,3,28,29]. Likewise, the MEP values were also higher in the group that performed the respiratory exercises. When compared to the control group, the values were greater from the 2nd PO onwards, which showed that the exercises favoured a better recovery. Even having better conditions than the control group, the exercise group only recovered the values registered in the pre-operative period in the 4th PO.

In conclusion, the respiratory kinesiotherapy contributed to the early recovery of both the pulmonary function and of the muscular strength of the patients who underwent laparoscopic colecistectomy, as was indicated by the treatment or prevention of post-operative pulmonary complications.

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