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Evaluation of the effectiveness of preoperative outpatient pulmonary preparation in patients undergoing esophageal surgery

Avaliação da efetividade do preparo pulmonar ambulatorial no período pré-operatório de cirurgia do esôfago

Evaluación de la efectividad del preparo pulmonar ambulatorial en el período pre-operatorio de cirugía del esôfago

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Abstract

Introduction: Preoperative inspiratory muscle training (IMT) can minimize the occurrence of complications after esophagectomy. **Objective**: To evaluate the effects of preoperative IMT in patients undergoing esophageal surgery by determining respiratory muscle strength (PImax and PEmax), pulmonary function (FEV1, FVC, FEV1/FVC) and functional capacity by the 6-minute walk test (6MWT). **Methods**: Twenty-two patients were randomized into two groups: a control group (CG; n = 10) and an intervention group (IG; n = 12). Only IG

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performed IMT for a minimum period of 2 weeks. The assessments were conducted pre- and post-surgery. **Results**: An increase of PImax was observed in IG, but not in CG, in the second preoperative assessment ($p = 0.014$). Assessment on postoperative day 1 showed a reduction in maximal respiratory pressures in the two groups, but the reduction was more marked in IG ($p < 0.05$). Partial recovery of the variables evaluated was observed at discharge in the two groups. These variables had fully returned to initial values on postoperative day 30. The distance walked in the 6MWT was greater in IG, but the difference was not significant ($p = 0.166$). There was no difference in the frequency of pulmonary complications between groups. **Conclusion**: Preoperative IMT performed in our study improved inspiratory muscle strength but did not influence the postoperative pulmonary function or functional capacity of patients undergoing esophagectomy.

Keywords*: Low Back Pain. Epidemiology. Occupational Health. Military Personnel.*

Resumo

Introdução: *O treinamento muscular inspiratório (TMI), realizado no pré-operatório, pode minimizar a ocorrência de complicações após esofagectomia.* ***Objetivo:*** *Avaliar os efeitos do TMI realizado no pré-operatório da cirurgia do esôfago através da força muscular respiratória (PImáx e PEmáx), da função pulmonar (VEF1, CFV, VEF1/CVF) e da capacidade funcional através do teste de caminhada de 6 minutos (TC6').* ***Métodos:*** *22 pacientes foram randomizados em: Grupo Controle (GC; n = 10) e Grupo Intervenção (GI; n = 12). Somente o GI realizou TMI por no mínimo 2 semanas. As avaliações foram realizadas no pré e pós-operatório.* ***Resultados:*** *Houve aumento da PImáx no GI na 2° PRÉ (p = 0,014), enquanto no GC não houve alteração. Na avaliação do 1°PO os dois grupos apresentaram redução das pressões respiratórias máximas, porém a redução foi mais acentuada no GI (p < 0,05). Na alta hospitalar ocorreu recuperação parcial das variáveis avaliadas em ambos os grupos e no 30°PO ocorreu recuperação plena em relação aos valores iniciais. Em relação ao TC6' houve um aumento da distância percorrida no GI, mas não foi significante (p = 0,166). Não houve diferença na ocorrência de CP entre os grupos.* ***Conclusão:*** *O TMI realizado em nosso estudo melhorou a força muscular inspiratória, mas não influenciou a função pulmonar e a capacidade funcional pós-operatória de pacientes submetidos a esofagectomia.*

Palavras-chave: *Fisioterapia. Terapia respiratória. Teste de Caminhada. Esofagectomia.*

Resumen

Introducción*: El entrenamiento muscular inspiratorio (TMI), realizado en el preoperatorio, puede minimizar la ocurrencia de complicaciones después de la esofagectomía.* ***Objetivo:*** *Evaluar los efectos del TMI realizado en el preoperatorio de la cirugía del esófago a través de la fuerza muscular respiratoria (PImáx y PEmáx), de la función pulmonar (VEF1, CFV, VEF1 / CVF) y de la capacidad funcional a través del test de caminata de 6 minutos (TC6').* ***Métodos:*** *22 pacientes fueron randomizados en: Grupo Control (GC, n = 10) y Grupo Intervención (GI; n = 12). Sólo el GI realizó TMI por lo menos 2 semanas. Las evaluaciones se realizaron en el pre y postoperatorio.* ***Resultados****: Hubo aumento de la PImáx en el GI en el 2°PRÉ (p = 0,014), mientras que en el GC no hubo alteración. En la evaluación del 1°PO los dos grupos presentaron reducción de las presiones respiratorias máximas, pero la reducción fue más acentuada en el GI (p < 0,05). En el alta hospitalaria ocurrió recuperación parcial de las variables evaluadas en ambos grupos y en el 30°PO ocurrió recuperación plena en relación a los valores iniciales. En relación al TC6'hubo un aumento de la distancia recorrida en el GI, pero no fue significativo (p = 0,166). No hubo diferencia en la ocurrencia de CP entre los grupos.* ***Conclusión:*** *El TMI realizado en nuestro estudio mejoró la fuerza muscular inspiratoria, pero no influenció la función pulmonar y la capacidad funcional postoperatoria de pacientes sometidos a esofagectomía.*

Palabras clave*: Fisioterapia. Terapia respiratória. Prueba de Caminata. Esofagectomía.*

Introduction

Chagas disease is an important public health problem since it continues endemic in several Latin American countries, with 16 to 18 million infected people and another 100 million at risk of contracting the disease. An estimated 10 million people are infected in Brazil. Each year, the disease kills an average of 17,000 people, with 60 million being at risk in 18 endemic countries [1]. Eight to 40% of patients with Chagas disease develop different degrees of esophageal manifestations, which represent a large socioeconomic problem in Brazil and reduce the quality of life of patients due to dysphagia, which is often severe [2].

The etiological agent of Chagas disease, *Trypanosoma cruzi*, destroys the nerve plexuses of the esophageal wall, which results in reduced peristalsis and a hypertonic lower esophageal sphincter, causing achalasia (absence of peristaltic movements in the esophagus and narrowing of the cardia) and megaesophagus (dilatation of the esophagus) [3]. The main symptoms of megaesophagus are dysphagia, bronchoaspiration of regurgitated food, weight loss, vomiting, excessive salivation, retrosternal pain, and heartburn. Nighttime coughs, lung abscesses, and airway infections may also occur. Chagasic megaesophagus is more common in males and in the age range of 30-40 years. The onset of dysphagia before the age of 40 is observed in 80% of cases [4].

More advanced megaesophagus (grade IV) requires major surgery, with removal of the sick organ, i.e., esophagectomy, being the treatment of choice. This approach is aimed at partially removing the esophageal body extensively compromised by the destruction of the myenteric plexuses that are responsible for motility and contraction of the esophagus [5]. However, although surgery is the therapeutic procedure that provides the best outcomes in these patients, it can cause important pulmonary complications that delay the recovery of the patients and even increase mortality [6].

Pre- and postoperative respiratory physiotherapy has been used successfully for the prevention of pulmonary complications in this type of surgery. According to a recent study [7], respiratory physiotherapy combined with respiratory muscle training is one of the most promising preoperative interventions described.

The objective of the present study was to evaluate the effects of preoperative inspiratory muscle training (IMT) in patients undergoing esophageal surgery on the development of postoperative pulmonary symptoms.

Methods

This was a randomized clinical trial conducted at the Sector of Digestive Tract Surgery of the University Hospital of Universidade Federal do Triângulo Mineiro (HC-UFTM). Twenty-two male patients participated in the study. Ten patients were randomly assigned to the control group (CG) and 12 to the intervention group (IG). With respect to diagnosis, four patients (40%) in CG had cancer and six (60%) had megaesophagus. In IG, six patients (50%) had cancer and six had megaesophagus. Laparoscopic esophagectomy was the surgical procedure performed.

Respiratory muscle strength was evaluated by assessing the following variables: maximal inspiratory pressure (PImax) and maximal expiratory pressure (PEmax) on PRE1 and PRE2, PO1, discharge and PO30; pulmonary function by forced expiratory volume in the first second (FEV1), forced vital capacity (FVC) and the ratio between these variables (FEV1/FVC) on PRE1, PRE2, discharge and PO30; functional capacity by the six-minute walk test (6MWT) on PRE1, PRE2, discharge and PO30.

The study was approved by the Ethics Committee of UFTM (Approval Nº 1823). The data of each patient were recorded on an assessment chart and all patients provided written informed consent.

The criteria for inclusion of the patients were a diagnosis of megaesophagus (grades III and IV) or resectable esophageal cancer and age older than 18 years. Patients operated upon within less than 2 weeks after initial evaluation and those who did not understand or did not adhere to the intervention proposed were excluded.

First Preoperative Physiotherapeutic Evaluation (PRE1)

During anamnesis, personal data, history of past and present disease, history of smoking and presence of comorbidities, including pulmonary and heart diseases, were collected. Physical examination consisted of the measurement of anthropometric variables (weight, height, and BMI). Respiratory muscle strength and pulmonary function were evaluated by the measurement of PImax and PEmax and by spirometry. Functional capacity was evaluated by the 6MWT.

Second Preoperative Physiotherapeutic Evaluation (PRE2)

The second physiotherapeutic evaluation (PRE2) was performed up to 48 hours (1 or 2 days) before surgery and was identical to the first evaluation (PRE1), except that the anamnesis was not repeated.

Postoperative Physiotherapeutic Evaluation (PO1)

Postoperative physiotherapeutic evaluation was performed 48 hours after the surgical procedure (PO1), obtaining only PImax and PEmax.

Hospital Discharge and Postoperative Day 30 (PO30)

PImax, PEmax, pulmonary function (FEV1, FVC, FEV1/FVC), and functional capacity (6MWT) were evaluated at discharge and on PO30.

Measurement of Maximal Respiratory Pressures

The maximal respiratory pressures were obtained to evaluate respiratory muscle strength. For these measurements, the patient was seated and used a nose clip. A properly calibrated analog manovacuometer (ranging from 0 to ± 300 cmH_2O) (GeRar, Sao Paulo, SP, Brazil) was used for the pressure measurements. PImax was measured from residual volume and PEmax from total lung capacity as described by Neder et al. [8].

At least three measurements of each variable were obtained, with a resting period of approximately 1 minute between maneuvers. The maneuver was only considered valid when the pressure was sustained for at least 2 seconds. If the highest value was observed in the third maneuver, the measurement was repeated until the same or a lower value was obtained, with a variation < 10% between measurements.

The highest value of each variable (PImax and PEmax) was considered for analysis, given that it was not the value obtained in the last maneuver. These measurements were made weekly in the outpatient clinic.

Spirometry

Spirometry was performed at HC-UFTM with a properly calibrated Master Screen-Pneumo apparatus (Jaeger®) to obtain the following variables: FVC, FEV1, and FEV1/FVC. The test was carried out according to the Guidelines for Pulmonary Function Tests of the Brazilian Society of Pneumology and Tisiology. The reference values reported by Pereira et al. [9] were used.

Functional Capacity

Functional capacity was evaluated by the 6MWT according to the recommendations of the American Thoracic Society (ATS) [10]. The test was performed at least 2 hours after meals. The patients were asked to wear comfortable clothing and footwear and to continue their usual medication. The test was administered in a hallway with a minimum length of 30 m and free of other people. The patients were asked to walk at their own pace as far as possible for 6 minutes. The patients received clarification about possible cardiorespiratory changes that could arise and were allowed to walk slowly or to stop when necessary, returning to walk when they felt able to start over. After 10 minutes, blood pressure, heart rate, respiratory rate, SpO_2, and sensation of dyspnea and fatigue were measured. The last two were evaluated by the modified Borg scale, which ranges from zero (no effort) to 10 (maximal effort). The subjects were encouraged to walk every minute using standard phrases. At the end of the test, the initially collected vital data and the perception of dyspnea and fatigue were again evaluated. In addition, the distance walked by the patient was calculated. Two tests were performed at a minimum resting interval of 30 minutes. The test was repeated to eliminate the effect of learning and to ensure reproducibility of the procedure.

Control Group

Patients of CG were taught to perform the respiratory exercises (diaphragmatic and in three times) and breathing-associated upper and lower limb exercises. The subjects were asked to perform 10 repetitions of each respiratory and limb exercise, 5 times per week. In addition, they received instructions about the importance of pre- and postoperative physiotherapy and were encouraged to remain active within their physical limits.

Written instructions in the form of explanatory leaflets about the exercises that should be performed at home were given to the patients. In addition, the patients were asked to record on the exercise sheet whether they had performed the exercise and whether they had experienced some type of discomfort during their execution.

After the first preoperative evaluation, the patients were asked to perform these exercises at home as instructed and returned to the outpatient clinic once a week until the date of hospital admission. During the weekly return visits, the responsible researcher verified whether the exercises had been performed correctly and the instructions were reinforced.

Intervention Group

Patients of IG received the same instructions as those of CG, except for the addition of IMT. The Threshold IMT (Philips Respironics, NJ, USA) was used for training at an initial load of 60% PImax. The patients performed three sets of 12 repetitions, 5 times per week. The load was adjusted weekly in the case of an increase in PImax in order to maintain the load at 60% of PImax. In addition to the exercise leaflets, the patients received a Threshold IMT provided by HC-UFTM so that they could perform the intervention proposed at home. In this group, the patients were also asked after the first evaluation to perform the exercises at home and returned to the outpatient clinic once a week until the date of hospital admission. The same researcher accompanied the patients of the two groups during the preoperative period.

The exercises were performed by patients of CG and IG during the preoperative period between the first (PRE1) and second (PRE2) evaluation, i.e., 48 hours before the surgical procedure.

Statistical Analysis

The Kolmogorov-Smirnov test was used to determine whether the data were normally distributed. Parametric data were compared by the Student t-test and nonparametric data by the Wilcoxon test. Pearson's and Spearman's correlation coefficients were calculated to evaluate correlations. Differences were considered significant when $p < 0.05$. Statistical analysis was performed using the Microsoft Excel 2010, GraphPad Prism 5.0, and SPSS 16.0 programs.

Results

Table 1 shows the anthropometric characteristics and risk factors (incidence of smoking and alcohol consumption) of the groups in the first physiotherapeutic evaluation.

Table 1 - Anthropometric data and risk factors of patients of the control and intervention groups obtained in the first preoperative evaluation (PRE1)

Variables	CG (n=10)	IG (n = 12)	p
Anthropometric			
Age (years)	54.5 ± 9.9	53.3 ± 12.6	0.815
Male, n (%)	4 (40.0)	7 (58.3)	0.392
BMI (kg/m2)	23.1 ± 5.0	24.6 ± 4.8	0.479
Risk factors			
History of smoking, n (%)			0.728
Non-smoker	4 (40.0)	4 (33.3)	
Ex-smoker	1 (10.0)	3 (25.0)	
Smoker	5 (50.0)	5 (41.7)	
Alcohol consumption, n (%)	3 (30.0)	4 (33.3)	1.00

Note: Continuous variables are reported as mean ± standard deviation. CG = control group; IG = intervention group; BMI = body mass index.

Table 2 - Respiratory muscle strength, pulmonary function and functional capacity of the control and intervention groups in the first and second physiotherapeutic evaluation, in the postoperative evaluations immediate after surgery and on day 30, and at discharge

(To be continued)

	Group	PRE1	PRE2	PO1	Discharge	PO30	p
Respiratory muscle strength							
PImax (cmH_2O)	CG	-76.0 ± 37.8	-74 ± 36	-35 ± 23	-60 ± 27	-81 ± 33	0.014
	IG	-90.0 ± 33.8	-103 ± 20	-42 ± 17	-57 ± 20	-86 ± 16	

(Conclusion)

	Group	PRE1	PRE2	PO1	Discharge	PO30	p
Respiratory muscle strength							
PEmax (cmH_2O)	CG	97.0 ± 25.0	98 ± 32	68 ± 36	77 ± 30	99 ± 26	0.095
	IG	110.8 ± 28.1	123 ± 22	58 ± 29	74 ± 28	108 ± 31	
Pulmonary function							
FEV1	CG	91.1 ± 15.0	91.1 ± 15.0	-	68.3 ± 16.9	86.1 ± 14.8	0.58
(% predicted)	IG	88.8 ± 19.9	86.6 ± 19.3	-	60.7 ± 14.1	84.8 ± 10.1	
FVC	CG	99.2 ± 14.5	99.2 ± 14.5	-	71.2 ± 19.2	92.9 ± 15.1	0.561
(% predicted)	IG	95.9 ± 14.7	95.4 ± 15.3	-	61.6 ± 14.3	88.0 ± 12.7	
FEV1/FVC	CG	74.9 ± 7.9	74.9 ± 7.9	-	78.8 ± 7.7	75.7 ± 7.8	0.499
	IG	74.4 ± 11.3	73.4 ± 11.2	-	80.2 ± 8.9	78.9 ± 8.6	
Functional capacity							
6MWT	CG	507.5 ± 83.7	486 ± 62	-	442 ± 75	515 ± 73	0.02
	IG	499.4 ± 73.6	514 ± 85	-	362 ± 90	458 ± 59	

Note: Continuous variables are reported as mean ± standard deviation. *$p < 0.05$. CG = control group; IG = intervention group; PRE1 and PRE2 = first and second preoperative physiotherapeutic evaluation; PO1 = postoperative evaluation 48 hour after surgery; PO30 = evaluation on postoperative day 30; PImax = maximal inspiratory pressure; PEmax = maximal expiratory pressure; FEV1 = forced expiratory volume in the first second; FVC = forced vital capacity; 6MWT = 6-minute walk test.

Patients of IG exhibited a significant increase in PImax after preoperative training compared to CG (p = 0.014). PImax increased by 22% between PRE1 and PRE2. A reduction of 3% in mean PImax was observed in IG and CG. On PO1, there was an important reduction of PImax in the two groups, which was more marked in IG (p = 0.011; contrast analysis). A partial increase in PImax was observed on the day of discharge in the two groups, but recovery was greater in CG (p = 0.015; contrast analysis). Full recovery of baseline values was found in both groups on PO30, but patients of IG did not reach the PImax achieved in PRE2, i.e., after IMT (p = 0.005; contrast analysis).

PEmax showed a similar trend as PImax, increasing in IG and practically remaining unchanged in CG after training; however, the difference was not significant (p = 0.095). On PO1, patients of the two group exhibited an important reduction in PEmax, which was more marked in IG (p = 0.007; contrast analysis). A partial increase in PEmax was observed on the day of discharge in the two group, but recovery was greater in CG (p = 0.022; contrast analysis). Full recovery of baseline values was found on PO30 in both groups.

With respect to pulmonary function, a reduction in these parameters was observed on PRE2, discharge and PO30 when compared to PRE1, without a significant difference between groups: FEV1 (% predicted, p = 0.58), FVC (% predicted, p = 0.561) and FEV1/FVC (p = 0.499).

After intervention, patients of IG increased the distance walked in the 6MWT by 15 m, while a reduction of 22 m was observed in CG, but the difference was not statistically significant (p = 0.166). The distance walked in the 6MWT was reduced in the two groups on the day of discharge. However, when compared to PRE2, the reduction was more important in IG compared to CG (p = 0.02; contrast analysis). On PO30, the distance walked increased in both groups (p = 0.02).

Pulmonary complications were observed in 40% of patients of CG and 35% of IG at some point between postoperative days 1 and 5. However, there was no significant difference between the two groups (p = 0.562). Only one patient of IG developed pneumonia. The most frequent complications in the two groups were hypoxemia ($SpO2 \leq 90\%$ in ambient air) and productive cough.

Table 3 shows the duration of the surgical procedure (min) and mechanical ventilation (min) and the length of hospital stay after surgery (days).

Table 3 - Duration of the surgical procedure and mechanical ventilation and length of hospital stay after surgery

Variables	CG (n = 10)	IG (n = 12)	p
Duration of surgery (min)*	278 (230-334)	288 (239-434)	0.456
Duration of MV (min)*	225 (170-300)	325 (191-785)	0.123
Length of hospital stay (days)#	9.6 ± 5.1	8.5 ± 6.4	0.665

Note: *Median (IQ 25-75%); #mean ± standard deviation. CG = control group; IG = intervention group; MV = mechanical ventilation.

Discussion

The incidence of megaesophagus continues to be high in Brazil because of its association with Chagas disease. It is estimated that 5% to 8% of patients with Chagas disease develop megaesophagus [11]. Surgical interventions in these patients are associated with complications during the immediate postoperative period as a result of the use of general anesthesia and the fact that organ manipulation is done close to the lungs. Postoperative pulmonary complications in these patients include reduced pulmonary function and respiratory muscle strength, diaphragm paralysis, pleural effusions, atelectasis, pneumonia, respiratory insufficiency, and pulmonary embolism [12]. Esophagectomies (complete or partial resection of the esophagus) can lead to a reduction in lung volume and ventilatory capacity of about 40% and 60%, respectively, with consequent important pulmonary complications [13].

Preoperative physiotherapy establishes a link with the patient, identifying the main risk factors for postoperative pulmonary complications, and prevents and guides the physiotherapeutic techniques used for recovery [14]. Evidence indicates the need for preoperative physiotherapy in upper abdominal and thoracic surgeries, including respiratory muscle training to prevent future complications. This training was found to increase strength and endurance of the diaphragm, with improvement in pulmonary function [15]. Kendall et al. [16] recommended physiotherapy using maneuvers of sustained maximal inspirations with a linear load Threshold device to treat postoperative pulmonary complications.

In the present study, preoperative IMT resulted in a significant increase in PImax, but this increase in inspiratory muscle strength did not provide satisfactory PImax levels during the postoperative period and did not influence recovery of the patients. Patients of IG exhibited a greater reduction in maximal respiratory pressures on PO2 and in the distance walked in the 6 MWT on the day of discharge when compared to the reduction observed in CG. These results can be explained by different factors, although the groups were homogenous before surgery, the duration of surgery and mechanical ventilation was longer in IG. Another factor that might have compromised more satisfactory results after IMT is the important nutritional deficit of these patients, who require a longer period of training than that adopted in our study in order to exhibit a real gain in muscle strength [17]. The minimum period of IMT established in our study was shorter than that adopted in other studies [18, 19]. Our patients were asked to perform IMT 5 times per week for a minimum period of 2 weeks (at least 10 sessions). We chose a period that could have benefits for the patients and, at the same time, was feasible within the routine outpatient care of the institution.

Kulkarni et al. [18] showed that preoperative IMT before major abdominal surgeries performed twice a day, 7 days per week, for a minimum period of 2 weeks, attenuated the decline in PImax during the postoperative period compared to other interventions. Morano et al. [19] found that preoperative IMT performed 5 times per week, for 4 weeks, significantly increased maximal respiratory pressures, 6MWT performance and FVC in patients undergoing lung cancer resection divided into two groups, a rehabilitation group (strength and endurance) and a pulmonary physiotherapy group (exercises for lung expansion).

Another important point is that the type of IMT used in our study differed from that adopted in other clinical trials [20, 21]. Our patients performed IMT of high intensity (3 sets of 12 repetitions at an initial load of 60% PImax), while IMT was performed at low intensity in the other studies, with the initial load ranging from 20% to 30% of PImax maintained for 15-30 minutes. In the study of Morano et al. [19], the load was increased progressively until reaching 60% of PImax. However, we do not believe that the type of training performed has contributed to our results since evidence indicates that high-intensity IMT is more effective than low-intensity training.

No significant alterations were observed in the spirometry variables. However, these data agree with another study that reported that, although spirometry is an important technique to determine the degree of obstruction, it has not been effective in detecting differences after rehabilitation programs [22].

The surgical incision can directly affect the integrity of respiratory muscles (muscle tissue and/or innervation) and consequently compromise their function. In addition, these patients are likely to experience more pain, which may contribute to inspiratory muscle dysfunction. The adoption of a superficial respiratory pattern, which is characterized by low tidal volumes and a high respiratory rate, also contributes to the maintenance or greater reduction in lung volumes during the postoperative period. The type of incision can also alter the configuration of the rib cage and influence the occurrence of atelectasis, events that decrease complacency of the respiratory system, increasing respiratory work and reducing the mechanical effectiveness of the respiratory muscles [23, 24]. In a cohort study, Canet et al. [25] evaluated 2,464 surgical patients to identify independent predictors of postoperative pulmonary complications. The authors found that patients with the surgical incision in the upper abdomen were 4.4 times more likely to develop pulmonary complications than patients with incisions at peripheral sites. If located in the chest, the chance increased to 11.4.

Regarding the 6MWT, an increase in the distance walked was observed in IG after the intervention, but the result was not significant ($p = 0.166$). Morano et al. [19] found significant improvement ($p = 0,020$) of the distance walked in the 6 MWT after 4 weeks of preoperative IMT in patients undergoing lung cancer resection. In the study of Winkelmann et al. [26], patients with heart failure and respiratory muscle weakness were divided into a group submitted to aerobic training on a cycle ergometer and a group undergoing the same training combined with IMT at a load of 30% PImax for 30 minutes per day. A significant difference in 6MWT values was observed for the group submitted only to aerobic training ($p < 0.001$).

Since IMT did not attenuate he reduction of PImax in IG compared to CG during the early postoperative period and did not influence the behavior of the other variables, it is not surprising that there was no significant difference in the frequency of pulmonary complications between the two groups. However, the incidence of clinically significant complications in the two groups (35% versus 40% in IG and CG, respectively) was similar to that reported in the recent literature [27, 28].

In the present study, the two groups studied did not differ in the frequency of pulmonary complications between postoperative days 1 and 5. These results agree with those reported by Weiner et al. [29] who studied patients undergoing myocardial revascularization surgery. The patients were divided into a control group and a treatment group that was submitted to preoperative IMT for 2 to 4 weeks at an initial load of 15% PImax, with a load increment of 5% every session until reaching 60% of PImax. The authors found a significance increase in inspiratory muscle strength and endurance, but there was no significant difference in the incidence of postoperative pulmonary complications compared to the control group.

A systematic review of the effects of preoperative training interventions before thoracic and abdominal surgeries showed that most articles on preoperative IMT involve patients undergoing heart surgeries. The authors concluded that there is moderate evidence that IMT increases muscle resistance and low evidence that it increases muscle strength and lung volume and decreases postoperative pulmonary complications and the length of hospital stay [30].

Conclusion

The IMT performed in our study improved inspiratory muscle strength but did not influence the postoperative evolution of pulmonary function or functional capacity in patients undergoing esophageal surgeries. Further studies investigating preoperative IMT using the Threshold device in patients undergoing esophageal surgeries that include a larger number of subjects and adopt a period of training longer than 2 weeks are needed in order to more accurately determine whether preoperative IMT reduces the rate of postoperative pulmonary complications.

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