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Pulmonary function in women: comparative analysis of conventional versus single-port laparoscopic cholecystectomy

Análise comparativa da função pulmonar em mulheres submetidas à colecistectomia laparoscópica convencional e por portal único

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ABSTRACT

Objective: *to evaluate the pulmonary function of women submitted to conventional and single-port laparoscopic cholecystectomy.* **Methods**: *forty women with symptomatic cholelithiasis, aged 18 to 70 years, participated in the study. We divided the patients into two groups: 21 patients underwent conventional laparoscopic cholecystectomy, and 19, single-port laparoscopic cholecystectomy. We assessed pulmonary function through forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), and the FEV_1/FVC ratio, measured before and 24 hours after the procedure.* **Results**: *in both groups, FVC and FEV_1 were lower in the postoperative period than those obtained in the preoperative period, with a greater reduction in the group undergoing conventional laparoscopic cholecystectomy. Regarding the FEV_1/FVC (%) values, there was no statistically significant difference in any of the groups or times analyzed.* **Conclusion**: *there was a greater decline in FVC and FEV_1 in the postoperative group of patients submitted to conventional laparoscopic cholecystectomy.*

Keywords: *Cholelithiasis. Cholecystectomy, Laparoscopic. Respiratory Function Tests. Pulmonary Function. Women.*

INTRODUCTION

Despite the excellent results of laparoscopic surgery, the intention of having a 'no-scar' surgery did not stop. In 1985, Mühe[1] performed the first laparoscopic cholecystectomy by means of a multicanal single-port trocar with only one incision in Germany. The first natural orifice transluminal endoscopic surgery (NOTES) occurred in 2007, further minimizing access trauma, with no visible scarring. The "competition" between standard laparoscopy with three or four trocars, NOTES and single incision laparoscopy led to the rapid development of special single-port trocars[2]. The evolution was due to the combination of the surgical ability developed in the video-laparoscopic techniques and the high technology of the modern flexible instruments, aiming at reducing pain, reducing hospitalization time, reducing the incidence of hernias, and improving aesthetic results[3,4].

Abdominal surgical procedures may alter lung function, reducing lung volumes and capacities and, consequently, impairing gas exchange and increasing hospitalization time. In laparoscopic cholecystectomy, manipulation of the abdominal cavity, as explained by Ribeiro *et al.*[5], leads to a decrease in pulmonary volumes and capacities, which may result in hypoxemia and atelectasis due to diaphragmatic dysfunction. Diaphragmatic paresis associated with the induced pneumoperitoneum may lead to atelectasis in bases, resulting in a collapse of alveolar ventilation, with alteration in ventilation-perfusion or shunt causing hypoxemia[6].

The aim of this study was to evaluate pulmonary function, through forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), and the FEV_1/FVC *ratio* of women submitted to conventional and single-port laparoscopic cholecystectomy before and 24 hours after the surgical procedure.

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METHODS

We carried out a prospective, cross-sectional study in the discipline of Digestive System Surgery of the Clinics Hospital of the Triângulo Mineiro Federal University. We studied 40 women with symptomatic cholelithiasis, aged between 18 and 70 years, divided into two groups: 21 patients submitted to conventional laparoscopic cholecystectomy, and 19, to single-port laparoscopic cholecystectomy. The study was approved by the Ethics in Research Committee of the Triângulo Mineiro Federal University (UFTM) - Opinion nº 2503 - and all patients an informed consent form after clarification.

We recorded patient data on an evaluation form that contained information such as age and anthropometric variables. The inclusion criteria were women with symptomatic cholelithiasis, aged between 18 and 70 years. Exclusion criteria were pregnancy, body mass index greater than 35kg/m², neurological or cognitive deficits that made it impossible to perform the respiratory muscle strength test, systemic diseases and respiratory infections in the four weeks prior to the start of the study and/or allergic sinus disease, chronic obstructive pulmonary disease (COPD), previous diagnosis of bronchial asthma, pleuropulmonary abnormalities, chest deformities, suspected or confirmed liver cirrhosis, coagulopathy (platelet count below 50,000/ul), double medication with platelets antagonists (acetylsalicylic acid and clopidogrel), acute pancreatitis, and jaundice.

We performed conventional laparoscopic cholecystectomy with the patients positioned in horizontal dorsal decubitus at the operative table and undergoing general anesthesia with perioperative monitoring performed with cardioscopy, non-invasive blood pressure monitoring, pulse oximetry and capnography. We introduced four trocars: one 10-mm trocar in the supra-umbilical region for the optics, one 5-mm trocar on the right flank for cranial traction of the gallbladder and two other trocars on the same line, one 5-mm in the right hypochondrium for gallbladder traction, and one 10-mm trocar on the epigastrium, at the left side of the round ligament, for dissection and hemostasis. We maintained the pneumoperitoneum with carbon dioxide at a pressure of 14mmHg.

We performed single-port laparoscopic cholecystectomy with the patients in dorsal decubitus position under general anesthesia, with a discreet proclivity and left lateralization, and the lower limbs placed in leggings (French or European position). The surgeon stood between the patient's legs, and the first assistant, on the left. We positioned the monitors at the level of the patient's right shoulder. We performed a horizontal incision of about 1.5cm transumbilically for placement of the Veress needle by puncture. When there was an umbilical hernia, we dissected the hernial ring for placement of a needle or trocar under direct vision. Thereafter, we induced pneumoperitoneum and maintained it at 14mmHg with CO_2 insufflation. In this incision, we inserted a 10-mm trocar through which we positioned the 30° optic. We inserted a second trocar, 5-mm or 10-mm, above and to the right of the first, for positioning the hook or scissors, among other instruments handled by the surgeon's right hand. A third trocar (5-mm or 3-mm) was inserted to the left and at the same height of the second trocar for placement of the clamps. In cases where it was necessary, we inserted a 2-mm trocar into the right flank for the positioning of the apprehension clamp to aid the exposure of the Calot triangle and dissection of the cystic duct and cystic artery. When available, was used a 5-mm, 30° optics at the time of placement of clips into the cystic duct and cystic artery, allowing passage of the clipper through the 10-mm trocar previously inserted into the umbilical scar. When not available, we inserted a second 10-mm trocar into the 5-mm trocar position.

Evaluation of Pulmonary Function

A specialist performed the spirometry in the Pulmonary Function Laboratory of the Pulmonology Department of UFTM. A computerized spirometer (Master Screen PFT Jaeger) was used, and the examination was performed according to the standards of the American Thoracic Society (ATS). The patients were instructed to remain in a comfortable, sitting position for five to ten minutes before the test, and at the time of the test, they were instructed to keep the head in a neutral and stable position. The procedure was explained and demonstrated, asking patients to inhale as deeply as possible and exhaled quickly into the mouthpiece of the spirometer, thus preventing air leakage around the spirometer. The examination was performed three times at five-minute rest intervals, and the best values were recorder in the evaluation form.

The evaluation of pulmonary function through spirometry is one of the preoperative procedures performed routinely in patients of the UFTM Department of Digestive Surgery to identify and quantify pulmonary functional alterations. In this study, spirometry was performed in two moments: before and 24 hours after the surgical procedures. The parameters evaluated in this study were forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1) and FEV_1/FVC *ratio*. We expressed the values obtained in liters/second and in percentage of predicted.

FVC is one of the spirometric variables used to determine ventilatory changes and is obtained through forced expiratory maneuver. It represents the maximum volume of exhaled air with maximum effort, from the point of maximum inspiration. When below 80% of predicted, in the presence of normal FEV_1/FVC *ratio*, it suggests restrictive disorder. Confirmation can be made by measuring total lung capacity (TLC). In the absence of these methods, radiologic findings compatible with restrictive disease, associated to the reduction of forced vital capacity, confirm the hypothesis.

FEV_1 represents the amount of air exhaled in the first second of the FVC maneuver. It is the measure of pulmonary function used to determine obstructive ventilatory disorders. FEV_1 is measured by the introduction of time measurements (one second) in the FVC maneuver. It basically evaluates obstructive disorders. When FVC is diminished by restrictive disorders it will decrease proportionally.

The FEV_1/FVC ratio is the *ratio* between these two measures and is the one that best evaluates the presence of obstructive disorders. The expected value for a given individual is derived from the chosen equation. For individuals up to 45 years old, the value of 75% or higher is expected. Below this value, the diagnosis of obstruction is suggestive and should be defined through the parallel analysis of other values such as FEF_{25-75}, FEV_1 and other terminal flows.

RESULTS

Table 1 shows the mean ± standard deviation of age and the anthropometric variables of patients submitted to conventional and single-port laparoscopic cholecystectomy. Height differed significantly between groups (p=0.022). However, this anthropometric variable is not related to the formation of gallstones.

Table 1. *Mean ± standard deviation of anthropometric variables and age.*

Variables	CLC	SPLC	p
Age (years)	38.38±11.72	34.21±10.51	NS
Weight (kg)	69.4±16.76	64.81±9.63	NS
Height (m)	1.57±0.07	1.62±0.04	0.022
BMI (kg/m^2)	27.9±6.52	24.52±3.67	NS

CLC: conventional laparoscopic cholecystectomy; SPLC: single-port laparoscopic cholecystectomy; BMI: body mass index; NS: not significant. Comparison between categories by the Fisher exact test. Comparison of numeric variables, expressed as mean ± standard deviation, by the Student's t test.

The mean time between the beginning and the end of surgical procedures in the group undergoing conventional laparoscopic cholecystectomy was 62.15±27.75 minutes, and in the group submitted to single-port laparoscopic cholecystectomy it was 60.12±18.16 minutes. The mean time between induction/anesthesia and the end of surgical procedures in the group undergoing conventional laparoscopic cholecystectomy was 83.16±29.20 minutes, and in the group undergoing single-port laparoscopic cholecystectomy it was 80.50±18.37 minutes.

Concerning the habits and living conditions questioned in the initial protocol regarding the presence or absence of respiratory diseases and smoking, we observed that in the group undergoing conventional laparoscopic surgery only two patients (9.5%) had bronchitis, one (4.8%) had allergic rhinitis and two patients (4.8%), sinusitis. In the group submitted to single-port laparoscopic surgery, only one patient (5.3%) had sinusitis.

Concerning smoking, we found that only three patients (14.3%) were smokers in the group undergoing conventional laparoscopic surgery; in the group undergoing sigle-port surgery, only six patients (31.6%) were smokers, as shown by table 2.

Table 2. *Comparative analysis the presence of respiratory diseases and smoking in patients undergoing conventional and single port laparoscopic cholecystectomy.*

	CLC		SLPC		p*
	n	%	n	%	
Respiratory diseases					0.4
Bronchitisquite	2	9.5	0	0.0	
Allergic rhinitis	1	4.8	0	0.0	
Sinusitis	1	4.8	1	5.3	
None	17	81.0	18	94.7	
Smoking					0.19
Yes	3	14.3	6	31.6	
No	18	85.7	13	68.4	

*CLC: conventional laparoscopic cholecystectomy; SPLC: single-port laparoscopic cholecystectomy; *Chi-square test.*

Of the 40 patients participating in the study, the ones undergoing spirometry were 14 (66.6%) of the 21 patients in the conventional laparoscopic cholecystectomy group and 16 (84.2%) of the 19 patients in the single-portal group.

Regarding the presence of respiratory diseases, only one (7.14%) patient with bronchitis from the group undergoing conventional laparoscopic cholecystectomy underwent the spirometric tests. The tests of this patient were normal before and after the surgical procedure. In the group submitted to single-port laparoscopic cholecystectomy, the only patient who reported presenting respiratory system disease did not undergo spirometry.

Regarding smoking, only one (7.14%) smoker of the group undergoing conventional laparoscopic cholecystectomy performed the spirometric tests. The tests of this patient were normal before and after the surgical procedure.

In the single-port group five (31.25%) smokers performed the spirometric tests, three (18.75%) presented normal results before and after the surgical procedure, and two (12.5%) presented mild restrictive ventilatory disorder after the surgical procedure. Only one patient in the group undergoing conventional laparoscopic cholecystectomy had respiratory disease and was a smoker, but she did not undergo the spirometric tests.

When comparing the FVC values in the preoperative period with the postoperative period for the conventional laparoscopic cholecystectomy group, the means were, respectively, 3.20±0.12 liters and 2.52±0.14 liters, p=0,0005. When comparing the pre and postoperative FVC values for the single-port group, the mean results were 3.67±0.14 liters for 3.08±0.15 liters, p<0.0001.

When comparing the values of FVC of the conventional *versus* single-port laparoscopic cholecystectomy in the preoperative period, the means were, respectively, 3.20±0.12 liters *versus* 3.67±0.14 liters, p=0.0219 . When comparing the FVC values in the conventional *versus* single-port laparoscopic cholecystectomy in the postoperative period, the means were, respectively, 2.52±0.14 liters *versus* 3.08±0.15 liters, p=0.0119 (Figure 1).

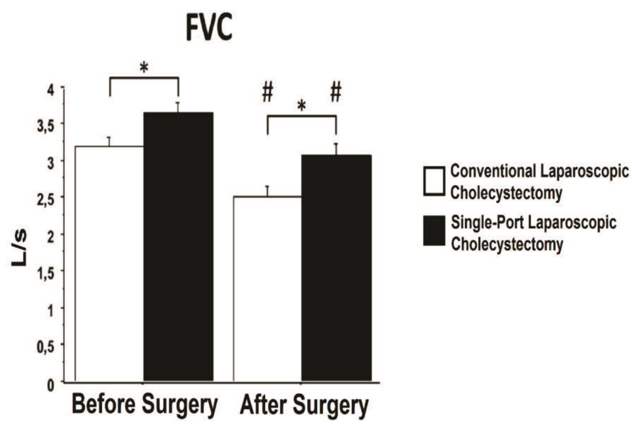

Figure 1. *The bars indicates the mean, and the lines, the standard error of the mean.*
**p<0.05 when comparing the two types of surgery at the same point in time (Student's t-test); #p<0.05 when comparing the pre and preoperative levels of the same procedure (paired Student's t-test).*

When comparing the FEV_1 values in conventional laparoscopic cholecystectomy in the preoperative period, the mean results were 2.69±0.12 liters for 2.12±0.13 liters, p=0,0007. When comparing FEV_1 values for laparoscopic cholecystectomy with a single-port in the preoperative period for the postoperative period, the results of the mean values were 3.11±0.10 liters for 2.64±0.11 liters, p<0.0001.

When comparing the FEV_1 values of the conventional *versus* single-port laparoscopic cholecystectomy in the preoperative period, the mean were, respectively, 2.69±0.12 liters *versus* 3.11±0.10 liters, p=0.0139 . When comparing the FEV_1 values of the conventional *versus* single-port laparoscopic cholecystectomy in the postoperative period, the means were 2.12±0.13 liters vs. 2.64±0.11 liters, p=0.0068 (Figure 2).

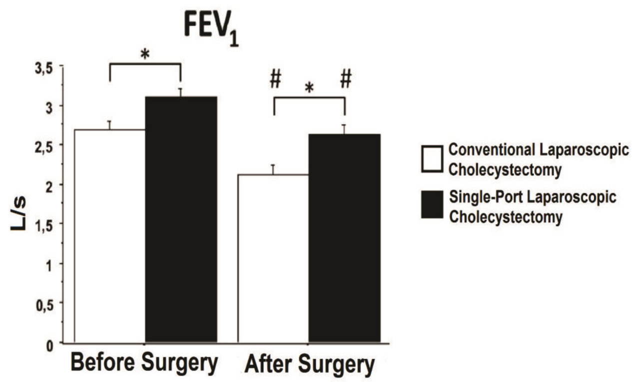

Figure 2. *The bars indicates the mean, and the lines, the standard error of the mean.*
**p<0.05 when comparing the two types of surgery at the same point in time (Student's t-test); #p<0.05 when comparing the pre and preoperative levels of the same procedure (paired Student's t-test).*

When comparing the FEV_1/FVC values of the conventional laparoscopic cholecystectomy in the preoperative period with the postoperative period, the means were, respectively, 84.12%±1.77% and 84.14%±2.13%. When comparing the FEV_1/FVC values for laparoscopic cholecystectomy with a single-port in the preoperative period for the postoperative period, the mean results were 85.25±1.89% for 86.01±1.70%.

When comparing the FEV_1/FVC values in the conventional *versus* the single-port laparoscopic cholecystectomy in the preoperative period, the means were, respectively, 84.12%±1.77% *versus* 85.25%±1.89%. When comparing the values of FEV_1/ FVC in the conventional laparoscopic cholecystectomy group with the single-port one in the postoperative period, the means were, respectively, 84.14±2.13% *versus* 86.01±1.70% (Figure 3).

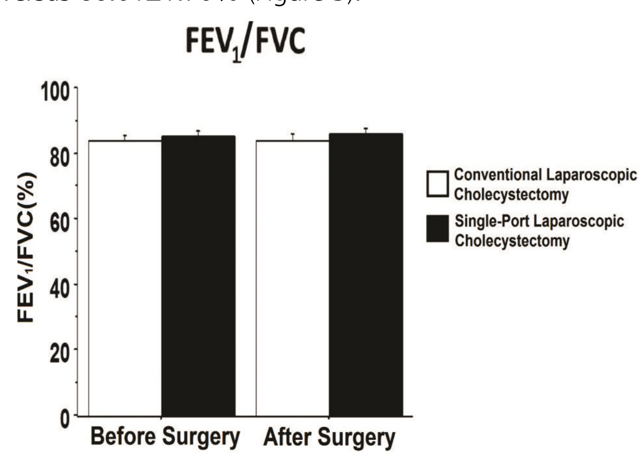

Figure 3. *The bars indicates the mean, and the lines, the standard error of the mean.*
**p<0.05 when comparing the two types of surgery at the same point in time (Student's t-test); #p<0.05 when comparing the pre and preoperative levels of the same procedure (paired Student's t-test).*

DISCUSSION

Some surgical procedures interfere with pulmonary mechanics and tend to develop restrictive ventilatory changes, with a reduction in FEV_1 and FVC, which may reach approximately 40 to 50% of the preoperative value and remain reduced for at least one to two weeks[7]. In most abdominal surgical procedures, these derangements peak on the first postoperative day, when the respiratory system becomes more vulnerable to postoperative pulmonary complications[8,9]. These changes occur especially in upper abdomen operations and are mainly determined by diaphragmatic dysfunction, triggered by the surgical stimuli[10-12].

Several causes have been suggested to explain the decrease in lung volume in abdominal surgery, including pain, anesthesia, surgery time, surgical trauma, and others. However, today, what is most accepted is that this decrease is caused by diaphragmatic paresis, consequent to a reflex inhibition of the diaphragm[13-15]. Ramos *et al.*[16] showed mild restrictive ventilatory disorders, more intense in the immediate postoperative period, with reduction of FVC and FEV_1 in both groups of patients when these two variables were compared pre and postoperatively.

Changes in the pulmonary function in the postoperative of laparoscopic cholecystectomy are less severe, as they produce minimal muscle disruption, minor postoperative pain and allow rapid ambulation[17]. However, some factors specific to laparoscopic surgery tend to increase the risk of thrombosis, such as longer duration of the surgical act in the learning curve, insufflation pressure used for the pneumoperitoneum causing venous stasis of the lower limbs and compression of the inferior vena cava and iliac veins, reversed Trendelemburg position – inverted supine position – necessary for adequate exposure of the operative field that accentuates venous stasis, and hypercoagulability induced by the pneumoperitoneum[18].

Saad and Zambom[19] reported a decrease in lung capacity and FEV_1 in the immediate postoperative period, but total recovery of these values on the fifth postoperative day in large thoracic-abdominal surgeries. The recovery of lung functions after laparoscopic cholecystectomy occurs between five and ten days[20]. In laparoscopic cholecystectomy, the most expected pulmonary complication in the days following surgery is atelectasis, which varies from 10% to 35%[21-23].

Patients' age may also be considered a factor capable of interfering in the postoperative evolution. In our study, the mean age of the two groups was not a risk factor for pulmonary complications.

The incidence of postoperative pulmonary complications such as atelectasis, transient dyspnea and cough is higher in patients with chronic lung disease, increasing the risk of morbidity and mortality after any surgical procedure[24]. Patients included in the present study who reported having some type of respiratory disease did not present respiratory symptoms three months before surgery, which could interfere in the evaluation of lung function loss after the procedures studied. Regarding the presence of respiratory diseases, only one patient with bronchitis, belonging to the group undergoing conventional laparoscopic cholecystectomy, was submitted to the spirometric tests. The results of this patient were normal before and after the procedure. In the group submitted to single-port laparoscopic cholecystectomy, the only patient who reported having respiratory disease did not undergo spirometry. Therefore, we cannot conclude that the presence of respiratory diseases interfered with the spirometric results, since the number of patients submitted to the test who presented respiratory diseases was too small and insufficient for an accurate statement.

Paschoal and Pereira[25] showed that, regardless of the patient's preoperative conditions, the anesthetic and surgical procedure produce changes in the pulmonary physiology that will be determinant in the postoperative evolution. These factors are directly involved in the origin of pulmonary complications, both in patients with previous pulmonary problems and those who have never had pulmonary disease.

Smoking seems to be important in the genesis of postoperative pulmonary complications, since it is associated with a decrease in the secretion transport, an increase in mucus secretion, and in airway narrowing[26-28]. In our study, only one smoker in the conventional laparoscopic cholecystectomy group underwent the spirometric tests, with normal results before and after the surgical procedure. In the single-port group, five patients were smokers: the results showed mild restrictive ventilatory disorder in two patients after the surgical procedure, and in the other three patients, the results were normal before and after the surgical procedure.

The physiological disadvantages of prolonged anesthesia have been widely discussed and include, among others, arrhythmias, myocardial depression, hypotension and hypoxia[29,30]. There is association between the higher incidence of pulmonary complications in the postoperative period of abdominal surgery with an average time of surgery exceeding 210 minutes[31]. In the study by Chiavegato *et al.*[6], there was an average surgical time of 112 minutes, which is already an advantage of laparoscopic cholecystectomy because it reduces the probability of pulmonary complications. In the present study, this advantage was verified in both surgical procedures, since in the group submitted to conventional laparoscopic cholecystectomy the mean time between induction of anesthesia and the end of the surgical procedure was 83.16±29.20min, and in the group submitted to single-port laparoscopic cholecystectomy, 80.50±18.37min.

The impairment of postoperative pulmonary function is lower in laparoscopic surgery than in open surgery, which suggests a lower predisposition of these patients to the development of complications. However, it has been shown that laparoscopy produces small changes, which do have an impact on lung function, especially in patients with previous pulmonary compromise[32]. In the evaluation of respiratory muscle strength in patients of both groups, a greater decline in the maximal inspiratory pressure (MIP) has been observed after 24 hours in the group of patients submitted to conventional laparoscopic cholecystectomy, with a significant difference between groups (p=0.0308)[33].

Laparoscopic cholecystectomy is a surgical procedure with less incidence of pulmonary complications because it has less potential to alter respiratory function[34]. The advantages of single-port laparoscopic cholecystectomy compared to conventional laparoscopic cholecystectomy include decreased surgical trauma, reduced postoperative pain, rapid postoperative mobilization, and shorter hospital stay[35]. In the present study, the values of FVC and FEV_1 were significant when comparing the two types of surgery at the same time and also in the pre and postoperative periods. The results of FVC in this study showed more satisfactory values in the group of patients submitted to single-port laparoscopic cholecystectomy at the times analyzed and in comparison with conventional laparoscopic cholecystectomy.

FVC was characteristically reduced in restrictive disorders. In the present study, we observed that in the postoperative period of the group submitted to conventional laparoscopic cholecystectomy, two patients had mild restrictive ventilatory disorder, one patient, moderate, and one, severe. One patient presented mild restrictive respiratory disorder in the pre and in the postoperative period. In the group of patients submitted to single-port laparoscopic cholecystectomy, five patients presented mild restrictive ventilatory disorder in the postoperative period.

Our FEV_1 results also showed more satisfactory values in the group of patients submitted to single-port laparoscopic cholecystectomy at the times analyzed and in comparison to conventional laparoscopic cholecystectomy. FEV_1 is reduced in obstructive airway diseases, and in the present study, the only one patient undergoing single-port laparoscopic cholecystectomy presented mild obstructive ventilatory disorder. We observed a greater reduction of FVC and FEV_1 in the postoperative period in the group submitted to conventional laparoscopic cholecystectomy.

R E S U M O

Objetivo: avaliar a função pulmonar, através da capacidade vital forçada (CVF) e volume expiratório forçado no primeiro segundo (VEF_1), e a relação VEF_1/CVF% de mulheres submetidas à colecistectomia laparoscópica convencional e por portal único, antes e 24 horas depois do procedimento. **Métodos:** quarenta mulheres com colelitíase sintomática, com idades entre 18 e 70 anos, participaram do estudo. As pacientes foram distribuídas em dois grupos: 21 pacientes foram submetidas à colecistectomia laparoscópica convencional e 19 à colecistectomia laparoscópica por portal único. **Resultados:** nos dois grupos submetidos aos procedimentos cirúrgicos os valores espirométricos da CVF e da VEF_1 no pós-operatório foram inferiores aos valores obtidos no pré-operatório, com redução maior no grupo submetido à colecistectomia laparoscópica convencional. Quanto aos valores da VEF_1/CVF (%) não houve diferença estatisticamente significativa em nenhum dos grupos ou tempos analisados. **Conclusão:** houve maior declínio na CVF e no VEF_1 no pós-operatório do grupo de pacientes submetidas à colecistectomia laparoscópica convencional.

Descritores: Colelitíase. Colecistectomia Laparoscópica. Testes de Função Respiratória. Função Pulmonar. Mulheres.

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