

## Cardiorespiratory evaluation in pre and post operative moments of laparoscopic cholecystectomy<sup>1</sup>

Tatiana Eing Granado Khenafes<sup>I</sup>, Juliana Ferreira de Lima<sup>II</sup>, Rodrigo Severo de Camargo Pereira<sup>III</sup>, Daniele Cristina Cataneo<sup>IV</sup>

DOI: <http://dx.doi.org/10.1590/S0102-86502014000600008>

<sup>I</sup>Fellow Master degree, Postgraduate Program in General Basis of Surgery, Botucatu School of Medicine, Sao Paulo State University (UNESP), Botucatu-SP, Brazil. Acquisition of data.

<sup>II</sup>Fellow PhD degree, Postgraduate Program in General Basis of Surgery, Botucatu School of Medicine, UNESP, Botucatu-SP, Brazil. Acquisition of data.

<sup>III</sup>PhD, Surgeon Assistant, Division of Gastroenterological Surgery, Botucatu School of Medicine, UNESP, Botucatu-SP, Brazil. Acquisition of data.

<sup>IV</sup>PhD, Associate Professor, Division of Thoracic Surgery, Botucatu School of Medicine, UNESP, Botucatu-SP, Brazil. Conception, design, intellectual and scientific content of the study.

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### ABSTRACT

**PURPOSE:** To analyze the changes in both respiratory function and cardiopulmonary exercise tests results in patients subjected to laparoscopic cholecystectomy.

**METHODS:** Fifty patients were evaluated (76% women) and the average age was 47.8±14.2 years. All individuals underwent the measurement of spirometry, manovacuometry, 6-minute walk test (6MWT) and stair-climbing test (SCT). All tests were performed at the first (PO1), fifth (PO5) and thirtieth (PO30) postoperative days.

**RESULTS:** BMI average was 28.8±4.8 kg/m<sup>2</sup>. Sample comprised 68% non-smokers, 20% current smokers, and 12% former smokers. There was no incidence of postoperative complication whatsoever. There was a significant decrease in spirometric values at PO1, but values were similar to the ones of PRE at PO30. Manovacuometry showed alterations at PO1 displaying values that were similar to the ones of PRE at PO30. 6MWT was significantly shorter at until PO5, but at PO30 values were similar to ones of PRE. As for SCT, values were significantly compromised at PO5 and PO30 since they were similar to the ones of PRE.

**CONCLUSION:** Patients submitted to laparoscopic cholecystectomy present a decrease in cardiorespiratory function on the first postoperative moments but there is a rapid return to preoperative conditions.

**Key words:** Cholecystectomy, Laparoscopic. Lung Function Tests. Exercise test.

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## Introduction

At the end of the last century the surgical treatment of gallstones showed a significant advance because of the emergence of new analgesics and anesthetics of quick clearance as well as the development of surgical techniques with minor abdominal wall trauma such as minilaparotomy and laparoscopy<sup>1</sup>.

The laparoscopic surgery technique has rapidly spread because it offers several advantages over conventional open surgery. The diminishment in postoperative pain provided a positive human impact, and the reduction in hospital stay as well as the earlier return to work generated a socioeconomic impact; and the minimal scarring favored aesthetic aspects<sup>2</sup>. However, despite being minimally invasive this surgical method, postoperative complications shall not be disregarded. Among all downsides, pulmonary complications stand out as risk factors of high morbidity in upper abdominal surgery<sup>3</sup>. Among the findings of revolutionary techniques, pneumoperitoneum, which is imperative for the laparoscopy, became the object of important studies owing to its high morbidity rate within the procedures<sup>2</sup>.

It has been evinced that the manipulation of the abdominal cavity in this sort of surgery leads to a diminishment in both pulmonary volume and capacity that might result in respiratory complications such as hypoxemia and atelectasis<sup>4,5</sup>. Thus, the objective of the present study is to analyse the respiratory function behavior in the postoperative moment of laparoscopic cholecystectomy, when compared to the values that were obtained in the preoperative moment (control). It also aimed to assess if mechanical alterations might directly interfere in the results of cardiopulmonary exercise tests such as the 6-minute walk test (6MWT) and stair-climbing test (SCT), since there is no report concerning both tests in the literature.

## Methods

This study was performed in the “Dr. Arnaldo Prado Curvêllo” Bauru State Hospital and was approved by the Ethics Committee from the São Paulo State University, UNESP, Botucatu.

One hundred twenty five patients who signed the free consent and awareness term were subjected to laparoscopic cholecystectomy. Seventy five subjects were excluded from the experiment because: procedure evolved to open surgery (15 patients), there was consent withdrawal at PO1 (20 patients), patient did no return at PO5 (15 patients) or at PO30 (25 patients). Fifty patients were thoroughly evaluated (76% women) and age range was 19 to 74 years, with the average age of  $47.8 \pm 14.2$ .

The sample size was determined based on previous studies in the literature<sup>5</sup>, in which we observed an expected average difference of around 200 mL between pre and postoperative values for the variable “forced expiratory volume” within the first second after surgery ( $FEV_1$ ), with standard deviation of 400 mL, having test power of 95% and 5% level of significance ( $n=50$ ).

This experiment only included patients, who were referred for elective laparoscopic cholecystectomy, aging over 18 years and signed the term of free consent and awareness. Surgery was indicated according to the patient’s clinical conditions which were evaluated by the surgeon, but it was not denied by any unsatisfactory test results since it was blind to them. Subjects with prior lung disease, history of unstable angina or myocardial infarction within the previous three months, as well as decompensated heart failure, musculoskeletal, neurological or vascular alterations that impeded ambulation, resting pulse higher than 120 bpm and needed to change surgical technique at the intraoperative moment were excluded from the experiment.

The anamnesis was performed at the preoperative moment (PRE) and it gathered the patient’s age, weight and height for the calculation of body mass index (BMI), and collected the history of the current disorders, presence of comorbidity, previous surgeries, the use of medication and smoking habit history. Subjects also answered a questionnaire concerning physical exercise activities<sup>6</sup>. Then, they underwent pulmonary function tests (spirometry), respiratory muscle strength test (manovacuometry) and cardiopulmonary exercise test (6MWT) and SCT.

The diaphragmatic index (DI1) was established by the formula  $DI_1 = \Delta AB / \Delta AB + \Delta TC$ , in which  $\Delta$  corresponds to the difference between the abdominal circumference (AB) and the thorax circumference (TC), measured during maximum inspiration followed by regular expiration<sup>5</sup>. The thorax expansion ( $DI_2$ ) was determined by the formula  $DI_2 = \Delta XF / \Delta XF + \Delta AX$  by measuring the circumference from the axillary fold (AX) and the xiphoid process (XF), in the same way that was performed for  $DI_1$ <sup>7</sup>. Measuring was performed twice and the average from both values were taken into consideration. Spirometry was performed with a calibrated portable Pony FX<sup>®</sup> spirometer with the patient seated, using a nose clip according to American Thoracic Society (ATS). Standards<sup>8</sup> in order to obtain the forced vital capacity (FVC), tidal volume (TV),  $FEV_1$ , and maximum voluntary ventilation (MVV). The minute volume (MV) was obtained with the patient seated and breathing quietly for one minute in a Wright Respirometer<sup>®</sup> (haloscale standard) using a nose clip. The maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) were respectively measured starting from the residual volume (RV) and total lung capacity (TLC) according to brazilian guidelines<sup>9</sup>, using a Salcas<sup>®</sup> analog manometer with the range of -200 to + 200 cm/

H<sub>2</sub>O. The predicted values were expressed according to the equations suggested for the Brazilian population<sup>10</sup>.

The 6MWT was performed according to the ATS guidelines<sup>11</sup>, in a 30-meter-long corridor at the basement of the Bauru State Hospital. This corridor had well-signalized “start” and “finish” marks at the track and each meter that was walked had also a sign. Enright and Sherrill<sup>12</sup> formulas were used to estimate the distance. Still, by the end of the test, it was applied a classification scale for the subjective perception concerning the level of effort (Borg’s effort perception index<sup>13</sup>). SCT was performed in the shadow according to Cataneo *et al.*<sup>14</sup> on a 12.24 m ladder. The stair climbing time (SCT) was measured in seconds (s) and the patient’s weight was used for the calculation of power (PTE) in watts (w) through the classical formula<sup>15</sup>. At the beginning and end of the tests the respiratory rate (RR), heart rate (HR) and peripheral oxygen saturation (SpO<sub>2</sub>) were measured.

The intra-operative period was monitored by the observation of the anesthetic record and surgery description in order to detect possible intra-operative complications. All patients had their follow-ups performed by the very same observer who did all the tests previously mentioned at the first (PO1), fifth (PO5) and thirtieth (PO30) post-operative days. Only the SCT was not performed at PO1.

The general characteristics of the studied population including pre, intra and post-operative data were presented by descriptive statistics. For all variables, except pain, it was used the analysis of variance for repeated measurements followed by Tukey test to compare the average of moments. Friedmann test was used for the pain scale since this variable did not present a

normal distribution. For variables in which the interest laid on the comparison of two different moments, it was used the Student’s t-test for dependent populations. For the statistical analysis it was used the Statistical Analysis System (SAS) version 9.2.

### Results

Sixty-eight percent of those subjects were non-smokers, 12% were former smokers, and 20% were smokers and BMI range from 20.4 to 38.9 with the average of 28.8±4.8 kg/m<sup>2</sup>. As for comorbidities, 18 patients presented hipertension, and out of these patients five also presented associated diabetes mellitus, four presented kidney failure and two presented epilepsy. When it comes to physical activities, 30 patients were considered moderately active, 11 active and nine inactive.

All individuals underwent general anesthesia with average surgery time of 102.6±31.2 minutes. There was not any expected post-operative complication as a consequence of alterations in ventilation. Ambulation started at PO1 and patient was discharged on the very same day, as for the pain it was registered as being of low intensity only at PO1 and PO5.

DI1 and DI2 did not present statistical differences in any of the studied moments (Table 1). FVC and FEV<sub>1</sub> displayed a significant decrease at PO1, being similar to PRE values at PO30. MVV presented a significant decrease at PO1, presenting values similar to the ones of PRE at PO5 (Table 1). TV and MV did not show any statistical difference in any studied moment, it just increased at PO1 (Table 1). MIP and MEP had a decrease of 25% and 26%, respectively in relative

**TABLE 1** - Mean values and standard deviation regarding diaphragmatic index, spirometry, manovacuometry and p values.

Variable	MOMENTS					P
	PRE	PO1	PO5	PO30		
DI <sub>1</sub>	0.45±0.10	0.44±0.12	0.45±0.11	0.47±0.11		0.50
DI <sub>2</sub>	0.55±0.12	0.58±0.11	0.56±0.10	0.54±0.11		0.19
FVC (L)	3.09±0.80a	2.55±0.81c	2.87±0.76b	3.07±0.82a		<0.001
FVC %	99.3±17.7a	81.6±22.8c	91.7±15.6b	98.1±17.2a		<0.001
FEV <sub>1</sub> (L)	2.69±0.70a	2.25±0.70c	2.46±0.68b	2.63±0.71a		<0.001
FEV <sub>1</sub> (%)	100.7±17.6a	83.7±22.9c	93.3±16.9b	97.8±22.2ab		<0.001
MVV (L)	97.6±25.8ab	74.8±25.3c	90.4±32.6b	98.9±31.5a		<0.001
MVV %	90.3±20.9a	69.4±22.4b	86.6±23.0a	92.7±23.4a		<0.001
TV	0.42±0.20	0.43±0.22	0.40±0.18	0.42±0.24		0.84
MV	6.9±2.7	7.9±2.9	7.0±2.3	7.1±4.2		0.16
RR	17.4±5.7b	19.5±6.1a	18.5±5.5ab	17.8±6.1b		0.001
MIP <sub>(cmH2O)</sub>	-68.6±33.6a	-50.8±25.0b	-70.1±30.5a	-68.6±33.6a		<0.001
MIP <sub>(%)</sub>	72.0±32.0a	54.0±24.0b	66.0±27.0a	74.0±28.0a		<0.001
MEP <sub>(cmH2O)</sub>	87.6±38.1a	65.9±32.9c	78.9±35.7b	92.1±36.8a		<0.001
MEP <sub>(%)</sub>	91.0±35.0a	67.0±29.0c	81.0±32.0b	95.0±32.0a		<0.001

Lower case letters compare the mean values of time moments. Moments followed by at least one letter in common are not statistically different.

values at PO1. MIP showed values that were similar to the ones of PRE at PO5 and MEP showed the same pattern only at PO30 (Table 1).

The distance that was covered in the 6MWT was significantly shorter than the one of PRE for both PO1 and PO5, but at PO30 values were similar to the ones of PRE (Table 2). SCT values were significantly compromised at PO5 and at PO30 since they were already similar to the ones of PRE (Table 2). According to Borg's scale it was observed that the fatigue was significantly higher at PO1 after 6MWT, whereas SCT showed no difference

no complication even though 20% of the studied population was consisted of smokers.

The average BMI was 28.8Kg/m<sup>2</sup>, which could have led to a diminishment in alveolar ventilation especially in dorsal decubitus<sup>18</sup>. Even though patients were overweight, this did not compromise the post-operative period.

Some authors found a direct correlation between a surgical time that exceeded 210 minutes and a higher incidence of pulmonary complications in the post-operative moment of

**TABLE 2** - Mean values and standard deviation regarding walking test, stair climbing test and p values.

Variable	MomentS				
	PRE	PO1	PO5	PO30	p
<b>6MWT</b> <sub>(m)</sub>	492.8±64.2a	423.1±73.9c	471.8±74.7b	501.2±66.4a	<0.001
<b>6MWT</b> <sub>(%)</sub>	89.0±15.0a	76.0±16.0c	85.0±15.0b	90.0±14.0a	<0.001
<b>SCT</b> <sub>(s)</sub>	48.0±16.2b	-	53.2±16.3a	47.6±12.0b	<0.001
<b>PTE</b> <sub>(w)</sub>	197.2±54.8a	-	178.6±54.9b	198.3±64.1a	<0.001
<b>BORG</b> <sub>6MWT</sub>	9.1±1.7c	10.7±2.0a	9.6±1.8bc	10.0±2.1a	<0.001
<b>BORG</b> <sub>SCT</sub>	13.4±1.8	-	13.5±1.9	13.4±2.6	0.91

Lower case letters compare mean values of studied time moments. Time moments followed by at least one letter in common are not statistically different.

among the three studied moments, despite the fact that SCT fatigue was higher than the one of 6MWT (Table 2).

After 6MWT there was no significant decrease in SpO<sub>2</sub>, but HR and RR increased at all studied moments (p<0.01). After SCT, there was significant decrease in SpO<sub>2</sub> at all studied moments, and both HR and RR had a higher increase in values when compared to those after 6MWT (p<0.001).

### Discussion

The frequency of female patients that are subjected to cholecystectomy ranges from 61.9% to 90%<sup>16</sup>, and this epidemiological characteristic was also revealed in the present study, in which 76% of the sample consisted of women.

Age is an important predictive factor for complications after cholecystectomy due to the increased incidence of complicated gallbladder disorder and higher morbidity of surgery in elder patients owing to correlated disorders. Despite the fact that our sample included several individuals aging over 60 years with several comorbidities, there were no complications in the post-operative moment. Smokers' red blood cells present a diminishment in the oxygen transportation capacity and thus increase the risk of atelectasis and pulmonary infections in the post-operative period<sup>17</sup>. However, in the present study there was

abdominal surgeries<sup>19</sup>. In our study the average surgical time was about half of the one mentioned by those authors, and thus this might have corroborated with the absence of pulmonary complications.

According to the literature, pulmonary complications in the post-operative period of conventional abdominal surgery usually range from 30% to 80%<sup>20,21</sup>. In laparoscopic cholecystectomy the most expected pulmonary complication on the days immediately after surgery is atelectasis, which varies in 10% to 35% of incidence<sup>4</sup>. In the present study it was observed mild restrictive ventilatory disorders, which were more severe on PO1, with the diminishment of FVC, FEV<sub>1</sub> and MVV. FVC and FEV<sub>1</sub> kept low values at PO5 ensuring the restrictive characteristic of the post-operative ventilatory disorder, which might have occurred owing to either microatelectasis or respiratory muscle deficit.

Despite the tendency to increase MV at PO1 due to the increase in RR, such difference was non-significant, and all post-operative MV values were similar to the ones of PRE. On the other hand, Chiavegato *et al.*<sup>5</sup> showed in their study concerning pulmonary function in the post-operative moment of laparoscopic cholecystectomy that there was a 26% decrease of MV and 36% of TV, thus suggesting that these variables present a decrease due to the diminishment of pulmonary compliance and the formation of microatelectasis. Maybe this discrepancy of results might have

occurred because in the present study the intensive care provided to the patients were focused on avoiding microatelectasis.

It is known that pulmonary function impairment in the post-operative moment of laparoscopic cholecystectomy is not as severe as in conventional open surgery, which leads to a lower tendency of developing complications. Nevertheless, it was demonstrated that even though laparoscopy produces minor alterations, they have certain impact on the pulmonary function, especially in those patients with previous pulmonary impairment<sup>4,5,21-25</sup>. Other studies also suggest that the muscle weakness is similar after both conventional open surgery and laparoscopic cholecystectomy, but the conventional one causes a lengthier reduction of muscle function, contributing to a higher incidence of respiratory complications<sup>5,22-25</sup>. In the present study, it was observed that MIP, in absolute numbers, was already lower if compared to the ones of the general population, taking into account that mean values did not reach 80%. The surgery itself led to a greater diminishment of MIP at PO1, but at PO5 values were already similar to the ones of PRE, proving that at that moment the subject has already returned to the normal condition of good alveolar ventilation. As for MEP, it presented regular values at the pre-operative moment, displayed a sharp decline at PO1, which continued but in a moderate fashion at PO5, showing that at that moment patients had bigger difficulty in eliminating secretions, which leads us to a bigger support concerning physiotherapy of patients of previous lung disorders during the pre-operative and first post-operative days<sup>26</sup>.

Some authors analyzed the DI of individuals that underwent laparoscopic cholecystectomy and found a decrease of 36 to 47% at PO1<sup>5,27</sup>, unlike the present study which showed that there was not any significant statistical difference in any studied moment. It is believed that there is a correlation between ambulation and DI, and ambulating patients would not have changes in DI, agreeing with the mean values of this study. This shows the importance of the early ambulation that was suggested in this study to patients at PO1 and also the early discharge. Notwithstanding, it is important to mention that data gathered at PO1 were obtained after ambulation, which might justify the discrepancy with data from other authors<sup>5,27</sup>.

The application of pre-operative exercise tests could detect alterations in the oxygen transportation that would only be discovered when the patient might have displayed a higher metabolic need in the intra or post-operative moment<sup>28</sup>. Prior studies<sup>14,15</sup> showed that if the patient is able to walk 500 meters or more in the 6MWT or takes 40 seconds or less to climb up a 12m ladder, it is most likely that his  $VO_2$  is above 25mL/Kg/min, which

makes him a patient of low risk for complications after toracic and upper abdomen surgeries. The subjects included in the present study showed a mean value for 6MWT at PRE that was about 500 meters and the SCt of 48 seconds, which proves their good performance at PRE. 6MWT and SCt decreases were significant from PO1 up to PO5, but their differences from PRE values were very little, thus proving that the aggression caused by the surgery did not lead to great performance loss for the patients.

Borg's scale is easy to be used, provides good repeatability, and has been used as a method to self-adjust to physical activities aiming to reach a desirable effort level, which includes the submaximal activity. It showed that fatigue in SCT is bigger when compared to 6MWT, which was proved by the bigger increase of HR and RR on SCT rather than on 6MWT.

The most important test for the PRE evaluation was the SCT because it revealed a significant decrease in  $SpO_2$  at PRE with a more significant increase of both RR and HR than in the 6MWT. Adding to these objective data, the subjective evaluation of Borg's scale also showed that fatigue was significantly higher after SCT. This evaluation allowed us to say that the stress of exercise showed that these patients had low surgical risk, because despite the fact that  $SpO_2$  had decreased in all studied moments, this decrease was little and it did not reach 4% which would be considered critical by Brunelli *et al.*<sup>29</sup>. Even after the surgery it could be noticed that the patients' performance was kept the same since the decrease in  $SpO_2$  as well as the increase of both HR and RR after exercise had no significant difference when compared to PRE values. Maybe if SCT was applied at PO1 there might have been a decrease in  $SpO_2$ , and that was the reason for not applying SCT on that moment, thus avoiding such risk to the patient.

## Conclusion

Patients subjected to laparoscopic cholecystectomy present a more significant decrease in cardiorespiratory function on the first postoperative moments but there is a rapid return to PRE conditions, and at PO5 there are many parameters that display no difference between PRE values.

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**Correspondence:**

Daniele Cristina Cataneo  
 Departamento de Cirurgia e Ortopedia  
 Disciplina Cirurgia Torácica  
 Faculdade de Medicina de Botucatu-UNESP  
 18618-970 Botucatu - SP Brazil  
 Tel.: (55 14)3811-609  
 Fax: (55 14)3815-7615  
 dcataneo@fmb.unesp.br

Received: Jan 22, 2014  
 Review: March 20, 2014  
 Accepted: April 23, 2014  
 Conflict of interest: none  
 Financial source: Sao Paulo Research Foundation (FAPESP)

<sup>1</sup>Research performed at Bauru State Hospital. Part of Master degree thesis, Postgraduate Program in General Basis of Surgery, Botucatu School of Medicine, Sao Paulo State University (UNESP), Bauru-SP, Brazil. Tutor: Daniele Cristina Cataneo.