

# Correlation between intra-abdominal pressure and pulmonary volumes after superior and inferior abdominal surgery

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**OBJECTIVE:** Patients undergoing abdominal surgery are at risk for pulmonary complications. The principal cause of postoperative pulmonary complications is a significant reduction in pulmonary volumes (FEV<sub>1</sub> and FVC) to approximately 65-70% of the predicted value. Another frequent occurrence after abdominal surgery is increased intra-abdominal pressure. The aim of this study was to correlate changes in pulmonary volumes with the values of intra-abdominal pressure after abdominal surgery, according to the surgical incision in the abdomen (superior or inferior).

**METHODS:** We prospectively evaluated 60 patients who underwent elective open abdominal surgery with a surgical time greater than 240 minutes. Patients were evaluated before surgery and on the 3<sup>rd</sup> postoperative day. Spirometry was assessed by maximal respiratory maneuvers and flow-volume curves. Intra-abdominal pressure was measured in the postoperative period using the bladder technique.

**RESULTS:** The mean age of the patients was 56 ± 13 years, and 41.6% 25 were female; 50 patients (83.3%) had malignant disease. The patients were divided into two groups according to the surgical incision (superior or inferior). The lung volumes in the preoperative period showed no abnormalities. After surgery, there was a significant reduction in both FEV<sub>1</sub> (1.6 ± 0.6 L) and FVC (2.0 ± 0.7 L) with maintenance of FEV<sub>1</sub>/FVC of 0.8 ± 0.2 in both groups. The maximum intra-abdominal pressure values were similar ( $p=0.59$ ) for the two groups. There was no association between pulmonary volumes and intra-abdominal pressure measured in any of the groups analyzed.

**CONCLUSIONS:** Our results show that superior and inferior abdominal surgery determines hypoventilation, unrelated to increased intra-abdominal pressure. Patients at high risk of pulmonary complications should receive respiratory care even if undergoing inferior abdominal surgery.

**KEYWORDS:** Abdominal Surgery; Intra-Abdominal Pressure; Pulmonary Volumes.

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## INTRODUCTION

The main risk factors associated with postoperative pulmonary complications are chest or superior abdominal surgery, smoking, chronic obstructive pulmonary disease (COPD), advanced age, obesity, emergency procedure, duration of surgery and anesthesia (1-9).

Patients undergoing abdominal surgery are at increased risk for pulmonary complications in the postoperative period, with consequent increases in both the length of hospital stay and morbidity and mortality (10-12). The incidence of these complications varies widely in the overall population, ranging from 10 to 80% (2,13), mainly due to the imprecise definition of pulmonary complications in the postoperative period (2,9,13,14). The most common respiratory complications are atelectasis, respiratory infections, wheezing and respiratory failure (2,3,7,8,13,15). The main cause of postoperative pulmonary complications is a significant reduction in the forced expiratory volume in one second (FEV<sub>1</sub>) and in the forced vital capacity (FVC) to approximately 65-70% of the predicted value (1-3,11,12). Nevertheless, inferior abdominal surgeries are associated with a reduction of only 10 to 15% of the preoperative

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functional residual capacity (FRC), whereas in superior abdominal surgeries, thoracotomy and pulmonary resection, the expected reduction is approximately 35% (3,16).

Another frequent occurrence after abdominal surgery is increased intra-abdominal pressure (IAP) (17-20). Elevated IAP can directly interfere with lung function, causing a reduction in compliance and pulmonary volumes (FVC, FRC), especially in the presence of intra-abdominal hypertension (IAH), which is defined as a sustained or repeated pathological elevation in IAP >12 mmHg (21-25). Nevertheless, postoperative abdominal surgeries and critically ill adult patients usually present an IAP between 5 and 7 mmHg (17-20). The association between the intra-abdominal pressure in the immediate postoperative period and changes in pulmonary volumes in patients undergoing abdominal surgery still remains unknown.

The aim of this study was to correlate the changes in FEV<sub>1</sub>, FVC and FEV<sub>1</sub>/FVC obtained in the postoperative period with the values of IAP after abdominal surgery.

## METHODS

We recruited 80 consecutive patients who underwent abdominal surgery between March 2007 and December 2008 in the Hospital das Clínicas, Gastroenterology Department, University of São Paulo Medical School. All patients over eighteen years of age who were undergoing elective open abdominal surgery with a midline incision and surgical time greater than 240 minutes were included after signing an informed consent (ethical committee protocol number 850). We excluded patients undergoing emergency surgery or thoracotomy (n=2), patients with COPD (n=3) and patients with heart disease (n=1), morbid obesity (n=1), or previous abdominal surgery (n=1). Ultimately, 72 patients were included in the study.

### Procedures

Patients were evaluated before surgery and on the 3<sup>rd</sup> postoperative day. Data regarding patient identification, anthropometrics and lung function tests were collected (10,26,27). Spirometry was assessed by maximal respiratory maneuvers and flow-volume curves (Micro Loop, California, USA). Patients breathed through a disposable mouthpiece positioned between the teeth and lips, ensuring that no leaks occurred during forced expiration. The adopted technical procedures and the criteria for acceptability and reproducibility follow the recommendations by the European Respiratory Journal (28). FEV<sub>1</sub> and FVC were assessed. Absolute values (in liters) and percentage (% predicted for the Brazilian population) were analyzed (25).

IAP was measured in the postoperative period via the bladder. In this technique, the drainage path of the Foley catheter that was previously introduced in the operating room for diuresis monitoring was occluded. A pressure transducer was connected to an 18-G plastic intravenous infusion catheter inserted into the culture aspiration port of the Foley catheter and zeroed at the level of the patient's mid-axillary line. The infusion catheter was previously flushed with saline and then attached to a stop-cock by arterial pressure tubing. With the patient in the supine position and the Foley catheter clamped, 20 ml of saline was injected into the bladder and the IAP was measured during end expiration. We recorded the maximum IAP value.

## Statistical analysis

The sample size was estimated to be 30 patients per group. The normality of the variables was tested with the Kolmogorov-Smirnov test. A descriptive analysis was performed on all data. The unpaired t test was used to compare continuous variables with a normal distribution and the Mann-Whitney test was used for variables with a non-normal distribution. To determine the influence of surgery on the spirometry variables, we used the two-way ANOVA analysis of variance with a Tukey post hoc test when a significant difference was detected. Analyses of the correlation between IAP and spirometry values were performed pre- and postoperatively using the Pearson test for parametric variables and the Spearman test for non-normal distribution. The tests were performed using Sigma Stat for Windows version 3.2 (San Jose, California, United States). A p value less than 0.05 was adopted as the level of statistical significance.

## RESULTS

Of the 72 patients included in this study, 12 were excluded (8 were unable to perform spirometry measurements postoperatively and 4 had the urinary catheter discontinued before the IAP measurement), leaving 60 patients for the final analysis. Among patients who completed the study, the mean age was 56 ± 13 years and 41.6% (25) were females. The mean BMI was 25 ± 4.6 kg/m<sup>2</sup> and 50 patients (83.3%) had malignant disease (gastric and colorectal cancer).

The patients were divided into two groups according to the surgical incision (superior or inferior – 30 patients in each group). The lung volumes obtained in the preoperative period showed no abnormalities (in the absolute values or percentage of predicted) in the FEV<sub>1</sub> and FVC in either group. Comparing the baseline values, there was no difference between the two groups. However, after surgery, there was a significant reduction in both FEV<sub>1</sub> (1.6 ± 0.6 L) and FVC (2.0 ± 0.7 L) (Table 1).

**Table 1 - Pulmonary volumes and intra-abdominal pressure before and after surgery.**

Pulmonary volume	Surgery	Preoperative	Postoperative	p
FEV <sub>1</sub> (L)	SUP	2.2 ± 0.8	1.6 ± 0.6*	0.02
	INF**	2.5 ± 0.8	1.9 ± 0.6*	0.01
FEV <sub>1</sub> (%)	SUP	87.0 ± 23.1	59.0 ± 19.9*	<0.001
	INF	90.0 ± 18.1	70.5 ± 19.9*	<0.001
FVC (L)	SUP	2.7 ± 0.9	2.0 ± 0.7*	0.01
	INF	3.0 ± 0.9	2.4 ± 0.7*	0.01
FVC (%)	SUP	87.5 ± 20.9	67.0 ± 18.6*	<0.004
	INF	83.5 ± 16.4	64.3 ± 16.6*	<0.001
FEV <sub>1</sub> /FVC	SUP	0.8 ± 0.2	0.8 ± 0.2	0.35
	INF	0.8 ± 0.1	0.8 ± 0.2*	0.04
FEV <sub>1</sub> /FVC (%)	SUP	99.5 ± 15.6	95.5 ± 23.7*	0.04
	INF	103.0 ± 10.1	104.0 ± 15.2	0.38
IAP (mmHg)	SUP		8.3 ± 2.9	0.59
	INF		8.1 ± 1.8	

Where: SUP= superior abdominal surgery; INF= inferior abdominal surgery; FEV<sub>1</sub> = forced expiratory volume in one second (Liters); FVC= forced vital capacity (Liters/min), % = percentage of the predicted value for the Brazilian population (25), IAP = intra-abdominal pressure (mmHg); \* p<0.05; \*\* p<0.01.



Nevertheless, the max IAP was similar ( $p=0.59$ ) in both groups (Table 1).

There was no association between the lung volumes and IAP in any of the groups.

## ■ DISCUSSION

The respiratory muscle functions are affected during and after abdominal surgery (8,12,14), especially in the upper abdomen, either from manipulation or from surgical incision of the abdominal muscle groups. The reduced activity of these muscles lasts for 48 hours after surgery and may persist for up to a week before gradually returning to normal. In the lower abdominal surgery, dysfunction of the respiratory muscles is less frequently observed (approximately 2-5%), whereas in the upper abdominal surgeries, dysfunction of the respiratory muscles affects 20-40% of patients (8,14). Anesthesia and pain also significantly contribute to the dysfunction of these muscles (8,12).

The pulmonary impairment frequently observed in postoperative abdominal surgery includes restrictive diseases (VT and FRC reductions), hypoxemia, changes in breathing patterns and increased respiratory rate (3,8,16,29,30). The risk of postoperative pulmonary complications decreases with the distance from the incision in relation to the diaphragm (3,16). However, our results indicate that abdominal surgery in the upper abdomen and in the lower abdomen leads to substantial reductions in lung volume without a significant difference between the groups. The FEV<sub>1</sub>/FVC ratio was maintained postoperatively in both groups (upper and lower abdominal surgery), demonstrating that there is a proportional reduction in lung volume with no predominance of restrictive or obstructive disorders. Interestingly, our results showed that, compared with the preoperative values, there was a 25% decrease in FEV<sub>1</sub> after inferior abdominal surgery, which is similar to the results found in the study by Lindberg et al. (31). Our findings confirm the results of a previous study that included an inferior abdominal incision as an independent risk factor for postoperative pulmonary complications in a study involving 266 patients (32).

The IAP showed no significant increase in either group and remained in the normal range. Our data are consistent with the findings of Khan et al. (33), who studied 197 patients who underwent laparotomy and found that 157 of them exhibited IAP within normal limits in the postoperative period.

Our study involves some methodological limitations: it was not possible to assess the IAP in the preoperative period, but no patient presented risk factors for intra-abdominal hypertension or abdominal compartment syndrome (20), such as major trauma or burns, gastroparesis, gastric distention, paralytic ileus, colonic obstruction, acute pancreatitis, distended abdomen, hemoperitoneum, intra-peritoneal fluid collection (infection/abscess), or liver cirrhosis with ascites before surgery. Additionally, we did not evaluate postoperative pain in our patients, although pain can influence lung volumes. However, there was no significant difference between groups in these variables.

Our results show that superior and inferior abdominal surgeries affect lung function, causing hypoventilation unrelated to an increase in intra-abdominal pressure. Patients at high risk of pulmonary complications should

receive attention and respiratory care even if undergoing inferior abdominal surgery (34,35).

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## ■ AUTHOR CONTRIBUTIONS

De Cleve R, Santo MA and Filho WJ were responsible for the study conception and design, manuscript drafting and critically review of the manuscript. Assumpção MS, Sasaya F, Chaves NZ, and Lunardi A measured the intra-abdominal pressure and performed the spirometry in all patients. All authors participated of the analysis and interpretation of the data. All authors contributed to and approved the final version of the manuscript. All authors take public responsibility for the content of the manuscript.

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