

# Incidence and risk factors for postoperative pulmonary complications in patients undergoing thoracic and abdominal surgeries

## *Incidência e fatores de complicações pulmonares pós-operatórias em pacientes submetidos à cirurgias de tórax e abdome*

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### ABSTRACT

**Objective:** to determine the incidence of postoperative pulmonary complications in patients undergoing abdominal and thoracic surgery and investigate the risk factors for their occurrence. **Methods:** we conducted a prospective, observational and analytical study with all the patients undergoing thoracic and abdominal surgeries at the Santo Antônio Hospital in Blumenau, SC. We collected data from medical records and structured interviews with patients, regarding the characteristics of patients and procedures. The outcome variable was the occurrence of postoperative pulmonary complications in the medical record. **Results:** we studied 314 patients, 65.6% female, with an average age of 46.61 years. Of the sample, 51.6% was ASA II, 55.7% of the surgeries were performed by laparoscopy or thoracoscopy, 85.4% were in the abdomen, and 61.5% were potentially contaminated and of medium-scale procedures. The average time of surgery was 126.65 minutes and the average length of hospital stay was 2.59 days. The incidence of postoperative pulmonary complications was 11.5%. The most common complications were respiratory failure, pleural effusion and pneumonia. The most important risk factor were diabetes, hospitalization for more than five days and the presence of pulmonary disease. Patients operated by laparoscopy or thoracoscopy had fewer complications. **Conclusion:** postoperative pulmonary complications are frequent and factors associated with greatest risk were diabetes, prolonged hospitalization and presence of previous lung disease.

**Keywords:** Postoperative Complications. Respiratory Tract Diseases. Risk Factors.

### INTRODUCTION

Despite advances in perioperative care, postoperative complications continue to affect the recovery of surgical patients<sup>1</sup>. Among surgical complications, pulmonary ones are the second most common type, following the complications related to surgical site infection<sup>2</sup>. They can be defined as conditions that compromise the respiratory tract and that may adversely influence the patient's clinical condition after surgery. They increase perioperative mortality and are the main cause of postoperative morbidity and mortality in both cardiothoracic and noncardiothoracic surgeries. They also contribute to the increase of the hospitalization time and the re-hospitalization rates, raising the financial expenses with health care<sup>2,3</sup>.

The incidence can vary from 2% to 40% according to risk factors of the patient or those of the surgical procedure. Postoperative pulmonary complications (PPC) include respiratory insufficiency,

pneumonia, tracheal re-intubation within 48 hours or tracheal intubation for more than 48 hours due to the maintenance of mechanical ventilation due to acute respiratory failure, atelectasis, bronchospasm, exacerbation of chronic obstructive pulmonary disease (COPD), pneumothorax and pleural effusion<sup>3</sup>. PPCs are more common in thoracic and abdominal surgeries, with incidence varying from 12 to 70%<sup>4</sup>.

Risk factors for PPC are congestive heart failure, surgical risk classification by the American Society of Anesthesiologists (ASA) II or greater, functional dependence and advanced age, reduction of peripheral oxygen saturation, respiratory infection in the month preceding the surgical procedure, anemia (hemoglobin= 10g/dL), surgical incision near the diaphragm, surgery long duration and emergency surgery<sup>5</sup>.

In this sense, the objective of this study was to study postoperative pulmonary complications to assess their incidence submitted to chest and abdominal

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surgeries and identify the main factors involved in their occurrence.

## METHODS

This is a prospective, observational, analytical study, which used, as data collection tools, the electronic charts and previously structured interviews with patients submitted to chest and abdominal surgeries at the Blumenau Santo Antônio Hospital – SC – in a period of five months (August 2015 to December 2015).

Inclusion criteria were patients older than 18 years who underwent chest and/or abdominal surgery during the period of data collection. Intraoperative death, due to any cause, was considered an exclusion criterion. All participants signed a Free and Informed Consent Form and the Ethics in Research Committee of Santo Antônio Hospital approved the research project under the protocol number 44656215.6.0000.5359.

We collected data regarding age, gender, presence or absence of lung disease prior to the surgical procedure, smoking, weight and height for calculation of Body Mass Index (BMI), diabetes mellitus, systemic arterial hypertension, neoplastic disease and other comorbidities, data that were present in the patient's electronic medical records or reported by them during the structured interview.

Regarding the surgical procedure, was collected information on the procedure time, anatomical site (thorax and/or abdomen), ASA classification of surgical risk, degree of contamination (clean, potentially contaminated, contaminated, infected), procedure extension (minor, midsize, major), days of hospitalization after the procedure and type of surgical access, whether by video or not.

The outcome variable was the occurrence of PPCs recorded in the electronic patient record, through which the patients were monitored daily. We searched for pneumonia, tracheobronchitis, atelectasis, respiratory failure, prolonged tracheal intubation, bronchospasm, pulmonary embolism, pulmonary edema and pneumothorax or pleural

effusion. The criteria used to determine the presence and classification of postoperative pulmonary complications were those established by Silva *et al.*<sup>4</sup>.

We tabulated the collected data in the Microsoft Office Excel® program and later analyzed them through descriptive and inferential statistics. We present the characteristics of the participants in tabular form, as absolute and relative frequencies, with the respective 95% confidence intervals. For continuous variables, we calculated central (mean) and dispersion (standard deviation) trends. We studied the association between the outcome variable and the risk factors, which involved patient characteristics and surgical procedure, using the chi-square biostatistical test. We accepted a significance level of  $p < 0.05$ . We included the factors that presented  $p < 0.05$  at the chi-square test in a logistic regression analysis with the aid of the EpiInfo® program, and expressed the results with the odds ratio.

## RESULTS

There were 314 patients participating in the study. Table 1 shows the sample characteristics.

Table 2 shows the sample characteristics regarding the surgical procedure.

Postoperative pulmonary complications are presented in table 3 in descending order of frequency.

Table 4 describes the chi-square test statistically significant associations between variables related to the sample characteristics or to the surgical procedure and the PPC outcome variable. The variables: arterial hypertension, gender, surgical site, smoking and age were not significantly associated with the occurrence or not of PPC.

The result of the multivariate logistic regression analysis of the evaluated factors and the occurrence of PPC, presented in table 5, revealed some more strongly associated risk and protection factors.

During the study, there were seven deaths in the postoperative period, among which only one patient did not present PPC directly. Deaths were attributed to septic shock, cardiorespiratory arrest and multiple organ failure. This study was not able to

**Table 1.** Characteristics of the sample.

Descriptive characteristics	n (%)	95% CI
<b>Gender</b>		
Male	108 (34.4%)	(29.14-39.65)
Female	206 (65.6%)	(60.35-70.86)
<b>Smoking</b>		
No	178 (56.7%)	(51.21-62.17)
Yes	47 (15%)	(11.02-18.91)
Ex-smokers	86 (27.4%)	(22.46-32.32)
Not informed	1 (0.3%)	(0-0.94)
<b>DM</b>		
No	265 (84.4%)	(80.38-88.41)
Yes	47 (15%)	(11.02-18.91)
Not informed	2 (0.6%)	(0-1.52)
<b>SAH</b>		
No	210 (66.9%)	(61.67-72.08)
Yes	102 (32.5%)	(27.3-37.66)
Not informed	2 (0.6%)	(0-1.52)
<b>Comorbidities</b>		
No	194 (61.8%)	(56.41-67.16)
Yes	118 (37.6%)	(32.22-42.94)
Not informed	2 (0.6%)	(0-1.52)
<b>Previous lung disease</b>		
Yes	51 (16.2%)	(12.16-20.32)
No	261 (83.1%)	(78.98-87.26)
<b>Quantitative characteristics</b>		
	Mean $\pm$ SD	95% CI
Age (Years)	(46.61 $\pm$ 15.98)	(44.85-48.38)
Weight (Kg)	(77.25 $\pm$ 23.09)	(74.69-79.81)
Height (cm)	(165.12 $\pm$ 12.03)	(166.45-163.78)
BMI (Kg/m <sup>2</sup> )	(29.16 $\pm$ 15.69)	(27.42-30.9)

CI= confidence interval; SD= standard deviation; DM= diabetes mellitus; SAH= systemic arterial hypertension; BMI= body mass index.

evaluate whether or not these deaths were associated with postoperative pulmonary complications.

## DISCUSSION

In this study, patients submitted to chest and abdominal surgeries had a PPC incidence of 11.5%, higher than that found by the American College of Surgeons (5.8%) after abdominal surgeries<sup>2</sup>. Two large studies, the ARISCAT (Assess Respiratory Risk in Surgical Patients in Catalonia)<sup>6</sup> and the PERISCOPE (Prospective

Evaluation of a Risk Score for Postoperative Pulmonary Complications in Europe)<sup>7</sup>, that evaluated the risk factors for the occurrence of postoperative pulmonary complications in non-cardiac surgeries, presented complication rates of 5% and 7.9%, respectively. There was no statistically significant difference when surgery was performed on the thorax or abdomen.

Although the incidence of PPCs in this study may appear to be high compared to the ARISCAT, PERISCOPE and American College of Surgeons studies, we should note that these studies were not performed

**Table 2.** Characteristics related to the surgical procedure.

Characteristics	n	95% CI
ASA		
I	83 (26.4%)	(21.56-31.31)
II	162 (51.6%)	(46.06-57.12)
III	66 (21%)	(16.51-25.53)
IV	3 (1%)	(0-2.03)
V	0	0
Video surgery		
No	139 (44.3%)	(38.77-49.76)
Yes	175 (55.7%)	(50.24-61.23)
Surgical site		
Abdomen	268 (85.4%)	(81.44-89.26)
Chest	44 (14%)	(10.17-17.85)
Thorax and Abdomen	2 (0.6%)	(0-1.52)
Degree of contamination		
Clean	84 (26.8%)	(21.86-31.65)
Potentially contaminated	193 (61.5%)	(56.08-66.85)
Contaminated	34 (10.8%)	(7.39-14.26)
Infected	3 (1%)	(0-2.03)
Size of surgery		
Minor	14 (4.5%)	(2.18-6.74)
Medium	193 (61.5%)	(56.08-66.85)
Major	106 (33.8%)	(28.53-38.99)
Special	1 (0.3%)	(0-0.94)
Pulmonary complications		
Yes	36 (11.5%)	(7.94-14.99)
No	278 (88.5%)	(85.01 92.06-)
Surgery time (min)	Mean ± SD	95% CI
	126.65 ± 95.92	116.04-137.26
Length of stay (days)	Mean ± SD	95% CI
	2.59 ± 3.93	2.15-3.02

CI= confidence interval; SD= standard deviation.

specifically in patients undergoing chest and abdominal surgeries, but only in the abdomen (American College of Surgeons) and non-cardiac surgeries (ARISCAT and PERISCOPE). PPC are more common in thoracic and abdominal surgeries, and the incidence was 18.2% in a study performed by a group from Porto Alegre (RS)<sup>4</sup>.

In the ARISCAT study, the main complications reported were pulmonary infection (24%), respiratory insufficiency (4.7%) and pleural effusion (3.1%), compatible with the results of this sample, respectively 9.2%, 1.3 % and 1.3%.

In this study, we recorded only clinically significant pleural effusions, reaching 1.3% of the sample. However, we believe that the percentage of pleural effusion in the postoperative period is higher when also considering the clinically non-important ones. A group from São Paulo found a high rate of pleural effusion in the postoperative period (70.3%) through ultrasound examinations in a study that aimed to attest the sensitivity of this exam<sup>8</sup>.

Conditions such as systemic arterial hypertension, heart disease and diabetes mellitus have

**Table 3.** Postoperative pulmonary complications.

Complication	n (%)	95% CI
Respiratory failure	29 (9.2%)	(6.03-12.44)
Pleural effusion	4 (1.3%)	(0.03-2.51)
Pneumonia	4 (1.3%)	(0.03-2.51)
Prolonged mechanical ventilation	3 (1%)	(0-2.03)
Bronchospasm	2 (0.6%)	(0-1.52)
Tracheobronchitis	2 (0.6%)	(0-1.52)
Pulmonary edema	2 (0.6%)	(0-1.52)
Pneumothorax	1 (0.3%)	(0-0.94)
Atelectasis	1 (0.3%)	(0-0.94)
Pulmonary embolism	1 (0.3%)	(0-0.94)
Prolonged intubation	3 (1%)	(0-2.03)

CI= confidence interval.

previously been described in association with a higher risk for PPC<sup>4</sup>. Specifically on diabetes, one study identified the relationship between elevated glycated hemoglobin levels and the increased risk of developing postoperative complications, even with glycated hemoglobin levels lower than those established for the diagnosis of diabetes mellitus<sup>9</sup>. The diabetic patients in this sample had a nearly five-fold increased risk of presenting this outcome, emphasizing the metabolic control prior to the surgical procedure as an important factor in the prevention of PPC.

The presence of COPD is a commonly identified risk factor for PCP, being one of the most cited, with a risk greater than 18%, and varying with disease severity<sup>5</sup>. This factor was significantly associated with PPC in this study. However, when treated and controlled prior to the surgical procedure, COPD patients have the same incidence of PPCs as healthy subjects<sup>4</sup>, as is also expected to occur with diabetes.

The extremes of nutritional status, malnutrition and obesity, also have an influence on the risk of PPC development. In this study, although the univariate analysis was significant, the multivariate analysis no longer was. In malnourished patients, low serum albumin is an established risk for PPC because it is associated with changes in pulmonary dynamics and functioning of the respiratory muscles, and is related to

higher rates of pneumonia. On the other hand, obese patients present physiological changes such as decreased ventilation-perfusion ratio due to under-ventilation and to high tissue perfusion. They also present a decrease in pulmonary complacency and chest movement secondary to the accumulation of adipose tissue in the thoracic wall<sup>5</sup> and abdominal cavity, hampering the diaphragmatic mobility<sup>10</sup>. In addition, obese patients are more difficult to mobilize during the postoperative period, which implies greater risk of deep venous thrombosis and, consequently, pulmonary thromboembolism<sup>5</sup>.

The ASA risk classification was also associated with the development of PPC. According to the study conducted by Silva *et al.*<sup>4</sup>, ASA II patients have an increased risk of PPC. Surgical time is also important, and when greater than three hours, was associated with a higher occurrence of PPC. Likewise, the greater the surgical size, the greater the risk for PPC<sup>11</sup>.

Patients submitted to video surgeries (laparoscopic or thoracoscopic) presented lower PPC rates when compared with those submitted to conventional open procedures. We cannot state that video surgeries act as protective factors because it was not possible to measure the risks involved in the different procedures performed by video or open. However, it is known that patients submitted to

**Table 4.** Association of factors with pulmonary complications through the Chi-square test.

Factors	Postoperative pulmonary complications		Total	p
	Yes	No		
Diabetes				
Yes	11 (31.4%)	36 (13%)	47 (15.1%)	0.0041
No	24 (68.6%)	241 (87%)	265 (84.9%)	
Surgery by video				
No	30 (83.3%)	109 (39.2%)	139 (44.3%)	0.0000
Yes	6 (16.7%)	169 (60.8%)	175 (55.7%)	
Presence of neoplasm				
No	21 (58.3%)	214 (77%)	235 (74.8%)	0.0153
Yes	15 (41.7%)	64 (23%)	79 (25.2%)	
Previous lung disease				
No	20 (57.1%)	241 (87%)	261 (83.7%)	0.0000
Yes	15 (42.9%)	36 (13%)	51 (16%)	
BMI				
Low weight	6 (16.7%)	14 (5.1%)	20 (6.4%)	0.0300
Normal weight	12 (33.3%)	114 (41.3%)	126 (40.4%)	
Overweight	7 (19.4%)	89 (32.2%)	96 (30.8%)	
Obesity I	4 (11.1%)	33 (12%)	37 (11.9%)	
Obesity II	7 (19.4%)	25 (9.1%)	32 (10.3%)	
Obesity III	0 (0%)	1 (0.4%)	1 (0.3%)	
Surgical risk classification WING				
I	3 (8.3%)	80 (28.8%)	83 (26.4%)	0.0000
II	15 (41.7%)	147 (52.9%)	162 (51.6%)	
III	15 (41.7%)	51 (18.3%)	66 (21%)	
IV	3 (8.3%)	0 (0%)	3 (1%)	
V	0 (0%)	0 (0%)	0 (0%)	
Degree of contamination				
Clean	8 (22.2%)	76 (27.3%)	84 (26.8%)	0.0127
Potentially contaminated	20 (55.6%)	173 (62.2%)	193 (61.5%)	
Contaminated	6 (16.7%)	28 (10.1%)	34 (10.8%)	
Infected	2 (5.6%)	1 (0.4%)	3 (1%)	
Surgical size				
Minor	1 (2.8%)	13 (4.7%)	14 (4.5%)	0.0000
Medium	10 (27.8%)	183 (66.1%)	193 (61.7%)	
Major	25 (69.4%)	81 (29.2%)	106 (33.9%)	
Surgical time				
Up to 3 hours	24 (66.7%)	246 (88.5%)	270 (86%)	0.0004
Greater than or equal to 3 hours	12 (33.3%)	32 (11.5%)	44 (14%)	
Inpatient days				
Up to 1 day	6 (16.7%)	168 (60.4%)	174 (55.4%)	0.0000
2 to 5 days	18 (50%)	92 (33.1%)	110 (35%)	
More than 5 days	12 (33.3%)	18 (6.5%)	30 (9.6%)	

BMI= body mass index.

**Table 5.** Results of the multivariate analysis (logistic regression) of the factors assessed and the occurrence of PPC

Factors	Or	95% CI	Z-Statistic	p
Hospitalization for more than 5 days	7.2507	(2.54 -20.65)	3.7087	0.0002
Diabetes	4.8299	(1.87 -12.43)	3.2637	0.0011
Previous lung disease	5.5381	(2.28 -13.41)	3.7932	0.0001
Video surgery	0.1949	( -0.53 0.07)	-3.1796	0.0015
Infected surgery	9.3066	(0.63 -137.18)	1.6250	0.1042

Or= Odds Ratio; CI= confidence interval; Z= statistics generated by logistic regression analysis; p= value of significance.

video-surgeries present smaller incisions, less systemic inflammatory responses, reduced postoperative pain and better pulmonary function, which emphasizes the option for this type of surgical access<sup>5</sup>.

The degree of contamination was also associated with a higher occurrence of PPC in this study, and patients submitted to infected surgeries had a nine-fold greater risk of developing such complications.

The presence of neoplastic disease was associated with the occurrence of PPC. This association can be explained by the fact that these patients present severe disease, often with anorexia-cachexia syndrome (ACS). This syndrome is characterized by intense consumption, with consequent involuntary weight loss, malnutrition and physiological, metabolic and immunological changes. Malnutrition is often very prevalent in cancer patients and is associated with greater risks of postoperative infection and increased morbidity and mortality<sup>12</sup>.

Length of hospitalization greater than five days was strongly associated with the occurrence of PPC. However, we cannot say whether it is the longer hospitalization time that predisposes the occurrence of complications due to the decrease in mobility, the greater exposure to microbial agents, or the patients who present complications remain hospitalized for a longer time precisely to treat such complications. PPCs, in general, prolong the length of hospital stay, increase the consumption of hospital resources and may lead to patients' death<sup>13</sup>.

We found no relation between age and the occurrence of PPCs, though we expected this association. The physiological aging of the respiratory

system leads to a decrease in the elasticity of the parenchyma and pulmonary complacency, in the strength of the muscles involved in respiration, and a decrease in the alveolar surface and cilia of the respiratory tract. These changes may lead to poor coughing and increased respiratory work, with increased dependence on the diaphragm. There is also a decrease in oxygen partial pressure and an increase in the dead space, which decrease the pulmonary ventilation-perfusion ratio. These factors, associated with some postoperative conditions such as immobility and the use of narcotics, generally lead to a high probability of atelectasis and pulmonary aspiration, with the development of pneumonia<sup>14</sup>.

Another factor that was also expected to be a risk for the occurrence of PPC but was not significantly associated with this type of complication in this study was smoking. Smokers also present physiological changes that may alter the responses to surgical procedures, contributing to the increase in postoperative morbidity due to the high risk of developing respiratory, cardiovascular and healing complications<sup>15</sup>. One of the main alterations implicated in smoking is damage to the cilia of the tracheobronchial mucosa and increased mucus production with high consistency, in addition to an increased susceptibility to alveolar collapse, leading to a higher chance of infection in the lower airways and prolonged mechanical ventilation<sup>5</sup>.

We conclude that postoperative pulmonary complications were frequent in our study and are associated with higher morbidity and mortality. Identifying risk factors predisposing to this outcome may help in the elaboration of prevention strategies.

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## R E S U M O

**Objetivos:** avaliar a incidência de complicações pulmonares pós-operatórias em pacientes submetidos à cirurgias de tórax e abdome e os principais fatores envolvidos. **Métodos:** estudo analítico observacional prospectivo dos pacientes submetidos à cirurgias de tórax e abdome no Hospital Santo Antônio de Blumenau, SC. Os dados foram coletados dos prontuários eletrônicos e através de entrevistas estruturadas com os pacientes. Foram avaliados dados relativos às características dos pacientes e da cirurgia. A variável de desfecho foi a ocorrência de complicações pulmonares pós-operatórias. **Resultados:** foram estudados 314 pacientes, 65,6% do sexo feminino, com média de idade de 46,61 anos, 51,6% classificados como ASA II. Cirurgias por vídeo foram realizadas em 55,7% dos casos, abdominais em 85,4% e 61,5% dos procedimentos foram classificados como potencialmente contaminadas e de porte médio. O tempo médio de cirurgia foi de 126,65 minutos e os pacientes ficaram internados em média por 2,59 dias. A incidência de complicações pulmonares pós-operatórias foi de 11,5%. As complicações mais comuns foram a insuficiência respiratória, o derrame pleural e a pneumonia. Os fatores de risco mais importantes para estas complicações foram diabetes, internação hospitalar por mais de cinco dias e presença de doença pulmonar prévia. Os pacientes submetidos às cirurgias por vídeo apresentaram menor incidência de complicações. **Conclusão:** as complicações pulmonares pós-operatórias são frequentes e os fatores associados a maior risco foram diabetes, internação prolongada e presença de doença pulmonar prévia.

**Descritores:** Complicações Pós-Operatórias. Doenças Respiratórias. Fatores de Risco.

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Received in: 08/01/2017

Accepted for publication: 30/03/2017

Conflict of interest: none.

Source of funding: This study was sponsored by the Scientific Initiation Scholarship for the author Ana Carolina de Avila, Medical School graduate at the Regional University of Blumenau. The grant was provided by the National Council for Scientific and Technological Development (CNPq).

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