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## SCIENTIFIC ARTICLE

# Analysis of the prevalence of atelectasis in patients undergoing bariatric surgery<sup>☆</sup>



Letícia Baltieri<sup>a</sup>, Fabiana Sobral Peixoto-Souza<sup>b</sup>, Irineu Rasera-Junior<sup>c</sup>,  
Maria Imaculada de Lima Montebelo<sup>d</sup>, Dirceu Costa<sup>b,e</sup>, Eli Maria Pazzianotto-Forti<sup>d,\*</sup>

<sup>a</sup> Universidade Estadual de Campinas (Unicamp), Programa de Pós-Graduação em Ciências da Cirurgia, Campinas, SP, Brazil

<sup>b</sup> Universidade Nove de Julho (Uninove), Programa de Pós-Graduação em Ciências da Reabilitação, São Paulo, SP, Brazil

<sup>c</sup> Clínica Bariátrica de Piracicaba, Piracicaba, SP, Brazil

<sup>d</sup> Universidade Metodista de Piracicaba (Unimep), Programa de Pós-Graduação em Ciências do Movimento Humano, Piracicaba, SP, Brazil

<sup>e</sup> Universidade Federal de São Carlos (UFSCar), Programa de Pós-Graduação em Fisioterapia, São Carlos, SP, Brazil

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### KEYWORDS

Morbid obesity;  
Bariatric surgery;  
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### Abstract

**Background and objective:** To observe the prevalence of atelectasis in patients undergoing bariatric surgery and the influence of the body mass index (BMI), gender and age on the prevalence of atelectasis.

**Method:** Retrospective study of 407 patients and reports on chest X-rays carried out before and after bariatric surgery over a period of 14 months. Only patients who underwent bariatric surgery by laparotomy were included.

**Results:** There was an overall prevalence of 37.84% of atelectasis, with the highest prevalence in the lung bases and with greater prevalence in women (RR = 1.48). There was a ratio of 30% for the influence of age for individuals under the age of 36, and of 45% for those older than 36 (RR = 0.68). There was no significant influence of BMI on the prevalence of atelectasis.

**Conclusion:** The prevalence of atelectasis in bariatric surgery is 37% and the main risk factors are being female and aged over 36 years.

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<sup>☆</sup> Institution: Universidade Metodista de Piracicaba (Unimep), Piracicaba, SP, Brazil.

\* Corresponding author.

E-mail: [empforti@unimep.br](mailto:empforti@unimep.br) (E.M. Pazzianotto-Forti).

**PALAVRAS-CHAVE**

Obesidade mórbida;  
Cirurgia bariátrica;  
Atelectasia  
pulmonar;  
Especialidade  
em Fisioterapia

**Análise da prevalência de atelectasia em pacientes submetidos à cirurgia bariátrica****Resumo**

*Justificativa e objetivo:* Observar a prevalência de atelectasia em pacientes submetidos à cirurgia bariátrica e a influência do índice de massa corporal (IMC), sexo e idade sobre a prevalência de atelectasia.

*Método:* Estudo retrospectivo de 407 pacientes e laudos de radiografias de tórax realizadas antes e após a cirurgia bariátrica durante um período de 14 meses. Apenas os pacientes submetidos à cirurgia bariátrica por laparotomia foram incluídos.

*Resultados:* Houve uma prevalência geral de atelectasia de 37,84%, com maior prevalência nas bases pulmonares e em mulheres (RR = 1,48). Houve uma proporção de 30% para a influência da idade nos indivíduos com idade inferior a 36 anos e de 45% naqueles com idade superior a 36 anos (RR = 0,68). Não houve influência significativa do IMC sobre a prevalência de atelectasia.

*Conclusão:* A prevalência de atelectasia em cirurgia bariátrica é de 37%, e os principais fatores de risco são sexo feminino e idade superior a 36 anos.

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**Introduction**

Obesity has reached epidemic proportions, and in 2008 over 1.4 billion adults were overweight.<sup>1,2</sup> In addition to the comorbidities that accompany obese subjects, some changes in the respiratory system and lung function can also be found, due to the accumulation of fat around the ribs, diaphragm and abdomen, thus limiting movement of the rib cage.<sup>3</sup>

Obesity is a chronic disease,<sup>3,4</sup> and bariatric surgery is indicated for patients who do not respond to conservative treatment.<sup>4</sup>

In a study by Chung et al.<sup>5</sup> it was shown that obesity is a forerunner for the appearance of intra and post-operative respiratory complications during or after surgery. Since gastropasty, one of the bariatric surgery techniques, is upper abdominal surgery, it presents changes inherent to this procedure, such as reduced lung volumes, increased respiratory rate and respiratory muscle dysfunction.<sup>6</sup> The appearance of atelectasis is frequent amongst all types of patient during general anesthesia.<sup>7,8</sup> On submitting patients to elective upper abdominal surgery, Pereira et al.<sup>9</sup> found a 32% incidence of pulmonary complications in patients who presented the restrictive pulmonary syndrome, as compared to 6% of complications in patients without respiratory co-morbidities. Atelectasis appeared in 34% of the whole sample.

The situation is worse in obese patients in whom atelectasis may appear and persist for up to 24 h after extubation, which does not occur in non-obese patients.<sup>10</sup> Moreover, even during the surgical procedure, handling the abdominal cavity results in diaphragmatic elevation and further increases the possibility of atelectasis.<sup>11</sup>

According to Martí-Valeri et al.,<sup>12</sup> who studied patients suffering from obstructive apnea sleep syndrome (OASS), a prevalence of 17% of atelectasis was diagnosed by chest radiography after bariatric surgery.

However, there is a lack of data in the literature concerning the prevalence of atelectasias after bariatric surgery,

even though it is known that this could constitute one of the causes of pulmonary dysfunction and respiratory failure in these patients.

To recognize and identify postoperative respiratory complications after upper abdominal surgery could contribute to the development of preventive strategies.

The hypothesis of this study is that patients with morbid obesity who undergo surgery may have a higher index of atelectasis due to increased abdominal fat and the need for general anesthesia.

The aim of this study was to observe the prevalence of atelectasis in obese and morbidly obese patients who undergo gastropasty using the Roux-Y Gastric Bypass technique (RYGB) by laparotomy, evaluating the chest X-rays 48 h after surgery, and also observing any influence of the BMI, gender or age on the prevalence of atelectasis.

**Methods**

The study followed ethical guidelines and was approved by the Ethics Committee of the Methodist University of Piracicaba, SP, Brazil (protocol number 09/08). This is a retrospective study in which chest X-ray reports made after bariatric surgery were analyzed at the moment of hospital discharge (48 h after surgery). Data were collected for a period of 14 months. The reports were collected from the medical records of patients who had undergone bariatric surgery.

Only patients submitted to RYGB-type bariatric surgery by laparotomy, with a BMI above 35 kg/m<sup>2</sup>, no pulmonary symptoms or lung disease, normal pulmonary function test and normal preoperative chest X-ray, were included. All patients were submitted to the pulmonary function test and had a chest X-ray, but no lung diseases were identified. Dyspnea was not considered as a respiratory co-morbidity, since it is common in patients with morbid obesity.

Patients were excluded if they suffered from OASS or asthma, or showed any surgical (fistulas, bleeding, etc.) or clinical complications that could interfere with the length

of their hospital stay, lead to an increased risk of pulmonary complications, require hospitalization in the Intensive Care Unit (ICU) or the use of continuous pressure airway pressure (CPAP), bi-level positive airway pressure (BIPAP) therapy or additional oxygen-therapy apart from the standardized one during postoperative recovery, or who showed unstable postoperative conditions.

They were submitted to a pre-anesthetic of inhaled sevoflurane and intravenous propofol, with maintenance of the anesthetic by continuous infusion pumping of remifentanyl. Neuromuscular blockers (rocuronium, pancuronium) were administered during the procedure and also morphine, the latter being administered until complete post-anesthetic recovery, as required. Dipirona and ketoprofen were used as analgesics in the ward by way of a periferic catheter. Mechanical ventilation was carried out using the Dräger Fabius GS equipment in the controlled volume mode with a tidal volume of 6–8 mL/kg, PEEP of 5 cm H<sub>2</sub>O and inhaled oxygen fraction between 0.4 and 0.6. The patients remained in the hospital for three days and their pre-operative chest X-ray reports showed no parenchymal lung alterations according to the report made by the radiologist.

In the postoperative period, all patients received conventional respiratory physiotherapy twice a day, with deep breathing, use of incentive spirometry, resources for bronchial hygiene if needed, active or assisted coughing and assisted walking (at least 60m) during the session. In addition, all patients took part in a follow-up preoperative multidisciplinary group (doctor, physiotherapist, dietician, psychologist and physical trainer).

The radiological examinations were carried out during the postoperative period, i.e., 48 h after bariatric surgery, before hospital discharge. There were four sessions of physiotherapy before taking the chest X-rays, with two sessions on the first postoperative day and two sessions on the second postoperative day.

The chest X-ray examinations were evaluated from the report issued by the hospital radiologist. The following criteria were used to detect the presence of atelectasis according to Woodring and Reed<sup>13</sup>: displacement of interlobular fissures, pulmonary opacity, elevation of the diaphragm, displacement of the trachea, heart, mediastinum and pulmonary hilum, compensatory hyperinflation of the lungs, coming together of the ribs and loss of alveolar volume. Data regarding age, gender, height, current body mass, ideal body weight, body mass excess and BMI were also collected.

The data were processed using the Statistical Package for Social Sciences for Personal Computers (version 13.0) and the BioStat (version 5.3). The Shapiro–Wilk test was applied to test normality and, in the case of normality; the data were presented as the mean and standard deviation (SD). The patients included were computed in the database along with the demographic and dichotomized information as “yes” or “no” for the following radiographic changes: atelectasis, cardiac abnormalities, pneumoperitoneum, pulmonary congestion, pleural effusion and pneumonia. The statistical analysis was based on a study of the relationship between the results of the atelectasis detection test and the variables: BMI, age and gender, using the relative risk (RR) with a confidence interval of 95%. In addition, the

**Table 1** Characteristics of the group: continuous variables.

	Mean ± SD	Range
Age (years)	36.96 ± 10.16	18–68
Height (cm)	163.40 ± 8.33	142–194
Body mass (kg)	121.05 ± 21.99	79.8–238.3
Excess body weight (kg) <sup>a</sup>	65.98 ± 20.35	26–174.2
BMI (kg/m <sup>2</sup> )	45.16 ± 6.33	35.46–74.37

BMI, body mass index.

<sup>a</sup> Based on the ideal body weight recommended by the Metropolitan Life Foundation.<sup>14</sup>

chi-square (*G*-test) was used to analyze the statistical association between gender and atelectasis. For the BMI and age data, cut-off points were established for the analysis, based on the median of the data. *p*-Values ≤ 0.05 were considered statistically significant.

## Results

The mean surgery time was 132 ± 12 min. The patients remained in the post-anesthesia recovery room for an average of 3 h and received a 28% oxygen supply during this period. When necessary, they received analgesics according to a medical prescription and respiratory physical therapy twice a day during the post-operative period, including exercises with deep and fractionated inspiration, coughing, use of a respiratory encourager and deambulation.

Of the patients with normal preoperative chest X-rays, 413 patients were selected, and their postoperative chest X-rays (one per patient) were collected for analysis. Of these, six patients and their postoperative chest X-rays were excluded because they were taken in the expiration phases, hampering the analysis. Thus 407 patients and their exams were analyzed. Tables 1 and 2 summarize the characteristics of the group, and it can be seen that women made up the majority of the sample, 82.8%.

**Table 2** Characteristics of the group: categorical variables.

	<i>n</i>	%
<i>Gender</i>		
Female	337	82.8
Male	70	17.2
<i>BMI</i>		
<40	92	22.6
40–49	224	55.04
≥50	84	20.64
<i>Smoker</i>		
Yes	32	7.86
No	346	85.01
<i>Ex-smoker</i>		
Yes	29	7.13
No	317	77.89

BMI, body mass index.

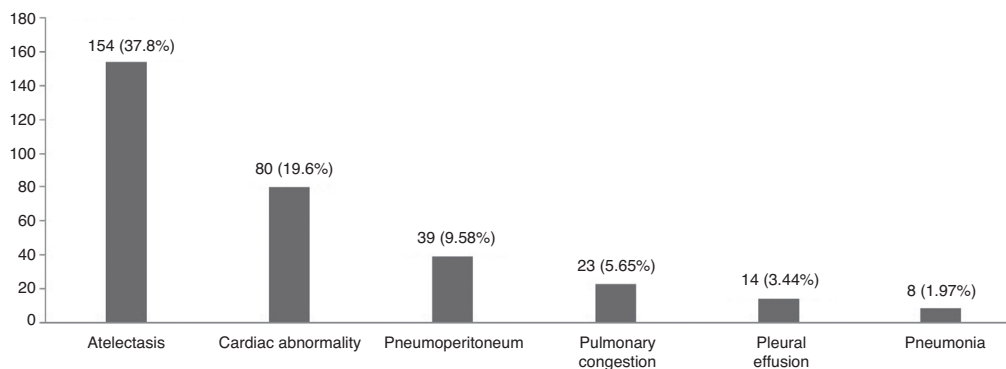


Figure 1 Prevalence of radiographic alterations.

Table 3 Location of atelectasis.

Location of atelectasis	n (%)
<i>Right lung</i>	
Base	26 (6.58)
Third middle	5 (1.27)
Apex	1 (0.25)
Base and third middle	1 (0.25)
<i>Left lung</i>	
Base	24 (6.08)
Third middle	9 (2.28)
Apex	1 (0.25)
Total	2 (0.51)
<i>Bilateral</i>	
Bases	58 (14.68)
Predominance on left	9 (2.28)
Predominance on right	7 (1.77)
Third middle	5 (1.27)
Bases and third middle	2 (0.51)
Others	4 (1.01)

On analyzing the radiology reports a prevalence of 37.84% of atelectasis was observed in the sample (Fig. 1), located mainly in the lung bases, as can be seen in Table 3.

It can be seen in Table 3 that some patients presented atelectasis in more than one region of the lung. However, it is worth mentioning that none of the patients diagnosed with atelectasis showed any clinical repercussions.

A statistically significant difference was found between the genders for the prevalence of atelectasis, with greater prevalence in women ( $p=0.043$ ). By analyzing the relative risk a RR of 1.48 (95% CI 0.98–2.21,  $p=0.02$ ) was observed and a ratio of 40% for women and 27% for men. When analyzing the influence of age on the prevalence of atelectasis an RR of 0.68 (95% CI 0.52–0.88,  $p=0.001$ ) was found and a ratio of 30% for individuals under the age of 36 years and 45% for individuals over the age of 36 years. The RR of the BMI for the prevalence of atelectasis was 0.94 (95% CI 0.73–1.21,  $p=0.35$ ) with a prevalence of 36% for individuals with BMI below 44 kg/m<sup>2</sup> versus 38% for individuals with a BMI above 44 kg/m<sup>2</sup>.

## Discussion

It can be seen that women made up the majority of the sample in this study, in agreement with the study of Ogden et al.<sup>15</sup> in which a higher prevalence of obesity was observed in women.

In bariatric surgery, several studies have reported that obesity is an independent risk factor for the development of postoperative complications,<sup>5,16,17</sup> and during general anesthesia, pulmonary complications often arise, including atelectasis.<sup>7,18</sup> However the results of this study showed no increase in the risk of atelectasis due to the increase in BMI. According to Woodring and Reed,<sup>13</sup> the morbidly obese can show compression atelectasis of the lung parenchyma as a result of the abdominal contents moving the diaphragm in a cephalic direction, which can be aggravated in the supine position. During general anesthesia, atelectasis can develop, even in healthy individuals, and is associated with an increased intra-operative shunt, leading to gas exchange impairment.<sup>19</sup> Perhaps the best explanation for its occurrence is a dysfunction of the diaphragm by way of an inhibition of the phrenic nerve reflex during surgical manipulation, with consequent diaphragmatic paresis.<sup>20</sup> Atelectasis appears within minutes after the induction of anesthesia at 85%–90%, and its adverse effects persist in the postoperative period, affecting recovery of the patient.<sup>10,19,21</sup> Such effects of general anesthesia are more pronounced in obese individuals.

In a study carried out by Eichenberger et al.<sup>10</sup> obese and eutrophic individuals were accompanied by chest computed tomography, carried out in the periods before the induction of anesthesia, after extubation and 24 h after surgery. They observed that atelectasis appeared in both patient profiles after the induction of anesthesia, but in the eutrophic individuals it was resolved in a few hours, whereas it persisted for up to 24 h after surgery in the obese individuals. The results presented in this study showed a high prevalence of atelectasis (37.84%) in the population of patients undergoing bariatric surgery. Although dealing with laminar atelectasis, the presence of this change can generate greater impact in the morbidly obese, who already have alterations in lung function and respiratory muscle mechanics.<sup>3,22,23</sup>

Chest radiography after bariatric surgery is a routine procedure in the hospital, and was always done on the

second day after surgery, or approximately 48 h after surgery. The study of Eichenberger et al.<sup>10</sup> stopped the assessments 24 h after extubation, but the present study still observed a high prevalence of atelectasis even 48 h after surgery.

The presence of atelectasis in the postoperative period may result in the very frequent complaint of dyspnea in morbidly obese patients.<sup>24</sup> Most of the atelectasis observed in the present study was located in the lung base regions. According to Sood<sup>25</sup> the obese individual has increased airway closure in the dependent regions of the lung and there is cephalic displacement of the diaphragm due to the compression of the abdominal contents. In these patients, these alterations are more pronounced after bariatric surgery, adding other factors such as pain, the fear of breathing deeply and suppression of the cough mechanism, either because of pain or decreased mucociliary clearance due to intubation, anesthesia and analgesia, causing the accumulation of pulmonary secretions and favoring the emergence of atelectasis.<sup>26</sup>

The hypotheses of this study included the possibilities of increasing atelectasis with increasing age and BMI. This hypothesis was only confirmed for the age variable, for which, by adopting the median value of 36 years, a higher prevalence of atelectasis was observed in the older group. The fact that no relationship was found between BMI and the prevalence of atelectasis can be explained by the sample being composed only of morbidly obese patients, those most at risk for developing atelectasis.<sup>10</sup> If the sample had been constituted of eutrophic individuals in the same postoperative clinical conditions and surgical procedure, maybe the risk observed would have been higher in the morbidly obese patients. As for the female gender as a risk factor for the development of atelectasis, one hypothesis which may explain this, at least in part, was the presence of excessively large breasts in these morbidly obese volunteers. According to Cunha et al.,<sup>27</sup> big and bulky breasts can have a restrictive effect on the chest, interfering with respiratory dynamics, and they observed an increase in total lung capacity (TLC) and residual volume (RV) in volunteers subjected to reductive mastoplasty. The decrease in TLC and RV prior to breast reduction may favor the appearance of pulmonary alterations.

Due to the great risk of pulmonary complications that patients are exposed to in the post-operative period, it would be helpful to think of effective methods to minimize these complications.

One way of preventing the pulmonary complications related to bariatric surgery and other upper abdominal surgery is the early onset of respiratory therapy, with monitoring at every stage of inpatient and outpatient sessions, including the use of incentive spirometry and positive pressure, which promotes rapid recovery of lung function and prevents the formation of atelectasis.<sup>26,28-32</sup>

Thus it was concluded that 48 h after bariatric surgery, the prevalence of atelectasis in the population in question was 37%, which can be considered relevant. The atelectasis was predominantly in the lung bases, and the main risk factors for its development were to be female and over 36 years of age.

## Limitations of the study

The limitation of this study is related to the fact that there was no group of eutrophic individuals undergoing upper abdominal surgery in parallel with the obese group, in order to compare the prevalence of atelectasis in these two populations and to establish the relative risk in patients with a wider range of BMI.

## Conflicts of interest

The authors declare no conflicts of interest.

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