









# Obesity in cases undergoing the surgical procedure of lung lobectomy: risk or benefit?

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## SUMMARY

**OBJECTIVE:** The aim of the study was to evaluate the effect of body mass index on patients' short-term results following lung lobectomy.

**METHODS:** In this retrospective study, we compared the perioperative and short-term postoperative results of obese (BMI  $\geq 30$  kg/m<sup>2</sup>) versus non-obese patients (BMI  $< 30$  kg/m<sup>2</sup>) who underwent anatomical lung resection for cancer. The two groups had the same distribution of input risk factors and the same ratio of surgical approaches (thoracoscopy vs. thoracotomy).

**RESULTS:** The study included a total of 144 patients: 48 obese and 96 non-obese patients. Both groups had the same ratio of thoracoscopic vs. thoracotomy approach (50/50%), and were comparable in terms of demographics and clinical data. The groups did not significantly differ in the frequency of perioperative or postoperative complications. Postoperative morbidity was higher among non-obese patients (34.4 vs. 27.1%), but this difference was not statistically significant ( $p=0.053$ ). Hospital stay was similar in both study groups ( $p=0.100$ ). Surgery time was significantly longer among obese patients ( $p=0.133$ ). Postoperative mortality was comparable between the study groups ( $p=0.167$ ).

**CONCLUSIONS:** Obesity does not increase the frequency of perioperative and postoperative complications in patients after lung lobectomy. The slightly better results in obese patients suggest that obesity may have some protective role.

**KEYWORDS:** Obesity. Lung lobectomy. Risk factor. Obesity paradox. Thoracoscopy.

## INTRODUCTION

Lung cancer is the most common cause of cancer-related death worldwide, resulting in 1.8 million deaths per year, and is the most common malignancy in men, with an annual incidence of 2.2 million new cases<sup>1</sup>. Reflecting this global trend, in the Czech Republic in 2021, the incidence reached 67 per 100,000, and mortality was 56 per 100,000. Over 5,000 people, mostly men, die from lung cancer each year in the Czech Republic<sup>1</sup>. Surgical resection is the primary treatment modality for patients with non-small cell lung cancer.

Obesity, which has become the largest pandemic of the 21st century, directly endangers 18.5% of the population in the Czech Republic. Being overweight is a proven risk factor for several surgical complications, including intra-abdominal perioperative complications, surgical site infections, and

incisional hernias after abdominal surgery<sup>2,4</sup>. Obesity also significantly increases the overall risk of postoperative complications, such as myocardial infarction and respiratory or urinary tract infections<sup>3</sup>. It is generally acknowledged that body mass index (BMI) is associated with postoperative complications in abdominal surgery. However, the relationship between BMI and thoracic surgery has not yet been sufficiently studied, particularly in terms of lung resection. Interestingly, the authors of several recent studies have suggested that the risk of postoperative complications after cardiothoracic surgery in obese patients may be similar to or even lower than in nonobese<sup>5-7</sup>. One recent meta-analysis refers to obesity as a possible protective factor in patients after lung resection<sup>8</sup>.

To the best of our knowledge, the available literature includes insufficient data regarding the relationship between BMI and

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short-term lung resection results. Therefore, in this study, it is purposed to investigate the effect of BMI on early postoperative outcomes in patients undergoing lung lobectomy.

## METHODS

We conducted a retrospective analysis of data from the cases who had undergone surgery at the University Hospital Ostrava in 2016–2018. This study included patients who received anatomical lung resection (lobectomy) for primary lung cancer. The analysis excluded patients with postoperative histologically unproven primary lung cancer (inflammatory tumors or metastases); patients with incomplete data with the emergency surgery, due to their different entry risks.

BMI was used to assess the degree of obesity, by dividing the cases into two groups: obese ( $\text{BMI} \geq 30$ ) and nonobese ( $\text{BMI} < 30$ ). The obesity threshold was set at a BMI of 30 in accordance with the official WHO classification. To maintain proportionality and to reduce the impact of unequal surgical burden, patients operated on via thoracotomy and by thoracoscopic approach were included in both groups in the same proportion.

Demographic and clinical data were extracted from medical records. The following parameters were analyzed: age, sex, BMI, risk of anesthesia according to the American Society of Anesthesiologists (ASA), tumor size and histopathology, perioperative outcomes (i.e., duration of surgery and blood loss), and short-term postoperative outcomes (i.e., length of hospital stay, 30-day postoperative morbidity, and mortality). Postoperative complications were evaluated according to the Clavien–Dindo classification adapted for thoracic surgery, which was introduced by Seely et al.<sup>9</sup> in 2010 (Table 1).

The extracted data were analyzed by the methods of descriptive statistics, utilizing the mean, standard deviation, and t-test for the quantitative values. The chi-square test was used for categorical values. A p-value of  $< 0.05$  was considered to indicate statistical significance.

## RESULTS

A total of 144 cases with lung lobectomy had been incorporated in this study for which Table 2 lists their demographic and clinical data. This study included 52 (36.1%) women and 92 (63.9%) men, with a mean patient age of  $63.9 \pm 8.9$  years (range, 25–83 years). Preoperatively, 82 (56.9%) patients were classified as ASA II and 55 (38.2%) as ASA III. The mean tumor size was  $3.4 \pm 1.6$  cm. The most common tumor types were revealed as adenocarcinoma and squamous cell carcinoma.

The mean BMI of the study group was  $27.8 \pm 5.0$   $\text{kg}/\text{m}^2$  (range, 18–39  $\text{kg}/\text{m}^2$ ). A total of 48 (33.3%) cases were classified as obese ( $\text{BMI} \geq 30$   $\text{kg}/\text{m}^2$ ), and 96 (66.7%) as non-obese ( $\text{BMI} < 30$   $\text{kg}/\text{m}^2$ ). The vast majority of obese ones had mild-to-moderate obesity, with a mean BMI of  $33.4 \pm 2.7$   $\text{kg}/\text{m}^2$ . The obese versus nonobese groups exhibited no statistically significant differences in age, gender, ASA classification, tumor size, or histopathological findings (Table 2).

Table 3 lists the patients' short-term postoperative outcomes. Of the 144 lung lobectomies, 72 (50%) were performed using a thoracoscopic approach, and 72 (50%) via thoracotomy. The mean operation time was  $101.2 \pm 32.2$  min (range, 45–190 min). The time interval for surgery was significantly longer in the obese group than in the nonobese ( $p = 0.133$ ). The bleeding was evaluated as a perioperative complication, and significant blood loss ( $\geq 300$  ml) was reported in 3 (2.1%) patients. No significant difference in the frequency of intraoperative complications between the study groups has been revealed ( $p = 1.000$ ).

**Table 1.** Classification of morbidity and mortality after thoracic surgery.

Grade	Complication	Necessary conditions
I.	Pneumothorax	Without chest tube reinsertion
	Delirium	<3 days
	Prolonged secretion from the chest tube	
II.	Prolonged air leak	>7 days
	Delirium	>3 days
	Pneumonia	
	Anemia	
IIIa.	Urinal infection	
	Pneumothorax	Requiring chest tube reinsertion
	Emphysema	Requiring chest tube reinsertion
IIIb.	Prolonged air leak	Requiring chest tube reinsertion
	Postoperative bleeding	Requiring surgical revision
	Pneumothorax	Requiring surgical revision
	Emphysema	Requiring surgical revision
IV.	Prolonged air leak	Requiring surgical revision
	Respiratory failure	
	Renal failure	
V.	Cardiac failure	
	Death	

The mean length of hospital stay was  $10.9 \pm 6.1$  days (range, 4–35 days), without significance ( $p=0.100$ ). The average 30-days postoperative morbidity rate was 31.9% and the incidence of postoperative complications was higher in non-obese (34.4% vs. 27.1%), without significance ( $p=0.053$ ). According to the Clavien-Dindo classification adapted

for thoracic surgery, the mild complications (Grades 1–2) were described in 34 (23.6%) cases while more serious ones (Grades 3–4) in 12 (8.3%). The nonobese patients exhibited a higher incidence of mild and severe complications without significance. The 30-day postoperative mortality rate was 2.8% without significance ( $p=0.167$ ).

**Table 2.** Demographics and clinical data of study patients.

	BMI<30 (n=96)	BMI≥30 (n=48)	p-value	Total (n=144)
Age in years, mean±SD	63.5±9.4	64.7±7.9	0.400	63.9±8.9
Gender, n (%)			0.668	
Female	33 (34.4)	19 (39.6)		52 (36.1)
Male	63 (65.6)	29 (60.4)		92 (63.9)
BMI, kg/m <sup>2</sup> , mean±SD	25.1±3.1	33.4±2.7	<0.001	27.8±5.0
ASA, n (%)			0.245	
I	2 (2.1)	1 (2.1)		3 (2.1)
II	58 (60.4)	24 (50.0)		82 (56.9)
III	32 (33.3)	23 (57.9)		55 (38.2)
IV	4 (4.2)	0 (0)		4 (2.8)
Tumor size, cm, mean±SD	3.5±1.7	3.3±1.7	0.334	3.4±1.6
Histopathology, n (%)			0.291	
Adenocarcinoma	55 (57.3)	22 (45.8)		77 (53.5)
Spino-cellular carcinoma	32 (33.3)	19 (39.6)		51 (35.4)
Neuroendocrine carcinoma	5 (5.2)	6 (12.5)		11 (7.6)
Parvocellular carcinoma	4 (4.2)	1 (2.1)		5 (3.5)

**Table 3.** Intraoperative and postoperative outcomes of study patients.

	BMI<30 (n=96)	BMI≥30 (n=48)	p-value	Total (n=144)
Surgery approach, n (%)			1.000	
Thoracoscopy	48 (50)	24 (50)		72 (50)
Thoracotomy	48 (50)	24 (50)		72 (50)
Surgery time, min, mean±SD	98.3±31.2	107.1±33.5	0.133	101.2±32.2
Operative blood loss, n (%)			1.000	
<300 mL	2 (2.1)	1 (2.1)		3 (2.1)
>300 mL	94 (97.9)	47 (97.9)		141 (97.9)
Hospital stay in days, mean±SD	11.5±6.4	9.8±5.3	0.100	10.9±6.1
30-Day postoperative morbidity, n (%)	33 (34.4)	13 (27.1)	0.249	46 (31.9)
Postoperative complications, n (%)			0.053	
1	6 (6.3)	7 (14.6)		13 (9.0)
2	17 (17.7)	4 (8.3)		21 (14.6)
3	10 (10.4)	2 (4.2)		12 (8.3)
4	0 (0)	0 (0)		0 (0)
5 (mortality)	4 (4.2)	0 (0)	0.167	4 (2.8)

## DISCUSSION

Obese persons represent a high-risk group of surgical patients, particularly concerning early and septic complications. Association between obesity and short-term thoracic surgery outcomes remains controversial though BMI is a significant risk factor for perioperative and postoperative complications after intra-abdominal surgery<sup>5-7,10,11</sup>.

Many studies have repeatedly demonstrated varying relationships between some risk factors and treatment outcomes, e.g., better dialysis outcomes in patients with obesity, hypertension, or high cholesterol<sup>12</sup> which findings contrast with the general observations in the otherwise healthy population, where obesity often appears to be a risk factor. This situation is described by the term “reverse epidemiology,” and the observation that obesity may play a protective role in some patients is called the “obesity paradox.”

The possible protective effect of obesity was first described in 1999 among obese cases undergoing hemodialysis<sup>13</sup> and has subsequently been studied and evaluated by many researchers, especially in cardiology<sup>14,15</sup>. In 2002, Gruberg et al.<sup>16</sup> described significantly better outcomes after percutaneous coronary intervention in moderately obese patients with ischemic heart disease. Several meta-analyses have demonstrated that the protective effect of obesity is a viable phenomenon even in patients with heart failure and heart attack<sup>15,17</sup>.

The perioperative results in our cohort suggest that obese patients do not have an increased risk of perioperative complications during lung lobectomy. The obese and nonobese groups showed comparable rates of significant perioperative blood loss. The operative time was significantly longer for obese patients, but higher BMI did not affect the chosen surgical approach (thoroscopic approach versus thoracotomy). Other authors have previously described the relationship between obesity and prolonged thoracic surgery. Julien et al. analyzed data from 19,337 patients, and found that obesity was associated with longer operation time but not with higher 30-day mortality<sup>18</sup>.

In our study, the obese and nonobese patient groups did not exhibit different outcomes when stratified according to the chosen surgical approach. This finding leads us to conclude that obesity does not affect the feasibility and safety of thoracoscopic lung lobectomy. The thoracoscopic approach is currently considered the standard method of lung lobectomy, as confirmed by several studies<sup>19,20</sup>.

The postoperative results in our cohort suggest that obesity is not a risk factor associated with increased postoperative morbidity and mortality in patients after lung lobectomy. It even appears that obese patients exhibited lower numbers of both mild and severe postoperative complications. Although

our data do not demonstrate that obesity was a significant protective factor, the p-value at the cutoff point may seem to support this paradox.

The available literature includes insufficient data regarding the effects of obesity on patients' postoperative outcomes after lung resection. Smith et al. evaluated 499 patients after anatomical lung resections. However, their study included a wide variety of cases and did not focus only on lung lobectomies, but rather included all procedures from segmentectomy to pneumonectomy. The authors did not describe any differences in the incidence of perioperative and postoperative complications between the groups of obese and nonobese patients. Interestingly, they observed that obesity appeared to have a protective effect against postoperative respiratory complications<sup>21</sup>. Petrella et al.<sup>22</sup> studied a group of 154 patients after standard pneumonectomy. In contrast to our outcomes and the conclusions of Smith et al.<sup>21</sup>, Petrella et al.<sup>22</sup> revealed that postoperative respiratory complications were five times more common among obese cases. The authors concluded that obesity should be considered as another risk factor in patients requiring pneumonectomy.

Launer et al.<sup>23</sup> conducted a study based on the largest inpatient care database in the United States. They analyzed a total of 1238 obese and 31,983 nonobese lung cancer cases after lung lobectomy and reported that postoperative morbidity and mortality did not significantly differ between these two patient groups. Therefore, the authors concluded that obesity should not be considered a risk factor for lung resection.

Importantly, the theory of obesity as a possible protective factor has not yet been sufficiently clarified or explained. Childers and Allison<sup>24</sup> used mathematical modeling methods to describe the main phenomena of reverse epidemiology. They found that mortality was highest in patients with extreme BMI: either severely underweight or morbidly obese. Patients with a moderate BMI (overweight, mild obesity, or moderate obesity) exhibited the lowest mortality: less than patients with a BMI within the normal range. In this study, the vast majority of obese patients had mild-to-moderate obesity, and no patient suffered from morbid obesity. We assume that a population with a higher proportion of morbidly obese patients would exhibit a higher frequency and severity of postoperative complications.

The chosen surgical approach has a significant effect on the postoperative course. Lung lobectomy performed via thoracotomy is associated with longer postoperative recovery and a higher risk of postoperative complications, particularly pneumonia, compared to lung lobectomy performed via the thoracoscopic approach<sup>25</sup>. To eliminate this unequal risk, we included patients operated on via thoracotomy and the thoracoscopic approach

in the same proportions in both the obese and nonobese study groups. The main limitation of our study is its retrospective and nonrandomized design. However, it was a single-institution study including a sufficient number of patients, and with targeted elimination of adverse factors affecting the outcome.

## CONCLUSIONS

Obesity does not increase the occurrence or severity of perioperative and postoperative complications in patients after lung lobectomy. Outcomes of this study might support theories that obesity is a benefit in patients undergoing lung resection. However, further larger studies are required to reliably confirm the mentioned claim.

## AUTHORS' CONTRIBUTIONS

**LT:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft. **IS:**

Investigation, Methodology, Project administration, Resources, Software, Supervision, Visualization, Writing – review & editing. **PI:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft. **PO:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft. **DT:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft. **PG:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft. **AP:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft. **DS:** Investigation, Methodology, Project administration, Resources, Software, Supervision, Visualization, Writing – review & editing.

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