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Body mass index as a predictor of postoperative complications after anatomical lung resection



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Abstract

Introduction: Lung cancer is the leading cause of cancer-related mortality worldwide. Surgical resection remains the standard treatment for early stage non-small cell lung cancer (NSCLC). Postoperative complications significantly affect patient outcomes, and nutritional status has emerged as an important factor influencing surgical morbidity. Body mass index (BMI) is a practical and widely used indicator of nutritional status; however, its impact on postoperative outcomes after lung resection remains controversial.

Aim: BMI is a practical and widely used indicator of nutritional status; however, its impact on postoperative outcomes after lung resection remains controversial.

Material and methods: This retrospective study included patients who underwent anatomical lung resection with systematic lymph node dissection for NSCLC between 2018 and 2021. Patients were categorized according to BMI as having moderate nutritional status (BMI 18–25 kg/m^2) or good nutritional status (BMI > 25 kg/m^2). Statistical comparisons between groups were performed using appropriate parametric and non-parametric tests, with a p-value < 0.05 considered statistically significant.

Results: A total of 172 patients were included in the analysis. Serum albumin levels were significantly higher in patients with good nutritional status (p = 0.027). Postoperative length of hospital stay was significantly longer in the moderate nutritional status group (p < 0.001). Additionally, postoperative complications and prolonged air leakage were significantly more frequent in patients with moderate nutritional status (p = 0.002, p = 0.009, respectively).

Conclusions: Patients with a good nutritional status demonstrated more favorable postoperative outcomes, including fewer complications, reduced incidence of prolonged air leakage, and shorter hospital stays. Higher serum albumin levels in this group suggest a protective effect of better nutritional reserves. These findings support the concept that nutritional status plays a critical role in postoperative recovery following lung cancer surgery. Although BMI is a simple and accessible tool, future studies incorporating detailed body composition analysis and standardized perioperative care protocols may further refine risk stratification and optimize outcomes in NSCLC patients.

Key words: body mass index, non-small cell lung cancer, postoperative complication.

Introduction

Lung cancer is the second most common cancer in both genders after breast cancer in women and prostate cancer in men worldwide [1]. It ranks first among cancer-related deaths worldwide [2]. Multiple risk factors play a role in the high incidence of lung cancer. Tobacco consumption is the foremost risk factor, followed by exposure to carcinogens (such as asbestos, ionizing radiation), air pollution, and chronic inflammation (tuberculosis, COPD) [3].

Histologically, lung cancer is divided into two main categories: small cell and non-small cell lung cancer (NSCLC). For early-stage NSCLC (Stage 1 and 2 without mediastinal lymph node involvement), standard treatment is surgery [4]. If the lesion can be completely excised, lobectomy is the preferred procedure for Stage 1 and 2 NSCLC over pneumonectomy [4]. Lobectomy can be performed via open thoracotomy or alternatively using video-assisted thoracoscopic surgery (VATS) and robotic-assisted thoracoscopic surgery (RATS) [5].

Complications arising after surgery affect the patient's survival and quality of life. Therefore, it is important for clinicians to prevent their occurrence and manage them effectively if they develop. Resection of lung parenchyma after lobectomy may lead to prolonged air leakage. Addi-

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tionally, patients may experience dyspnea and subcutaneous emphysema (pneumoderma). Pneumothorax is one of the complications that may develop in any surgery involving the pleural cavity, and the need for intensive care admission should not be overlooked, especially in patients with additional comorbidities [6].

Enhanced recovery after surgery (ERAS) includes procedures for accelerated discharge after surgery. It has been shown that patients undergoing ERAS experience fewer complications, shorter hospital stays, and shorter drainage durations. ERAS procedures involve patient care in the preoperative, intraoperative, and postoperative periods. While preoperative care includes correcting low albumin levels, addressing malnutrition, etc., intraoperative care involves minimal invasive surgery, and postoperative care includes early mobilization, initiation of antithrombotic therapy, etc. [7].

Obesity remains one of the most concerning public health issues worldwide due to its high prevalence [8]. Body mass index (BMI) is one of the most practical methods used to evaluate obesity and overweight. According to the BMI classification, obesity is defined as a BMI ≥ 30 kg/m². Based on this definition, approximately 40% of adults in the United States are classified as obese, while globally an estimated 1 billion men and 1.1 billion women are overweight or obese [8, 9]. Obesity or overweight in adults is associated with high morbidity and significantly reduced life expectancy [8]. Patients with a BMI > 25 kg/m² have a significantly increased risk of mortality from coronary heart disease, stroke, diabetes mellitus and chronic kidney disease [10, 11].

Aim

In our study, we aimed to compare the complication data of two groups evaluated as moderate and good in terms of nutritional status in patients who underwent anatomical lung resection and systematic lymph node dissection due to NSCLC.

Material and methods

Ethics committee approval was received for our study (date: 21/03/2019, number: 17109671-604.01.02-45889). In our study, data from 194 patients who underwent lung resection for non-small cell lung carcinoma at our clinic between 2018 and 2021 were examined. For each patient, gender, height, and weight were used to calculate BMI according to the formula BMI = weight (kg)/height (m)². The BMI was divided into two categories: those with BMI between 18 and 25 were classified as having a moderate nutritional status, while those with a BMI value above 25 were classified as having a good nutritional status. Twenty-one patients for whom BMI could not be calculated were excluded from the study. Of the remaining patients, 106 (61.6%) had a good nutritional status, while 66 (38.4%) had a moderate nutritional status.

Demographic data (age, gender), clinical parameters (smoking pack-year history, body weight, height, presence of comorbidities, diabetes history, cardiac risk index, pulmonary risk index, postoperative hospital stay, intensive care admission), respiratory parameters (FVC, FEV1, %FVC, %FEV1, FEV1/FVC, DLCO, DLCO/VA, pO_2, pCO_2), and laboratory parameters (HbA1C, %HbA1c, glucose, albumin, CRP, LDH, leukocyte count, lymphocyte count, monocyte count, neutrophil count, hemoglobin level) were retrospectively noted.

Statistical analysis

The normality of continuous variables was assessed using the Kolmogorov–Smirnov test. Continuous variables with normal distribution were expressed as mean ± standard deviation, while non-normally distributed variables were expressed as median (minimum–maximum). Parametric data were analyzed using the Student's *t*-test or Mann–Whitney *U* test, as appropriate. Categorical variables were compared using the χ^2 test and Fisher's exact test. A *p*-value < 0.05 was considered statistically significant. All statistical analyses were performed using SPSS version 27.0 (IBM Corp., Armonk, NY, USA).

Results

When evaluated in terms of demographic data, no statistically significant difference was observed between the two groups. The mean age in Group 1 was 61.0 ±10.6, while in Group 2 it was 60.4 ±12.9. In Group 1, there were 80 (75%) male patients and 26 (25%) female patients, while in Group 2, there were 54 (82%) male patients and 12 (18%) female patients (Table I).

When the groups were evaluated, they were found to be similar in terms of respiratory reserves, additional comorbidities, and Charlson comorbidity risk indices (Tables II and III). No statistically significant differences were observed between the groups according to the 8th TNM staging (Table III).

Albumin levels were statistically significantly higher in the group with good nutritional status, while no statistically significant differences were observed between the groups in terms of other biochemical parameters ($p = 0.027$) (Table II).

In the group with moderate nutritional status (Group 2) postoperative length of stay was statistically significantly higher ($p < 0.001$) (Table II).

The occurrence of postoperative complications and prolonged air leakage status were statistically significantly higher in the group with moderate nutritional status (Group 2) (respectively; $p = 0.002$, $p = 0.009$) (Table II).

Discussion

In this retrospective analysis of 172 patients who underwent anatomical lung resection for non-small cell lung cancer, we observed that patients with a good body mass index (BMI > 25) had significantly higher preoperative serum albumin levels, shorter postoperative hospital stays, and lower rates of postoperative complications and prolonged air leakage compared with patients with a moderate nutritional status [12–19].

Nutritional status has long been recognized as an important determinant of surgical outcomes, yet its role in thoracic oncology remains relatively underexplored. Consistent with our findings, previous studies have demonstrated

Table I. Demographic data

Parameter	Group with good nutritional status Group 1 (n = 106)	Group with moderate nutritional status Group 2 (n = 66)	P-value
Age	61.0 ±10.6	60.4 ±12.9	0.217
Sex			
Male	80 (75.5%)	54 (81.8%)	0.329
Female	26 (24.4%)	12 (18.2%)	Odds ratio: 0.68 (0.318–1.471)

Table II. Evaluation of parametric data for two groups based on body mass index (BMI): Group 1 with good nutritional status and Group 2 with moderate nutritional status (Student's t-test was used)

Parameter	Group with good nutritional status Group 1 (n = 106)	Group with moderate nutritional status Group 2 (n = 66)	P-value
HbA1c	54.29 ±24.64	68.71 ±36.96	0.123
%HbA1c	7.23 ±2.3	8.46 ±3.95	0.095
Mean glucose	142.15 ±56.18	143.90 ±84.75	0.427
Cigarettes pack-years	37.80±22.75	43.32 ±26.74	0.137
FVC	3288.05 ±864.63	3347.69 ±829.52	0.509
FEV1	2396.50 ±776.29	2342.46 ±853.08	0.569
%FVC	91.43 ±18.94	90.44 ±21.65	0.974
%FEV1	81.69 ±20.31	78.36 ±22.53	0.592
FEV1/FVC	91.46 ±14.27	88.75 ±17.87	0.193
DLCO	19.02 ±6.81	17.64 ±5.55	0.208
%DLCO	77.06 ±20.84	68.77 ±17.78	0.352
DLCO/VA	3.93 ±1.10	3.98 ±3.70	0.190
%DLCO/VA	91.28 ±17.51	80.76 ±19.03	0.313
Preoperative pO_2	71.76 ±23.77	71.94 ±22.65	0.716
Preoperative CO_2	39.45 ±8.75	40.46 ±6.80	0.279
VO2max	22.40 ±3.91	23.66 ±4.72	0.660
Albumin	5.82 ±12.92	4.29 ±0.42	0.017
CRP	17.54 ±43.37	27.44 ±51.76	0.064
LDH	242.43 ±103.49	222.36 ±103.77	0.893
Leukocytes	8.47 ±3.27	7.78 ±3.30	0.675
Lymphocytes	2.29 ±3.36	1.59 ±0.74	0.180
Monocytes	0.63 ±0.25	0.59 ±0.28	0.891
Neutrophils	6.52 ±5.58	6.22 ±6.23	0.895
Hemoglobin	13.31 ±2.01	12.47 ±1.90	0.714
Tumor SUVmax	10.28 ±7.09	10.82 ±7.55	0.760
Lymph node SUVmax Value	6.68 ±5.50	7.21 ±5.85	0.961
Postoperative length of hospital stay [days]	5.67 ±4.48	8.35 ±6.52	< 0.001

that BMI and markers of nutritional reserve are closely associated with postoperative pulmonary complications following lung resection.

Pierce *et al.* reported that BMI was one of the strongest predictors of respiratory complications in patients undergoing lobectomy or sublobar resections [20]. Similarly, Busch *et al.* identified significant weight loss and low serum albumin levels as major risk factors for postoperative complications, emphasizing the role of poor nutritional status in adverse outcomes [21]. Liu *et al.* further demonstrated that low preoperative serum albumin was an independent predictor of postoperative pulmonary complications after lobectomy, supporting the clinical relevance of albumin as a surrogate marker of nutritional status [22].

In our cohort, serum albumin levels were significantly higher in patients with a good nutritional status, while other biochemical parameters did not differ between groups. This finding supports the hypothesis that better nutritional reserves may contribute to improved tissue healing, reduced inflammatory response, and lower susceptibility to postoperative complications. Of particular importance, prolonged air leakage – a frequent and clinically relevant com-

Table III. Evaluation of the two groups with good nutritional status (Group 1) and moderate nutritional status in terms of non-parametric data (χ^2 test was used)

Parameter	Group with good nutritional status Group 1 (n = 106)	Group with moderate nutritional status Group 2 (n = 66)	*P*-value	Odds ratio (95% CI)
Comorbidity	87 (82.1%)	53 (80.3%)	0.771	1.12 (0.513–2.45)
Diabetes history	28 (26.4%)	12 (18.2%)	0.214	1.61 (0.755–3.454)
Charlson Comorbidity Risk Index			0.731	–
2	98 (92.5%)	61 (92.4%)		
3	5 (4.7%)	4 (6.1%)		
4	2 (1.9%)	1 (1.5%)		
9	1 (0.9%)	0		
TNM staging			0.295	
1A	35 (33.0%)	27 (40.9%)		
1B	12 (11.3%)	11 (16.7%)		
2A	13 (12.3%)	8 (12.1%)		
2B	33 (31.1%)	10 (15.2%)		
3A	12 (11.3%)	9 (13.6%)		
3B	1 (1.0%)	1 (1.5%)		
Complication	13 (12.3%)	21 (31.9%)	0.002	0.3 (0.138–0.652)
Prolonged air leak	1 (0.9%)	6 (9.1%)		
Subcutaneous emphysema	5 (4.7%)	5 (7.6%)		
Wound infection	3 (2.8%)	5 (7.6%)		
Atrial fibrillation	4 (3.9%)	5 (7.6%)		
Prolonged air leakage	1 (0.9%)	6 (9.1%)	0.009	0.09 (0.011–0.810)
Subcutaneous emphysema	5 (4.7%)	5 (7.6%)	0.436	0.6 (0.168–2.172)
ICU admission needed	20 (18.9%)	16 (24.2%)	0.126	0.73 (0.35–1.53)

plication after lung resection – was significantly more common in patients with a moderate nutritional status. This observation aligns with previous reports showing that low BMI and malnutrition are associated with impaired lung parenchymal healing and prolonged air leakage [23, 24].

ERAS protocols aim to reduce surgical stress, minimize complications, and shorten hospital stay through standardized perioperative care. Although ERAS was not directly evaluated as a variable in our study, its principles provide a useful framework for interpreting our findings. Previous studies have shown that ERAS protocols are effective across different BMI categories and may offer particular benefits in patients at nutritional risk. Shin *et al.* demonstrated that ERAS significantly reduced length of stay in plastic surgery patients, with the greatest benefit observed in patients with higher BMI [25]. Similarly, Tian *et al.* reported improved postoperative recovery and shorter hospitalization in gastric cancer patients managed with ERAS protocols, regardless of BMI category [12]. These data suggest that optimization of perioperative care, in combination with adequate nutritional status, may synergistically improve postoperative outcomes.

The relationship between obesity, cancer prognosis, and surgical outcomes remains complex. While obesity is a known risk factor for the development and progression of several malignancies, including breast, colorectal, and endometrial cancers, an "obesity paradox" has been described in operable NSCLC [13, 14]. Several studies have reported better survival rates and fewer postoperative complications in overweight and obese patients compared with underweight or normal-weight patients [14, 15]. In lung cancer surgery, underweight status has been consistently associated with increased respiratory and infectious complications, whereas overweight patients may benefit from greater metabolic and nutritional reserves [14, 15]. Our findings support this concept, as patients with a moderate nutritional status experienced higher complication rates and longer hospital stays.

Nevertheless, BMI alone is an imperfect marker of nutritional and metabolic health. Emerging evidence suggests that more refined measures, such as body composition analysis, muscle mass, fat distribution, and indices such as abdominal adiposity or body shape index, may provide superior prognostic information compared with BMI alone [16–18]. Additionally, smoking history – which is closely linked to both BMI and lung cancer prognosis – should be considered as a potential confounder when interpreting the relationship between BMI and postoperative outcomes [19].

This study has several limitations. First, its retrospective and single-center design limits the ability to establish causality and may reduce the generalizability of the findings. Second, BMI was used as the sole indicator of nutritional status; detailed body composition parameters such

as muscle mass, sarcopenia, or visceral adiposity were not available. Third, although albumin was included as a laboratory marker of nutrition, it can be influenced by inflammation and comorbid conditions, potentially confounding its interpretation. Fourth, ERAS implementation was not formally analyzed, and variations in perioperative management over the study period may have influenced outcomes. Finally, long-term oncological outcomes such as disease-free and overall survival were not assessed.

Conclusions

Our findings suggest that patients with a good body mass index undergoing anatomical lung resection for NSCLC have higher serum albumin levels, fewer postoperative complications, lower rates of prolonged air leakage, and shorter hospital stays compared with patients with moderate nutritional status. These results highlight the importance of preoperative nutritional status in predicting postoperative outcomes after lung cancer surgery. While BMI remains a practical and accessible tool in daily clinical practice, future prospective studies incorporating detailed body composition analysis and standardized ERAS protocols are warranted to better define the role of nutritional optimization in improving surgical outcomes in NSCLC patients.

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Ethical approval

Ethics committee approval was received for our study (date: 21/03/2019, number: 17109671-604.01.02-45889). Participation was voluntary, and informed consent was obtained from all respondents. This study was conducted in accordance with the principles of the Declaration of Helsinki.

Disclosures

The authors report no conflict of interest.

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